THE EFFECT OF USING DYNAMIC GEOMETRY SOFTWARE WHILE TEACHING BY GUIDED DISCOVERY ON STUDENTS' GEOMETRIC THINKING LEVELS AND ACHIEVEMENT

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ABSTRACT

THE EFFECT OF USING
DYNAMIC GEOMETRY SOFTWARE
WHILE TEACHING BY GUIDED DISCOVERY
ON STUDENTS' GEOMETRIC THINKING LEVELS AND
GEOMETRY ACHIEVEMENT

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This study aimed to investigate the effects of using dynamic geometry software while teaching by guided discovery compared to paper-and-pencil based guided discovery and traditional teaching method on sixth grade students' van Hiele geometric thinking levels and geometry achievement. The study was conducted in one of the private schools in Ankara and lasted six weeks. The sample of the study consisted 47 sixth grade students in the school. The present study was designed as pretest-posttest control group quasi-experimental study.

In order to gather data, Geometry Achievement Test (GAT) and Van Hiele Geometric Thinking Level Test (VHL) were used. At the end of the research, the data were analyzed by means of analysis of covariance. The results of the study indicated that there was a significant effect of methods of teaching on means of the collective dependent variables of the sixth grade students' scores on the POSTVHL after controlling their PREVHL scores, and there was a significant effect of methods of teaching on means of the collective dependent variables of the sixth grade students' scores on the POSTGAT after controlling their PREGAT scores.

Keywords: Geometry, Dynamic Geometry Software, Geometers' Sketchpad, Van Hiele Geometric Thinking Levels, Guided Discovery Approach.

ÖZ

DİNAMİK GEOMETRİ YAZILIMLARI DESTEKLİ YÖNLENDİRMELİ KEŞİF YÖNTEMİNİN ÖĞRENCİLERİN GEOMETRİK DÜŞÜNME DÜZEYLERİNE VE GEOMETRİ BAŞARISINA ETKİSİ

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Bu çalışma, dinamik geometri yazılımları destekli yönlendirmeli keşif yönteminin, kağıt-kalem temelli yönlendirmeli keşif yöntemi ve geleneksel öğretim yöntemiyle karşılaştırıldığında altıncı sınıf öğrencilerinin van Hiele geometrik düşünme düzeylerine ve geometri başarılarına olan etkisini araştırmayı amaçlamıştır. Araştırma Ankara' daki bir özel okulda yürütülmüş ve 4 hafta sürmüştür. Çalışmanın örneklemini bu okuldaki 47 altıncı sınıf öğrencisi oluşturmaktadır. Bu çalışmada ön-test son-test kontrol grup deseni kullanılmıştır. Veri toplamak amacıyla Geometri Başarı Testi ve Van Hiele Geometrik Düşünme Düzeyleri Testi kullanılmıştır. Elde edilen nicelikler kovaryans analizi ile incelenmiştir. Analiz sonuçlarına göre; gruplar arasında geometri başarı testinden alınan puanlara göre istatistiksel olarak anlamlı bir fark bulunmuştur. Ayrıca, Van Hiele geometrik düşünme düzeyleri testinden alınan puanlara göre gruplar arasında istatistiksel olarak anlamlı bir fark bulunmuştur.

Anahtar Kelimeler: Geometri, Dinamik Geometri yazılımları, Geometri Sketchpad,
Van Hiele Geometrik Düşünme Düzeyleri, Yönlendirmeli Keşif Yaklaşımı.

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LIST OF ABBREVIATIONS

ABBREVIATION

EG 1: Experimental Group 1
EG 2: Experimental Group 2
CG : Control Group
GAT: Geometry Achievement Test
VHL: Van Hiele Geometric Thinking Level Test
PREGAT: Students’ pretest scores on Geometry Achievement Test
PREVHL: Students’ pretest scores on Van Hiele Geometric Thinking Level Test
POSTGAT: Students’ posttest scores on Geometry Achievement Test
POSTVHL: Students’ postest scores on Van Hiele Geometric Thinking Level Test
ANCOVA: Univariate analysis of covariance
Df: Degree of freedom
N: Sample size
Sig: Significance

CHAPTER 1

INTRODUCTION

Most of the students given situations in which they have to apply their school knowledge, they do not know what to do.

Howard Gardner

This quote illustrates the students' situation in learning geometry. Geometry is an important area in mathematics education and it is not only a subject in mathematics courses but also a way of understanding the world around us. We live in an environment that includes objects and things having geometrical shapes. To use these objects appropriately and in the desired way requires knowing the shapes and relationship between the shape and function of the object (Altun, 2004). Knowledge of geometry helps individuals to interpret, understand and solve daily life problems. By learning the underlying principles of geometry, we can apply this knowledge in real world problems. In many research studies, usefulness of geometry knowledge to solve daily life problems like measurement of lengths, drawing, reading maps, etc. is frequently mentioned (Bussi & Boero, 1998; Kenney, Bewszka & Martin, 1992).

Learning geometry is a successive process. Preliminary and fundamental concepts of geometry should be taught in early ages, and the more complicated ones should be taught as the students grow up. Therefore, every step in the school geometry should be taken into consideration seriously. Clements and Battista (1992) describe the school geometry as the study of those spatial objects, relationships, and transformations that have been formalized and the axiomatic mathematical systems that have been constructed to represent them (p.420). Baykul (2005) stated the reasons why geometry concepts were included in the elementary school curriculum as,

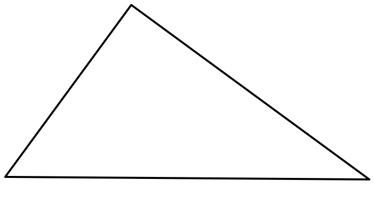
- Geometry studies are important in development of students' critical thinking and problem solving skills,
- Geometry concepts provide help in learning concepts in other mathematical areas, such as fractions and algebraic expressions,
- Geometry is one of the important areas of mathematics that is used in daily life.
- Geometry helps the students to realize the world around themselves and appreciate the worth of their world.
- Geometry is the way of entertaining and loving mathematics.

It has been argued that many students are not learning geometry as they need or are expected to learn (Baynes, 1998; Crowley, 1987; NCTM, 1989; Ubuz & Üstün, 2003). This argument is valid for Turkish students and consistent with the results of international studies such as TIMSS (1999) and PISA (2003). In both studies, Turkey is one of the least successful countries in mathematics, especially in geometry. Turkish students received their lowest rankings in geometry within five specific content areas in mathematics. To speak for geometry case, in PISA (Programme for International Student Assessment), 75% of students were at or under the basic competence level (known as level 2); where the mean of the OECD countries was on Level 3 in a 6 level scale. The results in TIMSS (Third International Mathematics and Science Study) were same with the ones in PISA. According to the TIMSS, Turkish students scored below the international average in the overall mathematics achievement and they got the lowest mean scores from the geometry area of the test comparing to other four content areas of fractions and number sense; measurement; data representation, analysis and probability; and algebra.

As this is the case, improving students' geometric thinking levels should be one of the major aims of mathematics education. New Mathematics curriculum in Turkey emphasizes the importance of this aim. In the first five years of the program, students are expected to recognize the shapes and 3D objects and to name them according to their visual characteristics. The students are expected to classify the shapes and objects according to the main characteristics. In the same vein, in the middle year's program, the aim is to help students to understand the properties of geometric objects and develop relationships between these properties.

It can be said that, students' understanding of geometric concepts is directly related to the way we teach geometry topics. In general, instruction in geometry has been teacher-centered and prescriptive (Baynes, 1998; Keiser, 1997; Mayberry, 1983). In such an environment, students will have lack of creativity, visualization, and conceptual development. This kind of result does not match the desired outcome of geometry teaching. According to National Council of Teachers of Mathematics report in USA, today's children' needs and interests are more different than the children of the past decades (NCTM, 2000) and technology serves valuable support to learning of today's children. Computers facilitate the construction of knowledge and lead to better understanding. Even with preschool children, computer-based programs are as effective in teaching about shapes as teacher-directed programs (von Stein, 1982).

To integrate technology into geometry teaching process, dynamic geometry software systems can provide useful help. Dynamic geometry software refers to interactive software in which students essentially create compass and straightedge constructions, which can then be "dragged," altering the size of the construction, but not affecting the axioms or theorems used in the construction (Mansi, 2003). Healy and Hoyles (2001) argue that "Dynamic geometry systems provide access to a variety of geometrical objects and relations with which users can interact in order to construct and manipulate new objects and relations" (p.235). In such environments students find opportunity to drag, construct, rotate, translate and etc. objects, in order to understand the nature of the phenomena related to particular concepts of geometry. In the dynamic environment, the size and position of the shape is changed while its invariant features remain same. By this way, the construction of geometric knowledge differs in dynamic geometry environments, from traditional, static paper and pencil environments. For instance, in a traditional classroom environment, when the teacher draws a shape as in the figure 1.1, "shape a", on the blackboard, no matter which type it is, almost all of the students name this shape as triangle.



shape a shape b

Figure 1.1 Shape a and shape b

When this triangle is drawn as in Figure 1.1 “shape b” most of the students in early grades will be confused. Some of them will say that, it is not triangle and some of them will say it is “reverse triangle”. This example is only one among the several misunderstandings of students in learning geometry. This is due to the misinterpretations of teachers and textbook writers and static environment of the paper and pencil environments. In a static environment, students learn the geometric shapes as in their generic case. However, in dynamic environments, there is the opportunity to stretch, skew, rotate, and translate the shape without distorting its invariant features. By this way, students feel that they interact with the shape by dragging with computer mouse and investigate which features are common for all shapes in that type and which features can be changed. Students in dynamic environment will understand simply by dragging that Figure 1.1 shape a and b are same and the latter is only another appearance of the former in terms of position and retains its defining characteristics.

With an increase in the availability of technology, Dynamic geometry environments are becoming more prevalent in the classroom. New mathematics curriculum also offers a real integration of technology into the teaching of mathematics and claims the necessity of this integration at all levels.

Geometer’s Sketchpad (Jackiw, 1991) is one of the dynamic geometry environments that can be used in teaching the contents related to the polygons. By using Geometer’s Sketchpad (GSP), students investigate and explore geometric concepts and manipulate geometric structures. Essentially, GSP represents visually what students learn to do mentally. As July (2001) mentioned, “visual nature of the GSP dynamic representation may encourage constructing similar mental images as those displayed on the GSP screen” (p.35).

The research of Battista, Wheatley & Talsma (1982) suggests that geometric thinking skills can be improved through appropriate instruction. GSP as an instructional tool may help students gain access to higher geometric thinking levels by providing students an environment for exploration. NCTM (2000) stated that technology, when used appropriately provide a rich environment in which students’ understanding and intuition can be developed. Appropriate learning environment for using GSP may be designed with guided discovery approach. In this approach, students were led to discover for themselves a fact, construct, principle, or strategy through carefully planned instructional prompting and questioning (Howerton, 1987).

This study aimed to investigate that by designing appropriate instructional environments which are facilitated by GSP; if it is possible to help students improve their intuition about geometric shapes, progress through the levels of geometric thinking. In this study, instructional environments were designed based on guided discovery approach. The purpose of this study was to investigate the effect of using dynamic geometry software while teaching by guided discovery on students’ geometric thinking levels and achievement. In addition to this, the effect of using guided discovery technique without the support of technology in teaching of geometry concept will be investigated.

1.1 Research question and sub-problems

1.1.1 Research Question

The study addresses the following research question:

What are the effects of using dynamic geometry software while teaching by guided discovery compared to paper-and pencil-based guided discovery and traditional teaching method on sixth grade students’ van Hiele geometric thinking and achievement on polygons when students' prior van Hiele geometric thinking and achievement scores are controlled?

1.1.2 The Sub-problems

The following sub-problems were investigated based on the research question.

1. Is there a significant difference between the effects of using dynamic geometry software while teaching by guided discovery compared to traditional teaching method on sixth grade students' van Hiele geometric thinking level test scores when students' prior van Hiele geometric thinking level test scores are controlled?

2. Is there a significant difference between the effects of using dynamic geometry software while teaching by guided discovery compared to paper-and-pencil based guided discovery, on sixth grade students' van Hiele geometric thinking level test scores when students' prior van Hiele geometric thinking level test scores are controlled?

3. Is there a significant difference between the effects of teaching by paper-and-pencil based guided discovery compared to traditional teaching method on sixth grade students' van Hiele geometric thinking level test scores when students' prior van Hiele geometric thinking level test scores are controlled?

4. Is there a significant difference between the effects of using dynamic geometry software while teaching by guided discovery compared to traditional teaching method on sixth grade students' geometry achievement when students' prior geometry achievement scores are controlled?

5. Is there a significant difference between the effects of using dynamic geometry software while teaching by guided discovery compared to paper-and-pencil based guided discovery, on sixth grade students' geometry achievement when students' prior geometry achievement scores are controlled?

6. Is there a significant difference between the effects of teaching by paper-and-pencil based guided discovery compared to traditional teaching method on sixth grade students' geometry achievement when students' prior geometry achievement scores are controlled?

1.2 Hypotheses

In order to answer the quantitative research problems the following null hypotheses were used:

Null Hypothesis 1:

There will be no significant effects of methods of teaching (teaching by guided discovery using dynamic geometry software versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' posttest scores of van Hiele geometric thinking level test when students' prior van Hiele geometric thinking level scores are controlled.

Null Hypothesis 2:

There will be no significant effects of methods of teaching (teaching by paper-and pencil based guided discovery versus teaching by guided discovery using dynamic geometry software) on means of the collective dependent variables of the sixth grade students' posttest scores of van Hiele geometric thinking level test when students' prior van Hiele geometric thinking level scores are controlled.

Null Hypothesis 3:

There will be no significant effects of methods of teaching (teaching by paper-and-pencil based guided discovery versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' posttest scores of van Hiele geometric thinking level test when students' prior van Hiele geometric thinking level scores are controlled.

Null Hypothesis 4:

There will be no significant effects of methods of teaching (teaching by guided discovery using dynamic geometry software versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' posttest scores geometry achievement test when students' prior geometry achievement scores are controlled.

Null Hypothesis 5:

There will be no significant effects of methods of teaching (teaching by paper-and pencil based guided discovery versus teaching by guided discovery using dynamic geometry software) on means of the collective dependent variables of the sixth grade students' posttest scores geometry achievement test when students' prior geometry achievement scores are controlled.

Null Hypothesis 6:

There will be no significant effects of methods of teaching (teaching by paper-and-pencil based guided discovery versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' posttest scores geometry achievement test when students' prior geometry achievement scores are controlled.

1.3 Definition of the important terms

1.3.1 Guided Discovery

According to Weimer (1975), guided discovery is one of the discovery learning types, which falls in between the expository and pure discovery. In this study, guided discovery refers to the same meaning in which students were guided by teacher by means of some questions in order to help them in exploring, conjecturing and constructing their geometrical knowledge.

1.3.2 Dynamic Geometry Software

Dynamic geometry software is an environment which provides students explore geometric relationships and make and test conjectures. In dynamic geometry learning environments, students find opportunity to drag, construct, rotate, translate and etc. objects, in order to understand the particular concepts of geometry.

1.3.3 Geometer's Sketchpad

Geometer's Sketchpad is a kind of dynamic geometry software, which enables manipulation of geometric objects. Geometric objects are manipulated by changing position, size and shape of the objects, while relationships defined in the original sketches are preserved (Lester, 1996, p.6).

1.3.4 Traditional Instruction

Teacher-centered, textbook based approach. In the traditional instruction environments, teacher lectures and sometimes ask questions to the students. Rules, definitions and generalizations are given first, and then examples are given. The students are passive listeners and note takers.

1.4 Significance of the Study

This study was aimed to investigate how integrating dynamic geometry software into guided discovery setting influences students' van Hiele geometric thinking levels and their achievement. There are many studies underlying the advantages of using dynamic geometry software on developing students' understandings of geometric concepts (Hativa, 1984; Jones, 2000; Jones, 2001; McCoy, 1991; Marrades, & Guitérrez, 2000; Velo, 2001).

In order to make dynamic geometry software more helpful, the kind of learning method should be considered. Usiskin (1982) and Fuys, Geddes, & Tischler (1988) promoted that the role of instruction is crucial in teaching and learning geometry. Usiskin (1982) claimed that, to involve students in the lessons and get rid of rote learning, learning environments should promote discovery. Researches documented that guided discovery is one of many successful teaching methods (Anastasiow et al., 1970; Foletta, 1994; Choike, 2000; Gerver&Sgroi, 2003; Kroesbergen&Van Luit, 2002; Mayer, 2004; Moreno, 2004; Ubuz and Üstün, 2004).

The literature documented the positive effects of using dynamic geometry software and guided discovery method. However, the effect of using dynamic geometry software in the learning environment designed with guided discovery approach is still need to be investigated. Considering this fact, there is a need to design an experimental study on using dynamic geometry software while teaching by guided discovery and to document the facilities of using dynamic geometry software determined by quantitative measures.

Findings of this study will be significant in validating the use dynamic geometry software while teaching by guided discovery. Such kind of information will provide idea for prospective teachers in designing learning environments and preparing their lesson plans for both teaching by paper-and-pencil based guided discovery lessons and teaching by guided discovery lessons by using dynamic geometry software lessons.

1.5 Assumptions

There are several assumptions and limitations in the present study. Assumptions for this study were listed as follows:

1. All tests were administered to the experimental and control groups under the same standard conditions.
2. The subjects of the study were sincere while responding to the test items.
3. Students from different classes did not interact and communicate about the items of post achievement tests before administration of these tests.

1.6 Limitations

The identifiable factors that limit the generalizability of the research or that would have enhanced the effectiveness of the treatment were as follows:

1. Subjects were not randomly assigned to the experimental and the control group. Therefore the study was a quasi-experimental study.

