THE EFFECT OF DYNAMIC GEOMETRY USE TOGETHER WITH OPEN-ENDED EXPLORATIONS IN SIXTH GRADE STUDENTS' PERFORMANCES IN POLYGONS AND SIMILARITY AND CONGRUENCY OF POLYGONS

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ABSTRACT

THE EFFECT OF DYNAMIC GEOMETRY USE TOGETHER WITH OPEN-ENDED EXPLORATIONS IN SIXTH GRADE STUDENTS' PERFORMANCES IN POLYGONS AND SIMILARITY AND CONGRUENCY OF POLYGONS

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The aim of this study was to investigate the effects of using a dynamic geometry environment together with open-ended explorations on sixth grade students' performance in polygons and congruency and similarity of polygons. Two groups of sixth grade students were selected for this study: (1) An experimental group composed of 66 students whom 34 were boys and 32 were girls; and (2) a control group composed of 68 students whom 35 were boys and 33 were girls. While the students in the control group received instruction via traditional methods, the students in the experimental group studied the same topics by open-ended explorations in a dynamic geometry environment.

Geometry Test (GT) and Computer Attitude Scale (CAS) were used as data collection instruments. All students had taken the GT as pre-test, post-test, and delayed post test. However, CAS was administered only to the experimental group at the end of the instruction. Furthermore, some qualitative data were collected through video-taped classroom observations and interviews with selected students.

Pre-test scores showed no statistical difference between control and experimental group students in terms of their performances in polygons and congruency and similarity of polygons before the study. On the other hand, the results of the post and delayed-post tests which are analyzed by independent t test showed that experimental group achieved significantly better than the control group students. In addition, a statistically significant correlation between CAS and GT was observed. Those results were also supported by the qualitative data. In conclusion, the results indicated that dynamic geometry environment together with open-ended explorations significantly improved students' performances in polygons and congruency and similarity of polygons.

Keywords: Technology Integration, Dynamic Geometry Software, Open-ended Explorations, Teaching Experiment.

ÖZ

DİNAMİK GEOMETRİ YAZILIMLARININ AÇIK UÇLU ARAŞTIRMALARLA BİRLİKTE ALTINCI SINIF DÜZEYİNDE ÇOKGENLER VE ÇOKGENLERDE EŞLİK-BENZERLİK ÖĞRENİMİNE ETKİSİ

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Bu çalışmanın amacı, dinamik geometri ortamının açık uçlu araştırmalarla birlikte 6. sınıf öğrencilerinin çokgenler ve çokgenlerde eşlik - benzerlik üzerindeki performanslarına etkisini ölçmektir. Öğrenciler, kontrol ve deney grubu olmak üzere iki ayrı gruba ayrılmıştır. Deney grubu ,34 erkek ve 32 kız olmak üzere 66 öğrenciden oluşmaktadır. Kontrol grubu ise 35 erkek ve 33 kız olmak üzere 68 öğrenciden oluşmaktadır. Kontrol grubunda, geleneksel eğitim metodu kullanılırken, deney grubu konuları açık uçlu araştırmalarla birlikte dinamik geometri ortamında çalışmıştır.

Çalışmada, araç olarak Geometri testi ve Bilgisayarlı Eğitime Karşı Tutum Ölçeği kullanılmıştır. Geometri testi, deney ve kontrol grubunun her ikisine de ön test, son test ve kalıcılık testi olarak uygulanmıştır. Bilgisayarlı Eğitime Karşı Tutum Ölçeği eğitimin sonunda sadece deney grubuna uygulanmıştır. Ayrıca kamera yardımıyla kayıt altına alınan sınıf gözlemleri ve seçilmiş öğrencilerle yapılan röportajlarla nitel datalarda toplanmıştır.

Ön test skorlarının değerlendirilmesi sonucunda tüm grupların eğitimin başında eşit durumda olduğu görülmüştür. Diğer taraftan, son test ve kalıcılık testleri bağımsız t test analizi ile değerlendirilmiştir ve deney grubunda kontrol grubuna göre belirgin bir iyileşme görülmüştür. Ardından, Pearson momentler çarpımı korelasyon katsayısı kullanılarak, Bilgisayarlı Eğitime Karşı Tutum Ölçeği ile Geometri Testi arasında anlamlı bir ilişki olduğu belirlenmiştir. Ayrıca,bu sonuçlar niteliksel analizle de desteklenmiştir.Özetle, bu çalışma Dinamik Geometri ortamının, açık uçlu araştırmalarla birlikte öğrencilerin çokgenler ve çokgenlerde eşlik-benzerlik konularındaki performansını arttırdığını göstermiştir.

Anahtar Kelimeler: Teknoloji Entegrasyonu, Dinamik Geometri Yazılımı, Açık Uçlu Araştırmalar, Öğretim Teknikleri Deneyi.

To My Parents

You both have inspired me more than you will ever know.

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LIST OF ABBREVIATIONS

GSP : The Geometer's Sketchpad

CG : Control Group

EG : Experimental Group

GT : Geometry Test

CAS : Computer Attitude Scale

N : Sample Size

Mdn : Median

SD : Standard deviation

K-R 20 : Kuder-Richardson formula

t : t-Test Value

p : Significance Value

df :degree of freedom

CHAPTER I

INTRODUCTION

"Geometry is grasping space...that space in which the child lives, breathes and moves. The space that the child must learn to know, explore, conquer, in order to live, breathe, and move better in it". (National Council of Teachers of Mathematics, 1989, p.48). Geometry has an important place in schools. School geometry is the study of spatial objects, relationships, and transformations that have been formalized, and the axiomatic mathematical systems that have been constructed to represent them. There is general agreement on the goals of geometry instruction. By studying geometry, students develop logical thinking abilities, spatial intuition about the real world, knowledge needed to study more mathematics, and skills in the reading and interpretation of mathematical arguments (Suydam, 1985). NCTM argues that by studying geometry, "students will learn about geometric shapes and structures and how to analyze their characteristics and relationships" (NCTM, 2000, p.41). Furthermore, by discussing the importance of spatial visualization and how geometry is a natural setting for developing students' reasoning and justification skills. Geometry is important in representing and solving problems in mathematics and in real-world situations.

While tools such as compasses and straightedges have traditionally been used in the study of geometry at the elementary and secondary level, new tools have emerged in the recent past with the development of geometry software programs for computers and calculators. These new technological developments have tremendous potential to impact the teaching and learning of geometry in our schools (Healy & Hoyles , 2001; Hölzl, 2001; Jones, 2000; Laborde, 2001). Ministry of National Education acknowledges the important role of dynamic geometry software in the teaching and learning of geometry (MNE, 2004). Mariotti (2000) explores the various positive influences of dynamic geometry soft wares on student learning of geometry. Sträßer (2001) also indicated dynamic geometry software's important impact on geometry learning.

Now at the beginning of the 21st century, a fresh medium for building geometric constructions stands alongside familiar tools of the trade. A breed of software programs known collectively as "dynamic geometry" (DG) has established itself in schools, teaching journals, and university mathematics' departments as an attractive alternative to straightedge and compass (Olive, 1998). The Geometer's Sketchpad (Jackiw, 1991) and Cabri Geometry (Texas Instruments, 1994), two of the earlist and most popular DG software packages, reached the mathematics community in the early 1990s.The characteristics of DG software contrast to the capabilities of traditional geometric tools' are that geometric objects can be moved and reshaped interactively. By clicking and "dragging" with the computer mouse, the software user can animate static images, thereby making them "dynamic" in nature. Segments can stretch and shrink, angles can change measurement; objects can rotate and translate across the screen. In addition a single onscreen image represents a whole class of geometric objects. By constructing built-in constrains, a DG user can build a square that will change its size and orientation when dragged, but still retain the invariant features common to all squares- four equal sides and four 90-degree angles.

One of the important tools of the technological chance in geometry lessons is the use of Geometers' Sketchpad (GSP) (Jackiw, 1991). GSP enables students and teachers to investigate and construct unlimited geometric shapes. The shapes are first created and they can be explored and manipulated to an ideal concept. The distinction between a drawing and a construction is subtle, yet important in the way and manner in which GSP is used. In a classroom, when a teacher draws a figure on the board and informs a class that the figure is a square ABCD, the teacher is trying to tell the class "let ABCD represent a square, and let all properties inherit in a square be attributed to figure ABCD." So even though the diagram on the board $|AB|$ is longer than $|CD|$, and the opposite sides DA and BC are not exactly parallel, as illustrated in Figure 1.1, the understanding the teacher would like to get across is: "let this diagram represent a square."

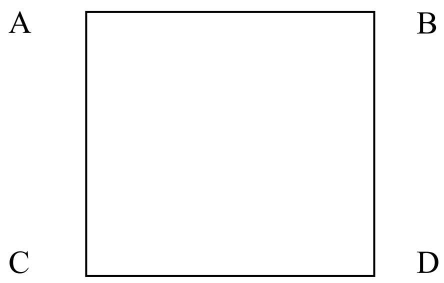


Figure 1.1 A shape that could represent the square

The student is expected to understand that square ABCD is a generic square, and will remain a square no matter what its orientation or scale. The difference between a drawing and a diagram construction depends upon how the drawing or diagram is pieced together, a difficult concept to describe in a static medium such as pen or paper. The squares can be constructed by GSP, for example by following this steps: (a) using the segment tool, construct a quadrilateral (b) from the measure menu, measure each of the sides, and each of the angles of square ABCD; (c) using the selection (translation) tool, drag the vertices around until all sides measure the same, and all angles measure 90º. In addition square can be constructed in a manner similar to a compass and straight edge construction: (a) using the segment tool, construct a segment AB; (b) from the construct menu, construct lines through points A and B perpendicular to AB; (c) from the construct menu, construct circles with centers at A and B with radius AB; (d) construct the points of intersection between the circles and the lines parallel to AB, relabel these points C and D; (e) hide the construction objects; (f) with the segment tool connect BC, CD, and DA. Moreover students can drag the figures that they construct. Dragging is a critical component of dynamical software; it enables a student to form a different perception, or perhaps a different understanding of geometry.

As in the example of the teacher at the chalkboard, the student is being requested to think beyond the visual input of a drawn figure. In this case however the student needs to be conditioned to place constraints on constructions. In this way the student can study aspects of a square.

Student Perception

Once the constraints have been placed, and the student drags the construction around to view different initial conditions, what is that the student perceives? It is unknown how students glean geometric ideas from complexly moving figures. How do they develop a sense of where to look, what objects to tract, what questions to ask, what experiments to perform? Under what circumstances will students focus on figures which do not conform to standard criteria? For example a non-convex or non simple quadrilateral would both be considered figures which do not conform to standard criteria, because neither case conforms to the mental image of a prototypical quadrilateral.

The research of Goldenberg (1988), Goldenberg and Kliman (1990), and Goldenberg (1991) is based on the recognition that one's own mathematically informed perceptions of a display do not necessarily reflect what a student's mathematically more naive perception will be. They contend that one must look directly at students, see what they do in response to unfamiliar problems, and infer from their responses what the students are perhaps constructing in their minds.

Goldenberg (1991) suggest that students who are deforming a figure tend not to let go of the point that they are dragging when the result would be a figure which do not conform to standard criteria but, instead, leave points at standard positions when they cease dragging. If so, are they ignoring the continuity of the change and treating the screen data as discrete standard cases that just happen to be connected? In fact, the shock and delight that students often express at some unexpected behavior seems a good indicator that they are not ignoring the figures which do not conform to standard criteria. The avoidance of stopping at these cases might then be interpreted as evidence that students are attending to the variables and degrees of freedom, and trying to manage them while they come to understand the geometry and the display better. With attention being paid to the variables and degrees of freedom, it is evident that it can be developed a sense of where to look, and a sense of which objects to track.

1.1 Research Problem and Its Rationale

Through the study of geometry, students learn about geometric shapes and structures and how to analyze their characteristics and relationships. Geometry is a natural place for the development of students' reasoning and justification skills.

The notion of building understanding in geometry across the grade levels is from informal to more formal thinking, and this notion is consistent with the thinking of theorists and researchers (Burger& Shaughnessy, 1986; Fuys, Geddes & Tischler, 1988; Senk, 1989; van Hiele, 1986). Another important aspect of geometric thinking is spatial visualization: building and manipulating mental representations of two- and three-dimensional objects and recognizing an oriented object from different perspectives. Young children come to school with intuitions not only about shapes but also about how shapes might move (NCTM, 2000). NCTM recommends that beginning in the early years of schooling, students should develop visualization skills through various hands-on experiences with a variety of geometric objects and through the use of technology that allows them to turn, flip, and slide two-dimensional objects (NCTM, 2000). From the third through the sixth grades, students should "investigate the effects of orientations and begin to describe them in mathematical terms" (NCTM, 2000, p.58). The use of dynamic software may force students to develop an awareness of the elements needed to be constructing a shape (NCTM, 2000).

Mathematics educators and teachers have embraced dynamic geometry in part because interactivity and motion seem, on an intuitive level, like sound educational features of software (Hoyles & Noss, 1994; King & Schatschneider, 1997b). A square that can be resized with a simple click and drag of a mouse holds definite challenge for a generation accustomed to the static like nature of textbook illustrations.

Yet DG software is more than a copy of Euclidean geometry with interactive, eye-catching graphics. The tools, definitions, exploration techniques, and visual representations associated with dynamic geometry contribute to a learning environment fundamentally removed from its straightedge-and-compass counterpart (Laborde, 1998). However how the students come to understand geometry in this setting remains an open question in the mathematics education literature (Goldenberg, 1998; Arzarello, Olivero, Paola and Robutti, 2002).

It seems necessary to investigate how utilizing dynamic geometry software in teaching and learning of geometry affects students' understanding and performance. Thus, the purpose of this study was to investigate the effect of using dynamic geometry software together with open-ended explorations on student's understanding of polygons and congruency and similarity of polygons compared to traditional teaching of these concepts in an experimental-control group design. This study also attempts to investigate the students' attitudes towards computer instruction and its relations with students' performance on geometry and its effect on students' retention.

The following research questions and related null hypotheses will be addressed in this study;

- Is there a significant mean difference in the geometry test scores of the experimental group and control group students prior to the treatment?
  (H_0: $M_C = M_E$)
- Is there a significant mean difference in the post geometry test scores of the experimental group and control group students on geometry upon the completion of the treatment?
  (H_0: $M_C = M_E$)
- Is there a significant mean difference in the delayed-post geometry test scores of the experimental group and control group students on geometry upon the completion of the treatment?
  (H_0: $M_C = M_E$)
- Is there a significant correlation between the geometry test scores and attitude scores?
  (H_0: $p = 0$)
- Is there a significant mean difference between girls' and boys' geometry test scores?
  (H_0: $M_G = M_B$)

- Is there a significant mean difference between girls' and boys' computer attitude scale scores?
  (H_0: $M_G = M_B$)
- What are the student's attitudes towards dynamic geometry environment?
- What are students' views and feelings about use of dynamic geometry software in teaching and learning of geometry?

1.2 Definitions of Terms

Computer Based Learning (CBL): The use of the computer as a key component in teaching and learning environment.

Dynamic Geometry Software: It is best "described as an enhancement of the drawing tools and methods for learning Euclidean geometry" (Cuoco & Goldenberg, 1998, p.1). This particular type of software allows a student to create and manipulate points and lines on a computer screen. If constructed correctly, points, lines, and figures can be moved around and still retain their geometric relationships. The "click and drag" feature is what separates dynamic geometry software from other software.

Geometer's Sketchpad (GSP) is the dynamic geometry software package created by Nicholas Jackiw in 1991. It is described as an ideal environment in order to facilitate spatial structuring process (Dixon, 1997).

Traditional Instruction: It is a type of teaching method that mostly teacher is in the center of the instruction and students generally learn the concepts by pencil and paper activities. Teacher sometimes create a discussion environment and takes students ideas. In addition, instruction takes place in the classroom.

CHAPTER II

REVIEW OF LITERATURE

This chapter provides an explanation for the theoretical framework of the study. The subjects which are students' performance in geometry, geometric thinking, spatial reasoning, conceptual and figural aspects in learning, understanding of polygons, representations of geometric ideas, attitude towards computer and gender differences in the learning of geometry are explained in this chapter.

2.1 Students' Performance in Geometry

There have been several benchmarking studies measuring and comparing students' performances in mathematics and geometry on the international level (TIMSS-R, 1999; PISA, 2003). One of the international benchmarking studies is the *Programme for International Student Assessment* (PISA). For example, a quarter of the mathematical tasks given to students in PISA are related to spatial and geometric phenomena and relationships (OECD, 2004). The knowledge and skills required to reach each level are summarized in appendix F. In PISA 2003, a quarter or more of students fail to reach Level 2 in Turkey. The results show that most students in Turkey are failed to learn the basic concepts in geometry when they are compared with the students from other nations (OECD, 2004). Other study Third International Mathematics and Science Study-Repeat TIMSS-R (1999) also show the same result. The achievement level of Turkish students is lower than the levels of EU states (Berberoğlu, 2004). The reasons are Turkish students have; simple definition, misconceptions, picking relevant information from a single source, using a single illustrational situation, using algorithms and formulae and direct analogy skills (Berberoğlu, 2004). In addition, students have lots of misconceptions in geometry too. For example,an angle must have one horizontal ray, a square is not a square if its base is not horizontal, and etc. (Clements & Battista, 1989; Fuys, Geddes, & Tischler, 1988; Hoffer, 1983). Apparently much learning of geometric concepts has been rote. Students can not perceive the relationships and implications (Mayberry, 1983). May be the most important reason of their failure is the curriculum both in what topics are treated and how they are treated. The major focus of standard elementary and middle school curricula is on recognizing and naming geometric shapes, writing the proper symbolism for simple geometric concepts, developing skill with measurement and construction tools such as compass and protractor, and using formulas in geometric measurement (Porter, 1989; Thomas, 1982). As we have seen, student's performance in geometry is woefully lacking. Neither what students learn in geometry nor the methods by which learn it are satisfactory. Therefore, geometry should be taken account in order to improve. How ever, how the geometry knowledge can be improved? What are the theoretical frameworks for geometric thinking?