2. The results of the study are limited to the population with similar characteristics.
3. The results of the study are limited to the polygons content. Therefore this focus limits to generalize the result of this study to other contents in geometry.
4. Duration of the treatment is four weeks. This duration is short to gain evidence about improvement of students' geometric thinking.

CHAPTER 2

REVIEW OF THE RELATED LITERATURE

The goal of this study was to investigate the effect of using dynamic geometry software while teaching by guided discovery on students' geometric thinking levels and achievement. This chapter is devoted to the review of literature related to this study. The concepts that will be covered in this chapter are; students understanding of geometry, van Hiele geometric thinking levels, dynamic geometry software, using Geometer's Sketchpad and guided discovery.

2.1 Students' Lack of Achivement in Geometry

Students' low achievement in geometry was reported by both national and international comparision studies (Carpenter, Corbitt, Kepner, Lindquist, & Reys, 1980; Crosswhite, Dossey, Swafford, McKnight, & Cooney, 1985). For example, Turkish elementary and middle grades students were outperformed in Geometry achievement tests by students in other nations (TIMSS, 1999; PISA, 2003). Many researches revelaed that many students encounter cognitive difficulties in learning geometry in both middle and high schools (e.g., Hoffer, 1981; Usiskin, 1982; Burger & Shaughnessy, 1986; Crowley, 1987; Fuys, Geddes, & Tischler, 1988; Gutierrez, Jaime, & Fortuny, 1991; Mason, 1997).

Clements and Battista (1992) cited evidence that, according to the National Assessment of Educational Progress in 1982, only 64% of 17-year-old American high school students who have taken geometry knew that a rectangle was a parallelogram, and only 16% could find the area of a figure made up of two rectangles.

Many studies confirmed that many students are not learning geometry as they need or are expected to learn (Baynes, 1998; Burger & Shaugnessy, 1986; Clements & Battissa, 1992; Crowley, 1987; Fuys 1985; Fuys, Geddes, & Tischler, 1988; Mayberry, 1983; NCTM, 1989; Senk, 1985; Ubuz & Ustün, 2003; Usiskin, 1982; van Hiele, 1986; van Hiele-Geldof, 1984). In can be said that, most of the elementary school students do not get the necessary skills those needed for entering into a high school.

In order to meet the students' needs, design appropriate learning environments and make them succesful in geometry achievement, development of their geometric thinking should be taken into account. The van Hiele model provides idea about students' geometric thinking.

2.2 Van Hiele Geometric Thinking Levels

In 1957, the van Hiele model was developed by two Dutch mathematics educators, P. M. van Hiele, and his wife (van Hiele, 1957). The van Hiele model of geometric thought outlines the hierarchy of levels through which students' progress as they develop of geometric ideas. Van Hiele promoted that; geometric thinking and students' progress via levels of thought from a visual level to proof have five levels (van Hiele, 1959; van Hiele, 1986, van Hiele-Geldof, 1984).

2.2.1 Level 0

At level 0, students are able to identify shapes by their physical attributes. For example, without being able to tell the properties of it, a student may be able to say something is a rectangle. According to the child in this level, it is a rectangle because it looks like a rectangle. Children may also classify another quadrilateral, for example parallelogram as a rectangle. Children at level 0 are able to form a visual and mental representation of geometric figures; however they do not comprehend the class inclusion. Students may be able to distinguish one figure from another simply based on its appearance.

In their study, Fuys, Geddes and Tischler (1988) stated the actions of students at this level. They contented that student at this level; identifies instances of a shape by its appearance as a whole, construct, draws, or copies a shape, names or labels shapes and other geometric configurations and uses standard and/or names and labels appropriately, compares and sorts shapes on the basis of their appearance as a whole, solves routine problems by operating on shapes rather than by using properties, which apply in general, identifies parts of a figure but does not analyze a figure in terms of its components, does not think of properties as characterizing a class of figures and does not make generalizations about shapes or use related language (pp.60-63).

2.2.2 Level 1

Children at level 1 are able to recognize shapes by their specific properties. In addition to the mental, visual representation acquired in level 0, children also have a mental representation based on properties of shape. For example, children at this level classify the parallelogram by some property of it, such as having four congruent sides. They begin to recognize that certain figures have certain properties; however, they still don’t have class inclusion. Although they see figures as collections of properties and they can recognize and name properties of geometric figures, but they do not see relationships between these properties.

As Fuys et al. (1988) asserted, student at this level; identifies and tests relationships among components of figures, recalls and uses appropriate vocabulary for components and relationships, compares two shapes according to relationships among their components, sorts shapes in different ways according to certain properties, interprets and uses verbal description of a figure in terms of its properties and uses this description to draw/construct the figure, interprets verbal or symbolic statements of rules and applies them, discovers properties of specific figures empirically and generalizes properties for that class of figures, describes a class of figures in terms of its properties, tells what shape a figure is, given certain properties, identifies which properties used to characterize one class of figures also apply to another class of figures according to their properties, discovers properties of an unfamiliar class of figures, solves geometric problems by using known properties of figures or by insightful approaches, formulates and uses generalizations about properties of figures (guided by teacher/ material or spontaneously on their own) and uses related language but does not explain how certain properties of a certain figure are interrelated, does not formulate and use formal definitions, does not explain subclass relationships beyond checking specific instances against given list of properties and does not see a need for proof or logical explanations of generalizations discovered empirically and does not use related language correctly (pp.60-63).

2.2.3 Level 2

At this level, children can include shapes to their classes. Children begin to see that some properties of shapes are inter-related and they can make informal deductions about classes of figures. They begin to organize properties of shapes hierarchically, perceive relationships between properties and between figures.

Fuys et al (1988) summarizes the characteristics of students' actions in this level of geometric thinking. Student at this level; identifies different sets of properties that characterize a class of figures and test that these are sufficient, identifies minimum sets of properties that can characterize a figure, formulates and uses a definition for a class of figures, gives informal arguments justifies the conclusion using logical relationships, having drawn a conclusion from given information, orders classes of shapes and orders two properties (pp.69-70)

2.2.4 Level 3

Students at this level can develop proofs. "Students can reason formally by logically interpreting geometric statements such as axioms, definitions, and theorems" (Battista & Clements, 1992, p.428). Students in level 3, can construct proofs, understand the role of axioms and definitions, and know the meaning of necessary and sufficient conditions.

As Fuys et al (1988) argued, student at this level; recognizes the need for undefined terms, definitions, and basic assumptions, recognizes characteristics of a formal definition and equivalence of definitions, proves in axiomatic setting relationships, proves relationships between a theorem and related statements, establishes interrelationships among networks of theorems, compares and contrasts different proofs of theorems, examines effects of changing an initial definition or postulate in a logical sequence, establishes a general principle that unifies several different theorems, creates proofs from simple sets of axioms frequently using a model to support arguments, gives formal deductive arguments but does not investigate the axiomatic themselves or compare axiomatic systems (pp.69-70).

2.2.5 Level 4

Students at this level are now able to reason outside of Euclidean geometry and explore other axiomatic systems. Furthermore, they are able to make connections and see relationships between different axiomatic systems.

As Fuys et al (1988) asserted that, student at this level rigorously establishes theorems in different axiomatic systems, compares axiomatic systems, spontaneously explores how changes in axioms affect the resulting geometry, establishes consistency of a set of axioms, independence of axiom, and equivalency of different sets of axioms; creates an axiomatic system for a geometry, invents generalized methods for solving classes of problems, searches for the broadest context in which a mathematical theorem/principle will apply, does in-dept study of the subject logic to develop new insights and approaches to logical inference.

Several studies have been conducted to discover the implications of the theory for current K-12 geometry curricula, and to confirm the aspects of the van Hiele model. Researches validated that the van Hiele levels are useful in describing students' development of geometric thinking, from elementary school to college (Burger & Shaughnessy,1986; Fuys et al.,1988; Han, 1986; Hoffer, 1983; Usiskin, 1982; Wirszup, 1976).

One of the first major studies done with the van Hiele model was by Usiskin (1982, as cited in Fuys, 1985). Usiskin developed a multiple-choice test to measure a student's van Hiele geometric thinking levels and this test has been widely used by other researchers. The reason why Usiskin developed this test was to find out if this test could at all predict student achievement in geometry. He tested 2900 10th graders and looked for a correlation between their van Hiele geometric thinking level and their geometry scores. As a result he found that, there was a moderately strong relationship between subjects' geometry grades and van Hiele geometric thinking level. Usiskin found that the students were generally at levels 0 or 1 and most of them were not ready for high school geometry.

Burger and Shaughnessy (1986) administered clinical interviews to students. The subjects varied in age from kindergarten to college level. Their study aimed to answer three questions related to the van Hiele model. First question of which they seek the answer was if these levels were reasonable for classifying students' thinking in geometry. Secondly, they were interested in specific indicators in students' reasoning which might be aligned with each of the levels. Lastly, they were aimed to develop an interview template to see if certain levels were more effective in students' thinking while studying for particular task. They found that students' behaviors were generally consistent with the van Hieles' original description of the levels. They further stated that, learners can be in transition between levels and that they will fluctuate between them during the transition period.

Mistretta (2000) conducted a study which aimed to raise van Hiele levels in eighth grade students. Before the study, she gave the pretest consisting of level 0, 1, and 2 questions in multiple choice and short answer form in order to assess each student's van Hiele level. 22% of the students were classified at level 0 and 43% were classified at level 1. None of the students were classified at level 2 or above and 35% were "non-classifiable". As a result of individual interviews, she reported that, students did not have clear understandings of area and perimeter in general and especially in the case of some irregular shapes. She further stated that, students were not aware of relationships between different types of polygons and their characteristics.

Fuys et al. (1988) aimed to develop a working model of the van Hiele levels. In their study they characterized the geometric thinking of students who enrolled sixth and ninth grades. Students were interviewed in six to eight 45-minute instructional assessment sessions. These assessment interviews were aimed to provide information about students' progress within and between the van Hiele geometric thinking levels at the end of the instruction. They noted that the sixth graders had not experienced much geometry in school.

Senk researched (1989) on the van Hiele model of geometric thinking. In her study, by looking for correlation amongst the through a series of tests she showed that most students who finished secondary school achieved only the first or second van Hiele level. She further found that students' progress from the second to the fourth level is very slow. Senk (1989) claimed that the results of this study indicated the importance of a student's entry geometric thinking level and its crucial role in student's success in high school geometry courses.

2.3 Dynamic Geometry Software

Dynamic geometry systems (DGS) have become widely used as classroom tools which support the teaching and learning of two-dimensional geometry. Dynamic Geometry software provides setting in which students interact with the computer and make constructions of geometrical objects. By experimenting, students understand the properties related to geometric objects. As Hoyles & Sutherland (1989) and Noss (1987) argued, by means of experimentation, students come to understand many ideas and processes related to the geometrical concepts through an appropriate invention in a meaningful way. Several researchers dealt with the effects of computer based learning and dynamic geometry software in developing students' understanding in geometry and found that the use of technology, particularly use of dynamic geometry software is beneficial for students in developing their understandings of geometric concepts since interacting with dynamic geometry software can help students explore, conjecture, construct and explain geometrical relationships (Hativa, 1984; Jones, 2000; Jones, 2001; McCoy, 1991; Marrades, & Guitérrez, 2000; Velo, 2001).

One advantage of dynamic geometry software is that, when students interact with DGS, they have the opportunity to see different constructions of the same object at once. In this case, construction in dynamic geometry differs from the drawing in static paper and pencil environment. Aarnes and Knutzon (2003) mentioned this facility of DGS by saying, “DGS gives an easier access to this insight than would have been possible by pencil and paper construction, because the point may be moved” (p.3). Due to this movement, students recognize the various positions of the shape rather than its specific-size and position which provide them to make conjectures and generalizations. Research with Dynamic Geometry Software was largely focussed on its potential as a conjecturing tool and as a way to investigate what kind of processes occurred during the constructions in geometrical contexts (Arcavi & Haddas, 2000; Goldenberg & Cuoco, 1998; Laborde & Capponi, 1994).

Balacheff and Kaput (1996) defined the visible part of the geometry activity of the learner as making distinction between the drawings and figures. They pointed out that dynamic geometry environments provide the distinction between drawings and figures. Laborde (1993) made the distinction between *drawing* and *figure* in the following way: “drawing refers to the material entity while figure refers to a theoretical object” (p.49). In DGS environments, to check conjectures and to construct of conjectures explanations and verification are possible by means of drag mode. There are numerous researches aimed to investigate the facilities of drag mode in Dynamic Geometry Software (e.g., Hölzl 1996, Arzarello et al. 2002; Jones, 1996; Jones, 2000; Sowder& Harel, 1998). Jones (2000) mentioned the facilities of drag mode in DGS as, “By operating in this fashion, dynamic geometry environments appear to have the potential to provide students with ‘direct experience’ of geometrical theory and thereby break down what can all too often be an unfortunate separation between geometrical construction and deduction make it possible for students to focus on what varies and what is invariant in a geometric figure and enable students to gain more a meaningful idea of proof and proving” (p.2).

The mediating function of computer as a link between the individual experience of the learner and formal representation of a geometrical knowledge domain can be experienced by several dynamic geometry learning environments. These environments are packaged programs such as *Geometry Supposer* (Schwarts & Yerushalmy, 1984), *Cabri-géométre* (Laborde, 1990) and *Geometer's Sketchpad* (Jackiw, 1991) and programming environments such as *Logo* (Papert & Feurzeig, 1970).

Since its development *Logo*, has been widely used as a rich programming environment for students. The *Logo* environment provides students to explore geometry and became a point of interest in many researches (Clements & Sarama, 1993; Yelland, 1995; Clements, Battista & Sarama, 2001, Papert, 2002).

As a dynamic geometry system, *Geometry Supposer* (Schwarts & Yerushalmy, 1984), provides opportunity for students' in conjecturing and reasoning. In *Geometry Supposer,* students chose a shape, such as rectangle and perform measurement operations on it. Several studies related to *Geometry Supposer* cited evidence that students who use this program performed better than the ones who did not use (Lampert, 1988; Wiske & Houde, 1988; Yerushalmy, Chazan, & Gordon, 1987).

Cabri-géométre (Laborde, 1990) is another dynamic geometry software, in which constructions can be made simply by dragging. In Cabri environment, invariant properties belonging to the shapes retained, wheras the its size and position can be changed by dragging action. This property of Cabri provides students to validate their conjectures. Across studies, several findings are consistent on the benefits of the use of *Cabri-géométre* (Arzarello et al., 1998; Laborde, 2001; Mariotti, 2001*).*

One of the recent studies related to the effects of using dynamic geometry software is the study of Gawlick (2002). He presented the results of their study concerning differential effects of using dynamic geometry software on students' achievement. The purpose of the study was to investigate how the step from experimental to regular dynamic geometry software use will probably take place in the classroom. As a result of the study, some steps which are necessary in integrating dynamic geometry software to a learning environment were underlined. According to the results of the study, one of the important issue, that should be considered in integrating DGS into classroom is the necessity of change of educational environment accordingly. Gawlick (2002) asserted that, "teachers must be put into a position to develop new teaching sequences, and schools must have the equipment to make dynamic geometry home work and assessment possible" (p.91).

The study of Jones (2001) aimed to gain information about interpretations of 12-year-old students while using dynamic geometry software. Analysis of the data from the study showed that, the use of dynamic geometry software can help students in making progress towards more mathematical explanation. She further mentioned that, especially in the early stages, the dynamic nature of the software influenced the form of explanation of students.

Hölzl (1999) studied on the effects of long-term use of dynamic geometry software in a classroom setting, where dynamic geometry software was an integral part of the learning environment. The study cited evidence that, dynamic geometry software possesses significant potential on transformation geometry and the application of dynamic geometry software should only be realised after thorough consideration.

Gillis (2005) designed a study in order to investigate students' conjectures in static and dynamic geometry environments. Data were examined both quantitatively and qualitatively. Qualitative data were collected by means of observations of participant, a survey, participant interviews, and a qualitative analysis of the conjectures which were made by the students in both dynamic and static environments. As a result of the study, students who used dynamic geometry software were found more succesful in making relevant conjectures. Moreover, the correctness of their conjectures was higher when compared to students working in a static geometry environment.

Marrades and Gutiérrez (2000) presented the results of two case studies where secondary school students worked with Dynamic Geometry, aiming to investigate ways in which dynamic geometry software can be used to improve students' understanding of the nature of mathematical proof and to improve their proof skills. The study aimed to teach geometric concepts and properties, and to help students to improve their proof skills and conception related to the nature of mathematical proof. After analyzing the answers of the students, by analyzing answers of the students to proof problems, they observed the types of justifications produced, and verified the usefulness of learning in dynamic geometry computer environments to improve students' proof skills.

Laborde (2001) reported an analysis of teaching sequences involving dynamic geometry software. Teaching seguences used in the study were developed by teachers over a period of three years. She showed that while dynamic geometry software was a visual provider of data, it became an essential constituent of the meaning of tasks through the teaching process. Through the last stage, the technology began to shape the conceptions of the mathematical objects that the students construct. As a result of the study, Laborde claimed that the integration of computer technology in mathematics classrooms is a long and difficult process.

Mariotti (2000) reported on a long-term teaching experiment carried out in the 9th and 10th grades of a scientific high school which is part of a larger co-ordinated research project. The purpose of the study was to clarify the role of a dynamic geometry software, in the teaching and learning process. The functioning of specific elements of the software was described and analyzed as instruments used by the teacher in classroom activities. According to Mariotti, students were greatly facilitated by the use of dynamic software that affords visualisation, exploration and the use of problem solving strategies.

In the light of all these studies, the facilities of dynamic geometry environment can be summarized. Firstly, dynamic geometry environments help students create mental models for thinking about geometric shapes (Jones, 2001; Üstün & Ubuz, 2004; Velo, 2001). Secondly, in a dynamic environment, students do not have to memorize the properties of geometrical shapes. Thirdly, dynamic geometry software allows the students to experience the property in action before using it at a more formal level (Laborde, 1995).

2.4 Geometer's Sketchpad

Geometer's Sketchpad is dynamic geometry software that was utilized in the current study. Taylor (1992) promoted that "Geometer's Sketchpad gives the user electronic versions of Euclid's tools-a point tool, a compass and a straightedge" (p.187). As in all dynamic geometry sotware, the students, compared with traditional paper and pencil environment, can generate several investigations related to the particular content of geometry. Robinson (1994) suggested that learning styles can be influenced and students can be encouraged to expand their thinking abilities regardless of their prior knowledge by involving learning environments supported by Geometer's Sketchpad. Geometer's Sketchpad has influences not only on students learning but also on interaction in environment. Hativa (1984) identified three types of interaction in such learning environments as interactions between teacher-student, student-student and student computer.

Baharvand (2001) studied the effects of using Geometer's Sketchpad compared to instruction by teacher-lecture and pencil-and paper activities on performance of students', students' retention level, and students' attitude toward learning geometric concepts. 26 seventh grade students received instruction by teacher lecture and another seventh grade class with 24 students learned the same concepts using the Geometer's Sketchpad. In order to analyze data, t-test was used and the results indicated that students taught with the GSP scored significantly higher on the posttest than the control group.

In his study, Han (2007) aimed to investigate the impact of using Geometer's Sketchpad compared to the use of traditional tools such as ruler and protractor in enhancing eighth-grade students' understanding of quadrilaterals and their mathematical reasoning ability. The participants of the study were ninety seven 8th grade students enrolled at a public middle school. Students in the experimental group were taught by GSP lessons working with software and students in the control group were taught paper and pencil lessons developed by researcher working with ruler and protractor. Students in both experimental and control groups worked in a discovery-based learning environments with hands-on experiences. At the end of his study, he administered the post-test in order to assess the effect of the two different learning tools on students' understanding of quadrilaterals. There was a statistically significant difference in student achievement between students using GSP lessons and control group students for the learning of quadrilaterals. The GSP group significantly outperformed the control group on the post-test.

Moyer (2003) examined the effect of using Geometer's Sketchpad (GSP) in geometry instruction to increase student achievement and van Hiele geometric thinking levels. He used a non-equivalent control group design in his study. The subjects were selected from four intact geometry classes. Two teachers had two classes, one of which used GSP throughout the study. The researcher designed content pre-test and two content posttests, one for each chapter of content. At the end of the study, he found that the use of GSP was not found to have a significant effect on the increase of van Hiele levels, and the increase on the content tests, each from pre-test to post test. He recommended that future research should address the investigation into what teacher skills are necessary in order to effectively use GSP as an instructional tool; a study that would measure the effect of the use of GSP in a classroom in concert with a textbook which is not based on constructivism or a discovery approach; and research concerning the use of GSP throughout the whole year rather than selected chapters.

Lester (1996) aimed to improve achievement of geometric knowledge through instructional use of Geometer's Sketchpad. In order to explore the capabilities of GSP, she designed a posttest-only control-group quasi-experimental study. Her study addressed the problem of improving achievement of geometric knowledge through instructional use of the software program The Geometer's Sketchpad (Jackiw, 1994).

Participants were 47 female high school geometry students. Subjects in experimental group used the Geometer's Sketchpad as a software tool and subjects in control group used traditional geometry tools: ruler, pencil, protractor, and compass. By posttest improvement of students' geometric knowledge, construction and geometric conjecturing were assessed. Results indicated that students understand geometry concepts at higher levels as a result of creating and manipulating dynamic visualization of geometric objects by using Geometer's Sketchpad and learn geometry skills with greater efficiency.

Hadas, Hershkowitz & Schwartz (2000) conducted a study which required creating constructions on Geometer's Sketchpad. 50 students were given two activities. In the first activity, students were expected to make a conjecture about the sum of interior angles of a convex polygon as the number of sides increases. Only 9 of the students gave complete explanations in the first activity. The second activity aimed at making conjecture about the sum of the exterior angle of a convex polygon as the number of sides increases. All of the students conjectured that the sum would increase as the number of sides did, just as in the first activity.

Battista (2002) designed a case study and studied with three children in learning of geometric concept, particularly quadrilaterals. He investigated the geometric learning of secondary school students during instruction on the basis of the Van Hiele model, with Geometer's Sketchpad as a learning tool. He investigated how students moved to higher levels of van Hiele geometric thinking and Geometer's Sketchpad helped students to investigate different forms and orientations of the shapes by modifying the objects' constructions.

Similar to the study of Battista, another study was conducted by Choi (1996). The purpose of this study was to investigate development of secondary school students' geometric thought during instruction based on a van Hiele model and using dynamic computer software, particularly GSP as a tool. The students' learning process was investigated with geometric topics of right triangles, isosceles triangles, and equilateral triangles. Three secondary students with diversity in ability participated in the study of Choi (1996). In order to gather data, the clinical interview procedure was used. As a result of posttest, after twenty-two hours of study, it was found that Geometer's Sketchpad, was found to provide an advantage to students. The facilities that GSP serves can be summarized as providing effective geometry instruction, enhancing students' interest, helping them to get over their learning difficulties, and saving learning time.

2.5 Guided Discovery

Guided discovery is a kind of instructional method in which students were guided by teacher by means of some questions in order to help them in exploring, conjecturing and constructing their geometrical knowledge.

In can be said that, instruction clearly affects what children learn. However, it does not determine it, because the children are actively participated in the construction of their own knowledge. Many researches suggests that instruction which is designed based on constructivist principles leads to better results than more direct, traditional mathematics education (Cobb et al., 1991; Klein, 1998).

Current educational theories emphasize students' active involvement in teaching and learning process (Karakırık & Durmuş, 2005). Students construct their mathematical knowledge through reflection and abstraction during these student-centered processes. New mathematics curriculum also favors learning environments in which students actively involves in construction of their own knowledge.

The role of instruction is crucial in teaching and learning geometry as Usiskin (1982) and Fuys, Geddes, & Tischler (1988) promoted. The more systematically structured the instruction, the more helpful it will be for middle school students to overcome their difficulties and to increase their understanding of geometry.

Usiskin (1982) cited evidence that systematic geometry instruction might help students gain greater geometry knowledge and proofwriting success. To involve students in the lessons and get rid of rote learning, learning environments should promote discovery. Battista (2002) contended that, geometry instruction should facilitate learning environment that support inquiry, problem solving and sense making in which students invent, test, and refine ideas to build complex, abstract, and powerful mathematical meanings.

Research studies promoted that guided discovery is one of many successful teaching methods (Choike, 2000; Gerver&Sgroi, 2003). Gerver&Sgroi (2003) explains the reason why guided discovery is useful method in teaching mathematics by the development of it. They stated that since mathematics was developed through discovery, it makes sence to teach it using discovery. Choike (2000) asserted that, the teachers need to involve students in guided explorations to help them learn by discovery.

Kroesbergen & Van Luit (2002) studied on two kinds of math intervention, guided versus structured instruction in order to compare their effectiveness with regular math instruction. Participants were 75 students aged from seven to thirteen who are from regular and special education. Ability and automaticity multiplication tests were administered as pretests before the treatment and posttest after the four-month training period. The results of their study showed that the students in both of the experimental groups improved more than that of control group. They further stated that, some additional differences were found between the two experimental interventions in favor of the experimental group that received guided instruction. Follow-up test which was administered after three months showed the acquired knowledge to be well-established in both experimental groups.

Anastasiow et al. (1970) investigated the impact of discovery, guided discovery or didactic instruction on teaching pre-math concepts and principles to kindergarten poverty children. Different results were obtained due to the level of achievement of learner and content that was taught. Guided discovery was found most effective for pre-math principles for all students. It was effective for both pre-math principles and concepts only for high level students.

Mayer (2004) reviewed research on studies conducted from 1950 to the 1980's comparing 'pure discovery learning', defined as unguided, problem based instruction, with guided forms of instruction. He mentioned that in each literature he reviewed, pure discovery methods in which students are free maximally to explore were compared with guided discovery methods in which they are provided systematic guidance focused on the learning objective. Mayer concluded that "the debate about discovery has been replayed many times in education but each time, the evidence has favored a guided approach to learning." (2004, p. 18).

In their study Ubuz and Üstün (2004) aimed to investigate student's development of geometrical concepts through a dynamic learning environment. They preferred to use Geometer's Sketchpad as a dynamic geometry software. They investigated the students' understanding of and performance in lines, angles and polygons (triangles, square, rectangle, parallelogram), compared to traditional learning environment with pretest-postest design. As a result of their study, comparison of the pre-and post-test means of the students indicated that the treatment resulted in marked improvement in their performance in lines, angles, and polygons in the experimental group, who received treatment with GSP. They promoted that Geometer's Sketchpad enables students to test whether their geometric constructions work in general or whether they have discovered a special case of the original construction and further stated that GSP is used for exploration and guided discovery which enables students to test their conjectures and be more engaged in their learning.

In her study, Foletta (1994) aimed to investigate the effects of guided discovery and Geometer's Sketchpad. She used data from small group observations, class observations, student interviews, students' hand-written and computer-generated work, teacher interviews, principal interview, and student mathematics belief survey. As a result of the study, she concluded that the role of the Sketchpad, design of investigations, and nature of peer interactions were the factors contributing to the students' discovery.

Beyond these studies, Moreno (2004) concluded that there is a growing body of research showing that students learn more deeply from strongly guided discovery than from pure discovery.

2.6 Summary of the Literature Review

Developing students' geometric thinking and achievement can be done by means of appropriate instructional design. The role of technology, particularly dynamic geometry software is important in designing such learning environments. Research indicates that, using dynamic geometry can facilitiate students' development of geometric thinking and achievement. It is also underlined in the review that, instructional methods based on the constructivist approach help students understand geometrical concepts. As the literature confirms, using dynamic geometry software and guided discovery method are beneficial in geometry learning. However, the effects of teaching by guided discovery with dynamic geometry software was taken as a research topic in a few studies. More research is needed in this area, due to the mixed results of using dynamic geometry software and guided discovery. This study aimed to investigate the effects of using dynamic geometry software in guided discovery setting and report the benefits of designing such an instructional environment, on students' geometric thinking and achievement.

CHAPTER 3

METHOD

The aim of this chapter is to present the procedures for the study. This chapter includes descriptions of the research design, the population and the sample, the description of the variables, the data collection instruments, development of activities used in experimental groups, the design of the instruction, the treatment procedure and the data analyses procedure.

3.1 The Research Design

The research question of this study was "What are the effects of using dynamic geometry software while teaching by guided discovery compared to paper-and-pencil-based guided discovery and traditional teaching method on sixth grade students'van Hiele geometric thinking level test scores and achievement on polygons when students' prior van Hiele geometric thinking level and achievement scores are controlled?" The participants of the study were not randomly assigned to experimental and control groups. Therefore the research question was examined through a quasi-experimental research design.

3.2 The Population and Sample

The study was conducted with sixth grade students in a private elementary school in Ankara. There were three sixth grade classes in the school and all the classes were included in the study. The results of the study can be generalized for a population limited to the students of this private school. The participants included 48 sixth grade students (27 girls and 21 boys). The number of subject in each class is given in the Table 3.1.

Table 3.1 Sixth grade classroom distributions

Class	Number of Girls	Number of Boys	Total
6-A	8	7	15
6-B	10	5	15
6-C	9	9	18
Total number	27	21	48

Due to the strict regulations of the school, it was difficult to assign students randomly to experimental and control groups, therefore convenience sampling (using as the sample whoever happens to be available) was used in this study. The school was located in a university campus and had totally 600 students. Most of the students had high socioeconomic status. There were three sixth grade classes taught by the same mathematics teacher in this school. One of the classes was formed as the experimental group to experience guided discovery with dynamic geometry software treatment, another class also constituted the experimental group which experience guided discovery treatment and the other class was formed as the control group. Classes were randomly assigned to experimental and control groups. Distribution of the participants in the experimental and control groups in terms of classrooms is given in Table 3.2.

Table 3.2 The distributions of participants in the groups in terms of classrooms.

Groups	Class	No of subjects
Experimental Group 1 (Guided discovery with Dynamic Geometry Software)	6C	18
Experimental Group 2 (Paper-and pencil based guided discovery)	6B	15
Control group (Traditional Instruction)	6A	15
Total number		48

3.3. Variables

In this study there were 5 variables that can be classified as dependent and independent variables. Classification of those variables was presented in the Table 3.3.

Table 3.3 Classification of the variables of the study

Name	Type of Variable	Type of Value
Posttest scores on Geometry Achievement Test	Dependent	Continuous
Posttest scores on van Hiele Geometric Thinking Test	Dependent	Continuous
Pretest scores on Geometry Achievement Test	Covariate	Continuous
Pretest scores on van Hiele Geometric Thinking Test	Covariate	Continuous
Treatment	Independent	Categorical

3.3.1 Dependent Variables

The dependent variables of this study were students' raw scores on geometry achievement and van Hiele geometric thinking level test. The raw scores on geometry achievement obtained from post implementation of Geometry Achievement Test (POSTGAT) and the raw scores on van Hiele geometric thinking level tesr obtained from post implementation of van Hiele Geometric Thinking Level Test (POSTVHL). Both of these variables are interval and continuous variables. The possible minimum and maximum scores range from 0 to 100 for the POSTGAT, and 0 to 10 for the POSTVHL respectively.

3.3.2 Independent Variables

The independent variables of this study included both covariates and membership. The raw scores on geometry achievement obtained from pre implementation of Geometry Achievement Test (PREGAT) and the raw scores on van Hiele geometric thinking obtained from pre implementation of van Hiele Geometric Thinking Level Test

(PREVHL) were considered as covariates. Both of these variables are interval and continuous variables. Instruction type or treatment (paper-and-pencil based guided discovery, guided discovery with dynamic geometry software and traditional instruction) was considered as categorical variable and was measured on nominal scale.

3.4 The Data Collection Instruments

In this study, Geometry Achievement Test (GAT) and van Hiele Geometric Thinking Level Test (VHL) was used as data collection instruments.

3.4.1 Geometry Achievement Test (GAT)

The effectiveness of teaching guided discovery with dynamic geometry software was determined by comparing the geometry achievement of the groups by Geometry Achievement Test (GAT).

Geometry Achievement Test was developed by the researcher. The original version of the instrument consisted of 12 open-ended questions. Most of the questions were related to the quadrilaterals, and some of them were related to the triangles. Questions addressed the goals specified in the Mathematics Curriculum for Elementary Schools, published by Turkish Ministry of National Education (MEB, 2002). After the control of a mathematics educator who is a faculty member and another mathematics teacher in the school, pilot study of the test was conducted with 10 randomly selected 8th grade students at the same school. Two of the questions could not be solved by the students and found extremely difficult and complicated. After the pilot study, those two of the questions were excluded from the test. Cronbach Alpha reliability measure for the final administration of the Geometry Achievement Test was found as .79, which indicates a high reliability. All the items were provided with the sufficient blank spaces for solution processes. Students' responses to each question were scored as 10 for correct response, 5 for half correct response and 0 for incorrect response. In this test, possible minimum score from the test was 0 and maximum score was 100. The Geometry Achievement Test (GAT) was presented in Appendix C.

3.4.2 Van Hiele Geometric Thinking Level Test (VHL)

The van Hiele Geometric Thinking Level test which was developed by Usiskin (1982) and included 25- multiple choice questions. This test was used in order to determine students' geometric thinking. In this test, the first five items represent level 1, the second five items represent level 2, the third five items represent level 3, the fourth five items represent level 4, and the last five items represent level 5.

According to the van Hiele, primary school mathematics leads students only reach to the third level (van Hiele, 1986). Since the study was conducted to sixth grade students the first 15 questions of the test were taken into consideration. The questions in first three levels and the objectives of each question were presented in the Table 3.4.

Table 3.4 Objectives of each task for first 15 items of Van Hiele Geometric Thinking Level Test.

Question	Level	Objective
1	1	Identifying square
2	1	Identifying square
3	1	Identifying rectangle
4	1	Identifying square
5	1	Identifying parallelogram
6	2	Comprehend properties of square
7	2	Comprehend properties of rectangle
8	2	Comprehend properties of diamond
9	2	Comprehend properties of isosceles triangles
10	2	Comprehend properties of radius and tangent of a circle; and comprehend properties of rhombus
11	3	Show simple deduction related to properties of triangle
12	3	Show simple deduction related to rectangle and triangle
13	3	Comprehend hierarchy between square and rectangle
14	3	Compare rectangle and parallelogram
15	3	Comprehend hierarchy between square and rectangle and parallelogram

As indicated in the Table 3.4, in the first level, students were expected to identify polygons. To solve questions in the second level, students needed to comprehend properties of polygons and circle. The questions in the third level were about the hierarchy between polygons, comparison of them and properties of triangle. Among those 15 questions, 10 were related to the contents of triangles and rectangles. Therefore, in this study, the questions 1, 2, 3, 4, 6, 7, 9, 11, 12, 13 were used. Each question was 1 point in the van Hiele Geometric Thinking Level Test. Therefore, possible minimum score from the test was 0 and maximum score was 10. This test was translated into Turkish by Duatepe (2000) and Cronbach Alpha reliability measures were found as .82, .51, and .70, for the first, second, and third level, respectively. The reliability of the test used in this study was also calculated and Cronbach Alpha reliability measure was found as .76. Van Hiele Geometric Thinking Level Test (VHL) was presented in Appendix D.

3.5 The design of the instruction

The aim of the study was to investigate the effect of using dynamic geometry software while teaching with guided discovery on students' geometric thinking and achievement. The design in this study was non-equivalent control group design of quasi-experimental designs. In this design, three different learning environments, teaching with guided discovery, using dynamic geometry software while teaching with guided discovery and traditional teaching were compared. This design was selected because pretest was required and subjects were not randomly selected.