2.2. Theoretical Frameworks for Geometrical Thinking

There are three theoretical perspective about the development of geometric thinking; Piaget, Van Hiele, and cognitive science. According to Piaget and Inhelder (1967); while manipulating with the environment actively, a child constructs the representation of the space. Also, the organization of geometric ideas has a logical order; topological relations (*connectedness*, *enclosure*, and *continuity*), projective relations (*rectilinearity*), and Euclidean relations (angularity, parallelism, distance). They give the differences between the topological relations, and projective, or Euclidean relations since in topological relations the different figures and objects are related to each other for children.

According to Van Hiele; 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). The first level is the visual level. In this level, the students recognize the figures as a whole and they often use visual prototypes. The second level is the descriptive/analytic level, and while observing, measuring, drawing, and modeling students gradually learn the properties of geometric shapes. The third level is the abstract/relational level where students can form abstract definitions. Through formal deduction, they can discover the properties of figures; they can make connections between the geometric figures. The fourth level is the formal deduction level. In this level, students establish theorems and axiomatic system. The rigor/metamathematical level is the fifth level in which students reason formally about mathematical systems.

According to cognitive science, to understanding students' learning of geometry has been applied. It tries to integrate research and theoretical work from psychology, philosophy, linguistics, and artificial intelligence. There are three cognitive science models; *Anderson's Model of Cognition* (ACT), *Greeno's Model of Geometry Problem Solving*, and *Parallel Distributed Processing* (PDP) *Networks*.

Anderson's Model of Cognition (ACT) (Anderson, 1983) is one of the cognitive science models. It postulates two types of knowledge: declarative and procedural. Declarative knowledge is "knowing that"; for example, schemas store postulates and theorems together with the knowledge about their function, form, and preconditions. Procedural knowledge is "knowing how". It is stored in the form of production systems, or sets of condition action pairs. If the condition, or cognitive contingency that specifies the circumstances under which the production can apply, matches some existing patterns of declarative knowledge, the action is performed. According to the ACT model, all knowledge initially comes in declarative form and must be interpreted by general procedures. Thus, in procedural learning one learns only by doing. When declarative information is in the form of direct instructions, step-by-step interpretation is straightforward.

Greeno's Model of Geometry Problem Solving (Greeno, 1980) is similar to Anderson's model of cognition. It is based on think-aloud protocols obtained from six ninth-grade students. A computer simulation was designed to solve the same problems that the students were able to solve, and in the same general ways the students solved them. The simulation is a production system in which there are three types of productions. It reflects the following three domains of geometry which are required for students to solve the problems they are given. First, propositions are used in making inferences. These inferences are the main steps in geometry problem solving. Second, perceptual concepts are used to recognize patterns which mentioned in the antecedents of many propositions. Third, strategic principles are used in setting goals and planning. Instructional materials include explicitly the first two domains; but not strategic knowledge. References to that knowledge in the materials are indirect. Therefore, most teachers do not clearly identify principles of strategy in their teaching. Students must make induction by observing the examples solutions to acquire this knowledge. Thus, the induced strategic principles are in the form of tacit procedural knowledge. They involve processes that the student can perform. However, they can not describe or analyze these processes. For the domain of problems, these strategic principles are quite specific. Greeno suggest that they should be taught directly. The interpretation of the direct teaching as the teacher imposition of prescribed steps on students contrasts with van Hiele's characterization of students finding their own way in the network of relations. However, the interpretation of direct teaching as teacher facilitation of students' construction and development of explicit awareness of strategies, the two positions, unguided discovery and explicit form of instruction, complete each other.

Parallel Distributed Processing (PDP) Networks (Mcclelland, Rumelhart, & The PDP Research Group, 1986) suggests more low-level detail models. In PDP networks, students' knowledge levels are different from van Hiele levels. For example, neural network units that recognize visual features are formed in the pre-recognition level and these features become recognizable. Shapes are "recognized" when the students reconcile the links of a class of visual stimuli.

These theoretical perspectives help to explain the unsuccessful students.Many students in the current curriculum acquire mathematical ideas only procedurally, without connecting procedural to conceptual knowledge. That is, students often perform sequences of mathematical processes without being able to describe what they are doing or why, perhaps as visually moderated sequences as described by Davis (1984). Most of the cognitive science models as mentioned above do not address students' development of qualitatively different levels of thinking and representation, belief systems, motivation, and meaningful interpretation of subject matter, and they de-emphasize the roles of sensorimotor activity, intuition, and culture in mathematical thinking (Cobb, 1989; Fischbein, 1987). Nevertheless, the theories provide insights and useful metaphors, as well as specific explications missing from most other perspectives like Piaget and van Hiele theories. Each theory complete each other and all of them can be effective if the students has spatial ability since spatial ability and visual imagery play vital roles in mathematical thinking (Lean & Clements, 1981; Wheatley, 1990).

2.3 What is Spatial Reasoning?

Gardner (1983) argues that spatial ability is one of the several “relatively autonomous human intellectual competences” which he calls “human intelligences.” (p.8) Spatial thinking is essential to scientific thought, representing and manipulating information in learning and problem solving. Numerous mathematicians and mathematics educators have suggested that there is a relationship between spatial thinking and mathematics. Yakimanskaya (1971) claims that the bases of assimilating abstract knowledge and individual concepts are visualizations. (p.145). Furthermore, there are positive correlations between spatial ability and mathematics achievement at all grade levels (Fennema & Sherman, 1977, 1978; Guay & McDaniel, 1977). It is clear to see this relationship since there are numerous concepts in mathematics that have an obvious visual dimension.

In fact, visualizations in mathematics might be especially important at the elementary school level (Stigler et al., 1990) because young children rely more heavily on imagery than do adults (Kosslyn, 1983). Brown and Wheatley (1989) interviewed with fifth grade girls with low spatial ability and high spatial ability and they reported that low spatial girls performed well in the school mathematics but high spatial girls’ understanding of multiplication and division was more relational. Similarly, Tartre (1990a) suggested that 10^{th} grade students who scored high on spatial orientation were better than the students who grade low in terms of understanding nongeometric problems and linking them to previous work.

The nature of spatial abilities:

Gardner (1983) states that “Central to spatial intelligence are the capacities to perceive the visual world accurately, to perform transformations and modifications upon one’s initial perceptions, and to be able to re-create aspects of one's visual experience, even in the absence of relevant physical stimuli." (p.173). Two major components or factors of spatial tasks have been identified (Gardner, 1983):

- Spatial orientation that is understanding and operating on the relationships between the positions of objects in space with respect to one's own position-for instance, finding ones' way in a building.
- Spatial visualization that is comprehension and performance of imagined movements of objects in two and three-dimensional space.

What are the spatial components that are relevant for mathematics learning?

Bishop (1983) has suggested two spatial components for mathematics learning. The first is the ability to interpret figural information and understand visual representations and vocabulary. The second is the ability for visual processing. It involves two processing: manipulation and transformation of visual representations and images; translation of abstract relationships into visual representations. Other authors (Guay, McDaniel, &Angelo, 1978) believe that the formation and transformation of visual images as organized wholes are the essence of true spatial ability. They argue that many so-called spatial tests are not good at measuring spatial ability. There is evidence that different groups of individuals use different processes on spatial tasks. Some represent problems visually; others represent them verbally. Some give more attention to whole stimulus at once; others attend to parts of it at a time. Some individuals use processing aids, such as marks on paper, object manipulation, and body movement.

How can the spatial ability be improved?

As stated in many studies, spatial ability can be improved through training (Bishop, 1980). Through the scores they gained, Ben-Chaim, Lappan, and Houang reported that thanks to a three-week instructional training program, the spatial visualization ability of 5-8 grades students increased. They suggested that seventh grade might be the optimal time for spatial visualization training. Bishop (1980) found that in primary schools, students who used manipulative materials performed better than students who were lacking use of such materials. Although students' spatial skills improved during the course of an informal geometry course (Battista, Wheatley, & Talsma ,1982), there is no improvement in spatial ability results from a standard geometry course (Bishop, 1980). If the grade level increases, performance on spatial tasks also increases (Ben-Chamin et al., 1988; Johnson & Meade, 1987).

In addition, spatial ability can be improved by dynamic geometry environment (Christou, Jones, Pitta-Pantazi, Pittalis, Mousoulides, Matos, Sendova, Zachariades & Boytchev, 2007). They report on the design of a library of software applications for the teaching and learning of spatial geometry and visual thinking in their paper. The main objective of these implimentations is the development of a set of dynamic environments, which enables students to construct, observe and manipulate configurations in space, students to study different solids and relates them to their corresponding nets, and students to promote their visualization skills through the process of constructing dynamic visual images. During the developmental process of software applications the key elements of spatial ability and visualization (mental images, external representations, processes, and abilities of visualization) are carefully taken into consideration by them. They claimed that applications will enhance students' dynamic visualization ability and enable them to gain a greater understanding of three dimensional spatial concepts. We can say that based on the report which is mentioned just above, the students can develop the visual-perceptual limitations which affect the identification ability of individuals so they can overcome the conceptual and figural aspects problems in geometry while learning.

2.4 Conceptual and Figural Aspects in Learning

Definitions are the rules systems. The boundaries of the concept or the category as well as its critical attributes (the attributes that each example should have in order to belong to the category) are defined by these rules and definitions have an important place in a concept (Austin, Bruner & Goodnow, 1956). Mathematical definitions help us to understand the concept. Mathematical definitions consist of critical attributes and non-critical attributes (attributes which only some of the concept examples possess). Moreover, verbal definitions itself usually include a minimal subset of critical attributes sufficient to define the concept (Hershkowitz, 1990).

When a concept name is used, usually the concept image is remembered, not the concept definition. The concept image is associated with the concept name. During the mental processing of recall and manipulating a concept, some special examples (figures in the case of geometry) are evoked into play and affecting the meaning and usage. These examples are called prototypes. The prototype is a result of our visual-perceptual limitations which affect the identification ability of individuals.

Individuals use the prototypical example as a model in their judgments of other instances (Hershkowitz, 1989, 1990; Shwarz & Hershkowitz, 1999). Indeed, several different research studies have showed us how definitions and special examples play an important role in concept learning (e.g. Furinghetti & Paola, 1999; Matsua, 2000; Shir & Zaslavsky, 2001). The prototype phenomenon and prototypical judgments seem to be mostly a product of visual process (Hershkowitz, 1989). The prototypes' non-critical properties usually have strong visual characteristics, and therefore they are attained first and then act as distracters.

Geometry is interested in specific mental objects and figural concepts. Figural concepts possess both conceptual and figural aspects which are usually in tension so that geometrical reasoning is characterized by logical between them.(Fischbein, 1993)

Shelton (1985) used a computer program on 2 to 6 year old children. The examples that were given based on isosceles and right triangles' different shapes and orientations. After the treatment, most of the children were free from upright position prototypes and generalized their concept image of triangles to include all triangular shapes and orientation. From the view of that we can say that a rich and dynamic learning environment overcome perceptual limitations. What are the perceptual limitations in polygons?

2.5 Students' Understanding of Polygons

Many studies are available on students' concept images on polygons, square, rectangle, and parallelogram (Hoffer, 1983; Wilson, 1983; Hershkowitz & Vinner, 1983; Prevest, 1985; Burger & Shaughnessy, 1986; Hershkowitz, Vinner & Bruckheimer, 1987; Hershkowitz, 1989; Tirosh & Stavy, 1998; Ubuz, 1999).

Burger and Shaughnessy (1986) made clinical interviews with the students from kindergarden to college. They applied these interviews to contribute a characterization of the Van Hiele levels in terms of specific student behaviors on polygons. For example, they observed following students' behaviors in response to the tasks : Inclusion of irrelevant attributes when identifying and describing shapes such as orientation of the figure ; references to visual prototypes to characterize shapes; sorting by single attributes; inability to use properties as necessary for a shape; prohibiting class inclusions among general types of shapes. Besides, according to the Van Hiele Levels, they reported that the first three findings were on the level 0 and the rests were on level 1.

Hershkowitz and Vinner (1983), Hershkowitz, Vinner and Bruckheimer (1987) investigated students and teachers concept images of basic geometrical concepts. They found that each concept has one or more prototypical examples and these are accomplished first. Therefore, they exist in the concept image of most subjects. Likely, Wilson (1983) made an investigation to define the concept. He explored the relationships between children's definitions of rectangles and their choice of examples by asking the subjects. Eventually, he found that the students' choice of examples was based on more on their own prototypes rather than on their own definitions. Also, he founded that while students were choosing examples, they wrote definitions that they did not apply. Moreover, such prototypical judgments are demonstrated by other studies (Hoffer ,1983 and Hershkowitz, 1989). Hoffer (1983) reported that students often could not identify a right angled trapezoid as a trapezoid if it does not look like a prototypical trapezoid. Hershkowitz (1989) found that students do not consider a square as quadrilaterals because it has four equal sides and other quadrilaterals do not.

Prevost (1985) studied with seventh and eighth grade students in order to identify and define polygons. He found that most of the students were not able to identify common figures like rectangles, squares and trapezoids. Most of the students could say the definitions they had learned at school. If they did not familiarize with the figures properly, they used the structure "looks like" to explain their definitions.

Ubuz (1999) investigated 10^{th} and 11^{th} grade students' understanding of basic geometric concepts and showed that students thought trapezoid as a parallelogram without thinking its properties. Another misconception was on regular polygons; students applied properties of regular polygons to any pentagon. Representations of geometric ideas have important roles on misconceptions. These roles are explained below.

2.6 Representations of Geometric Ideas

2.6.1 Concept Images

Vinner and Hershkowitz (1980) claim that people do not use definitions of concepts while they are thinking. However, they use concept images, combinations of all the mental pictures and properties that have been associated with the concept. Their research proved that these concept images existed for a number of geometric concepts, but such images could be adversely affected by inappropriate instruction. For example, for many students, an obtuse angle has a horizontal ray and this concept image might result from the limited set of examples they see in texts and a "gravitational factor". Concept images were also distinguished their components; for example, students' concept image for a right triangle were most likely to include a right triangle with a horizontal and a vertical side. It less likely included a similar triangle rotated slightly. Also, it was least likely to include a right isosceles triangle with a horizontal hypotenuse. Researches about such concept images may provide useful information about errors that students make. For example, students may know the correct verbal description of a concept and have a specific visual image or prototype associated tightly with that concept, but they may have difficulty applying the verbal description correctly. (Clements & Battista, 1989; Hershkowitz, Ben-Chamin, Hoyles, Lappan, Mitchelmore & Vinner, 1990; Vinner & Hershkowitz, 1980)

2.6.2 Using Diagram

2.6.2.1 The Use of Manipulative

Manipulative are an essential aid in learning geometry. The use of manipulative makes an observational support even for older students, especially those at lower levels (Fuys, Geddes & Tischler, 1988). It was observed that the use of manipulative allowed students to try out their ideas, examine and reflect on them, and modify them. This physical approach made students to maintain their interest. It seemed to assist students in creating definitions and new conjectures, and to aid them in gaining insight into new relationships.

2.6.2.2 The Use of Computers

Computer allows its users to explore, investigate and pose problems, and to offer flexible representations of situations on symbolic and formal level. This ability is the main feature of the computer. Computers provide an ideal medium for studying geometry. Geometry permits interesting recent developments based on the new access to direct manipulation of geometrical drawings. Thanks to manipulation of geometrical drawings for providing to view conceptualization in geometry as the study of the stationary properties of drawings while dragging their components around the screen. The statement of a geometrical property now becomes the description of a geometrical phenomenon accessible to observation in the new fields of experimentation.

It has been revealed that computer based learning have some benefits for teaching geometry, and it was slightly better for teaching verbal concepts related to geometry. However, the traditional approach was better for teaching non-verbal ideas (Kantowsky, 1981). In the computer environment, students' geometrical performance was affected by continuous variation of geometric figures (Kakihana & Shimizu, 1994). Dortler (1993) supports the view that using computer tools, geometric figures, constructions and system of relationships themselves can become the objects of the activity.