For this study, the lesson plans were developed by the researcher. In developing the lesson plans, the objectives of the sixth grade geometry, specifically the ones related to polygons, suggested by Ministry of National Education were considered. Lesson plans were included activities related to the content in order to aid to teaching process in both of the experimental groups. Lesson plans were prepared weekly and had different contexts and activities. In the case of experimental groups' lesson plans, the activities were prepared in such a way that, students were only guided in the activities and construct their own learning by following the steps in activities. Prepared lesson plans were checked by a mathematics educator and two mathematics teachers.

In the traditional instruction environment the teaching was mostly based on textbook approach using chapters related to polygons from İlköğretim Matematik 7 (Can Yayınları).

3.6 Procedure

In all of the three groups, pretests were administered in the first week of the study. Students took the instruments in a regular mathematics classroom. They were given van Hiele Geometric Thinking Level Test (VHL) for 20 minutes in the first period of the block hours. After the students completed the VHL, Geometry Achievement Test (GAT) was administered for 40 minutes. The students were administered both test in a regular examination setting. The questions in the Geometry Achievement Test (GAT) were open ended and the students were expected to do all their work in the spaces on the test paper. In van Hiele Geometric Thinking Level Test (VHL), the questions were prepared as multiple choice items, and the students were expected to circle the correct answer. In administration of both tests, students were assisted when they had difficulty in reading the word or phrase. During the administration of the tests, no feedback was given about the correctness of their answers. The students were encouraged to do their bests.

The treatment process began after the administration of the pretests. Prior to the treatment, the sixth grade students who were in experimental group1 received two hours of dynamic geometry software training. As a Dynamic Geometry Software, *Geometer's Sketchpad* was used.

The students in each group were taught the same topic in the second term of 2005-2006 academic year. The teaching period lasted 20 lesson hours. There were five mathematics lessons in each week, and each lesson lasted 40 minutes. The teaching in experiment group 1, which was taught by using dynamic geometry software, was conducted in computer laboratory. The teaching in experiment group 2 and control group was conducted in sixth grade mathematics classroom. Treatments in all groups were implemented by the researcher. The outline of the study presented in Table 3.5

Table 3.5 Outline of the procedure of the study

	Experimental Group1	Experimental Group2	Control Group
Pretests	Van Hiele Geometric Thinking Level test (PREVHL) Geometry Achievement Test (PREGAT)		
Treatment	Guided discovery with dynamic geometry software	Guided discovery	Traditional Instruction
Posttests	Van Hiele Geometric Thinking Level test (POSTVHL) Geometry Achievement Test (POSTGAT)		

The researcher gave the same homework assignments to all of the groups. These assignments were provided from the textbook. At the end of the treatment, the researcher administered the same posttests to all groups in order to elicit their understandings. Posttests were administered in the same way that was described for the pretests.

3.7 Development of activities used in experimental groups

While developing lesson plans and activities sixth grade mathematics objectives, developed by Ministry of Education were considered. In order to cover all objectives related to the content, activities were prepared for both experimental groups.

For the treatments of each group, four weekly plans and activities were prepared. In the first week subjects were given the pretests and experimental group 1 received two hours of dynamic geometry software training, in the second week they were taught the perimeter of triangle, in the following week the content was the perimeter of rectangle, the fourth and fifth week of the study, they were taught area and relationship between area and perimeter. In the last week, the subjects were given the posttest. Content of the weekly plans, their orders and administration of the tests are summarized in the Table 3.6.

Table 3.6 Content of the weekly plans, their orders and administration of the tests

Week	Content of the weekly plan
1	Administration of Pretests
2	Perimeter of triangle
3	Perimeter of square and rectangle
4	Area
5	Perimeter-Area Relationship
6	Administration of posttests

A mathematics educator, who is a faculty member and two mathematics teachers, examined the weekly plans and activities, in order to check whether they were appropriate for the desired objectives and mathematically correct. By the directions of this checking, all weekly plans and activities were checked and their appropriateness for the objectives was examined.

3.8 Treatment

This part includes the description of treatment for experimental and control groups.

3.8.1 Treatment in Experimental Group 1

The treatment in Experimental Group1 was mainly based on guided discovery approach. The activity sheets were prepared in such a way that by the guidance of the teacher, students would explore their ideas in dynamic geometry environment.

In the first few minutes of the lesson, the content of the lesson was introduced to the students. Students were asked about their expectations from the lesson. After the introduction of the topic, brief explanation about the lesson was done by the teacher. The teacher distributed the activity sheets and asked the students to read the activities. Then the students started to work with activity sheets. While students were dealing with the activities, sometimes, the teacher gave feedback on the students' errors and guide about their questions. For example, in one of the activities related to the area of the right triangle, students were expected to realize that the area of the right triangle is half of the area of the costructed rectangle. Students were given a rectangle as in Figure 3.1

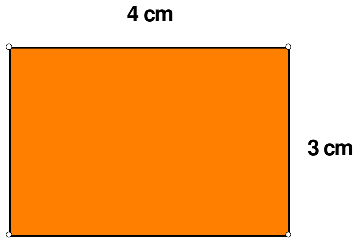


Figure 3.1 Rectangle

Students constructed the diagonal of the rectangle by connecting the opposite corners. By doing this, they constructed two identical right triangles of which the length of perpendicular sides were equal with those of rectangle. The students calculated the area of rectangle and the area of each triangle. After that, they changed the size, and position of the shape, and therefore the triangles. By several dragging motions, the students found that the area of each triangle was measured as half of the area of the rectangle. While discovering this fact, students were guided by teacher by questions such as, "What is the relationship between the sides of rectangle and the sides of the triangles?" "What will happen when you change the size of rectangle?" and etc. Students were guided by questions written in activity sheets, by asking questions orally and by prompting during the activities. Activity sheets used for experimental group 1 were presented in Appendix B.

When each of the activities was completed by all students, the answers of the questions were discussed in class. Such an application provided feedback for the researcher on the students' understanding, misunderstandings and errors.

The students were responsible for saving their activity sheets until the activity was completed and for bringing them to every mathematics lesson. Class periods were 80 minutes consisting of two block lessons. At the end of each period, the teacher gave homework assignment to the student. Table 3.7 summarized the design of the ordinary lesson in experimental group 1.

Table 3.7 The design of the ordinary lesson in experimental group 1

Part of the lesson	Teacher Activity	Student activity	Duration
Introduction	Introduce the lesson	Say expectations from the lesson	2 minutes
	Explain the main idea of the activity	Listen to explanations	5 minutes
Development	Guide students when necessary	Do the activities in GSP	
		Fill the activity sheets	50 minutes (3minutes break)
Conclusions	Review the important parts of today's topic	Discuss the answers with class	10 minutes

3.8.2 Treatment in Experimental Group 2

The design of the treatment was similar with the design in experimental group 1. In experimental group 2, activity sheets were also used. Content of the activities and durations of the parts of the lesson were planned in the same manner. As in the case of experimental group 1, the teacher introduced the topic and explained idea of the activity at the beginning of the lesson. The activity sheets were distributed then, and students were expected to complete the activities. While doing the activities, several questions were asked by the teacher in order to guide students. For example in one of the activities related to the perimeter of triangle, students were asked to investigate what would happen to the perimeter of the triangle when they changed the size of it. To investigated this, they were given a triangle as in Figure 3.2

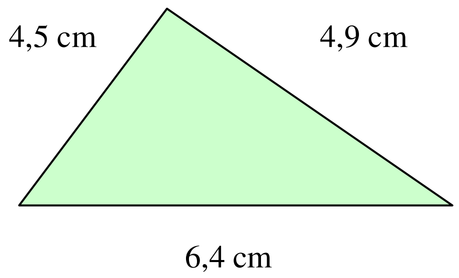


Figure 3.2 Triangle

The students were calculated the perimeter of the given triangle by paper-and-pencil. After that, they multiply the length of each side with 2, 3, 4 and 5 and calculated the perimeter in each case. As a result they were expected to find out that when the lengths of the sides of the triangle were increased by some ratio, then the perimeter was also increased in the same ratio. While discovering this fact, students were guided by teacher by questions such as, “What is the relationship between the sides of triangle and the perimeter of it?” “What would happen when you changed the size of triangle?” and etc. Students were guided by questions written in activity sheets, by asking questions orally and by prompting during the activities. The activity sheets used for experimental group 2 was presented in Appendix A.

3.8.3 Treatment in Control Group

The researcher used traditional method during four week treatment process in control group. Instruction in the control group was based on giving explanation about the strategy needed to solve questions. By giving example, the researcher illustrated the strategy to solve those kinds of problems. When the examples were given, students took notes and sometimes say their opinion about the solution by raising their hands. After the researcher solved a few examples and gave the rules, the students were asked to solve similar questions to the examples. Sometimes, the researcher wrote exercises to the board and called the students to solve them. These questions were from their textbooks.

The students in control group were expected to listen to the researcher and take notes written on the blackboard and solve the exercises. At the end of each class period, the researchers gave homework assignment to the students and make them note assignments to their agendas. The lessons in the case of control group were held as follows;

1. Examples were given.
2. Rules or strategies were explained to solve exercises.
3. Similar exercises were solved by students.
4. Homework assignment was given.

The comparison of the experimental and control groups was given in Table 3.8

Table 3.8 The comparison of the experimental and control groups

Groups	Environment	Roles of teacher	Roles of students
Experimental Group1	Computer laboratory	- guided the students when necessary - monitored the students' work - controlled the study environment	- dealt with activity sheets - dealt with Geometer's Sketchpad - discussed their work with class
Experimental Group2	Regular classroom environment	- guided the students when necessary - monitored the students' work - controlled the study environment	- dealt with activity sheets - discussed their work with class
Control Group	Regular classroom environment	- gave information - presented the topic - solved questions	- took notes - listened to the teacher

3.9 Data Analyses

Data were collected by the instruments that were mentioned above. The statistical analyses were done using SPSS. The data obtained in this study were analyzed in two parts. In the first part, descriptive statistics and in the second part, inferential statistics were used.

3.9.1 Descriptive Statistics

The mean, median, mode, standard deviation, skewness and kurtosis of the variables were initially presented according to the instructional method. Descriptive statistics techniques were used to compare the groups mathematically. After the inferential statistics, these values were interpreted in the light of the results.

3.9.2 Inferential Statistics

In order to compare the impact of different interventions, analysis of covariate (ANCOVA) was used. There were three levels of independent variable and two dependent variables in this study. ANCOVA allowed exploring differences between groups statistically while controlling for an additional continuous variable. In this study these continuous variables, in other words covariates were pretest scores obtained from PREGAT and PREVHL. ANCOVA is also very useful for quite small sample sizes, as in the case of this study (Pallant, 2001). This statistical analysis was performed by using Statistical Package Program for Social Sciences (SPSS). The level of significance was set to 0.05 since it is the mostly used value in education studies. Details of variables names and labels used for this analysis is given in Table 3.9

Table 3.9 The variable-set composition and statistical model entry order for the ANCOVA used in this study

Variable set	Entry order	Variable name
A (covariates)	1st	X1: PREVHL X2: PREGAT
B (Group membership)	2nd	X3: Teaching Method
C (covariates*group interaction)	3rd	X4: X1*X3 X5: X2*X3
D (dependent variables)	4th	Y1: POSTVHL Y2: POSTGAT

CHAPTER 4

RESULTS

The purpose of this study was to investigate the effect of using dynamic geometry software while teaching by guided discovery on students' geometric thinking and achievement. This chapter presents the descriptive statistics related to Geometry Achievement Test and van Hiele Geometric Thinking Level Test, inferential statistics related to the research question and follow up analyses.

4.1 Descriptive Statistics

Descriptive statistics collected on the data to identify means, standard deviations, kurtosis, skewness, minimum and maximum scores for the groups were presented here.

4.1.1 Descriptive Statistics of the Geometry Achievement Test

Descriptive statistics related to the PREGAT and POSTGAT for two experimental groups and the control group is presented in Table 4.1. Descriptive statistics presented here aimed to give information about means, standard deviations, kurtosis, skewness, minimum and maximum scores for the three groups.

Table 4.1 Descriptive statistics related to the scores from PREGAT and POSTGAT for experimental and control groups.

	EG1		EG2		CG	
	PREGAT	POSTGAT	PREGAT	POSTGAT	PREGAT	POSTGAT
N	18	18	15	15	15	15
Mean	60.83	73.06	50.00	53.00	44.33	48.00
Median	65.00	75.00	50.00	55.00	45.00	55.00
Minimum	20	30	15	10	10	15
Maximum	100	100	90	100	65	70
St. Deviation	20.02	20.08	22.76	26.78	15.57	17.51
Kurtosis	.823	-.465	-.625	-.936	-.367	-.835
Skewness	-.521	-.494	.131	.143	-.938	-.697

As it is seen in the Table 4.1, for Geometry Achievement Test, mean scores of both experimental groups were higher than control group mean scores. When the mean scores from the pretests and post administrations of them were compared, for the Geometry Achievement Test, the Experimental group 1 showed an increase from 60.83 to 73.06. An increase in mean scores was observed for the experimental group 2, as from 50.00 to 53.00. Mean scores of control group was changed from 44.33 to 48.00 at the end of the process. The clustered boxplots related to the PREGAT and POSTGAT for three groups are displayed in Figure 4.1.

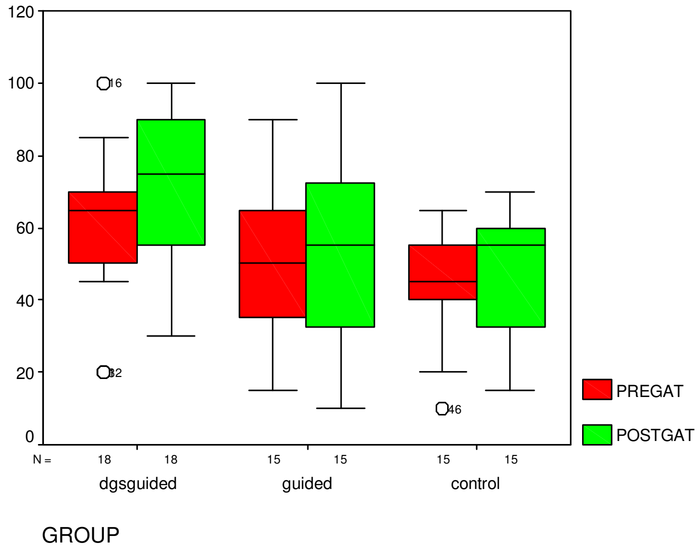


Figure 4.1 Clustered boxplot of the PREGAT and POSTGAT for the Experimental Group 1, Experimental Group 2 and Control Group

As it seen in the figure 4.1, there was a lower outlier in the PREGAT of the control group and first experimental group. Also, there was an upper outlier in PREGAT of the first experimental group. In the boxplot, the box includes mid 50% and each whisker represents upper and lower 25 % of the cases (Green, Salkind, & Akey, 2003). The median of the Experimental Group 1 was higher than the median of the Experimental Group 2 and Control Group for both PREGAT and POSTGAT.

4.1.2 Descriptive Statistics of the Van Hiele Geometric Thinking Level Test

Descriptive statistics related to the PREVHL and POSTVHL for two experimental groups and the control group is presented in Table 4.2.

Table 4.2 Descriptive statistics related to the scores from PREVHL and POSTVHL for experimental and control groups.

	EG1		EG2		CG	
	PREVHL	POSTVHL	PREVHL	POSTVHL	PREVHL	POSTVHL
N	18	18	15	15	15	15
Mean	6.33	7.67	5.53	7.00	5.40	5.40
Median	6.00	7.50	6.00	7.00	5.00	6.00
Minimum	4	6	2	4	3	4
Maximum	9	10	8	10	8	7
St. Deviation	1.46	1.53	2.00	1.69	1.50	1.06
Kurtosis	-1.170	-1.412	.053	.000	-.752	-1.174
Skewness	-.243	.306	-.990	-.410	-.070	-.118

As it is seen in the Table 4.2, for Van Hiele Geometric Thinking Level Test, mean scores of both experimental groups were higher than control group mean scores. When the mean scores from the pretests and post administrations of them were compared, for the Van Hiele Geometric Thinking Level Test, the Experimental group 1 showed an increase from 6.33 to 7.67. An increase in mean scores was observed for the experimental group 2 from 5.53 to 7.00. Mean scores of control group did dot change at the end of the process.

4.2 Quantitative Results

This part presents the missing data analysis, determination of covariates, assumptions of ANCOVA, Findings related to analyses for research question and the follow-up analysis related to the study.

4.2.1 Missing Data analyses

There were no missing data in pretests and posttests. Some students did not answer some questions in Geometry Achievement Test. The questions which were not answered were coded as wrong answer during the analyses.

4.2.2 Determination of the Covariates

Before conducting the ANCOVA, two independent variables; the PREVHL and PREGAT were determined as possible confounding variables of this study. These two independent variables were taken as covariates in order to equalize the differences between the Experimental Group 1, Experimental Group 2 and Control Group statistically. These independent variables were correlated with the dependent variables POSTVHL and POSTGAT in order to determine whether they should be considered as covariates. The results of Pearson product-moment correlation coefficients and significances were presented in Table 4.3.

Table 4.3 Pearson correlation coefficients between potential covariates and dependent variables and their significance test for the EG1, EG2 and the CG.

	Correlation Coefficients
PREVHL- POSTVHL	.742
PREGAT-POSTGAT	.905

* Correlation is significant at the 0.05 level (2-tailed)

As presented in Table 4.3, both of the potential covariates have significant correlations with the dependent variables. The correlation coefficients between the variables PREGAT and POSTGAT is .905 and between the variables PREVHL and POSTVHL is .742 respectively. According to Cohen (1988), the correlation values between .50 and 1.0 indicate the large correlation. Both of these correlation values indicate large correlation. Therefore, the independent variables PREVHL and PREGAT were determined as covariates for the inferential analyses for the EG1, EG2 and the CG.

4.2.3 Assumptions of ANCOVA

In analysis of ANCOVA there are eight underlying assumptions that need to be verified.

1. Normality
2. Homogeneity of Variance
3. Measurement of the covariate
4. Reliability of the covariates
5. Correlations amongst the covariates
6. Linearity
7. Homogeneity of regression slopes
8. Independency of observations

For the normality assumption, skewness and kurtosis values of scores on POSTGAT, POSTVHL were checked. Table 4.4 shows the skewness and kurtosis values of these variables.

Table 4.4 Skewness and kurtosis values of POSTGAT and POSTVHL

	Skewness		Kurtosis	
	Statistics	Std. Error	Statistics	Std. Error
POSTVHL	-.121	.343	-.743	.674
POSTGAT	.196	.343	-.574	.674

As it is seen in Table 4.4, skewness and kurtosis values were in almost acceptable range.

The second assumption of satisfying the homogeneity of variances was controlled by Levene's Test of Equality. Table 4.5 shows the results of the Levene's Test of Equality.

Table 4.5 Levene's test of equality of error variances for posttest scores for the EG1, EG2 and the CG.

	F	df1	df2	Sig.
POSTGAT	1.537	2	45	.720
POSTVHL	2.779	2	45	.071

As indicated in Table 4.5, significance values for POSTGAT and POSTVHL were .720 and .071 respectively. Since significance values are greater than .05, the assumption of homogeneity of variance had not been violated.

In this study, pretest scores of Geometry Achievement Test and Van Hiele Geometric Thinking Level Test were determined as covariates. These covariates were measured before the treatment. The pre-application of tests provided the control of measurement of covariance assumption.

Since there was more than one covariate in this study, correlation amongst the covariates assumption was checked. The correlation coefficient amongst covariates, namely PREVHL and PREGAT was found as .494. Since this value is below .8, these covariates were not too strongly correlated (Pallant, 2001).

The assumption concerning the reliability of the covariate was also part of this research design. In the study of Duatepe (2000), Cronbach Alpha reliability measures of the Van Hiele Geometric Thinking Level Test were found as .82, .51, and .70, for the first, second, and third level, respectively. Cronbach Alpha reliability measure for the Geometry Achievement Test was found as .79. This value is above .7, which implies that the test was reliable.

To check the linearity assumption, scatter plots between the dependent variables and each of the covariates were generated. Figure 4.2 and Figure 4.3 shows the scatter plots generated for linearity assumption.

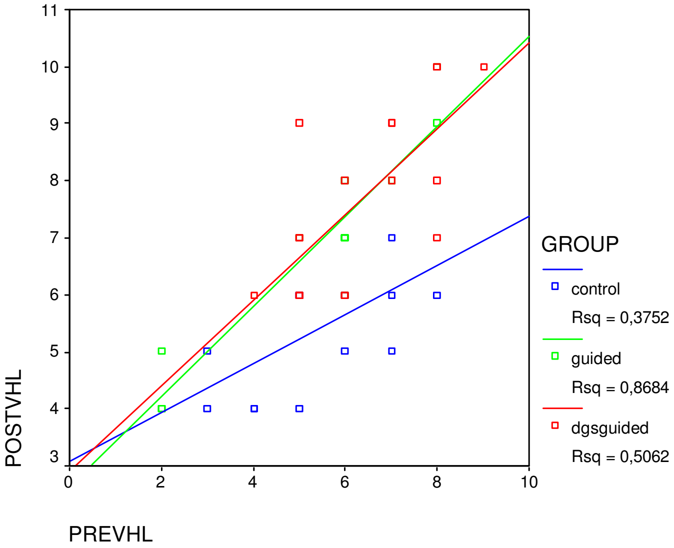


Figure 4.2 Scatter plot between PREVHL and POSTVHL

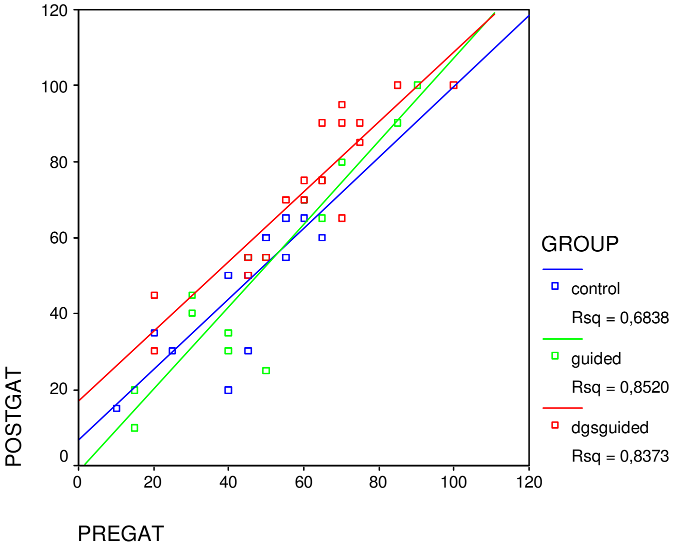


Figure 4.3 Scatter plot between PREGAT and POSTGAT

In both scatter plots, linear relationship was appeared. Since the relationship is linear, the linearity assumption was not violated. The R squared values, given in the legend for each of the groups in the study indicated the strength of the relationship between dependent variable and covariate. In the case of the relationship between the PREVHL and POSTVHL, the R squared values were calculated approximately as 0.38, 0.87 and

0.51 for control group, experimental group 2 and experimental group 1 respectively. In the case of the relationship between the PREGAT and POSTGAT, the R squared values were calculated approximately as 0.68, 0.85 and 0.84 for control group, experimental group 2 and experimental group 1 respectively. These values were due in part to the pre-intervention, post-intervention design, which used the same test administrated on two different occasions.

Homogeneity of regression slopes assumption was examined in order to check that there was no interaction between the covariate and the treatment. The significance level for the interaction between group membership and covariate PREVHL was .196. Since this value is not less than or equal to .05, the interaction is not significant. Therefore, the homogeneity of regression slopes assumption was not violated for PREVHL covariate. The significance level for the interaction between group membership and covariate PREGAT was .549, indicating that homogeneity of regression slopes assumption was not violated for PREGAT covariate.

Lastly, independency of the observations assumption was examined. The researcher observed all of the groups during the administration of all pretests and posttest. From the observations it can be mentioned that the participants did all the tests by themselves.

4.2.4 Findings Related to Analyses for Research Question

This study aimed to investigate the answer for the following research question;

What are the effects of using dynamic geometry software while teaching by guided discovery compared to traditional teaching method on sixth grade students' scores on van Hiele geometric thinking level test and achievement on polygons when students' prior van Hiele geometric thinking level test and achievement test scores are controlled?

A one-way between groups analysis of covariance was conducted twice to compare the effectiveness of using dynamic geometry software while teaching by guided discovery compared to traditional teaching method.

In the first time, the independent variable was the type of treatment and the dependent variable consisted of scores on the van Hiele Geometric Thinking Level Test (VHL) administered after the treatment was completed. In the first time, null hypothesis related to the van Hiele geometric thinking levels were tested. These hypotheses were as follows;

Null Hypothesis 1:
There will be no significant effects of methods of teaching (teaching by guided discovery using dynamic geometry software versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' posttest scores on van Hiele geometric thinking level test when students' prior van Hiele geometric thinking level scores are controlled.

Null Hypothesis 2:
There will be no significant effects of methods of teaching (teaching by paper-and pencil based guided discovery versus teaching by guided discovery using dynamic geometry software) on means of the collective dependent variables of the sixth grade students' posttest scores on van Hiele geometric thinking level test when students' prior van Hiele geometric thinking level scores are controlled.

Null Hypothesis 3:
There will be no significant effects of methods of teaching (teaching by paper-and-pencil based guided discovery versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' posttest scores on van Hiele geometric thinking level test when students' prior van Hiele geometric thinking level scores are controlled.

Participants' scores on the pre-intervention administration of van Hiele Geometric Thinking Level Test (PREVHL) were used as the covariate in this analysis. The results of the analysis were presented in Table 4.6

Table 4.6 Test of between-subjects effects for VHL

	df	F	p	η^2	Observed Power
PREVHL	1	67.965	<.01	.607	1.000
GROUP	2	14.561	<.01	.398	.995
Error	44				

a Computed using alpha = .025

b $R^2 = .730$ ($R^2_{Adj} = .711$)

As it is seen in Table 4.6, significant value in the line corresponding to our independent variable, group is <.01. After adjusting for pre-intervention scores, there was a significant difference between three intervention groups on post-intervention scores on VHL test, $\underline{F}(2,45)=14.56$, $\underline{p}<.01$, $\eta^2=.398$. There was a strong relationship between pre-intervention and post-intervention scores on VHL, as indicated by an eta value of .607. This means that statistically significant differences were identified between the groups receiving the guided discovery method with dynamic geometry software, paper-and-pencil based guided discovery and traditional method on the collective dependent variables of the POSTVHL. Therefore, the first three null hypotheses were rejected.

Since independent variable had three levels, it was necessary to conduct follow-up analysis in order to determine where the significant differences lie. To identify which groups were different significantly in van Hiele Geometry Achievement Test, step-down analyses were performed. In order to select correct analyses, the mean scores of PREVHL and POSTVHL for each group were checked. These values were presented in Table 4.7

Table 4. 7 Mean scores of PREVHL and POSTVHL

	PREVHL	POSTVHL
Experimental Group 1	6.33	7.67
Experimental Group 2	5.53	7.00
Control Group	5.40	5.40

As indicated in table 4. 7, the difference in students pretest scores was significant. Since students pretest scores on PREVHL showed statistically significant difference for different groups, the step down analysis were performed by using gain scores. The result of this analysis was presented in Table 4.8

Table 4.8 Results of step-down analysis on gain scores of VHL

	Mean difference	p
Experimental Group 1-Experimental Group 2	.133	.930
Experimental Group 1-Control Group	1.33*	.002
Experimental Group 2-Control Group	1.47*	.001

*The mean difference is significant at the level .05 level.

As indicated in Table 4.8, Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Experimental Group1 (M=7.67, SD=1.53) was significantly different from Control Group (M=5.40, SD=1.06). Experimental Group 2 (M=7.00, SD=1.69) was significantly different from Control Group. Experimental group 1 did not differ significantly from Experimental Group 2. This means that students taught by guided discovery with dynamic geometry software instruction got higher gain scores on posttest than the students instructed by traditional method. Furthermore, students taught by paper-and-pencil based guided discovery got higher gain scores on each posttest than the students instructed by traditional method.

In the second time, null hypothesis related to the Geometry achievement were tested. These hypotheses were as follows;

Null Hypothesis 4:

There will be no significant effects of methods of teaching (teaching by guided discovery using dynamic geometry software versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' posttest scores geometry achievement test when students' prior geometry achievement scores are controlled.

Null Hypothesis 5:

There will be no significant effects of methods of teaching (teaching by paper-and pencil based guided discovery versus teaching by guided discovery using dynamic geometry software) on means of the collective dependent variables of the sixth grade students' posttest scores geometry achievement test when students' prior geometry achievement scores are controlled.

Null Hypothesis 6:

There will be no significant effects of methods of teaching (teaching by paper-and-pencil based guided discovery versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' posttest scores geometry achievement test when students' prior geometry achievement scores are controlled.

The independent variable was the type of treatment and the dependent variable consisted of scores on the Geometry Achievement Test (GAT) administered after the treatment was completed. Participants' scores on the pre-intervention administration of Geometry Achievement Test (PREGAT) were used as the covariate in this analysis. Preliminary checks were conducted to ensure that there was no violation of the assumptions. The results of the analysis were presented in Table 4.9

Table 4.9 Test of between-subjects effects for GAT

	df	F	p	η^2	Observed Power
PREGAT	1	184.893	<.01	.808	1.000
GROUP	2	4.457	.017	.168	.629
Error	44				

a Computed using alpha = .025

b R^2 = ,850 (R^2_{Adj} = .839)

As it is seen from Table 4.9, significant value in the line corresponding to our independent variable, group is .017. This value is less than alpha level, therefore the result is significant. After adjusting for pre-intervention scores, there was a significant difference between three groups on post-intervention scores on GAT, F(2,45)=4.457, p=.017, η^2=.168. This means that statistically significant differences were identified between the groups receiving the guided discovery method with dynamic geometry software, paper-and-pencil based guided discovery and traditional method on the collective dependent variables of the POSTGAT. Therefore, the fourth, fifth and sixth null hypotheses were rejected.

In order to select correct step-down analyses, the mean scores of PREVHL and POSTVHL for each group were checked. These values were presented in Table 4.10.

Table 4. 10 Mean scores of PREGAT and POSTGAT

	PREGAT	POSTGAT
Experimental Group 1	60.83	73.06
Experimental Group 2	50.00	53.00
Control Group	44.33	48.00

To identify which groups were different significantly in Geometry Achievement Test, step-down analyses were performed by using one-way ANOVA on gain scores, since the the difference in mean scores on pre-intervention of the GAT was significant for each group. Table 4.11 displayed the results of step-down analysis of gain scores on GAT.

Table 4.11 Results of step-down analysis on gain scores of GAT

	Mean difference	Sig.
Experimental Group 1-Experimental Group 2	9.22*	.022
Experimental Group 1-Control Group	8.56*	.035
Experimental Group 2-Control Group	-.66	.980

*The mean difference is significant at the level .05 level.

As indicated in Table 4.11, Post-hoc comparisons using the Tukey HSD test indicated that the mean score for Experimental Group 1 (M=73.06, SD=20.08) was significantly different from Experimental Group 2 (M=53.00, SD=26.78) and Control Group (M=48.00, SD=17.51). Experimental Group 2 did not differ significantly from either group. Control group did not differ significantly from experimental groups. This means that students taught by guided discovery with dynamic geometry software instruction got higher scores on posttest than the students instructed by traditional method.

4.3 Summary

In the light of the findings obtained by hypotheses testing for students' geometric thinking levels and achievement, the following conclusions can be deduced:

There was a significant effect of methods of teaching (teaching by guided discovery using dynamic geometry software versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' scores on the POSTVHL after controlling their PREVHL scores.

There was a significant effect of methods of teaching (teaching by paper-and-pencil based guided discovery versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' scores on the POSTVHL after controlling their PREVHL scores.

There was no significant effect of methods of teaching (teaching by paper-and pencil based guided discovery versus teaching by guided discovery using dynamic geometry software) on means of the collective dependent variables of the sixth grade students' scores on the POSTVHL after controlling their PREVHL scores.

There was a significant effect of methods of teaching (teaching by guided discovery using dynamic geometry software versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' scores on the POSTGAT after controlling their PREGAT scores.

There was a significant effect of methods of teaching (teaching by paper-and pencil based guided discovery versus teaching by guided discovery using dynamic geometry software) on means of the collective dependent variables of the sixth grade students' scores on the POSTGAT after controlling their PREGAT scores.

There was no significant effect of methods of teaching (teaching by paper-and-pencil based guided discovery versus traditional teaching method) on means of the collective dependent variables of the sixth grade students' scores on the POSTGAT after controlling their PREGAT scores.

CHAPTER 5

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

This chapter presents the discussion and interpretation of the results and recommendations. In the first part, the results were restated and discussed. In the second part, the internal and external validity of the study and actions done to reduce the impact of the threats of these validity issues were presented. The following section includes implications and the last part presents recommendations for further reseach.

5.1 Conclusions and Discussion

The main question of this study was to investigate the effectiveness of using dynamic geometry software by guided discovery on student's geometry achievement and van Hiele geometric thinking level test scores. In order to investigate this problem, a quasi-experimental design was used. Data were gathered from three sixth-grade classess. One of the groups was experimental group, who received guided instruction with dynamic geometry software. Second group was another experimental group, receiving the paper-and-pencil based guided discovery method, and the last group was control group, taught with traditional method.

Students geometry achievement was measured by using Geometry Achievement Test (GAT) and their geometric thinking were determined by van Hiele Geometric Thinking Level Test (VHL). Geometry Achievement Test was developed by the researcher. Van Hiele Geometric Thinking Level Test was originally developed by Usiskin (1982), and translated into Turkish by Duatepe (2000).

5.1.1 Students' Geometry Achievement

In this study, according to the results of analyses related to the geometry achievement of the students, there were significant differences between the groups from the aspect of their geometry achievement. In order to investigate which groups differ, follow-up analysis were conducted. The follow-up analysis revealed that, at the end of the study, the experimental group 1 had a statistically high gain score on the GAT.

This research study reported the significant influence of using dynamic geometry software while teaching by guided discovery method on students' geometry achievement. There might be several reasons for the positive effects of using dynamic geometry software while teaching by guided discovery. The reasons might be due to the use of dynamic geometry, the use of guided discovery or using them together.

One of the possible reasons that affects students achievement who are in experimental group 1 can be the visualization provided by dynamic geometry software environment. The importance of visualization is defined as the core part of geometry in the result of previous research (Battista, 1994; Bishop, 1989; Hershkowitz, 1989). Visualization helps students to better understand the abstract concepts in more concrete way.

The significant difference in achievement in this study was partly attributable to the dynamic environment of the software. In traditional, static paper and pencil environment, students do not have a chance to observe variations. Dynamic geometry software provides a rich environment where students realize the invariant properties and changeble characteristics of the shapes. In static environment, students deal with the static drawings. These drawings present the figure as in the form of its generic case. Wheras, dynamic geometry software provides construction of a figure rather than drawing. In construction, when a shape is dragged form its corner, it conserves the properties which are related to its constrain. Although the size and its position change, the shape remains as its original. This kind of characteristic of dynamic geometry environment brings the students to comprehend the shape with its all characteristics. The results gathered in this study are consistent with the results of previous research concerning the effects of dragging (Arzarello et al. 2002; Jones, 2000; Healy & Hoyles, 2001; Hölzl, 1996; Sträßer, 2001).