In many studies, the role of dynamic geometry software in teaching and learning geometrical shapes has been emphasized. First, at the beginning of the 70's, *Logo* (Papert, 1970) provides a specific bridge between geometry and graphical phenomena. Logo is completely defined by a set of primitive actions and objects (i.e., numbers & lists), and a syntax that defines allowable combinations of actions and manipulations. *Logo* has been increasingly used as an environment for students to explore geometry since its development (Clements & Sarama, 1993 ; Yelland, 1995; Clements, Battista & Sarama, 2001 ; Papert, 2002). Through *Logo,* students had a powerful and flexible environment to represent and explore of geometric ideas. Clements (1987) proved the positive impacts of *Logo* programming for geometric learning among children in grades. It was indicated by another research that rich geometrical environments can be designed via Logo and in these environments students can act. Then, students come to understand a range of ideas and processes concerning geometrical concepts through an appropriate invention in a meaningful way (Hoyles & Sutherland, 1989; Noss, 1987).

Constructing programs like *Geometric Supposer* facilitate students making and testing conjectures. This is the key point of constructing programs.*The Geometric Supposer* (Schwartz & Yerushalmy, 1984) is one of the widely used software program at the secondary schools and it affects those classrooms and laboratories where it is used. It changed the typical geometry course to a very little exercise in conjecturing and reasoning. *The Geometric Supposer* made an important step. It offered getting modifications of the current Euclidean construction but it did not restate its specifications completely.However, *Cabri-géométre* (Laborde, 1993) has made the achievement of the links between geometry and its experimental field, drawings of geometrical shapes. This achievement replaces the *Geometric Supposer* repeat feature. Then, Jackiw (1991) developed the *Geometer's Sketchpad*. A group of primitive objects (i.e., point, line, segment, etc.) and a set of elementary actions (i.e., draw parallel line, etc.) characterize these dynamic geometry environments. Through dragging and grabbing around any point, the drawing on the screen can be manipulated (Laborde, 1993).

There are numerous studies about the effects of computer based learning and dynamic geometry software to develop students' understanding in geometry (Devaney, 1992 ; Hativa, 1984 ; Işıksal& Aşkar, 2005; Jones,2000 ; Jones,2001; McCoy ,1991 ; Marrades & Gutiérrez, 2000; Scher ,2002 ; Straesser, 2000; Velo ,2001).

McCoy (1991) studied the geometry achievement of a class. He used *the Geometric Supposer* regularly during one academic year and compared it with the class which was implemented by the traditional teaching of geometry. The results of the study showed that the post-test results are significantly higher in the treatment group.

Straesser (2000) firstly explains his perspective on geometry and dynamical geometry software (DGS). He analyses that DGS-use influences traditional geometry. Additionally, the research highlights changes in the interactions between geometry, the tool computer and DGS and the human user. It takes into account the user of DGS and focuses on changes in the teaching and learning of geometry. Conclusion shows that if it is taken as a human activity, DGS deeply changes geometry.

Marrades and Gutiérrez (2000) present an analytic framework to describe and analyze students' answers to proof problems. Using this framework, they 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. They present the results of two case studies where secondary school students worked with *Cabri-Géomètre* to solve geometry problems structured in a teaching unit. The teaching unit had the aims of: a) Teaching geometric concepts and properties, and b) helping students to improve their conception of the nature of mathematical proof and to improve their proof skills. By applying the framework defined, they analyze students' answers to proof problems, observe the types of justifications produced, and verify the usefulness of learning in dynamic geometry computer environments to improve students' proof skills.

In his 1992 review of the Geometer's Sketchpad, mathematician Robert Devaney (1992) communicates an appreciation of dynamic geometry that persists among the mathematics community. GSP allows mathematics to be thought visually to the class as a whole, to small groups, or to individuals by creating dynamic and productive three way interaction between teacher, student, and computer (Hativa, 1984). In addition, Scher (2002) said that The Geometer's Sketchpad is one of the most effective pieces of software that he has ever encountered. The interview summaries provided in Scher's dissertation focused on students' intellectual inquiries, but they could equally well have told a story of their engagement with the software. The interviews reported in this dissertation expressed students' surprise and frequent delight with the animated images they viewed and constructed on screen. Throughout this dissertation, a single theme reappears in the contexts of motion, language, and construction. This theme can be summarized in that static geometry is not the same as dynamic geometry. Scher reported that how students learn and think with a paper and pencil is not equivalent to how they function with computer screen and mouse.

Velo, (2001) study investigates whether regular use of dynamic geometry software enhances students' abilities to make generalizations in geometry. Three high school geometry classes participated in the study. The experimental group consisted of two classes taught by the researcher, and used Cabri Geometry II (on individual TI-92 calculators) on a regular basis for exploring concepts in geometry. The third class, taught by another teacher, served as a control group. While both groups used the same textbook and followed the same course of study, the control group did not use dynamic geometry software. Data sources for the study were scores on an Entering Geometry Student Test (EGST), a generalization pre and post test, task based interviews, and classroom observations of each group. No significant differences were found between the groups on the EGST or on the generalization pretest. Analysis of covariance (ANCOVA) was used to control for initial differences on the EGST and the generalization pretest. Results of the ANCOVA test did not show any significant differences between the groups on the generalization posttest.Task based interviews with a subset of fifteen students from each group were conducted to further investigate differences between the groups on their ability to generalize. Six geometry tasks were posed to the students. The sixth task contained multiple parts. Student's responses to the tasks were classified into high, medium, or low response categories based on criteria developed by the researcher. A chi-square analysis showed that there was a significant relationship between group membership and performance in ten of the fifteen categories of the task analysis. The experimental group showed a greater tendency to make and test conjectures during the interviews. As a result of this study, he said that, regular use of dynamic geometry software seems to enhance students' abilities to make generalizations in geometry.

Işıksal & Aşkar (2005) investigated the effect of spreadsheet and dynamic geometry software on the mathematics achievement and mathematics self-efficacy of 7th-grade students. The gender differences with respect to computer self-efficacy, mathematics self-efficacy and mathematics achievement are examined in this study. In addition, they investigate the relationship among these three constructs. An experimental design was used to evaluate. They used two software programs, Excel and Autograph, in experimental groups separately, and a control group took traditional-based instruction without using any technological tools such as a computer or calculator. During the spring semester of the 2001/02 academic year, they carried out the study and three instructional methods of study, which are autograph-based instruction, spreadsheet-based instruction and traditionally based instruction, were randomly assigned to the three classes. In order to assess the students' performance on mathematics, they used to the Mathematics achievement test. A Mathematics self-efficacy scale and Computer self-efficacy scale were developed respectively to determine the self-efficacy expectation of the students with respect to mathematics and computers. There were analysis of covariance, bivariate correlations and t-test which were used to analyze outcome data. The results of their study showed that the Autograph group and Traditional group had significantly greater mean scores than the Excel group with respect to mathematics achievement. The Autograph group had considerably greater mean scores than the Traditional group. However, there was no significant mean difference between the Autograph and Excel groups and between the Excel and Traditional groups with respect to mathematics self-efficacy. Additionally, there was no significant mean difference between boys and girls with respect to mathematics achievement and mathematics self-efficacy. On the other hand, boys had significantly greater mean scores than girls with respect to computer self-efficacy. In addition, they found important correlations among efficacy scores and achievement. It is suggested that students had great enthusiasm for Autograph. Concerning mathematics achievement and mathematics self-efficacy, unlike other groups, students in the Autograph group had the highest scores. Besides, boys reported significantly higher scores with respect to computer self-efficacy. During the Autograph-based instruction and spreadsheet-based instruction, boys were more enthusiastic in order to solve activities using computers compared to girls. On the other hand, it was seemed that treatments did not have any effect on gender regarding mathematics self-efficacy and mathematics achievement.

Jones, (2000) reported the data from a longitudinal study of 12-year-old students' interpretations of geometrical objects and relationships when using dynamic geometry software. The main point of the study is the progressive mathematisation of the student's sense of the software, examining their interpretations and using the explanations that students give of the geometrical properties of various quadrilaterals that they construct as one indicator of this is the . In the research, he suggests that the students' explanations can evolve from imprecise, everyday expressions, through reasoning that is overtly mediated by the software environment, to mathematical explanations of the geometric situation that transcend the particular tool being used. It is suggested that this latter stage should help to provide a foundation on which to build further notions of deductive reasoning in mathematics.

Jones, K. (2001) explores that dynamic geometry software promises direct manipulation of geometrical objects and relations. Aspects of a research study deigned to examine the impact of using such software on student conceptions are reported in this study. Through the analysis of the data from the study, he finds that the dynamic nature of the software influences the form of explanation, especially in the early stages, while the use of dynamic geometry software can assist students in making progress towards more mathematical explanation. However we should not be forget the attitudes effect in computer based learning?

2.7 Attitude towards Computer

Attitudes are very important in computer based learning performance as they make students more willing to use computers. Munger and Loyd (1989) conducted a research on sixty high school students. They examined the relationship of their mathematics performance and attitudes toward computers. The result of the analysis showed that a significant relationship exists between mathematics performance and attitudes toward technology. Only the computer confidence among attitudes, contributed significantly to prediction of mathematics performance. Likely, Troutman (1991) claimed that students who feel confident in their own personal use of computers also feel positive toward the use of computers in the schools.

Kulik, Bangert and Williams (1983) analysed 51 independent evaluations of computer based teaching in grades 6 through 12. They used quantitative techniques to integrate their results and they reported stronger positive effects of computer based teaching on students' achievement. Also, they indicated that students who were thought on computers developed very positive attitudes towards computer.

Levine and Donita-Schmidt (1998) presented a computer attitudes questionnaire which they piloted on school children. They identified five main scales. These were; computer self- confidence, attitudes towards computers as an educational tool, stereotypical attitudes, perception of computers as a tool for enjoyment, and importance of computers. First of all, computer self-confidence largely reflected the concept of computer anxiety. Rest of all loaded on to a latent attitude dimension and confidence was reciprocally related to this. Generally, attitudes were significantly associated with commitment to learning about computers.

Equity and computer use for secondary mathematics learning was the focus of a three year study of Forgasz (2003). A survey was administered by Forgasz to a large sample of grade 7-10 students. Some of the survey items were aimed at determining home access to and ownership of computers, and students' attitudes to mathematics, computers, and computer use for mathematics learning. Responses to these items were examined by several equity factors, by grade level, and by mathematics achievement self-ratings. Equity factors were more salient with respect to computer ownership than with attitudes. The results show that attitudes to computers for mathematics learning were more strongly related to attitudes to computers than to attitudes to mathematics but if attitudes to computers were related to gender or not.

2.8 Gender Differences

2.8.1 Gender Differences in the Learning of Geometry

Gender differences, especially as they relate to mathematics and geometry learning has been studied and researched within the fields of education. Studies by Halpern (1986), Fennema (1974), Fennema and Carpenter (1981), and Stage, Kreinberg, Eccles, and Becker (1985), were all in agreement that gender differences, as they related to mathematics and geometry performance, were not apparent in early childhood. Their studies showed that differences in abilities emerge between 13 and 16 years of age. In high school, and particularly when focused on high cognitive level tasks, males outperformed females. In tasks requiring less complexity, such as computation, females outperformed males.

Linn and Hyde (1989) synthesized several studies performed after 1974 and divided them into subcategories of cognitive ability to include verbal ability, spatial ability, quantitative ability, and other cognitive skills. The findings regarding verbal ability supported a conclusion that these differences favored females only slightly and were negligible. The researchers believed that differences between the genders in spatial abilities are declining, and that processes regarding differences in these abilities responded positively to training (Linn& Hyde,1989). This study also verified that geometry test mean difference between genders was negligible.

2.8.2 Gender Difference Effect on Computer Attitudes

A review of the literature shows that demographic variables have been extensively investigated for their relationships to computer attitudes. Especially gender has been frequently studied in relation to computer attitudes. Some of the studies are;

Koohang (1989) reports that male students scored significantly higher on computer usefulness subscale than female students did. Chen (1986) found that men held more positive attitudes of interest in and confidence with computers, and had lower computer anxiety than women. Levin and Gordon (1989) conclude that boys have significantly more positive effective attitudes towards computers than girls. In addition, Massoud (1991) found that male students had more positive attitudes towards computers in all the subscales measured-anxiety, confidence and liking. Moreover, Shashaani (1993) reports that female students have less computer interests and less self-confidence in their ability to use computers than male students. This study also showed that male students showed greater interest in the computer and its uses than females.

2.9 Summary

Geometry learning is an area rich with possibilities for future research. Given students' poor performance in this area, such research is sorely needed. Given a constructivist view of learning, research that describes the development of geometric concepts and thinking in various instructional environments is certainly required. Indeed qualitatively different and improved environments for education in geometry will not emerge without the presence of the theoretically cognizant teacher and the student armed with a full array of tools for geometric investigations including manipulatives, most importantly computer softwares. However, the dynamic geometry softwares can not evolve without research that investigates the use of them, examines how students' knowledge develops within different instructional environments, and discovers how teachers can utilize both these environments and this knowledge about students' learning. In this study dynamic geometry can serve two purposes. Reducing the amount of static figures in the classroom will help rid the students of certain misconceptions, mentioned in literature, that are the results of seeing only one figure as an example. A second purpose is to allow the students to experiment and discover what works and what does not, to construct their own knowledge base, and build that solid foundation for future learning.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

The design and methodology of the study is described in this chapter. First, the participants, procedures of the study and treatments for the control and experimental groups are explained in detail. Then, the instruments, the setting and data collection procedures are given.

3.1 Participants

The participants in this study were 134 sixth grade students, of whom 65 were girls and 69 were boys, in a public elementary school in Elvankent,Ankara. The students' social economical statuses were nearly same in the school. This school was chosen since it had computer laboratory with twenty computers and high numbers of sixth grade students in order to make the sample size as big as possible. The computer lab was used for only special project assignments, such as using a spreadsheet to plan a party, create a budget or to watch documentaries. There were five 6^{th} grade classes in the school. The same teacher was teaching mathematics to all groups. The teacher was 44 years old and this year is her 21st year in teaching profession. Classes A and D constituted the experimental group (EG) and the classes B and C constituted the control group (CG). Assignment of classes to control and experimental groups was based on the levels of the classes as explained by their mathematics teacher. The classes' levels are determined by their teacher according to students' last semester mathematics scores in primary school. The classes were also selected so that there can be equal number of students in both groups. The experimental group consisted of 66 students whom 32 were girls and 34 were boys and the control group consisted of 68 students whom 33 were girls and 35 were boys. Also students' ages in both group ranged from 12 to 14.

3.2 Procedure

The aim of this study was to investigate the effects of a dynamic geometry environment together with open ended explorations on sixth grade students' performance on polygons and congruency and similarity of polygons. The study was designed as an experimental study in which two different teaching and learning environments; one with traditional and the other with nontraditional where a dynamic geometry activities were utilized. The traditional instructional environment was merely based on a text-book using chapters related to subjects (i.e., polygons and congruency and similarity of polygons) from the official 6th grade textbook of Ministry of National Education (Aktaş, Atalay, Aygün, Aynur, Bilge, Çelik, Çuha, Karaman, Öcal, Öncü, Özçelik, Ulubay, & Ünsal, 2006). The treatment in the experimental group included exploring and manipulating concepts related to polygons, regular polygons and congruency and similarity of them. The teacher, students and computer activities (based on GSP) interactions were available in dynamic geometry environment. The activities were prepared to allow student inquiry, while guiding and helping them to clarify relationships and make conjectures.

The experiment was carried out in both groups at the same time in the first semester of the 2006-2007 academic year. It took two weeks. In the control group, teacher taught the geometric topics of polygons and congruency and similarity of polygons. In the experimental group students worked on the GSP activities (Appendix C), which are prepared by the researcher, at computers in computer laboratory. The activities were completed in the computer laboratory by researcher because of the teacher's lack of computer skills and lack of experience with Geometer's Sketchpad software. This was not causing problem, the researcher helped the students in computer lab during the treatment.

The students in the experimental group were taught about GSP before the treatment by the researcher and it took approximately two class hours (i.e., 40 + 40 = 80 minutes). During the training the students were required to do activities that involved constructing points, drawing a line segment, moving/dragging the objects, measuring the angle and side, drawing perpendicular and parallel lines, constructing a circle and copying polygons and labeling objects in GSP.

Both of these classroom and computer sessions were observed and videotaped by a mathematic teacher who is a teacher for three years and continue to her profession. Instruments used in this study include a Geometry Test (GT) and

Attitude Scale towards Computer Instruction (CAS). Geometry test was developed by the researcher by taking the related literature into account. It involved 20 tasks and some of the tasks have subtasks. The test was based on 6^{th} grade geometry topics which were; polygons and congruency and similarity of polygons. In addition, there were 21 questions in CAS. These questions were used to investigate students' attitude towards computer and dynamic geometry environment.

Geometry Test was piloted with three seventh grade students. The pilot study was done by face to face interview in the first semester of 2006-2007 academic year. These three students were identified by their mathematics teacher as high level, middle level and low level. The purpose of the pilot study was to determine students' difficulties on understanding the questions and to prepare worksheets for the main study. If the student has a difficulty to understand the question, the sentences are made simpler in order to help the student to understand the question. The students' errors and prototypes were taken into consideration while preparing the worksheets for the main study.

The geometry test was administered to both groups of students as a pre-test, post-test, and a delayed post test. Attitude Scale towards Computer Instruction was administered only to the experimental group students at the end of the training.

The pre-test was administered to the students before the treatment in order to be sure that two groups were equal in understanding of polygons and congruency and similarity of polygons at the level of significance 0.01. The post-test and attitude scale towards computer instruction were administered upon the completion of the treatment. A delayed post-test was given three months after the completion of the treatment to both groups in order to investigate the effectiveness of computer instructional environment together with open-ended explorations and its impact on long-term memory. (Alpha level was set as 0.01 for independent sample t-tests in quantitative data analyses.)

After the completion of the training, researcher made interviews with four students from the experimental group. Two of the students were male and the other two were female. The interview was done in order to get students feeling about computer instructional environment. Four students that were placed in the experimental group were randomly selected from each category formed by the independent variables of gender and geometry test results. The four categories were males who have high- geometry test score (HM), males who have low- geometry test score (LM), females who have high- geometry test score (HF), and females who have low- geometry test score (LF). Geometry test score category is determined based on the mean of post geometry test score. The males who got higher than the mean is categorized with males who have high- geometry test score and the males who got scores under the mean is categorized with males who have low- geometry test score. This categorization is same among females too. The students were interviewed after they had been exposed to treatment so that they could make comparisons between the use of the computer software and the construction tools when performing their lessons.

The statistical package for science SPSS 15.0 (SPSS, Inc., 2007) was used in order to conduct statistical analyses of quantitative data. Independent samples t test was applied in order to examine whether there was a significant mean difference between experimental group and control group students' geometry test scores before the instruction. Moreover, independent samples t test carried out in order to determine the existence of any significant differences between experimental and control group. After scoring each item on each test, frequencies and percentages of each item on each test according to the scoring criteria were computed. In addition descriptive statistics were calculated for each test. The Pearson correlation coefficients were calculated in order to look at the correlation among post-test, delayed-post test and CAS. Furthermore, qualitative analyze was used for lessons' video tapes, personal interviews and the open-ended questions' answers in CAS.

3.3 Treatments for the Experimental and Control Group

Before the study, two classes, class A and class D, were assigned as the experimental groups and other two classes, class B and class C, were assigned as the control groups based on the level of the classes as explained by their math teacher. The classes' levels are determined by their teacher according to students' last semester mathematics scores in primary school. The classes were selected to the groups in order to make statistically equal groups. The control groups were taught by the teacher in the classrooms. The experimental groups learned by computer activities in the computer lab. The study lasted two weeks. There were four mathematics class hours in a week and each took two class hours of 40 minutes. The sixth grade mathematics textbook published by the MNE (Aktaş et al., 2006) was used in control group. The instructional environments in control and experimental groups are explained in detail in the following section.

3.3.1 Treatment for the Control Groups

In control groups, traditional type of instruction was dominant although they used the book which has been prepared based on the new curriculum (MNE, 2004). There were many activities based on construction in the book however these were not applied in the class. The teacher explained the concepts by writing definitions and properties on the board and then allowed students to write them on their notebooks. Some of the lessons began with discussions which were about the new subject. For example when the topic was similarity, they discussed on these questions: "what is the similarity?" and "what comes your mind when you hear the word similarity?" The teacher asked questions similar to these and the class discussed the results. While starting the lesson, teacher generally reviewed of the previous lesson by writing main characteristics of the subject. Then she asked similar exercises which were done in previous lessons and let the students solve them or began the lesson by writing new procedure. Students in the control groups were taught using chapters from the textbook followed (Aktaş et al., 2006).Teacher usually used ruler and protractor. Also the students used same tools for measuring angles and sides of polygons. However, only a few students brought ruler and protractor to the class. The students who brought the materials measure the angles and sides, the rest of the class waited for the results. In exercises part, one or two students among the volunteer students was called and he/she explained his/her solution for the exercise. Then the teacher explained again the solution of the exercise upon the completion of the solutions by the students. The teacher assigned home works from the textbook each time when the topic was completed.

3.3.2 Treatment for the Experimental Groups

Before the treatment, experimental group students were familiarized with the Geometer's Sketchpad (GSP) and its proper usage based on construction. Two hours of practice were given at the computer lab. Two hours were enough since the students got computer courses in the last two years of the primary school. After those practices all students were able to constructing points, labeling constructed objects, drawing a line segment, moving/ dragging the objects, measuring the angle and side, drawing perpendicular and parallel lines, constructing a circle and copying polygons on computer. There were 20 computers in the lab so students worked in pairs at the computer. The computers at the lab were arranged forming a U shape. All of the instruction in the experimental group took place in the computer lab. In the computer lab, the researcher made a brief introduction to the new topic especially taught the some properties of the GSP. These properties would be the clues of the activities that students discover in worksheets. Following the students worked on the worksheets using GSP at the computer lab. Ten worksheets were developed for the study (See Appendix C). The objectives of the worksheets were given in Table 3.1 and worksheets were prepared based on the creative nature. It means students discover the properties and make conclusions by themselves. Worksheets guided students towards discovering a specific property or sets of properties of the subjects. Students discovered meaningful geometric concepts by measuring, exploring, manipulating and transforming the geometric shapes. For example the worksheets 7 and 8 guided students to discover the properties of congruency and similarity. The students measured and manipulated the geometric shapes to see what relationships they can find that can be generalized for congruency and similarity. At the end of the each worksheet the students and the researcher discussed together the findings come out in the computer lab with the help of the worksheet. At each computer session, daily worksheets were distributed to the students. Upon the completion on working on each, students wrote their findings on their worksheets. Then researcher asked students about their findings and discussed those with the students. In this way, the students discussed and construed the findings. After the discussion, worksheet was completed and the next worksheet was distributed to the students. All the activities in the worksheets were done following this procedure.

Table 3.1 Objectives of the activities in the worksheets

Worksheets	Objectives
1 **Duration:** **20 minutes**	a. Create points that are not on the same line b. Label the points c. Create lines by connecting the points d. Find interior region of the figure e. Find exterior region of the figure
2 **Duration:** **20 minutes**	a. Identify the polygons from the given sketches b. Construct polygons c. Find the number of the side, corner and angle of the polygons d. Write the relationship between the number of the sides, vertices and angles of the polygons and name the polygons.
3 **Duration:** **40 minutes**	a. Find the measures of interior angles and side of a given regular polygon. b. Write the properties of the regular polygons.
4 **Duration:** **40 minutes**	a. Measure the interior angles and side lengths of the given polygons. b. Compare the measurement of the sides' length and interior angles of the polygons. c. Determine the polygons which are regular or which are not. d. Write the differences between polygons and regular polygons.

Table 3.1 (continued)

5 **Duration:** **40 minutes**	a. Construct square b. Construct rectangle c. Find the properties of the parallelogram according to its angles and its sides.
6 **Duration:** **40 minutes**	a. Construct polygons with circles. b. Measure the sides and angles of the polygons. c. Determine the polygons which are drawn by circles are regular or not.
7 **Duration:** **20 minutes**	a. Copy the polygons b. Measure the sides and angles of the copied polygons. c. Write the congruency properties.
8 **Duration:** **20 minutes**	a. Find the properties of the rectangles. b. Compare the rectangles. c. Write the similarity properties.
9 **Duration:** **40 minutes**	a. Determine the triangles which are equal and which are similar. b. Show equal triangles by using the congruency symbol. c. Show similar triangles by using the similarity symbol.

Table 3.1 (continued)

10 **Duration:** **40 minutes**	a. Label the polygons. b. Measure the sides and angles of the polygons. c. Determine the polygons which are congruent. d. Determine the polygons which are similar. e. Write the differences between congruency and similarity. f. Explain if the equal figures are also similar or not. g. Explain if polygons that have different number of sides can be congruent/similar or not.

3.3.3 The Comparison of the Experimental and Control Groups

The control groups were lectured in the regular classrooms. The problems were solved from the textbook followed. Ruler and protractor were used as a material by teacher and students. Teacher was in a presenter role and students were reading and solving. Students worked alone.

The experimental groups studied in the computer lab. Students investigated the activities in worksheets and answered the open-ended questions which were also in the worksheet. Geometer's Sketchpad was used as a tool for discovering the properties of the subjects and make conclusions based on these properties. Researcher was only in a facilitator role. Students were reading, doing, reporting, discovering, reviewing and discussing. Students worked in pairs.

3.4 Instruments

3.4.1 Geometry Test (GT)

The aim of the Geometry Test was to investigate 6^{th} grade students' performance on geometry (See Appendix A). GT involves 20 tasks and some of the tasks have subtasks. The test was prepared by the researcher and controlled by five mathematic teachers of whom two were also mathematics textbook writers. The test was based on 6th grade geometry topics; properties of polygons and congruency and similarity of polygons.

All of the tasks in GT were evaluated by giving 1 for each correct answer and 0 for each incorrect answer. Also each explanation given under each tasks were also taken as a different task and therefore evaluated as 1 or 0. In addition, some of the tasks' percentage was higher than the others. These tasks were based on the topics which are learned firstly and the students do not have any idea about them before. Possible maximum and minimum GT scores were 100 and 0 respectively.

The test was administered to the students as a pre-test, post-test and delayed-post test. 50 minutes were given for the test. Post-test results yielded a Kuder-Richardson (KR-20) reliability coefficient of internal consistency of 0.83. Ideally, the Kuder-Richardson reliability coefficient of a scale is desired to be above .70 (Pallant, 2005).

3.4.1.1 Piloting of Geometry Test

The geometry test including 20 questions was developed for the study in order to determine the students' understanding of polygons and congruency and similarity of polygons. Seven of those questions are from polygons, three from regular polygons and ten from congruency and similarity. Geometry test consisted of two multiple choice question; one matching type question, one true-false question and the rest were open-ended questions. Open-ended questions were chosen because the students can explain the reason in details for their answer. Geometry Test was piloted with three 7th grade students. The pilot study was done by face to face interview in the first semester of 2006-2007 academic years. These three students were identified by their mathematics teacher as high level, middle level and low level. The purpose of the pilot study was to determine students' difficulties in understanding the tasks used in the test and to prepare sheets for the main study based on these results.

Before the interviews, an appropriate time schedule was arranged for the students. Interviews were conducted in three days, one day for each student in September 2006. Each interview took approximately an hour even though there was no time limit.

During the interviews, the students initially read each problem aloud. Later the students were given time to think about the problem. Then student explained his/her solution and was asked to provide justification to the solution offered. After the justifications the interviewer made general inquires such as explain, clarify…and continued to ask more specific questions, if necessary, until a response was elicited or it appears that all knowledge had been elaborated. Further, the students were asked to write their responses. This process was repeated for each problem in Geometry Test. Interviews was videotaped. The result of the interviews, the discussion and conclusions of the Geometry Test pilot study is given in the Appendix E.

3.4.2 Attitude Scale towards Computer Instruction (CAS)

There are 21 questions in the CAS. The first five statements in the survey were written by the researcher. These items were used to investigate students' attitude towards computer. The rest of the statements were selected from a likert type attitude scale towards computer instruction developed by Brown (1966) in order to understand students' attitude towards computer instruction. Some of the statements of this scale were not suitable for the 6^{th} grade students so 13 of these 43 were selected to be used in this study (See Appendix B). For instance, "I am not in favor of computer instruction because it is just another step toward de-personalized instruction" was not used in this study since this statement could not be understood by 6^{th} grade students. There were 9 negative and 9 positive statements in the scale with five possible alternatives: Strongly disagree, disagree, uncertain, agree and strongly agree. Each statement was graded as 0, 1, 2, 3 and 4. In addition, three open-ended questions were posed to the students to get their feelings and their judgments about computer based instruction. Possible maximum and minimum CAS scores were 72 and 0 respectively. If a student got 60 in this test it means that he or she has a positive attitude to the dynamic geometry environment. If student got 35, it means he or she is neutral, if student got 15, it means he or she has a negative attitude to the dynamic geometry environment. CAS was administered only to the experimental group as a post-test, allowing 30 minutes to complete. In this study CAS results yielded a split-half reliability coefficient of internal consistency of 0.96. One of the most commonly used indicators of internal consistency is Cronbach's alpha coefficient. Ideally, the Cronbach alpha coefficient of a scale is desired to be above .7 (Pallant, 2005).

3.5 The Setting and Procedures for Video Taping

The experimental group study was conducted in a computer laboratory with a (desktop computer loaded with The Geometer's Sketchpad, version 4.06) videotape recording of the lessons made sense, as researcher wished to capture the actions occurring on the computer screen as students discussed their work. If a student were to say, "Something strange happens to my line when I move point B over here," videotape would allow us to pinpoint the exact behavior under scrutiny. In addition, in the control group lessons, the actions and facial expressions of the students are captured by videotape recording.

Researcher was fortunate to have the resource to videotape the sessions from a camera angles. Aside from a camera that recorded the computer screen, and also camera videotaped the students. Thus even when the students remained silent during their investigations, researcher was able to monitor their facial expressions and gestures as clues to onscreen activity that surprised or puzzled them.

In the experimental group lessons, students worked in pairs. By studying students together, researcher hoped they would be more likely to discuss their mouse actions and interpretations of onscreen images.

The Roles of the Researcher

Before beginning the first of the two lessons in the experimental group, the researcher began by providing students with a brief summary of the study's purpose and their role in the research. A paraphrased account of this introduction follows:

We've invited you here to learn the geometry with a new kind of geometry software called The Geometer's Sketchpad. As you explore the software, we're going to be videotaping your actions on the computer screen. We won't always know what's going on inside your head, we're going to be asking you a lot of questions about what you're doing and what you're thinking.

As the students progressed through the worksheets, the researcher went to their side and asked them to explain their actions and observations. During the lessons, the researcher functioned in two roles:

1. When a student was uncertain whether Sketchpad contained a particular feature or forgot where it was located, the researcher offered assistance. Throughout the lessons, the researcher reminded students that the study was not a test of how well they had memorized the software commands; rather, it was intended to uncover how they thought about the objects on screen and they develop their geometry thinking.

2. As students worked through the construction challenges, the researcher would periodically ask questions like. "What are you trying to do? Describe to me what you're seeing. Can you explain why that line behaves the way it does? How might you test your theory?" The researcher would also restate or rephrase some of the students' observations to spotlight comments that would benefit from their further attention. Confrey (1993) terms this method "close listening":

"Close listening involves an act of decent ring by an adult or possibly a peer, in order to imagine what the view of the child might be like. It includes repeated requests or a child to explain what the problem is that she is addressing, what she sees herself doing, and how she feels about her progress. It requires one to ask for elaboration from the child about what, where, how, and why." (p. 311)

3.5.1 The Experimental Group Lessons' video tapes

The study was divided into three parts; the activities in Parts I include concise techniques of Sketchpad. This part occupied roughly the first three lessons. Students began Part II and III, where the focus shifted to construction challenges requiring applications of the techniques from part I. This portion of the study spanned five lessons.

Below is a brief summary of all three parts.

Part I: Getting Comfortable with Drawing Tools

In worksheets 1 to 4 while students applying the activities, students used Sketchpad's point, segment, line tools to create simple drawings and measure angles and line segments length. Students were given time for unstructured doodling. To emphasize that figures, once drawn, could be translated, rotated, stretched, or shrunk, researcher asked students to drag objects and describe the resulting effects.

Part II: Building Geometric Constructions

In worksheets 5 and 6, students used Sketchpad's construction menu items by building midpoints, parallel lines, and perpendicular lines.

Part III: Analyzing and Reconstructing pre-Made Sketches

Now, with a basic understanding of Sketchpad's drawing and construction features, students moved to the activities which students was interpreting and reconstructing pre-made sketches. Prior to the sessions, researcher built constructions and saved them. When students opened the sketches, researcher asked them to drag each sketch element with their mouse and describe the resulting onscreen actions. They were encouraged to consider the types of motion, the constraints that might be present in the construction, and the geometric relationships of the objects. With these conjectures in hand, students attempted to build the identical sketches from scratch.

While not every student was able to complete the constructions, intention was not to mark them as either "successful" or "unsuccessful" in their attempts. Rather, researcher wished to document the experimentation techniques and spoken commentary underlying their work.

3.5.2 The Control Group Lessons' video tapes

The control group lessons are not divided into parts while analyzing. The lessons are examined completely since the method which was used in the lessons is same all over every lesson. The observations are made based on the all lessons since the profile was not change in the lessons.

3.5.3 Analysis of the video taped lessons

In total, lessons yielded 10 hours and 40 minutes of videotape along with a complete set of written transcriptions. With this much raw data, researcher decided to focus on just some section of the lessons. Appendix G contains complete information and examples of researcher analysis method. Appendix G also describes an alternative means of analysis proposed by Schoenfeld (1985) as a point of contrast.

CHAPTER IV

RESULTS

In this chapter results of pre-test, post-test, delayed-post tests of geometry test with attitude scale towards computer instruction and the results of the correlation analysis between GT and CAS are given in details in this chapter. Moreover, the qualitative analysis of the open-ended question in CAS, interviews and lessons video tapes are presented.

4.1 Geometry Test Results

Geometry test was administered as a pre-test, post-test and delayed-post test to both experimental groups and control groups. Descriptive statistics for the pre-test, post-test and delayed-post test for experimental and control groups are given in Table 4.1. In addition, frequencies and percentages of experimental group and control group students' correct answers in pre-test, post-test and delayed-post test are presented in Appendix D.