It can also be mentioned that, dynamic geometry environment provides some calculation opportunities for the students, such as calculation of perimeter and area. In traditional setting, students should memorize some formula in order to make these calculations. From this aspect, traditional method in geometry teaching is criticized since it forces students to memorize (Fuys, Geddes, and Tischler, 1988; Mayberry, 1983). Memorization without understanding the idea behind, reveals forgetting or confusing information at the end. Dynamic geometry software not only provide understanding of these calculations but also realizing the relationships. In this study, by resizing the figure in dynamic environment, students immediately realized the relationship between the length of the sides and its perimeter, relationship between the length of the sides and area of the shape and relationship between perimeter and area. Such kind of property provided students make their own conjectures about the relationships.

The reasons for the positive effects of using dynamic geometry software while teaching by guided discovery might be due to the instruction. Several studies argued on the crucial role of instruction in teaching and learning geometry (Usiskin, 1982; Fuys, Geddes, & Tischler, 1988). In this study, guided discovery method is used as an instructional method. By appropriate guidance, students found the correct way of constucting their own knowledge. In other research studies, guided discovery is found as one of the many successful teaching methods (Choike, 2000; Gerver & Sgroi, 2003).

5.1.2 Van Hiele Geometric Thinking Levels

In this study, van Hiele Geometric Thinking Level Test (VHL) was administered to the experimental and control groups as a pretest in order to define students' present geometric thinking and the pretest scores of the groups were put as covariates in analysis.

At the end of the study, students in experimental group 1 performed significantly better on the van Hiele Geometric Thinking Level Test (VHL) than experimental group 2 and the control group students. This result is consistent with the previous research which support the accuracy of the model for assessing student understandings of geometry (Burger 1985; Burger and Shaughnessy 1986; Geddes et al. 1982; Geddes, Fuys, and Tichler 1985; Mayberry 1981; Shaughnessy and Burger 1985; Usiskin 1982). However, the increase in their mean scores between pretest to posttest process did not indicate a large difference. This result is consistent with the results of previous studies (Johnson, 2002; van Hiele-Geldof, 1984). These studies showed that, to investigate the rise in students van Hiele geometric thinking requires time. In this study, the treatment period was four weeks and this duration is not enough time to make conclusion about the development of students geometric thinking. To observe long-term and significant increase in the students geometric thinking, a longer period of time is needed.

Although the duration of the study was relatively short, the students showed increase in their geometric thinking in experimental group 1. This result is consistent with the previous researches which support the importance of constructivist teaching experiments in increasing students van Hiele geometric thinking levels. In designing constructivist teaching experiments; the content, materials, method and instruction are important areas of pedagogical concern and progress through the van Hiele geometric thinking levels is more dependent on the instruction. Researches confirmed that, by developing systematic plan and instruction, it is possible to raise the van Hiele levels of thinking of elementary and middle school students(Wirszup, 1976; Fuys, Geddes, & Tischler, 1986). This study provide an example for such kind of systematic instruction.

5.2 Validity Issues

There were possible threats to the internal and external validity of this study. These threats and how they were handled was explained here.

5.2.1 Internal Validity

This study was a quasi-experimental design. In this design, students were not randomly assigned to any of the experimental and control groups which influences the possible occurrence of differential selection of participants' threat. Previous achivement of the students and their van Hiele geometric level test scores were potential factor that could affect the outcomes of the study. In order to prevent their potential effect, they were set as covariates in ANCOVA. By this way, students were matched on the previous achievement scores and van Hiele geometric thinking level test scores. Consequently, groups were made statistically equivalent and characteristics of subjects were minimized.

History threat can be defined as occurrence of unexpected events which are not part of the experimental treatment but affect the outcomes of the study. The period of the study was relatively short and any unexpected events did not occur between the pretests and posttests.

Administering the pretest was another threat from the aspect of repeated testing. All of the groups were administered beforehand and since the treatment lasted four weeks, there was a sufficient time between administration of pretests and posttests.

Mortality, which is another threat to internal validity, refers to the case in which participants drop out for different reasons in different numbers (Gay & Airasian 2000). All of the subjects were attended to administration of the tests and treatment process and there were no missing data in the tests. Therefore mortality was not a threat for internal validity.

5.2.2 External Validity

The accesible population was the sixth grade students in one of the private schools in Ankara. Since the participants were not randomly selected, in other words convenience sampling was used; the generalizability of the research was limited. Generalization can only be done to subjects who have similar characteristics with the subjects in this study. The results of this study can be applied to a broader population of samples who have similar characteristics and conditions with the ones in this study.

Both pretests and posttests were administered in a regular classroom setting during the regular lesson hours. All of the groups were administered the tests in standart conditions. The threats related to the ecological validity were controlled by this way.

The treatment was conducted by the researcher in all groups. This is a possible threat related to the experimenter effects. The characteristics, motivation and teaching ability of the reseacher might have influence on the treatment procedure and consequently on students' achievement. Researcher was their regular mathematics teacher at the same time and responsible for the students' better understanding regardless of being a member of experimental or control group. She tried to be unbiased during the treatment. Futhermore, the researcher scored the achivement tests without knowing whose answers are being scored.

5.3 Implications

Learning geometric concepts is difficult by only watching the teacher, listening the explanations and taking notes. Teaching environment, in which students are passive learners, does not serve meaningful learning experiences to students. Many concepts in geometry require students' active involvement. This study is an example of the learning environments designed by means of using dynamic geometry software while teaching by guided discovery approach.

In the current study it was found that, integrating dynamic geometry software into the guided discovery environment had a significant influence on students' geometric achievement and geometric thinking. Students were active participants of the learning process; they constructed their own knowledge by doing activities by themselves, made connections and reasoning.

This study confirmed that, using appropriate and meaningful activities is as important as integrating the technology into guided discovery learning environment. Therefore, in order to reach better results in teaching geometry, activities involving the use of dynamic geometry software by guided discovery should be prepared and varied.

5.4 Recommendations for Further Research

Geometry education is needed to be improved. This research study provide some ideas about how such improvement can be satisfied by reporting the effect of using dynamic geometry software while teaching by guided discovery. The results revealed from this study provide ideas for further research studies in geometry education from the aspects of teaching method, using technology and their integration.

This study focused on some contents in sixth grade polygons unit. Therefore the findings documented here cannot be generalized to other grade levels, other contents and other learning areas in mathematics. In order to examine the effects of using dynamic geometry software, using guided discovery approach and using dynamic geometry software in guided discovery settting, further research should be conducted including not only one topic on different levels, different contents and different learning areas is needed.

This study was conducted for four weeks period. Further research should be conducted in order to gain evidence related to the long-term effects of using dynamic geometry software with guided discovery on students geometry achievement and geometric thinking.

This study was conducted in a private school, in which the class sizes were too small. Especially in public schools, class sizes are not as small as the ones in this study. All of the students in experimental group, which received guided discovery with dynamic geometry software had a chance to use a computer on their own. In crowded classrooms, such kind of setting may not be satisfied. Therefore, similar studies should be conducted with different class sizes in order to determine the effect of class size on achievement of students and their geometric thinking.

Related to the previous issue, similar studies can be conducted with cooperative groups in order to determine the effect of using cooperative learning on students' achievement and geometric thinking.

Since this study was conducted in a private school, the subjects were from high socioeconomic status. Similar studies can be conducted with a public schools in order to determine the effect of school type and/or socioeconomic issues on achievement of students and their geometric thinking.

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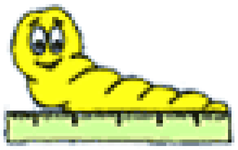
APPENDICES

APPENDIX A

LESSON ACTIVITIES IN EXPERIMENTAL GROUP 2

ÜÇGENDE ÇEVRE HESAPLAMALARI

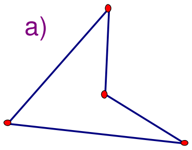


Bu etkinlikte çevre kavramının öğrenmeniz, verilen üçgenin çevresinin uzunluğunu hesaplamanız, çevre ile kenar uzunlukları arasındaki ilişkiyi kavramanız amaçlanmaktadır.

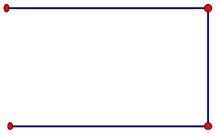
BÖLÜM 1

- Aşağıdaki çizimlerden hangileri çevre oluşturur?

a)

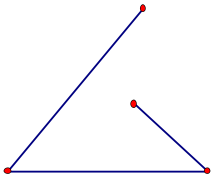


b)

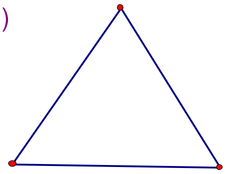


c)

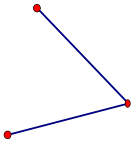
d)



e)



f)



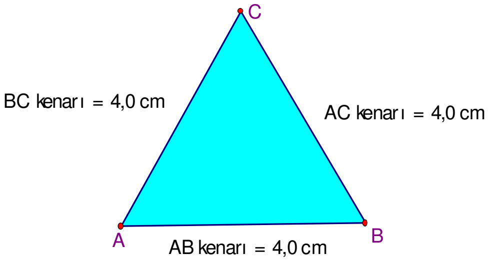
- Bu seçimlerinizde kararınızı belirleyen düşünce ne oldu?

- Buna göre kendi cümlelerinizle “**Çevre**” nin ne olduğunu açıklayınız.

BÖLÜM 2

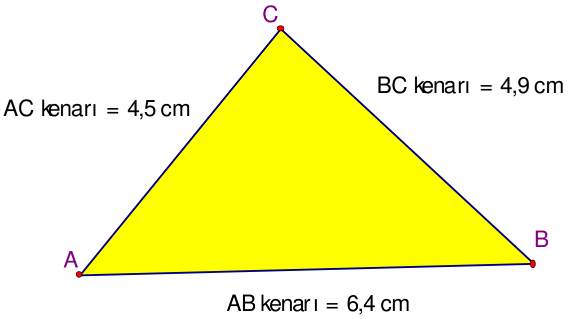
Elinizde 12 cm uzunluğunda bir tel var. Bu teli kullanarak farklı şekillerde çevreleri olan şekiller elde ediniz. (Bu şekillerin üçgen, kare ve dikdörtgen olmasına dikkat ediniz.)

Örnek: Bu tel ile bir kenarı 4 cm olan eşkenar üçgen çizilebilir.



BÖLÜM 3

@ Aşağıdaki üçgenin çevre uzunluğunu hesaplayınız.



@ Üçgenin kenar uzunlukları 2, 3, 4 ve 5 kat arttığında üçgenin çevresindeki değişim ne olur? Hesaplamalarınızı yaparak tabloyu doldurunuz.

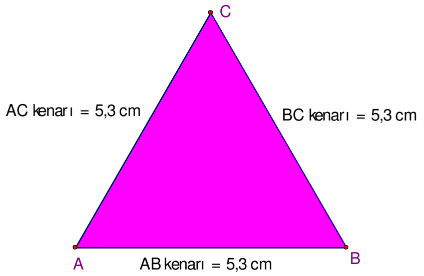
Durum	**AB kenarının uzunluğu**	**BC kenarının uzunluğu**	**AC kenarının uzunluğu**	**Çevre uzunluğu**
1 kat				
2 kat				
3 kat				
4 kat				
5 kat				

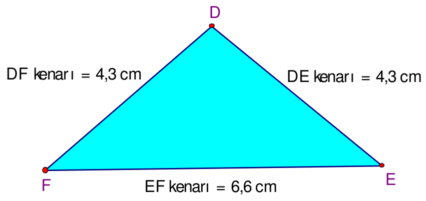
- Kenar uzunlukları değiştikçe çevredeki değişim ne oldu?

- Tablodan yararlanarak üçgenin kenar uzunlukları ile çevresinin uzunluğu arasında nasıl bir ilişki olduğunu açıklayınız.

BÖLÜM 4

- Şekildeki üçgenlerin türü nedir?



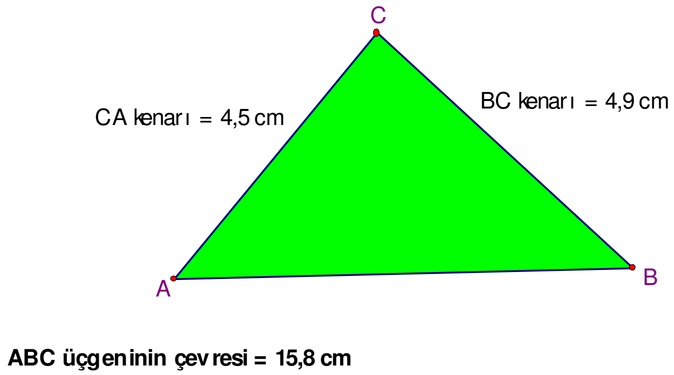


- B
  Bu üçgenlerin çevre uzunluğunu hesaplayınız.

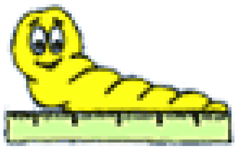
- Üçgenlerin kenar uzunluklarını 2 kat arttırdığınızda çevredeki değişim ne olur?

- Bölüm 3’te bulduğunuz ilişki bu tür üçgenler için de geçerli midir?

Aşağıda iki kenar uzunluğu ve çevresinin uzunluğu verilen üçgenin üçüncü kenarının uzunluğunu hesaplayınız.

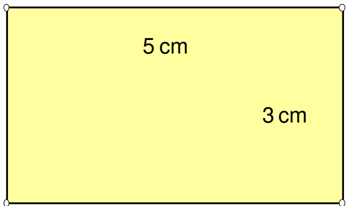


KARE VE DİKDÖRTGENDE ÇEVRE HESAPLAMALARI

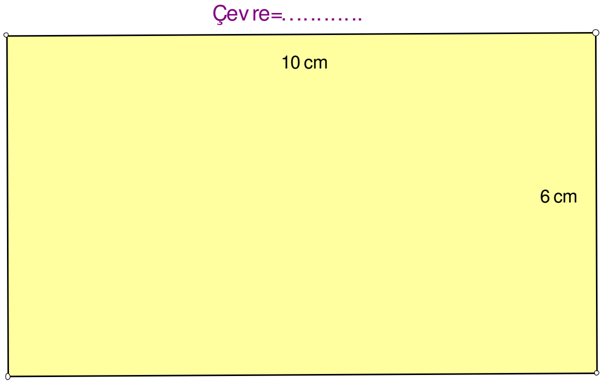


BÖLÜM 1

- Kenar uzunlukları 5 cm ve 3 cm olan bu dikdörtgenin çevresi kaç santimetredir?



- Aşağıda verilen dikdörtgenin çevre uzunluğunu hesaplayınız.

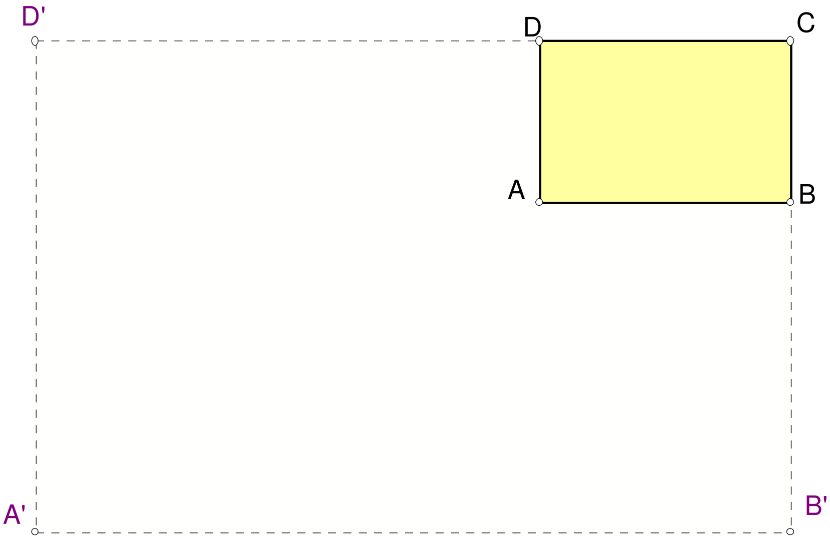


- Büyük dikdörtgen ile küçük dikdörtgenin kenar uzunlukları arasında nasıl bir ilişki vardır?

- Büyük dikdörtgen ile küçük dikdörtgenin çevresi arasında nasıl bir ilişki vardır?

BÖLÜM 2

Şekildeki ABCD dikdörtgeninin çevresi üç katına çıkarıldığında, yeni çevre 30 cm oluyor. Dikdörtgenin eni boyundan 1 cm fazla olduğuna göre boyunun ve eninin uzunluğunu bulunuz.



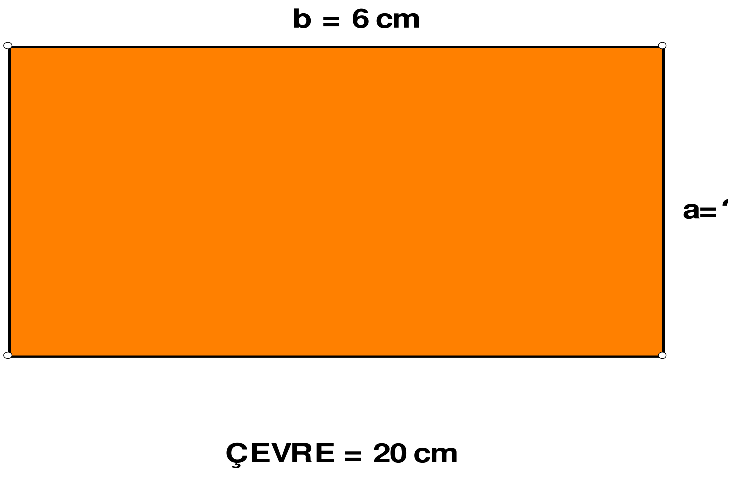
- Bu dikdörtgen ile ilgili bilgileriniz nelerdir?