Table 4.1
Descriptive statistics for pre-test, post-test and delayed-post test scores for the experimental group (EG) and the control group (CG).

	Control Group N = 68			Experimental Group N = 66		
	Mean	Mode	SD	Mean	Mode	SD
Pre-test	33. 24	15. 00	14. 35	29. 75	19. 00	12. 14
Post-test	44. 79	51. 00	9. 25	69. 19	63. 50	12. 36
Delayed-post test	40. 07	40. 50	11. 35	59. 96	49. 00	14. 94

It is seen from the Table 4.1 that although the Geometry Test scores were relatively lower at pre-test, they increase in the post-test noticeably (from 29. 59

to 69. 19 and from 33. 24 to 44. 79 for EG and CG respectively) and drop at the delayed-post test (to 59. 96 and 40. 07 for EG and CG respectively). However, whether these differences are large enough to be considered statistically significant or not needs further analysis.

Independent samples t-test was run in order to examine whether there was a significant mean difference between experimental group and control group students' geometry test scores before the instruction.

Table 4.2

Independent samples t test on experimental group and control group students' pre-test scores

	df	t	p	Eta squared
Groups	132	-1. 59	.11	.018

An independent -samples t-test was conducted to compare the geometry test scores for experimental and control group. Preliminary analyses were performed to ensure no violation of the assumptions of independence of observations, normal distribution, homogeneity of variance, sample size, effect size, alpha level and level of measurement. The assumption of equal variance was not violated (F = 1.11, p= .11). There was no significant difference in pre-test scores for experimental group (*M*= 29. 75, *SD*= 12. 14) and control group (*M*= 33. 24, *SD*= 14. 35; *t* (132) = -1. 59, *p*= .11). The magnitude of the differences in the means was very small (eta squared= .018). The pre-test results show that both groups were statistically equivalent in terms of their geometrical performance at the beginning of the experiment. When Appendix D was analyzed in detail, it was seen that, the frequency and percentages of correct and incorrect answers for each task in pre-test were nearly the same for experimental group and control group. The percentages of the explanation items (items which need interpretations of the students) were not adequately high enough, however the control groups' students' percentages of the explanation items were higher than the experimental group students. We can say that control group students concept definitions were better than the experimental group students. The percentages of the explanation items are given in Table 4.3.

Table 4.3 The percentages of the explanation items in geometry test

	Experimental Group			**Control Group**		
	Pre-Test	**Post-Test**	**Delay-Test**	**Pre-Test**	**Post-Test**	**Delay-Test**
Q1b expl.	10 (15.15%)	32 (48.48%)	31 (46.96%)	14 (20.58%)	18 (26.47%)	13 (19.11%)
Q1d expl.	40 (60.60%)	52 (78.78%)	49 (74.24%)	51 (75%)	58 (85.29%)	24 (35.29%)
Q1e expl.	8 (12.12%)	56 (84.84%)	50 (75.75%)	17 (25%)	24 (35.29%)	13 (19.11%)
Q1f expl.	14 (21.21%)	54 (81.81%)	52 (78.78%)	16 (23.52%)	29 (42.64%)	12 (17.64%)
Q1h expl.	6 (9.09%)	43 (65.15%)	41 (62.12%)	8 (11.76%)	22 (32.35%)	10 (14.70%)
Q3 expl.	10 (15.15%)	60 (90.90%)	58 (87.87%)	16 (23.52%)	32 (47.05%)	29 (42.64%)
Q5a expl.	2 (3.03%)	15 (22.72%)	14 (21.21%)	5 (7.35%)	8 (11.76%)	6 (8.82%)
Q5b expl.	2 (3.03%)	16 (24.24%)	15 (22.72%)	6 (8.82%)	10 (14.70%)	7 (10.29%)
Q5c expl.	1 (1.51%)	11 (16.66%)	11 (16.66%)	4 (5.88%)	6 (8.82%)	5 (7.35%)
Q16 expl.	2 (3.03%)	16 (24.24%)	14 (21.21%)	6 (8.82%)	8 (11.76%)	7 (10.29%)
Q18 expl.	9 (13.63%)	38 (57.57%)	36 (54.54%)	14 (20.58%)	19 (27.94%)	16 (23.52%)

Not: "expl." means explanation items.

Independent samples t-test was carried out in order to examine whether there was a significant mean difference between EG and CG students' GT scores upon the completion the treatment on geometry. The results showed that there was a significant difference in post-test scores for experimental group (M= 69. 19, SD= 12. 36) and control group (M= 44. 79, SD= 9. 25; t (120. 34) = 12. 9, p= .00). The magnitude of the differences in the means was large (eta squared= .55). This means that the EG showed a test mean score that was significantly higher than the CG.

Also, it was seen that in Appendix D, post test scores differed for two groups. Experimental group students had significant increase in percentages of the correct answers except for the Questions 2a, 6 and 14. The most important rising in experimental group students was seen in the explanation items of the questions. For instance, the frequency of the correct answers of Question 1 b-d-e-f-h, Question 7, Question 16, and Question 18 was raised from 10 to 32, 40 to 52. 8 to 56. 14 to 54. 6 to 43. 12 to 48. 2 to 16 and 9 to 38 respectively. These percentages increase based on some reasons that is found by analyzing the papers. When the students' answers in the papers were analyzed in details, it can be recognized that experimental group students did not addicted to the prototypes (During the mental process of recalling and manipulating a concept, some special examples, particularly figures in the case of geometry, are brought into play, consciously and unconsciously affecting the meaning and usage. These special examples are often called prototypes.).

In item 1, before the treatment students only defined the rectangle and parallelogram as a polygon and they did not write the explanations for the figures which are not polygons. After the treatment, most of the students in experimental group decide the polygons and write the explanations of the figures which are not the polygons with its reasons. In item 7, before the treatment only 12 students draw the correct figures. Rest of the students' identification of a polygon included the critical properties so they could not draw. In order to construct the figures it is also need to know the non-critical properties. Like parallelogram has parallel opposite sides is a critical property and not having right angles is the non critical property. After the treatment 48 students give correct answers to the question. In addition they construct more than one figure. For instance they draw parallelogram, rectangle and square under the explanation of draw a quadrilateral with at least one pair of the sides are parallel. Moreover, the experimental group students' explanations included information not related to the prototypical figures after the treatment. These results show that computer based instruction together with open-ended explorations have an important effect on overcoming the prototypes. In spite of the increasing in experimental group students' scores, the control group students' scores did not increase in the same degree of experimental group students' scores.

Finally, the difference of the scores between post-test and delayed post-test were calculated in order to examine whether there was a significant mean difference on delayed post-test between EG and CG. When t-test was conducted with these scores, it showed that there was no significant mean difference between the EG and CG ($t= 1.315$, $p= 0.19> 0.01$). However, when the independent samples t-test was carried out with delayed post-test scores, it was found that there was a significant mean difference between experimental group ($M= 59.96$, $SD= 14.94$) and control group ($M= 40.07$, $SD= 11.35$; $t\ (121.28) = 8.65$, $p= .00$). The magnitude of the differences in the means was large (eta squared= .36). We conclude from these analyses that EG students achieved significantly better than CG students.

In delayed post test scores frequency and percentages showed that nearly the frequency of all items showed a falling in both groups. In spite of this reduction, the mean of delayed-test in EG was significantly higher than CG. Furthermore, most of the experimental group students kept their true explanations in delayed post-geometry test.

In addition, profile plot was conducted in order to get rich descriptive picture of these statistical significance.

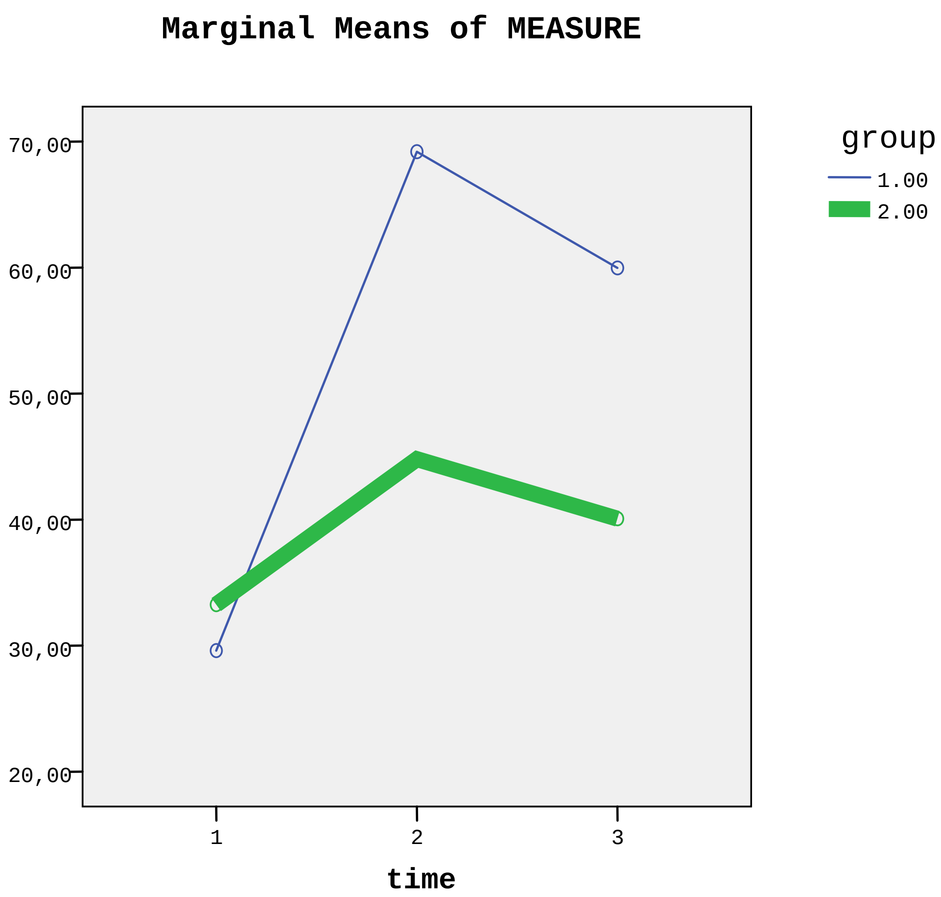


Figure 4.1 Profile plot showing the difference between experimental and control group’s mean scores of pre-test, post-test and delayed-post test.

Based on the Figure 4.1, we can say that experimental group students (group1) achieved better than control group students (group 2). The two groups of post-test (time 2) results were increased. The mean of the post-test in experimental group is higher than control group. The two groups’ means of delayed-post test (time 3) were decreased. In spite of this reduction, the mean of delayed-post test in experimental group was significantly higher than control group. We can conclude from this profile plot that dynamic geometry environment together with open-ended explorations also raised scores on follow-up examination given several months after the completion of the instruction, but these effects were not as high as the immediate effects of dynamic computer instruction together with open-ended explorations.

4. 2 Results of Computer Attitude Scale (CAS)

Frequencies and percentages of students' attitude scores for each item in CAS are given in Table 4.4 Descriptive statistics for the CAS scores for experimental groups are presented in Table 4.5

Table 4.4 Frequencies and percentages of students' attitude scores for each item in CAS

ITEMS	**Frequencies and percentages of CAS's items**				
	0	**1**	**2**	**3**	**4**
1	1.00 1.51%	.00 0%	1.00 1.51%	7.00 10.60%	57.00 86.36%
2	1.00 1.51%	1.00 1.51%	5.00 7.57%	9.00 13.63%	50.00 75.75%
3	.00 0%	.00 0%	4.00 6.06%	5.00 7.57%	57.00 86.36%
4	.00 0%	.00 0%	8.00 12.12%	20.00 30.30%	38.00 57.57%
5	.00 0%	.00 0%	6.00 9.09%	7.00 10.60%	53.00 80.30%
6	.00 0%	1.00 1.51%	8.00 12.12%	9.00 13.63%	48.00 72.72%
7	.00 0%	4.00 6.06%	11.00 16.66%	14.00 21.21%	37.00 56.06%
8	.00 0%	.00 0%	2.00 3.03%	7.00 10.6%	57.00 86.36%
9	1.00 1.51%	.00 0%	5.00 7.57%	17.00 25.75%	43.00 65.15%
10	.00 0%	.00 0%	6.00 9.09%	8.00 12.12%	52.00 78.78%

Table 4.4 (continued)

11	.00 0%	.00 0%	4.00 6.06%	6.00 9.09%	56.00 84.84%
12	.00 0%	.00 0%	5.00 5.05%	4.00 6.06%	57.00 86.36%
13	.00 0%	.00 0%	4.00 6.06%	3.00 4.54%	59.00 89.39
14	.00 0%	.00 0%	2.00 3.03%	7.00 10.60%	57.00 86.36%
15	.00 0%	.00 0%	5.00 7.57%	8.00 12.12%	53.00 80.30%
16	.00 0%	1.00 1.51%	5.00 7.57%	15.00 22.72%	45.00 68.18%
17	.00 0%	1.00 1.51%	8.00 12.12%	12.00 18.18%	45.00 68.18%
18	.00 0%	.00 0%	5.00 7.57%	9.00 13.63%	52.00 78.78%

Table 4.5
Descriptive statistics of the CAS scores for EG

	CAS Scores				
	N	Mean	Mdn	Mode	SD
Experimental Group	66	65. 71	68. 00	71. 00	5. 40

Table 4.5 shows that, the mean score for CAS was 65. 71 (out of 72). This indicates that most of the students had a positive attitude towards computer instruction. Frequencies and percentages of students' attitude scores for each

item in CAS confirm the same result. For example, in item 17, “In view of the subject I learned, I would say that computer instruction is superior to the traditional instruction”, 86.36% of the students were agree or strongly agree with this statement although 13.63% of them were disagree or uncertain with it.

In addition, item 12 is a negative statement based on the computer instruction and it has similar percentages. The statement is “Computer instruction is an inefficient use of the students’ time”. 92. 42% of the students was disagree or strongly disagree to this statement and only 5. 05% of them were uncertain with this statement. In addition item 16 is, “Subjects that can be boring would be interesting if it is presented with computer”. For this item , 90.90% of the students were agree or strongly agree but only 9.08% of the students were disagree or uncertain with this item.

From these results, we can say that students gained positive feelings and decisions towards computer instruction and they preferred computer instruction to traditional instruction.

4. 3 The Relation of Attitude towards Computer Instruction and Geometry Test Results

Table 4.6 gives the correlation between the post-Geometry tests, delayed-Geometry tests and CAS scores of experimental group students. As can be deduced from the table, the correlations between post- geometry test and delayed-post geometry test; post-geometry test and CAS; and delayed-post geometry test and CAS were significant.

Table 4.6

Correlations between post- geometry test and delayed-post geometry test; post-geometry test and CAS; and delayed-post geometry test and CAS

Experimental Group	Post-test	CAS	Delayed-post test
Post- test	—	.92	.86
CAS		—	.80
Delayed-post test			—

The relationships between post- geometry test and delayed-post geometry test; post-geometry test and CAS; and delayed-post geometry test and CAS was investigated using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. There was a strong, positive correlation between the post-test and CAS (r = .92, N = 66, r^2 = .84). In addition, There were strong, positive correlation between the post-test and delayed-post test (r = .86, N = 66, r^2 = .73); between the CAS and delayed- post test (r = .80, N = 66, r^2 = .64). From this result, we conclude that the students who have high attitude towards computer got better results in the post-geometry tests and delayed-post geometry tests.

4. 4 Experimental Group Students' Thoughts and Feelings about Computer Based Learning

There were three open-ended questions at the end of the computer attitude scale (CAS) in order to get students' thoughts and feelings about computer based instruction. While these open-ended questions were analyzed, the responses were categorized into broad topics. A tally of responses was made using these categories, and then these tallies were converted to percentage charts. These charts generated the trends and anomalies discussed in this study.

Question 1: **How does computer based learning is useful to you while you are learning geometry?**

Most of the students in the experimental group except three students were sure that computer based learning were useful for them. Three students claimed that computer based learning was not as useful as it would be because his/her friend who was the pair of the students in the study did not give much chance to use the computer. However those students also accepted that the figures seen on computer screen were permanent on their mind. Students wrote the benefits of the computer based learning in different ways. These different ways were categorized and the percentages and frequencies are given in table 4.7

Table 4.7: The answers analyses of Question 1: How does computer based learning is useful to you while you are learning geometry?

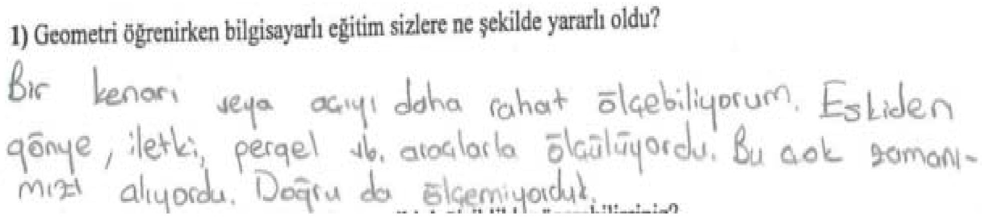
	Frequencies and Percentages
➢ Blank	4 % 6.06
➢ Measuring angles and doing calculations are very easy with GSP.	13 % 19.69
➢ More geometry subject/ concepts were covered with GSP in a short time. So there was no time missing.	6 % 9.09
➢ Solving geometry problems becomes easier with GSP.	9 % 13.63
➢ Seeing the concepts on the computer screen made learning more permanent.	10 % 15.15
➢ Using geometric shapes and animations in	7

Table 4.7 (continued)

GSP were interesting and fun.	% 10.60
➢ Studying with computer is amusing and easy.	6 % 9.09
➢ Studying with geometry was faster and more practical with GSP.	11 % 16.66
➢ Computer based learning were not useful	3 % 4.54

It is seen from the Table 4.7 that 4 students left the question blank, 3 students gave negative responses and 62 students gave positive responses. As it is mentioned above although these 3 students who gave negative responses wrote that the figures seen on computer screen were permanent on their mind.

Some of the students' answers and explanations are given below:


1) Geometri öğrenirken bilgisayarlı eğitim sizlere ne şekilde yararlı oldu?

Bir kenarı veya açıyı daha rahat ölçebiliyorum. Eskiden gönye, iletki, pergel vb. araçlarla ölçülüyordu. Bu çok zamanımızı alıyordu. Doğru da ölçemiyorduk.

Figure 4.2 Student A's response to open-ended question 1 in CAS

"I measure the sides and angles easily. We measured the sides and angles by setsquares, protractors, compasses…etc. However we loose time and we could not measure correctly."

1) Geometri öğrenirken bilgisayarlı eğitim sizlere ne şekilde yararlı oldu?

Konuyu daha iyi anlamamı sağladı. Eğlenceli oldu.

Figure 4.3 Student B’s response to open-ended question 1 in CAS

“ I learn the subject more effectively. It is enjoyable.”

1) Geometri öğrenirken bilgisayarlı eğitim sizlere ne şekilde yararlı oldu?

Bana hem deftere yazmıyoruz zaman gitmiyor. Hem daha zevkli.

Figure 4.4 Student C’s response to open-ended question 1 in CAS

“ We do not write on notebooks so we do not loose time. Also it is amusing.”

1) Geometri öğrenirken bilgisayarlı eğitim sizlere ne şekilde yararlı oldu?

Dersi zevkle dinlememe kolay öğrenmeme yardımcı oldu.

Figure 4.5 Student D’s response to open-ended question 1 in CAS

“It helps me listen the subject gladly and learn the subject easily.”

1) Geometri öğrenirken bilgisayarlı eğitim sizlere ne şekilde yararlı oldu?

Bilgisayarda bir şeklin açı ve kenar özelliğini kolaylıkla bulabiliyorum.

Figure 4.6 Student E’s response to open-ended question 1 in CAS

“I measure the angles and sides of the shapes easily on computer.”

Question2: **What kind of revisions do you suggest to computer based lessons of geometry?**

Most of the experimental group students stated that they were pleased with the computer based learning. Most of them did not offer any suggestions to improve the computer based lessons they involved. In addition four students gave different and interesting suggestions about GSP. They proposed adding a game to GSP so the students who solve the questions before play game until other students solve the question. Students' answers were categorized and the percentages and frequencies are given in Table 4.8

Table 4.8: The answers analyses of Question 2: What kind of revisions do you suggest to computer based lessons of geometry?

	Frequencies and Percentages
➢ Blank	2 % 3.03
➢ Everyone should have one computer	3 % 4.54
➢ Adding a game to GSP	4 % 6.06
➢ It is good so no suggestion	57 % 86.36

From the Table 4.8 we see that 2 students left the question blank, 3 students wanted to study alone, these students wrote that since their pairs did not give them a chance for using the mouse, they wanted to study alone. Four students proposed adding a game to GSP so the students who solve the questions before play game until other students solve the question. In addition 57 students wrote that they are pleased with the computer based instruction and they did not give suggestion.

Some of the students' answers and explanations are given below:

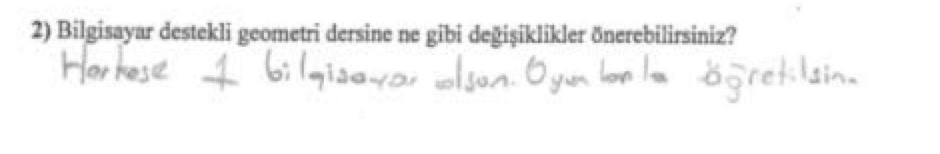

2) Bilgisayar destekli geometri dersine ne gibi değişiklikler önerebilirsiniz?
Herkese 1 bilgisayar olsun. Oyunlarla öğretilsin.

Figure 4.7 Student F's response to the open-ended question 2 in CAS

"2) Everyone should have one computer and the subject should be taught with game"

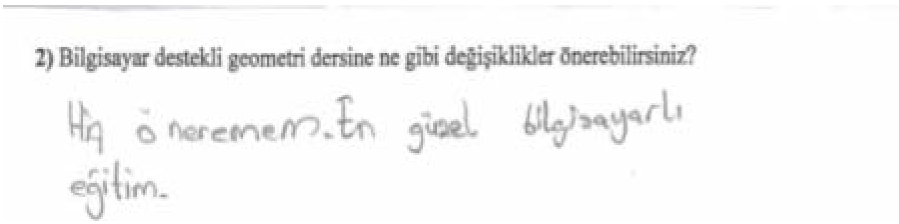

2) Bilgisayar destekli geometri dersine ne gibi değişiklikler önerebilirsiniz?
Hiç öneremem. En güzel bilgisayarlı eğitim.

Figure 4.8 Student G's response to the open-ended question 2 in CAS

"2) I do not have suggestion. Computer based instruction is very nice."

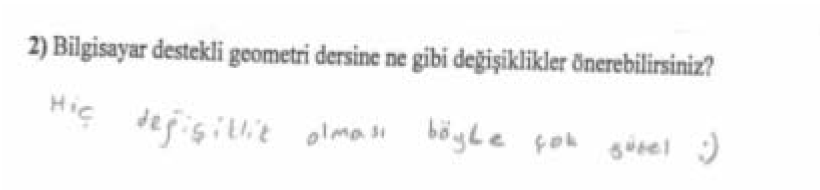

2) Bilgisayar destekli geometri dersine ne gibi değişiklikler önerebilirsiniz?
Hiç değişiklik olması böyle çok güzel :)

Figure 4.9 Student H's response to the open-ended question 2 in CAS

"2) I do not give any suggestion because it is very nice."

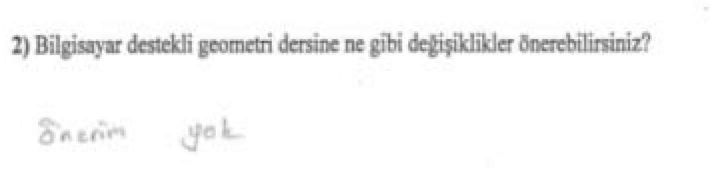
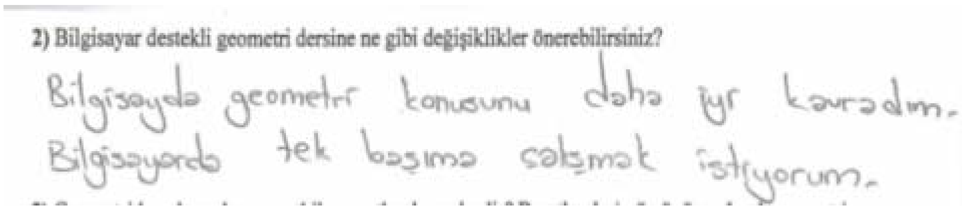

2) Bilgisayar destekli geometri dersine ne gibi değişiklikler önerebilirsiniz?
Önerim yok

Figure 4.10 Student I's response to the open-ended question 2 in CAS

"2) I do not have a suggestion."



2) Bilgisayar destekli geometri dersine ne gibi değişiklikler önerebilirsiniz?

Bilgisayda geometri konusunu daha iyi kavradım.
Bilgisayarda tek başıma çalışmak istiyorum.

Figure 4.11 Student J's response to the open-ended question 2 in CAS

"2) I understand the geometry better on computer. I want to study alone on computer."

***Question 3:* What are the factors that affect your studies in geometry? What kind of revisions do you suggest to geometry lessons based on the factors that affect your studies in geometry?**

For the first part of the question, most of the students stated that drawing figures, measuring edges, angles, using protractor and ruler got so much time so they saw these procedures as a waste of time. Also the students said that it is hard to solve questions in geometry since it is hard to remember.

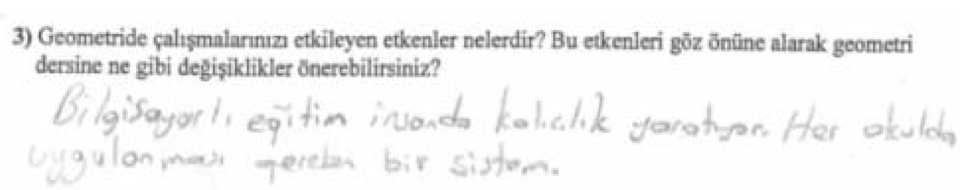
For the second part of the question, most of the students do not give suggestion; they stated that they wanted to continue computer based geometry lessons. Most of the students wanted to learn the other subjects of the geometry by computer based learning. Students' answers were categorized and the percentages and frequencies are given in Table 4.9

Table 4.9: The answers analyses of Question 3: What are the factors that affect your studies in geometry? What kind of revisions do you suggest to geometry lessons based on the factors that affect your studies in geometry?

	Frequencies and Percentages
➢ Blank	2 % 3.03
➢ Drawing figures, measuring edges, angles, using protractor and ruler got so much time so it is a waste of time	24 % 36.36
➢ It is hard to solve questions in geometry since it is hard to remember.	12 %18.18
➢ Continue computer based geometry lessons.	39 % 59.09
➢ Learn the other subjects of the geometry by computer based learning.	18 % 27.27

It is seen from the Table 4.9 that 2 students left the question blank and 57 students wanted to continue computer based geometry lessons and learn the other subjects of the geometry by computer based learning.

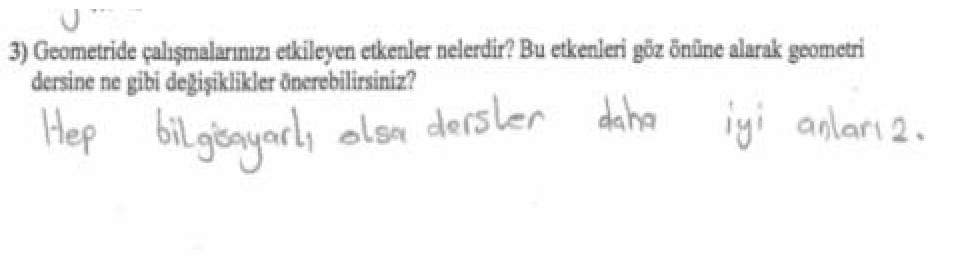
Some of the students' answers to Question 3 are given:


3) Geometride çalışmalarınızı etkileyen etkenler nelerdir? Bu etkenleri göz önüne alarak geometri dersine ne gibi değişiklikler önerebilirsiniz?

Bilgisayarlı eğitim insanda kalıcılık yaratıyor. Her okulda uygulanması gereken bir sistem.

Figure 4.12 Student K's response to the open-ended question 3 in CAS

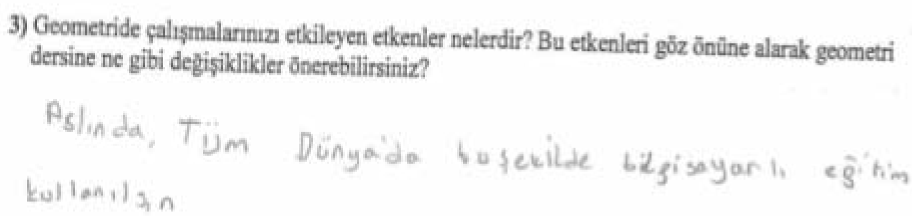
“3) Computer based instruction creates retention. The system should be applied in every school.”


3) Geometride çalışmalarınızı etkileyen etkenler nelerdir? Bu etkenleri göz önüne alarak geometri dersine ne gibi değişiklikler önerebilirsiniz?

Hep bilgisayarlı olsa dersler daha iyi anlarız.

Figure 4.13 Student L’s response to the open-ended question 3 in CAS

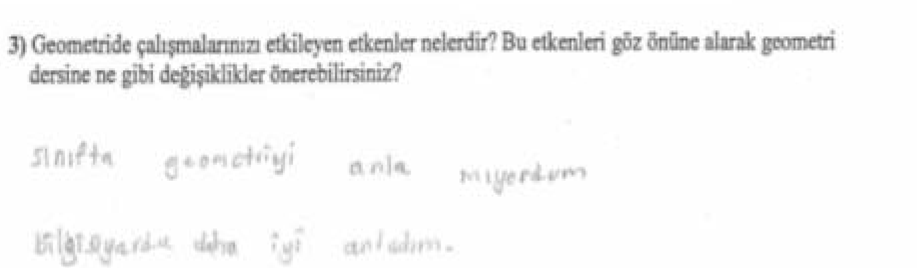
“3) We understand the subjects better if we learn them on computer.”


3) Geometride çalışmalarınızı etkileyen etkenler nelerdir? Bu etkenleri göz önüne alarak geometri dersine ne gibi değişiklikler önerebilirsiniz?

Aslında, Tüm Dünya'da bu şekilde bilgisayarlı eğitim kullanılsın

Figure 4.14 Student M’s response to the open-ended question 3 in CAS

“3) Computer based instruction like that is applied should be used in the world.”

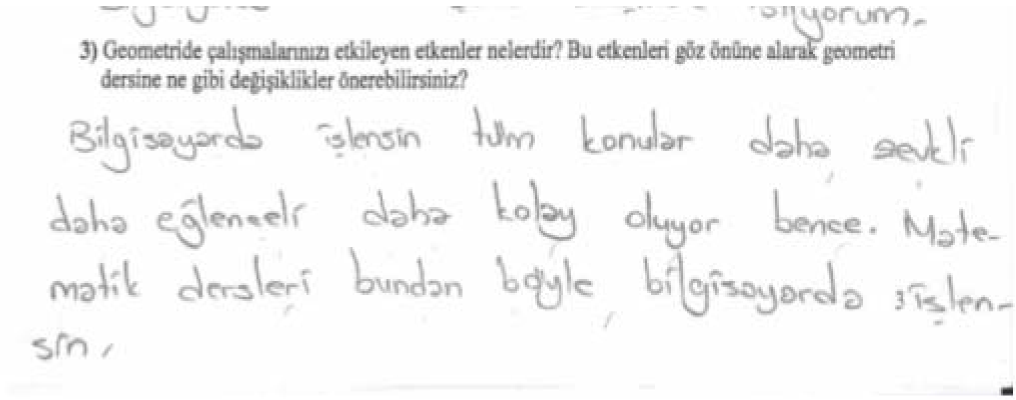

3) Geometride çalışmalarınızı etkileyen etkenler nelerdir? Bu etkenleri göz önüne alarak geometri dersine ne gibi değişiklikler önerebilirsiniz?

sınıfta geometriyi anlamıyordum

bilgisayarda daha iyi anladım.

Figure 4.15 Student N’s response to the open-ended question 3 in CAS

“3) I did not understand the geometry in class however; I understand the geometry better on computer.”

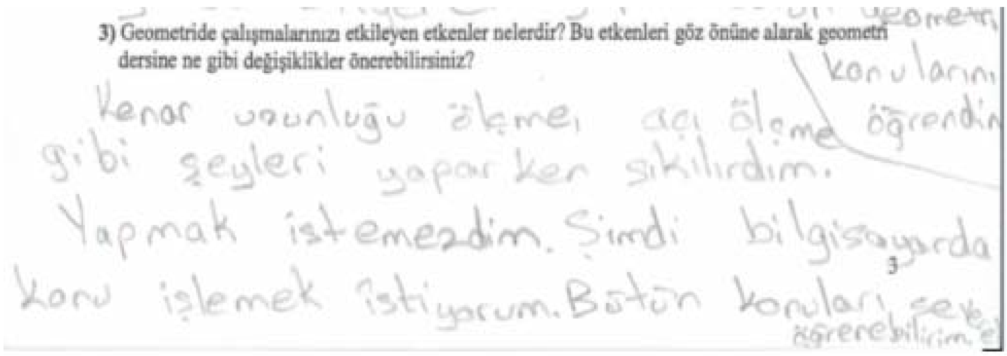


3) Geometride çalışmalarınızı etkileyen etkenler nelerdir? Bu etkenleri göz önüne alarak geometri dersine ne gibi değişiklikler önerebilirsiniz?

Bilgisayarda işlensin tüm konular daha sevkli daha eğlenceli daha kolay oluyor bence. Matematik dersleri bundan böyle bilgisayarda işlensin.

Figure 4.16 Student P's response to the open-ended question 3 in CAS

"3) I think, all the subjects should be taught on computer since it is more amusing, more enjoyable and easier."



3) Geometride çalışmalarınızı etkileyen etkenler nelerdir? Bu etkenleri göz önüne alarak geometri dersine ne gibi değişiklikler önerebilirsiniz?