- ABCD dikdörtgeninin çevresi kaç santimetredir?

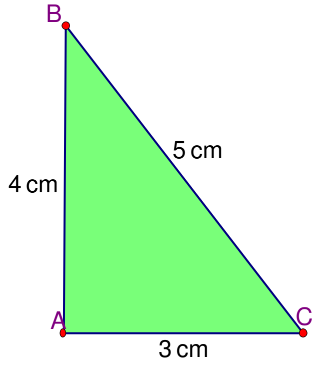
- ABCD dikdörtgeninin eni ve boyu kaç santimetredir?

BÖLÜM 3

Çevresi 20 cm olan bir dikdörtgenin boyu 6 cm ise eni kaç cm'dir?



BÖLÜM 4



- Verilen dik üçgenin çevresi kaç santimetredir?

- Aynı çevreye sahip, kenar uzunlukları doğal sayı olmak üzere kaç farklı dikdörtgen oluşturulabilir?

BÖLÜM 5

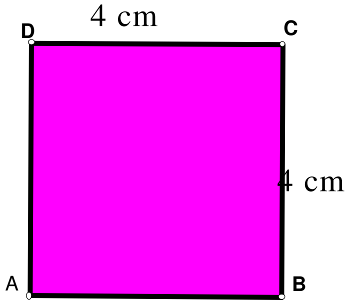
- Bir dikdörtgenin kenar uzunlukları %10 oranında arttırılırsa çevesinde değişim ne olur?

- Doğal sayı ve ondalık kesirleri kullanarak çevre uzunluğu 24 cm olan üç tane dikdörtgen oluşturunuz. Bütün dikdörtgenler aynı mı?

- Dikdörtgenin çevresinin uzunluğunu, kenarlarının uzunluğu türünden nasıl ifade edebiliriz?

- Bu ifade kare için de geçerli midir?

- Şekildeki karenin çevresi kaç santimetredir?



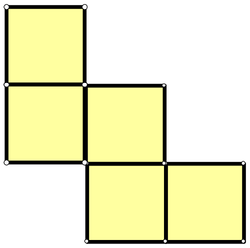
- Bu kare ile aynı çevre uzunluğuna sahip başka kareler çizilebilir mi? Neden?

- Çizdiğiniz kare ile aynı çevre uzunluğuna sahip bir eşkenar üçgen çiziniz.

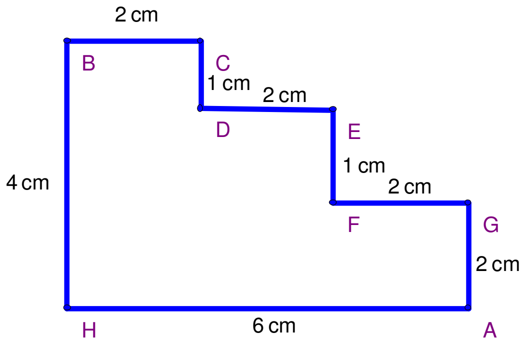
- Bu eşkenar üçgenin bir kenarı kaç cm'dir?

ÇEVRE İLE İLGİLİ ALIŞTIRMALAR

- Boyalı şekil, birbirine eş karelerden oluşmaktadır. Boyalı şeklin çevresinin uzunluğu, karelerden birisinin çevresinin uzunluğunun kaç katıdır?



- Yandaki şeklin çevresinin uzunluğunu hesaplayınız.



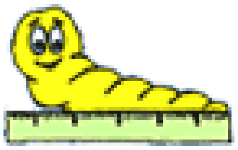
Aşağıdaki alıştırmalarda kendi çizimlerinizi yapınız.

- Çevresinin uzunluğu $4\frac{2}{7}$ metre olan eşkenar üçgenin bir kenarının uzunluğu kaç metredir?

- Eş kenarlarından biri 7 cm diğer kenarı 8 cm olan ikizkenar üçgenin çevresinin uzunluğu kaç cm'dir?

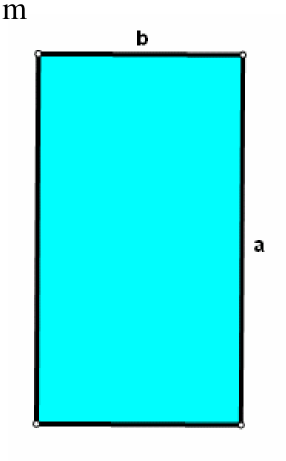
- Bir eşkenar üçgen ile karenin çevrelerinin çevre uzunluklarının eşit olması için kenarları arasında nasıl oran olmalıdır?

ALAN HESAPLAMALARI



Bu etkinlikte alan kavramının öğrenmeniz, verilen şekillerin alanını hesaplamanız, alan ile kenar uzunlukları arasındaki ilişkiyi kavramanız amaçlanmaktadır.

BÖLÜM 1



- Şekildeki dikdörtgenin kenar uzunlukları nelerdir?

- Bu dikdörtgenin alanını hesaplayınız.

- Aynı alana sahip başka dikdörtgenler de oluşturunuz.

- Bu alana sahip kaç tane dikdörtgen oluşturabilirsiniz?

- Bulduğunuz dikdörtgenlere göre tabloyu doldurunuz.

DİKDÖRTGEN	**A KENARI**	**B KENARI**	**ALAN**
1			
2			
3			
4			
5			

Tablodan yararlanarak dikdörtgenin kenar uzunlukları ile çevresinin uzunluğu arasında nasıl bir ilişki olduğunu açıklayınız.

BÖLÜM 2

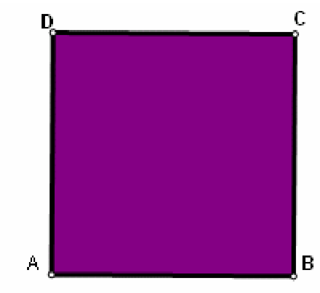
Alanı 28 cm^2 ve eni 4 cm olan dikdörtgen şeklindeki kalemliğin boyunun uzunluğunu hesaplayınız.

Bu uzunluklar iki katına çıkarılırsa alandaki değişim ne olur?

BÖLÜM 3

Dikdörtgenin kenarları ile alanı arasındaki ilişki kare için de geçerli midir?

a=4,5 cm



- Bu karenin kenar uzunluklarını hesaplayınız.

- Bu karenin alanını hesaplayınız.

- Farklı iki kare daha çizerek alanını hesaplayınız.

KARE	**1.durum**	**2.durum**	**3.durum**
Kenar uzunluğu			
Alanı			

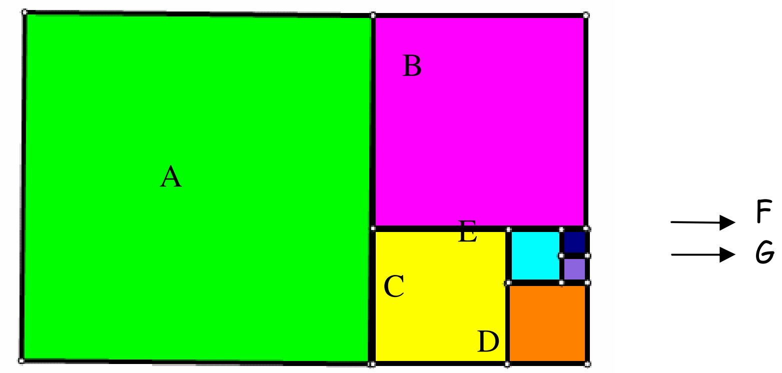
- Karenin alanı ile kenar uzunlukları arasında nasıl bir ilişki vardır?

- Karenin kenar uzunluğu 3 katına çıkarıldığında alanda nasıl bir değişim olur?

<u>BÖLÜM 4</u>

- Aşağıdaki dikdörtgende her şekil bir karedir. Buna göre dikdörtgenin alanı nasıl hesaplanabilir?

- Şekildeki karelerin alanları kaçar cm^2 dir?



A karesininin alanı=

B karesinin alanı=

C karesinin alanı=

D karesinin alanı=

E karesinin alanı=

F karesinin alanı=

G karesinin alanı=

Dikdörtgenin alanı=

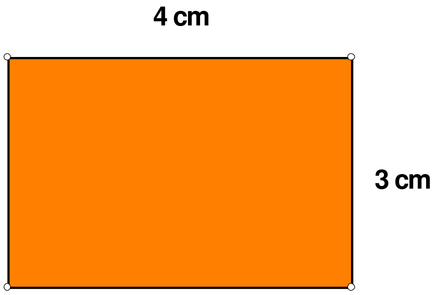
- Alanı 25 cm^2 olan karenin bir kenar uzunluğu kaç cm olabilir?

- Karenin kenar uzunluklarının 4 kat artması için alanı kaç kat artmalıdır?

BÖLÜM 5

Dikdörtgenin alanından yararlanarak bir dik üçgenin alanı nasıl hesaplanabilir?

- Şekilde kenar uzunlukları 3 cm ve 4 cm olan bir dikdörtgen bulunmaktadır.



- Bu dikdörtgenin karşılıklı köşelerindeki noktaları seçerek, dikdörtgenin bir köşegenini oluşturunuz.

- Şekilde birbirine eş iki üçgen oluşmuştur. Bu üçgenlerin türü nedir?

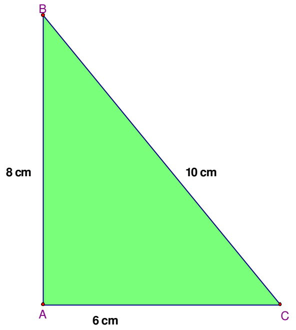
- Bu üçgenlerin kenar uzunlukları nelerdir?

- Dikdörtgenin alanını hesaplayınız.

- Dik üçgenlerden birinin alanını hesaplayınız.

- Dikdörtgenin alanı ile dik üçgenin alanı arasında nasıl bir ilişki vardır?

- Bu ilişki dikdörtgenin boyutlarını değiştirdiğinizde korunuyor mu?



- Verilen dik üçgenin alanını hesaplayınız.

- Bu üçgenin alanını iki katına çıkardığınızda kenar uzunluklarındaki değişim ne olur? Tahmin ediniz.

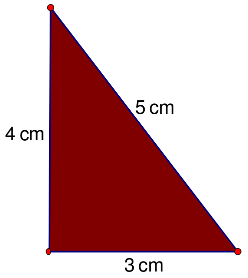
- Bu üçgenin alanını iki katına çıkardığınızda kenar uzunluklarındaki değişim ne olur?

- Dik üçgenin alanı hangi kenarlarının uzunlukları ile ilgilidir?

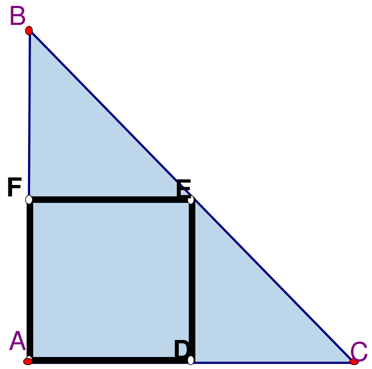
- Üçgenin alanını kenarların uzunluklarından yararlanarak nasıl hesaplayabiliriz?

ALIŞTIRMALAR

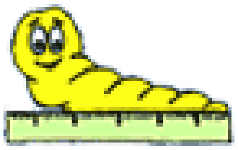
- Yanda verilen dik üçgenle aynı çevre uzunluğuna sahip bir dikdörtgen çiziniz.



Şekilde AFE ile EDC ikizkenar dik üçgenler, BDEF karedir. Karenin alanı 36 cm^2 ise ABC üçgeninin alanı kaç cm^2 dir?



ALAN-ÇEVRE PROBLEMLERİ



Bu etkinlikte üçgen kare ve dikdörtgenin alanları ve çevreleri ile ilgili hesaplamalar yapmanız, bu şekillerin çevre uzunluğu ile alanı arasındaki ilişkiyi kavramanız, bu şekillerin amaçlanmaktadır.

- Uzun kenarı kısa kenarının iki katı olan dikdörtgenin çevresinin uzunluğu 42 cm'dir. Bu dikdörtgenin alanı kaç cm^2'dir?

- ABCD karesel bölgesinin bir kenar uzunluğu 3 cm ise karesel bölgenin alanının çevre uzunluğuna oranı nedir?

- Çevresi 20 cm olan bütün dikdörtgenlerin alanları eşit midir?

-Eğer hepsinin alanları eşit değilse hangi tür dikdörtgenlerin alanı daha büyüktür?

- Alanı 36 cm^2 olan bir dikdörtgenin çevre uzunluğu en az kaç cm olabilir?

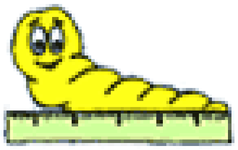
- Alanı ve çevresi eşit olan bir karenin bir kenarı kaç cm olabilir?

- Bir kare ikiye katlanarak dikdörtgen oluşturulmuştur. Oluşan dikdörtgenin çevresi 12 cm ise orijinal karenin alanı kaç cm^2 dir?

APPENDIX B

LESSON ACTIVITIES IN EXPERIMENTAL GROUP 1

ÜÇGENDE ÇEVRE HESAPLAMALARI



Bu etkinlikte çevre kavramının öğrenmeniz, verilen üçgenin çevresinin uzunluğunu hesaplamanız, çevre ile kenar uzunlukları arasındaki ilişkiyi kavramanız amaçlanmaktadır.

BÖLÜM 1

Bilgisayarınızın masaüstünden "cevre_ucgen.gsp" dosyasının 1. sayfasını açınız.

- 1. sayfadaki çizimlerden hangileri çevre oluşturur?

- Bu seçimlerinizde kararınızı belirleyen düşünce ne oldu?Nedenini açıklayınız.

- Buna göre kendi cümlelerinizle "**Çevre**" nin ne olduğunu açıklayınız.

BÖLÜM 2

"cevre_ucgen.gsp" dosyasının 2. sayfasını açınız.

Elinizde 12 cm uzunluğunda bir tel var. Bu teli kullanarak farklı şekillerde çevreleri olan şekiller elde ediniz. (Bu şekillerin üçgen, kare ve dikdörtgen olmasına dikkat ediniz.)

Not: çizimlerinizi dökümanınızın 3. sayfasında yapabilirsiniz.

BÖLÜM 3

"Cevre_ucgen.gsp" dosyasının 4. sayfasını açınız

1) ABC üçgensel bölgesini soldaki ↖ butonunu kullanarak seçiniz.

2) **MEASURE** menüsünden **PERIMETER** seçeneğini tıklayınız.

3) Üçgenin çevresini hesaplayınız.

4) Üçgenin herhangi bir köşesini ↖ butonunu kullanarak seçiniz.

5) Seçtiğiniz köşeyi sürükleyerek kenar uzunluklarındaki değişimi görünüz.

6) Yukarıdaki işlemi 5 kez yaparak aşağıdaki tabloyu doldurunuz.

Durum	AB kenarının uzunluğu	BC kenarının uzunluğu	AC kenarının uzunluğu	Çevre uzunluğu
1				
2				
3				
4				
5				

- Kenar uzunlukları değiştikçe çevredeki değişim ne oldu?

- Tablodan yararlanarak üçgenin kenar uzunlukları ile çevresinin uzunluğu arasında nasıl bir ilişki olduğunu açıklayınız.

BÖLÜM 4

"Cevre_ucgen.gsp" dosyasının 5. sayfasını açınız

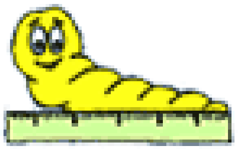
- Şekildeki üçgenlerin türü nedir?

- Bu üçgenlerin çevre uzunluğunu hesaplayınız.

- Üçgenlerin kenar uzunluklarını 2 kat arttırdığınızda çevredeki değişim ne oldu?

- Bölüm 3' te bulduğunuz ilişki bu tür üçgenler için de geçerli midir?

KARE VE DİKDÖRTGENDE ÇEVRE HESAPLAMALARI



Bilgisayarınızın masaüstünden "cevre_dikdörtgen.gsp" dosyasını açınız.

BÖLÜM 1

"cevre_dikdörtgen.gsp" dosyasının 1. sayfasını açınız.

- Soldaki dikdörtgeni seçiniz.
- **MEASURE** menüsünden **PERIMETER** seçeneğini tıklayınız.
- Kenar uzunlukları 5 cm ve 3 cm olan bu dikdörtgenin çevresi kaç santimetredir?
- Yukarıdaki işlemi yandaki büyük dikdörtgen için tekrarlayınız.
- Büyük dikdörtgen ile küçük dikdörtgenin kenar uzunlukları arasında nasıl bir ilişki vardır?
- Büyük dikdörtgen ile küçük dikdörtgenin çevresi arasında nasıl bir ilişki vardır?

BÖLÜM 2

"cevre_dikdörtgen.gsp" dosyasının 2. sayfasını açınız.

Şekildeki ABCD dikdörtgeninin çevresi üç katına çıkarıldığında, yeni çevre 30 cm oluyor. ABCD dikdörtgeninin eni boyundan 1 cm fazla olduğuna göre boyunun ve eninin uzunluğunu bulunuz.

- Bu dikdörtgen ile ilgili bilgileriniz nelerdir?

- ABCD dikdörtgeninin çevresi kaç santimetredir?

- ABCD dikdörtgeninin eni ve boyu kaç santimetredir?

BÖLÜM 3

“cevre_dikdörtgen.gsp” dosyasının 3. sayfasını açınız.

Çevresi 20 cm olan bir dikdörtgenin boyu 6 cm ise eni kaç cm’dir?

BÖLÜM 4

“cevre_dikdörtgen.gsp” dosyasının 4. sayfasını açınız.

- Verilen dik üçgenin çevresi kaç santimetredir?

- Aynı çevreye sahip, kenar uzunlukları doğal sayı olacak şekilde kaç farklı dikdörtgen oluşturulabilir?

<u>BÖLÜM 5</u>

"cevre_dikdörtgen.gsp" dosyasının 5. sayfasını açınız.