Kenar uzunluğu ölçme, açı ölçme gibi şeyleri yaparken sıkılırdım. Yapmak istemezdim. Şimdi bilgisayarda konu işlemek istiyorum. Bütün konuları seve seve öğrenebilirim.

Figure 4.17 Student R's response to the open-ended question 3 in CAS

"3) I bored when I was measuring sides and angles and I did not want to do. However now I want to learn the subjects on computer. I can learn the subjects willingly on computer."

4.5 Results of Gender Difference

4.5.1 Gender Difference on Geometry Test

Descriptive statistics for the pre-test, post-test and delayed-post test for females and males are given in Table 4.10.

Table 4.10
Means of pre-test, post-test and delayed-post test
based on the gender difference.

Gender	Pre-test		
	Mean	SD	N
Female	31.76	13.55	65
Male	31.15	13.07	69
Gender	Post-test		
	Mean	SD	N
Female	57.06	17.47	65
Male	56.57	15.37	69
Gender	Delayed post-test		
	Mean	SD	N
Female	49.69	17.40	65
Male	50.04	15.81	69

Table 4.10 shows that the mean difference between girls' and boys' geometry test scores is very small. However, we can not say that these differences are small enough to be considered statistically not significant so we need further analysis. Independent samples t-test was run in order to examine whether there was a significant mean difference between females and males' geometry test scores.

Table 4.11

Independent samples t test for gender difference on pre-test; post-test and delayed post-test.

	df	t	p	Eta squared
Pre-test	132	-1. 56	.16	.014
Post-test	132	-1.49	.19	.012
Delayed post-test	132	-1.36	.18	.013

An independent -samples t-test was conducted to compare the geometry test scores for females and males. Preliminary analyses were performed to ensure no violation of the assumptions of independence of observations, normal distribution, homogeneity of variance, sample size, effect size, alpha level and level of measurement. The assumption of equal variance was not violated ($F = 1.09$, $p = .16$) for pre-test, ($F = 1.17$, $p = .19$) for post-test and ($F = 1.15$, $p = .18$) for delayed post-test. There was no significant difference in pre-test scores for females ($M = 31.76$, $SD = 13.55$) and males ($M = 31.15$, $SD = 13.07$; $t(132) = -1.56$, $p = .16$). The magnitude of the differences in the means was very small (eta squared = .014). In addition, there was no significant difference in post-test scores for females ($M = 57.06$ $SD = 17.47$) and males ($M = 56.57$, $SD = 15.37$; $t(132) = -1.49$, $p = .19$). The magnitude of the differences in the means was very small (eta squared = .012). Moreover, there was no significant difference in delayed-post test scores for females ($M = 49.69$, $SD = 17.40$) and males ($M = 50.04$, $SD = 15.81$; $t(132) = -1.36$, $p = .18$). The magnitude of the differences in the means was very small (eta squared = .013).The results show that females and males were statistically equivalent in terms of their geometrical performance.

4.5.2 Gender Difference on Computer Attitude Scale (CAS)

In this part we look at the relationship between post-geometry test and computer attitude scale for males and females separately. In Table 4.12 we see the Pearson correlation coefficient between post-geometry test and computer attitude scale for males and females.

Table 4.12
Correlations between post-geometry test and computer attitude scale (CAS) for males and females

	FEMALE (N = 32)	
	Post-geometry Test	CAS
Post-geometry Test	——	.79
CAS		——

	MALE (N = 34)	
	Post-geometry Test	CAS
Post-geometry Test	——	.90
CAS		——

The relationships between post- geometry test and CAS for females and males was investigated using Pearson product-moment correlation coefficient. Preliminary analyses were performed to ensure no violation of the assumptions of normality, linearity and homoscedasticity. There was a strong, positive correlation between the post-test and CAS for females (r = .79, N = 32, r^2 = .62). In addition, There was strong, positive correlation between the post-test and CAS for males (r = .90, N = 34, r^2 = .81). Moreover observed value of z is 1.98 and we can conclude that there is a statistically significant difference in the strength of the correlation between geometry test and computer attitude scale (CAS) for males and females. We can conclude that geometry test explains significantly more of the variance in computer attitude scale (CAS) for males than for females. In addition, independent samples t-test was carried in order to examine whether there was a significant mean difference between females' and males' computer attitude scale scores. Table 4.13 shows the means of females' and males' computer attitude scale scores.

Table 4.13
The means of females' and males' computer attitude scale scores.

Gender	CAS scores		
	N	Mean	SD
Female	32	63. 62	.79
Male	34	67. 58	.43

It is seen from Table 4.13 that there is a mean difference between females' and males' computer attitude scale scores. In addition independent samples t-test was run in order to examine whether there was a significant mean difference between males and females' CAS scores.

Table 4.14
Independent samples test for females' and males' computer attitude scale scores.

	df	t	p	Eta squared
Groups	64	-4.37	.000	.12

An independent -samples t-test was conducted to compare the CAS scores for females and males. Preliminary analyses were performed to ensure no violation of the assumptions of independence of observations, normal distribution, homogeneity of variance, sample size, effect size, alpha level and level of measurement. There was significant difference in CAS scores for females (M = 63, 62, SD = .79) and males (M = 67. 58, SD = .43; t (64) = -4.37, p = .000). It is concluded that there is a statistically significant difference in the means of computer attitude scale scores for males and females. This result is also confirmed by the effect size. Eta squared is 0, 12 so the effect size is moderate (Cohen, 1988). The results show that females and males were not statistically equivalent in terms of their computer attitude scale scores. We can say that males got higher scores with respect to computer attitude scale than girls.

4.6 Personal Interview Results

Four randomly selected students from experimental group were personally interviewed by the researcher using a Personal Interview Protocol (see Appendix H). The results of this survey were used as an enhancement to the quantitative study. The intention of the survey was to find specifically what the students liked or disliked about various aspects of the computer based learning and the software. The questions asked them to explain what they did or did not like about experiences. The questions were structured because of the age of the student group. In many cases, unless 12 and 14-year-olds are prompted to answer to a particular characteristic or explain a reason, they will answer with minimal response. Some sample questions that were asked were, “What did you like most about your experiences using the Geometers’ Sketchpad?” and “What was the easiest part of doing the geometric activities ant constructions when using (a) the compass, ruler, and pencil? Or (b) Sketchpad?” An important component of this portion of the research was determining the students’ feeling and thoughts about computer based instruction, and these questions were tailored to determine this.

4.6.1 Results of the Personal Interview Questionnaire

As previously explained in Chapter 3, four students that were placed in the experimental group were randomly selected from each category formed by the independent variables of gender and geometry test results. The four categories were males who have high- geometry test score (HM), males who have low- geometry test score (LM), females who have high- geometry test score (HF), and females who have low- geometry test score (LF). Geometry test score category is determined based on the mean of post geometry test score. The males who got higher than the mean is categorized with males who have high- geometry test score and the males who got scores under the mean is categorized with males who have low- geometry test score. This categorization is same among females too. The students were interviewed after they had been exposed to treatment so that they could make comparisons between the use of the computer software and the construction tools when performing their lessons. The answers to each of the 23 questions were recorded by each of the students.

The questions that were asked attempted to determine if there were differences in gender or geometry test scores regarding their attitude toward the use of the dynamic geometry software. The first question asked, "What did you like most about your experiences using the Geometers' Sketchpad?" All four students indicated that using the software was easier to use than using the protractor and compass. Although the four students had different computer skills and geometry test scores, they were in agreement on this issue of ease of use- For them; the mouse was an easier tool to manipulate than the compass.

The answers to several of the questions seemed to indicate that there were differences that related more to gender than to geometry test scores. The males, for example, always responded positively to the use of the computers when comparing it to the use of hands on tools, not just for ease of use due to manipulation, but also for the understanding of concepts. The interactivity of the software provided them the opportunity for exploration. When asked what differences he noticed between the hands-on tools and the software program, the

LM answered by saying, "the computers let you experiment first," while the HM stated that the hands-on tools were more difficult to use when "having to make changes (to the drawings),"

There were questions, though, that included both females giving positive answers regarding the use of the software program, such as when the HF explained that the construction tools were '"harder to draw a figure- I didn't like the compass. I would always mess the circle up somehow." The LF said that she liked using the software because "you don't have to mess around with the tools." The females were not consistently positive, however, when directly asked-which method they preferred, using the computers or the hands-on tools. Both males answered this question with "computers," whereas both females said "hands-on tools." The explanation that the females' gave was that the hands on tools." The females were easier to use. This was a contradiction is difficult to explain. Perhaps a questionnaire that allowed for more in-depth responses would uncover the reasons behind these inconsistencies.

Some other differences that were found in the interview questions revealed that in many cases the males who have high and low geometry test score and female who have high geometry test score would concur on a response, but the low ability female would disagree. One instance of this was for the question that asked whether they thought they had to concentrate more than they normally did with the use of the software. Both males and the high geometry test score female answered "no." whereas the LF answered "yes." The next part that asked "...in what ways?" she responded by answering "yes" to each item in the list that included, "understanding constructions" "trying to understand the directions to perform activities," and "understanding (how to use) the software." She also favored the use of the construction tools when the others did not because she was more familiar with them than the software program. This was a contradiction to the answer she gave to the first question that asked what they liked most about their experiences using Geometers' sketchpad. For that question, she wrote that the software was easier to use than using the compass and protractor.

A later question asked the students whether they would recommend other students to have the same experience using the software program. All of them answered "yes" to this question, but their reasons were varied. The answers from both of the males indicated that it was a tool that helped them comprehend the information. The LM stated, “because it helps with polygons. It makes you understand them more” and the HM said, “because I thought it was an easier way to learn it.” The high geometry test score female's answer suggested that the manipulation of the software was easier than that of the construction tools, “because if you have to do a project and you need different shapes to draw, you just click on the points,” whereas the low geometry test score female's answer was difficult to interpret. She wrote, “(Others) would probably think it was easier to use,” suggesting that she did not think it was easier to use. She did, however, respond positively that she knew more about geometry than she did before she began the program. Interestingly enough, she also answered “yes” when asked if she thought that she learned more because of using Geometers’ Sketchpad, as did the two males. The high geometry test score female, though, answered that she was unsure “whether one method was better than the other.” This question was followed by “why or why not?” For this question the low geometry test score female (and the high geometry test score male) answered "because it was easier to learn," again contradicting several of the LF’s previous answers.

Because of these many contradictions and inconsistencies, it is difficult to make conclusions about whether the two interviewed females really thought that the software was easier to use, as they sometimes answered, or -whether they thought that “it was the correct answer to give.” The two females, especially the low ability female, showed a negative attitude regarding their inability to understand what they were to do (“it was kind of easy, but some of the lessons . . . were hard" to understand, and "sometimes it was [complicated] and sometimes you don't understand.”). This may have been because the lessons were designed to be "self-taught,” which was unlike the math classes that they were used to having at this school. They were familiar with a direct teaching environment; if they had questions about a topic or did not understand a concept, their questions would be answered immediately by the teacher. This provided a more comfortable and secure situation than the one that was used for this study. For the most part, the students had to determine answers with their pairs and make conclusions to questions that covered new subject. Although any student that had questions about the activities would have them explained immediately, the students needed to raise their hands to initiate this process. In many cases, some students, especially the quiet ones, chose not to ask questions.

The interviewed males were consistent in their answers, showing enthusiasm for the software program, its ease of use, the interactivity of the software, and the use of computers in the classroom. None of their answers reflected an inability to understand the lessons. When asked what they thought was the most difficult part when using the software, the LM replied that he did not think any of it was difficult. And when asked what part of the construction tools part they thought was easier, the HM replied that he thought that none of the construction tools part 'was easier.

The researcher understands that only four students were personally interviewed, which is certainly not a large sample, and that it is possible that the other males and females may not have had the same thoughts. The researcher also knows that one cannot state that a pattern exists based only on these few interviews. Then why, one might ask, were the interviews performed at all? The reason for the Personal Interview Protocol was to gain more insight about the underlying aspects of using the software that would not be evident from taking a written objective test. Certainly ease of use was a factor upon which all four students agreed. The ability to understand more complex relationships easier and faster, such as, the congruent polygons is also similar polygons, was apparent from their answers in worksheets that was collected. The researcher attempted to record and coded these events in the classroom.

The next four paragraphs attempt to give an overall characterization of the respondents and their reaction to their experiences, in the following order. Male who have high geometry test score, male who have low geometry test score, female who have high geometry test score and female who have low geometry test score.

Male Who Have High Geometry Test Score

The high geometry test score male had a score of 85 out of a possible 100 on the Post Geometry Test (GT), in which the overall mean was 69.19 and the mean for the males was 56.57 (see Table 4.10). His answers expressed confidence in the use of computers, and that he enjoyed using the software. All of his answers were very positive relating to the use of the software and its interactivity. He said that one of the things he be liked about the use of the software was that "if you had to go back and change it, you could go back and change it, and do more things in a period." This is a definite advantage for using the software in the classroom setting. He thought that the use of the software provided an "easier way to learn it," as compared to the use of the construction tools. His overall assessment of the software program was that there was "nothing: I really did not like." His Geometry Test score was 85 out of a possible 100, which is slightly higher than the mean for the high geometry test score males in the EG (**M** = 66) and higher than the males (**M** = 56.57).

Male Who Have Low Geometry Test Score

The low geometry test score male had a score of 49 out of a possible 100 on the Geometry Test, in which the mean for post geometry test was 69.19 (see Table 4.1). The LM stated that he liked using the computers and the software for the geometry lessons. He thought that the geometric ideas were easier to understand using the software as compared to the construction tools, because "it gave you more examples" and the "computers let you experiment first." His responses and attitudes regarding the software were positive. One of his responses stated that "computers were easier to work with" than the construction tools. His overall assessment of the experience was "Yes, I liked it. It was easy." Although the use of the software in the mathematics lessons was not of sufficient length to increase his overall geometry test scores, perhaps if it had been used in the classroom for a longer period of time, his geometry test scores would increase. His Geometry Test score was 49 out of a possible 100, which is slightly higher than the mean for the low geometry test score males in the EG (**M**= 47.14) and lower than the males (**M** = 56.57).

Female Who Have High Geometry Test Score

The high geometry test score female had a 82 out of a possible 100 on the Geometry Test, placing her slightly above the entire post test mean (M = 69.19 (see Table 4.1). She considered herself to be a novice to computers and the use of software in general; she gave an overall positive response toward the use of the dynamic software. She did not think that her low technology skill level hindered her performance. However, she was not as enthusiastic as the two males were about the use of the software. When asked if she thought that she learned more using Geometers' Sketchpad than with the use of manipulatives, she was not sure, and called it a "toss-up between the two." She believed that there were advantages and disadvantages to each method. When asked if she thought that using the software improved her learning, she answered, "Somewhat, yes." She explained this by saying that it was easier to manipulate shapes with the use of the software, for example, making them bigger by just "clicking on a point." She also thought that it was easier to visualize relationships with the use of the software, an important feature of this software program for enhancing the development of concepts. She rated her overall experience as "Good. It was interesting to use the software." Her Geometry Test score was 82 out of a possible 100, which is slightly higher than the mean for the high geometry test score females in the EG (**M**= 67.14) and higher than the females (**M** = 57.06).

Female Who Have Low Geometry Test Score

The Low geometry test score female had a score of 46 out of a possible 100 on the geometry test, in which the post geometry tests mean was 69.19. On the Personal Interview Protocol, she expressed having difficulty understanding the lessons. The lessons contained many situations that required the students to observe several examples of figures that followed a pattern or showed a relationship. These portions were always followed by an open-ended statement for each to complete in order to see if he or she understood the given pattern or relationship. Many students had difficulty completing these statements. When asked, "What was the most difficult part" of using the software, she replied, "trying to follow the directions and trying to understand (what to do)." Additionally, her answers were highly inconsistent. On early questions on the Personal Interview Protocol, she said that the software was easier to use than the construction tools; she responded on later questions that using the construction tools was easier because she was more familiar with how to use them. Later on the questionnaire; she indicated that the software made it easier to manipulate the lines, points, angles; easier to understand the relationships among lines, points, angles; and easier to visualize the relationships than with the use of the construction tools. Yet in another question she indicated that she had difficulty visualizing possible relationships. She also answered that the directions for the construction tools lessons were easier to understand, even reweigh the directions were exactly the same for both construction tools and software lessons. She mentioned several times that she had problems understanding how to perform the lessons, but she did not have any difficulties understanding how to use the software. She gave an overall assessment of the experience as “Good overall, although I sometimes got confused when trying to figure out what they wanted.” Her Geometry Test score was a 46 out of a possible 100, placing her at the mean for the others in her sample group of low geometry test score females (46.98), but slightly lower than the mean for the entire sample of females, of 57.06.

4.7 The Results of the Lessons Video Tapes

4.7.1 The Experimental Group Lessons

Part I: Getting Comfortable with Drawing Tools

In worksheets 1 to 4 while students applying the activities, students used Sketchpad's point, segment, line tools to create simple drawings and measure angles and line segments length. Students were given time for unstructured doodling. To emphasize that figures, once drawn, could be translated, rotated, stretched, or shrunk, researcher asked students to drag objects and describe the resulting effects.