- Bir dikdörtgenin kenar uzunlukları %10 oranında arttırılırsa çevesinde değişim ne olur?

"cevre_dikdörtgen.gsp" dosyasının 6. sayfasını açınız.

- Doğal sayı ve ondalık kesirleri kullanarak çevre uzunluğu 24 cm olan üç tane dikdörtgen oluşturunuz. Bütün dikdörtgenler aynı mı?

- Dikdörtgenin çevresinin uzunluğunu, kenarlarının uzunluğu türünden nasıl ifade edebiliriz?

- Bu ifade kare için de geçerli midir?

Bilgisayarınızın masaüstünden "cevre_kare.gsp" dosyasını açınız.

- Şekildeki karenin bir kenar uzunluğu kaç santimetredir?

- Şekildeki karenin çevresi kaç santimetredir?

- Bu kare ile aynı çevre uzunluğuna sahip başka kareler çizilebilir mi? Neden?

- Çizdiğiniz kare ile aynı çevre uzunluğuna sahip bir eşkenar üçgen çiziniz.

- Bu eşkenar üçgenin bir kenarı kaç cm'dir?

ÇEVRE İLE İLGİLİ ALIŞTIRMALAR

Bilgisayarınızın masaüstünden "cevre_kare.gsp" dosyasının 2. sayfasını açınız.

- Boyalı şekil, birbirine eş karelerden oluşmaktadır. Boyalı şeklin çevresinin uzunluğu, karelerden birisinin çevresinin uzunluğunun kaç katıdır?

cevre_kare.gsp" dosyasının 3. sayfasını açınız.

- Şeklin çevresinin uzunluğunu hesaplayınız.

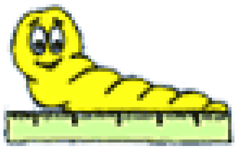
Yeni bir Geometer' s Sketchpad dökümanı açınız ve dosyaya kendi isminizi vererek kaydediniz.
Aşağıdaki alıştırmalarda kendi çizimlerinizi yapınız.

- Çevresinin uzunluğu $4\frac{2}{7}$ metre olan eşkenar üçgenin bir kenarının uzunluğu kaç metredir?

- Eş kenarlarından biri 7 cm diğer kenarı 8 cm olan ikizkenar üçgenin çevresinin uzunluğu kaç cm'dir?

- Bir eşkenar üçgen ile karenin çevrelerinin çevre uzunluklarının eşit olması için kenarları arasında nasıl oran olmalıdır?

ALAN HESAPLAMALARI



Bu etkinlikte alan kavramının öğrenmeniz, verilen şekillerin alanını hesaplamanız, alan ile kenar uzunlukları arasındaki ilişkiyi kavramanız amaçlanmaktadır.

BÖLÜM 1

Bilgisayarınızın masaüstünden "Alan.gsp" dosyasının 1. sayfasını açınız.

- Şekildeki dikdörtgenin kenar uzunluklarını belirleyiniz.
- **MEASURE** menüsünden **AREA** seçeneğini tıklayınız.
- Dikdörtgenin alanını hesaplayınız.
- Aynı alana sahip başka dikdörtgenler de oluşturunuz.
- Bu alana sahip kaç tane dikdörtgen oluşturabilirsiniz?
- Bulduğunuz dikdörtgenlere göre tabloyu doldurunuz.

DİKDÖRTGEN	A KENARI	B KENARI	ALAN
1			
2			
3			
4			
5			

- Tablodan yararlanarak dikdörtgenin kenar uzunlukları ile çevresinin uzunluğu arasında nasıl bir ilişki olduğunu açıklayınız.

BÖLÜM 2

"Alan.gsp" dosyasının 2. sayfasını açınız.

- Alanı 28 cm^2 ve eni 4 cm olan dikdörtgen şeklindeki kalemliğin boyunun uzunluğunu hesaplayınız.

- Bu uzunluklar iki katına çıkarılırsa alandaki değişim ne olur?

BÖLÜM 3

“Alan.gsp” dosyasının 3. sayfasını açınız.

Dikdörtgenin kenarları ile alanı arasındaki ilişki kare için de geçerli midir?

- Bu karenin kenar uzunluklarını hesaplayınız.

- Bu karenin alanını hesaplayınız.

- Karenin köşesinden sürükleyerek kenar uzunluklarındaki ve alandaki değişimi görünüz. Buna göre tabloyu doldurunuz.

KARE	**1.durum**	**2.durum**	**3.durum**
Kenar uzunluğu			
Alanı			

- Karenin alanı ile kenar uzunlukları arasında nasıl bir ilişki vardır?

- Karenin kenar uzunluğu 3 katına çıkarıldığında alanda nasıl bir değişim olur?

BÖLÜM 4

“Alan.gsp” dosyasının 4. sayfasını açınız.

- Şekildeki dikdörtgenin alanı nasıl hesaplanabilir?

- Şekildeki karelerin alanları kaçar cm^2 dir?

Mor karenin alanı=
Lacivert karenin alanı=
Turkuaz karenin alanı=

Turuncu karenin alanı=
Sarı karenin alanı=
Pembe karenin alanı=
Yeşil karenin alanı=

“Alan.gsp” dosyasının 5. sayfasını açınız. Problemler için kendi çizimleriniz üzerinde çalışınız.

- Alanı 25 cm^2 olan karenin bir kenar uzunluğu kaç cm olabilir?

“Alan.gsp” dosyasının 6. sayfasını açınız.

- Karenin kenar uzunluklarının 4 kat artması için alanı kaç kat artmalıdır?

BÖLÜM 5

“Alan.gsp” dosyasının 7. sayfasını açınız.

Dikdörtgenin alanından yararlanarak bir dik üçgenin alanı nasıl hesaplanabilir?

- Şekilde kenar uzunlukları 3 cm ve 4 cm olan bir dikdörtgen bulunmaktadır.

- Bu dikdörtgenin karşılıklı köşelerindeki noktaları seçerek, dikdörtgenin bir köşegenini oluşturunuz.

- Şekilde birbirine eş iki üçgen oluşmuştur.Bu üçgenlerin türü nedir?

- Bu üçgenlerin kenar uzunlukları nelerdir?

- Dikdörtgenin alanını hesaplayınız.

- Dik üçgenlerden birinin alanını hesaplayınız.

- Dik üçgenin alanı ile dikdörtgenin alanları arasında nasıl bir ilişki vardır?

- Bu ilişki dikdörtgenin boyutlarını değiştirdiğinizde korunuyor mu?

“Alan.gsp” dosyasının 8. sayfasını açınız.

- Verilen dik üçgenin alanını hesaplayınız.

- Bu üçgenin alanını iki katına çıkardığınızda kenar uzunluklarındaki değişim ne olur? Tahmin ediniz.

- Köşesinden sürükleyerek üçgenin alanını iki katına çıkarınız.(oluşan üçgenin de dik üçgen olduğuna dikkat ediniz.)

- Üçgenin kenar uzunluklarındaki değişim ne oldu?

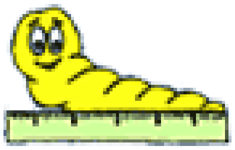
- Üçgenin alanı hangi kenarlarının uzunlukları ile ilgilidir?

- Üçgenin alanını kenarların uzunluklarından yararlanarak nasıl hesaplayabiliriz?

ALIŞTIRMALAR

Buradaki alıştırmaları çözebilmek için "Alan.gsp" dosyasının 9.ve 10 sayfalarını açınız.

ALAN-ÇEVRE PROBLEMLERİ



Bu etkinlikte üçgen kare ve dikdörtgenin alanları ve çevreleri ile ilgili hesaplamalar yapmanız, bu şekillerin çevre uzunluğu ile alanı arasındaki ilişkiyi kavramanız, bu şekillerin amaçlanmaktadır.

Bu etkinlikteki problemler için "Alan_cevre.gsp" dökümanınızı açınız.

- Uzun kenarı kısa kenarının iki katı olan dikdörtgenin çevresinin uzunluğu 42 cm'dir. Bu dikdörtgenin alanı kaç cm^2'dir?

- ABCD karesel bölgesinin bir kenar uzunluğu 3 cm ise karesel bölgenin alanının çevre uzunluğuna oranı nedir?

- Çevresi 20 cm olan bütün dikdörtgenlerin alanları eşit midir?

-Eğer hepsinin alanları eşit değilse hangi tür dikdörtgenlerin alanı daha büyüktür?

- Alanı 36 cm^2 olan bir dikdörtgenin çevre uzunluğu en az kaç cm olabilir?

- Alanı ve çevresi eşit olan bir karenin bir kenarı kaç cm olabilir?

- Bir kare ikiye katlanarak dikdörtgen oluşturulmuştur. Oluşan dikdörtgenin çevresi 12 cm ise orijinal karenin alanı kaç cm^2 dir?

APPENDIX C

VAN HIELE GEOMETRIC THINKING LEVEL TEST

VAN HIELE GEOMETRİ TESTİ

YÖNERGE

Bu test 10 sorudan oluşmaktadır. Sizden testteki her soruyu bilmeniz beklenmemektedir.

1- Bütün soruları dikkatlice okuyunuz.

2- Doğru olduğunu düşündüğünüz seçenek üzerinde düşünün. Her soru için tek bir doğru cevap vardır. Cevap kağıdına doğru olduğunu düşündüğünüz seçeneği işaretleyiniz.

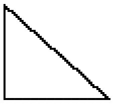
3- Soru kağıdındaki boşlukları çizim yapmak için kullanabilirsiniz.

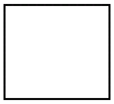
4- İşaretlemiş olduğunuz cevabı değiştirmek isterseniz, ilk işareti tamamen siliniz.

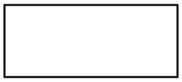
5- Bu test için size verilecek süre 20 dakikadır.

VAN HIELE GEOMETRİ TESTİ

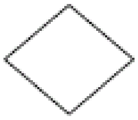
1- Aşağıdakilerden hangisi ya da hangileri karedir?
a) Yalnız K
b) Yalnız L
c) Yalnız M
d) L ve M
e) Hepsi karedir.

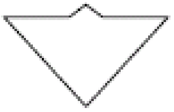

K


L

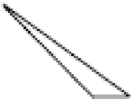

M

2- Aşağıdakilerden hangisi ya da hangileri üçgendir?
a) Hiçbiri üçgen değildir.
b) Yalnız V
c) Yalnız Y
d) Y ve Z
e) V ve Y


U


V

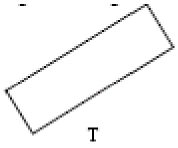

Y

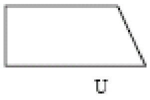

Z

3- Aşağıdakilerden hangisi ya da hangileri dikdörtgendir?

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

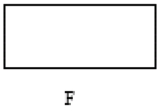

S

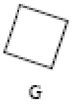

T

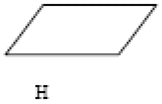

U

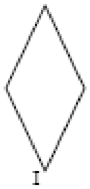
4- Aşağıdakilerden hangisi ya da hangileri karedir?

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


F

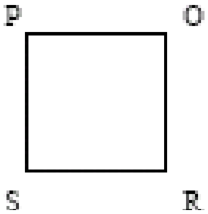

G


H

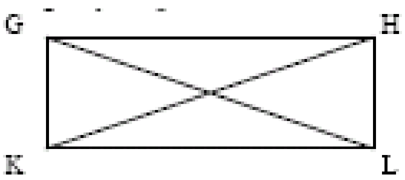

I

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

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



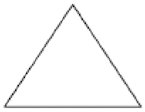
6-Bir GHLK dikdörtgeninde, [GL] ve [HK] köşegendir. Buna göre aşağıdakilerden hangisi her dikdörtgen için doğrudur?

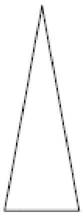


a) 4 dik açısı vardır.
b) 4 kenarı vardır.
c) Köşegenlerinin uzunlukları eşittir.
d) Karşılıklı kenarların uzunlukları eşittir.
e) Seçeneklerin hepsi her dikdörtgen için doğrudur.

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

Aşağıdaki seçeneklerinden hangisi her ikizkenar üçgen için doğrudur?





a) Üç kenarı eşit uzunlukta olmalıdır.
b) Bir kenarının uzunluğu, diğerinin iki katı olmalıdır.
c) Ölçüsü eşit olan en az iki açısı olmalıdır.
d) Üç açısının da ölçüsü eşit olmalıdır.

e) Seçeneklerinden hiçbiri her ikizkenar üçgen için doğru değildir.

8- Önerme S: ABC üçgeninin üç kenarı eşit uzunluktadır.
Önerme T: ABC üçgeninde, B ve C açılarının ölçüleri eşittir.

Buna göre aşağıdakilerden hangisi doğrudur?

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

9- Önerme 1: F şekli bir dikdörtgendir.
Önerme 2: F şekli bir üçgendir.

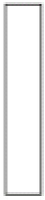
Bu iki önermeye göre aşağıdakilerden hangisi doğrudur?

a) Eğer 1 doğruysa, 2 de doğrudur.
b) Eğer 1 yanlışsa, 2 doğrudur.
c) 1 ve 2 aynı anda doğru olamaz.
d) 1 ve 2 aynı anda yanlış olamaz.
e) Yukarı seçeneklerin hiçbiri doğru değildir.

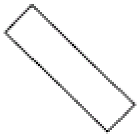
10-Aşağıdaki şekillerden hangisi ya da hangileri dikdörtgen olarak adlandırılabilir?

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

P



O



R

APPENDIX D

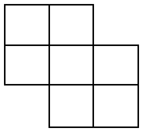
GEOMETRY ACHIEVEMENT TEST

GEOMETRİ SINAVI

1. Çevresinin uzunluğu 56 cm olan bir dikdörtgenin uzun kenarı, kısa kenarının üç katından 4 cm kısa olduğuna göre uzun kenarı kaç cm dir?

2. Çevresinin uzunluğu $12\frac{3}{5}$ cm olan eşkenar üçgenin bir kenar uzunluğunu bulunuz.

3. Aşağıdaki şekil, birbirine eş olan küçük karelerden oluşmaktadır. Küçük karelerden birinin çevresi 6,4 cm olduğuna göre şeklin çevresinin uzunluğu kaç cm dir?



4. Alanının ölçümü 144 cm^2 olan karesel bölgenin çevresi kaç cm dir?

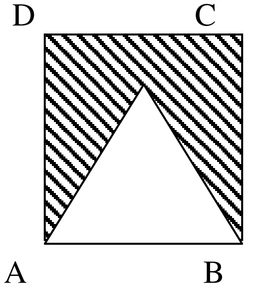
5. Dikdörtgen şeklindeki bir halının çevresi 20 metredir. Uzunluğu genişliğinden 1,2 metre daha uzundur. Bu halının 1 m^2 si 50 YTL olduğuna göre halının değeri kaç liradır?

6. Eni boyundan 8 cm uzun olan dikdörtgenin eni ile boyunun toplamı 40 cm dir. Buna göre dikdörtgensel bölgenin alanı kaç dm^2 dir?

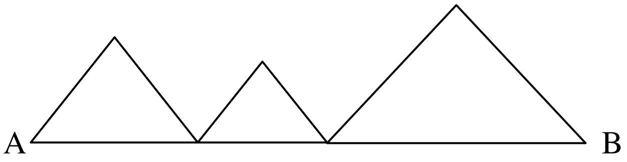
7. Bir kare ile dikdörtgenin alanları birbirine eşittir. Dikdörtgenin kenar uzunlukları 4 cm ve 9 cm olduğuna göre karenin çevresi kaç cm dir?

8. Kısa kenarı 8 cm, uzun kenarı 12 cm olan bir dikdörtgenin uzun kenarı $\frac{1}{3}$ ve kısa kenarı % 25 oranlarında arttırıldığında yeni oluşan dikdörtgenin çevre uzunluğu ile önceki dikdörtgenin çevre uzunluğu arasındaki fark kaç cm olur?

9. Şekilde ABCD karesiyle ABE eşkenar üçgeni verilmiştir. Taralı şeklin çevresinin uzunluğu 40 cm ise karenin çevresi kaç cm dir?



10. Aşağıdaki üçgenler birer eşkenar üçgen olup [AB] uzunluğu 14 cm dir. Buna göre bu üç üçgenin çevreleri toplamı kaç cm dir?



APPENDIX E

RAW DATA OF THE STUDY

No	Group	PREVHL	POSTVHL	PREGAT	POSTGAT
1	1	8	10	70	90
2	1	4	6	65	75
3	1	5	6	20	45
4	1	5	7	75	90
5	1	7	9	75	85
6	1	8	8	65	75
7	1	5	9	65	90
8	1	7	8	55	70
9	1	6	6	60	75
10	1	6	8	50	55
11	1	9	10	70	65
12	1	5	6	20	30
13	1	8	10	85	100
14	1	5	6	70	95
15	1	6	6	45	55
16	1	7	9	100	100
17	1	5	7	60	70
18	1	8	7	45	50
19	2	6	8	70	80
20	2	8	9	90	100
21	2	6	8	40	30
22	2	6	7	50	55
23	2	8	10	85	90
24	2	6	7	30	40
25	2	7	8	65	75

26	2	6	7	45	55
27	2	2	4	15	10
28	2	6	7	40	35
29	2	6	6	50	25
30	2	5	7	60	70
31	2	2	4	30	45
32	2	2	5	15	20
33	2	7	8	65	65
34	3	3	5	40	50
35	3	7	7	55	65
36	3	7	6	65	60
37	3	6	7	45	30
38	3	6	5	60	70
39	3	4	4	50	60
40	3	3	4	45	50
41	3	5	6	60	65
42	3	4	4	55	55
43	3	5	6	40	20
44	3	5	6	50	60
45	3	7	5	45	55
46	3	6	6	10	15
47	3	5	4	25	30
48	3	8	6	20	35