In the conversation excepted below, student A and B draw a triangle and they tried to decide the regions in worksheet 1.

Student A: I think we want…all these points to have different characteristics. Point A moves on point B (students A drags point A and sees the triangle grow around the stationary point B)… Point B moves on point A (student A drags point B, creating the same behavior.

Student B: That is also changing the size of the interior and exterior region of the triangle.

Student A: Yes….

Unlike student A and B, student C and D discussed that if the polygons itself is a region or not.

Student C: As you see we can create point in the exterior region and in the interior region. Also we can create points on the triangle too.

Student D: I think it is also a region

Student C: triangle?

Student D: yes

Most of the students discussed if a polygon itself is a region or not and students tried to decide by dragging the points of the triangle. In addition some of the students like A and B only focused on interior and exterior region.

In worksheet 2, students tried to decide the figures are polygons or not and they create polygons and labeled them. In the conversation excepted below, student E and F discussed the properties of polygons while they were creating polygons;

Student E: Let's draw a quadrangle we know that it is a polygon and then we label it.

Researcher: Please drag the quadrangle that you create, if you do not connect two sides it will be a polygon or if I change the one of the line segment to the curve, it will be a polygon too.

Student F: I think they are not be polygons

Most of the students discussed the properties of polygons and they labeled the polygons based on the number of the sides.

Student F: quadrangles have four sides, four angles and four edges so we should label the polygons based on the number of sides, angles and edges

Student E: Sides number is enough since the number of sides, angles and edges are equal.

Student F: True…

By this way students have a chance to create polygons and transformed them into irregular forms so that the students could discover special cases of their original constructions. In this way, the dynamic geometry environment allowed students make their own explorations and investigations and have their own conclusions without depending on prototypes.

In worksheet 3, students used basic properties of GSP and they define the regular polygons based on their measures;

Student G: I want to measure the length of the sides and the angles of the first figure

Student H: OK, then I do them for the second figure

Student G: It is very good all the length of the sides and the measures of the angles are equal

Student H: It is same for the second figure

Student G: We can write here that regular polygons are the polygons which have equal sides and angles

Student H: I am writing

Students made their own conclusions based on their measures; they had a change to examine in a short time.

In worksheet 4, especially students used the easy way of experimentation. They compare many polygons if they are regular or not based on their measures of the length of the sides and the measures of the angles. It was observed that student were very glad since they measures length of the sides and the measure of the angles of many polygons in a very short time and they wrote their conclusions.

Student I: I finished the measures of the angles

Student J: I will finish the measure of the length of the sides

Student I: It is amazing

Student J: Yes, everything is automatic

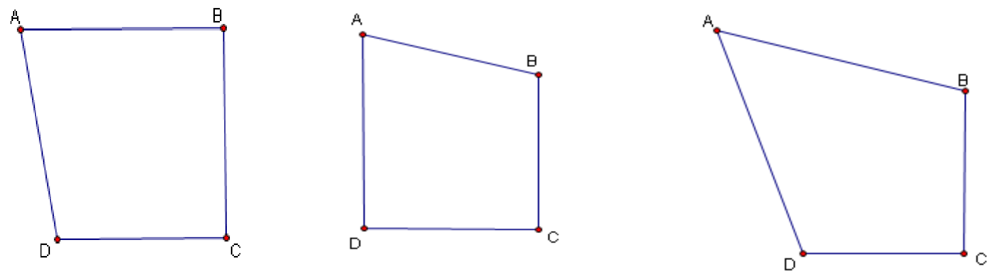
In addition students are sure that their measures are true and they trust themselves more. In worksheet 1 and 2 they were shy while they were explaining their answers but now most of them trust themselves and they were more willingly try to answer the questions.

Part II: Building Geometric Constructions

In worksheets 5 and 6, students used Sketchpad's construction menu items by building midpoints, parallel lines, and perpendicular lines.

In worksheet 5 students created square and rectangle. In the conversation excepted below, student K and L tried to construct rectangle, they could not constructed square correctly. They knew the properties however one of their quadrilateral's angle is 89, 1 degree and they ignore this and they accepted that the quadrilateral that they constructed is a square. Student K is girl and Student L is boy. The conversation began with description of student L why his quadrilateral ABCD is not a rectangle

Student L: Well, it's not exactly a rectangle, but if you move point A out, then D has to come out with it. If you move point A up, B has to come. If you move point A diagonal, then they [points B and D] have to go up and to the side.



"out" "up" "diagonal"

Figure 4.18 The explanatory images for the Student L explanations while constructing a rectangle

Student K: I think we should begin with drawing a line segment, and then we can construct line segments which are perpendicular to this segment. However I forgot to draw perpendicular lines

Student L: I forget too but let me try

Student K: No, I think we should ask to the teacher

Student L: That is not need too, I can do

It is observed that most of the girls tried to ask to the researcher while they have a problem with the properties of the GSP, on the other hand boys tried to find by themselves. In addition, generally the boys stayed at the break times in order to discover the different properties of the GSP. Boys were more willing to solve activities using computers compared with girls.

Student L: I draw the perpendicular lines

Student K: Let me measure the angles if they are ninety degree or not

Student K: We now try to make the opposite sides to be equal

Student L: You have a point

Most of the students learn the aspects of the figures while they are constructing and dragging the figures. In addition students create mental models for thinking about geometric shapes while they are constructing.

In worksheet 6, students learned constructing the polygons in different ways. In the dialog below Student M and N constructed regular triangle and tried to construct hexagon.

Student M: I can not draw a circle which has the same radius with the other one

Student N: Let me try, you see it is very easy

Student M: I can draw the other circles

Student N: It is amazing if we connect the points, we can get a hexagon

Student M: I think it is a regular hexagon

Student N: yes it is a regular hexagon

Researcher: How can you decide if it is a regular polygon or not?

Student M: By measuring it is length of sides and angles

Researcher: look the measures…

Student N: they are same

It is observed that while students constructing the shapes, they were able to make connections between the shapes and their properties.

Part III: Analyzing and Reconstructing pre-Made Sketches

In this part, with a basic understanding of Sketchpad's drawing and construction features, students moved to the worksheets 7-8-9-10 which students was interpreting and reconstructing pre-made sketches. Prior to the sessions, researcher built constructions and saved them. When students opened the sketches, researcher asked them to drag each sketch element with their mouse and describe the resulting onscreen actions. They were encouraged to consider the types of motion, the constraints that might be present in the construction, and the geometric relationships of the objects. With these conjectures in hand, students attempted to build the identical sketches from scratch.

In worksheet 7, students compare the congruent figures.

Student P: I copied this polygon (hexagon)

Student R: I can measure the angles and the length of the sides

Student P: I think, it is not need to be because they are copies of each other so the measures must be same

Student R: So the figures must be equal

In worksheet 8, students compare the rectangles which are drawn by the researcher. These rectangles were saved on their computers. Students drag the rectangles.

Student T: I think the small rectangles are congruent

Researcher: What about the big rectangle and the small ones

Student U: we should measure the angles and length

It is observed that students investigate different forms and orientation of the rectangles by modifying the constructions.

In worksheet 9, students analyze the pre-made figures based on the congruency and similarity concept. In the conversation below students discussed the congruency and similarity.

Student V: I find the congruent ones

Student Y: The others are similar

Student V: But I can not decide that if the congruent figures are similar too.

Student Y: I think it is not

Student V: I find…It is similar because angles are equal and the length of the sides needs not to be equal…however if it is equal I think it is not a problem so congruent ones can be similar

Student Y: I do not think so

In the activities, it is observed that students are not spectators, all of them try to join the activities and discussed with their pairs about the activities.

In worksheet 10, it is the last activity and it is observed that in the break time still some of the students stayed in the computer laboratory in the break time in order to finish the activity as same as the other break times. In addition, students attend the lesson on time and participate the activity willingly like the previous activities. It is seen that their motivation was not decrease.

4.7.2 The Control Group Lessons

When the control group lessons analyzed in the same manner it is observed that students showed lack of interest and curiosity. Generally most of them are the spectators while they were measuring angles and the length of the sides of the figures since they generally forget the materials which are protractor and ruler. Most of them wait the results while their friends who brought the materials complete the measuring. In addition the students had problems while measuring the angles and generally they do not want to say their results.

Student X: the angle is 45 degree and the other is 50 degree

Student Z: I find two of them 50 degree

Student X: I will measure again

Students are not sure of their measurements and they were boring when they measure the angles of three or four polygons and they did not want to continue to measure. Generally the teacher remind the subject of the previous lesson while she beginning the new subject. She generally do this remind by asking questions and only a few students try to answer, others prefer to listen. Most of the students' motivation is low in the geometry lessons, only some of them willingly try to answer the questions.

CHAPTER V

DISCUSSIONS, CONCLUSIONS AND IMPLICATIONS

The discussions, conclusions and implications of the study are given in this chapter. First, the development of students' understanding of polygons and congruency and similarity of polygons, attitudes towards computer based learning, the relationship between attitudes towards computer instruction and students' geometry performance and dynamic geometry software are discussed and some of the conclusions are given. Then the implications and suggestions for further research part takes place.

5.1 The Development of Students' Understanding of Polygons, Congruency and Similarity of Polygons.

The aim of this study was to investigate the effect of Geometer Sketchpad (GSP) use in a dynamic instructional environment together with open-ended explorations on sixth grade students' geometry performance. The treatments on both experimental and control groups were applied at the same time period. Experimental groups' lessons took place in computer laboratory and the subjects were taught with GSP that means experimental groups were taught with computer-based teaching method. Several handouts were used in the training of the experimental groups. However, the control group students did not attend computer activities. The students in the control groups were taught by the traditional teaching method in regular classrooms. Pre-Geometry Test results showed that students' mean scores in the experimental and control groups did not differ significantly. Thus, it was concluded that both groups were equivalent in terms of their performance in geometry at the beginning of the experiment.

When we compare the pre and post geometry test means of the students in experimental and control groups, the results show that the treatment created prominent improvement in experimental group students' achievement in polygons and congruency and similarity of polygons. Likely, post Geometry

Test results and the qualitative study of lessons video tapes show that experimental group students' performance was increased by the treatment. This result point out that computer based learning together with open-ended explorations has expedited students' better understanding of the geometric concepts thought.

In addition, when the students' explanation items were analyzed (table 4.3), it denoted that experimental group students' understanding was deeper in content than control group. It means that students in the experimental groups use critical properties (the properties that each example should have in order to belong to the category) in their definitions and can give examples in their explanations. Moreover, they can look from the other aspects while they are answering the questions. The students who studied with GSP in this study were not addicted to prototypes. It was observed that there are important differences in students' definitions and explanations in pre and post tests. Although students' solutions in the experimental groups did not include any criticisms about the properties of the shapes, their solutions did include critical attributes in the post-test. The reason for this difference would be the visualization we can conclude this based on the qualitative analysis of lessons video tapes, interviews and open-ended questions in CAS especially the distinction between a drawing and a construction that GSP allows. Students can drag the figures while they are constructing. Dragging is a critical component of dynamical software; it enables a student to form a different perception, or perhaps a different understanding of geometry. Student needs to be conditioned to place constraints on constructions. In this way the student can study aspects of shapes. For example, in a classroom, a teacher draw figures on the board and informs the students that the figures drawn are polygons and give all the properties based on these figures.

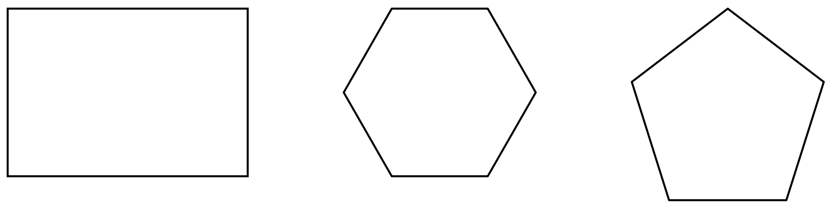


Figure5.1. Common teacher drawings of polygons in a geometry lesson

As an experienced teacher I have observed that the geometrical shapes that presented in Figure 5.1 are the common drawings of polygons in geometry lessons.” The figures are drawn on the board while introducing polygons are generally the regular polygons. Most of the students saw these regular polygons on the board so they did not accept irregular polygon as a polygon. When students’ answers were analyzed in pre-geometry test nearly all of the students write “it is a polygon” only to the regular polygons and they write “it is not a polygon” to the irregular polygons. These generic shapes of polygons cause students to have prototypical shapes on their minds. However, GSP allowed students to play with the figures, construct dynamic and flexible geometric shapes by dragging and dropping dynamic parts of the shapes, it was observed from the qualitative analyze of lessons video tapes . Moreover, they created polygons and transformed them into irregular forms so that the students could discover special cases of their original constructions. In this way, the dynamic geometry environment allowed students make their own explorations and investigations and have their own conclusions without depending on prototypes.

In fact, it would seem that many students acquire mathematical ideas only procedurally, without connecting procedural to conceptual knowledge. That is, students often perform sequences of mathematical processes without being able to describe what they are doing or why, perhaps as visually moderated sequences as described by Davis (1984). Most of the cognitive science models as mentioned in Chapter 2 do not address students’ development of qualitatively different levels of thinking and representation, belief systems, motivation, and meaningful interpretation of subject matter, and they de-emphasize the roles of sensorimotor activity, intuition, and culture in mathematical thinking (Cobb, 1989; Fischbein, 1987). Nevertheless, the theories provide insights and useful metaphors, as well as specific explications missing from most other perspectives like Piaget and van Hiele theories. Therefore, learning procedure in this study is explained by depending on cognitive science models. In this study procedural learning occurs in executing a skill means students learn by doing activities on computer. When declarative information is in the form of direct instructions in worksheets, step-by-step interpretation is straightforward. The student has opportunities to activate conceptual and procedural features of the current topics in this study simultaneously. By "activating" we mean certain mental or concrete manipulations of the representatives of each type of knowledge. Being in the intersection of two complementary approaches (procedural and conceptual), the simultaneous activation view is loaded with some expectations concerning the planning of learning environments. Dynamic environments give chance for these kinds of activities (Holton, 2001; Kadijevich& Haapasalo, 2001). Also, proceduralization is complemented by a composition process combining sequences of activities in computer laboratory.

In addition, the dynamic geometry environment helped students create mental models for thinking about geometric shapes (Jones, 2001; Üstün & Ubuz, 2004; Velo, 2001). Such studies also support students' development and understanding of the conceptual system which is based on properties and used in geometry to analyze shapes. In a dynamic geometry environment students do not have to memorize the properties of geometrical shapes. Thus, this would have increased level of students' geometrical thinking. Computer based learning involves students as conceptual participants, not spectators in the process of studying geometry. In this study, all of the students participate to the activities; none of them is a spectator. This results support the results of previous studies by Kakihana and Shimizu (1994) and Clements (1987).

Experimental group students had difficulties while they are naming the geometric shapes before the treatment. When the form of the shapes changed, the students could not define the shapes since they have shapes prototypes on their minds. In this respect, GSP helped students to investigate different forms and orientations of the shapes by modifying the objects' constructions. By this way, students start visual considerations of the geometrical shapes. At the end of the treatment, students were able to make connections between the shapes and their properties, and organize different classes of geometrical shapes hierarchically. This result of the study supports that dynamical geometry software together with open ended explorations helps students to develop better knowledge of geometric concepts and a richer understanding of conjecturing skills as reported by Clements and Battista (1992).

Computer based instruction together with open-ended explorations in the study had a significant effect on students' retention. This result is supported by delayed post-test results. Dynamic geometry environment together with open-ended explorations increased scores on follow-up examinations given three months after the completion of instruction, however retention effects were not as clear as the immediate effects of computer based teaching. This result indicated that experimental group students kept their knowledge after the treatment. This result is consistent with the findings of an earlier study (Kulik, Bangert, & Williams, 1983).

5.2 Attitudes towards Computer Based Learning

At the end of the treatment, an attitude scale towards computer instruction was administered to the students in the experimental groups to understand their attitudes towards computer based learning environment. Also, interviews were conducted with four students from the experimental group in order to get their feelings about computer based learning. Attitude scores and interview analyses showed that students had great interest in learning geometry with dynamic instructional environment. The researcher noticed from the interviews and classroom observations that experimental group students were rarely bored in the instruction (also they study at the free times between the lessons); however control group students often showed lack of interest and curiosity. In addition, experimental group students' approach to the topics and their motivations was better than that of the control group students. Most of the experimental group students said that they liked computer based study and enjoyed very much. Moreover, they wanted to continue the lessons with GSP. Similar results were reported by Alkalay (1993).

Dynamic geometry environment together with open-ended explorations also affect the students' behaviors in the positive manner. It was observed that students attended the lessons on time, participated the activities willingly and stayed at the computer laboratory after the class sessions for to study or examine the GSP in details. In the experimental group, it was also observed that students' works, results they found and comments they brought become more accurate and complicated than they used to be. At the beginning of the experiment students were backward while they were expressing their comments and they used everyday words in their comments. However, after one or two activities on computer, they saw that they made true measurements and they tried to use more complicated statements in their comments. In addition they trusted themselves and they were more willing to say their comments.

5.3 The Relationship between Attitudes towards Computer Instruction and Students' Geometry Performance

The results show that students who had more positive attitude toward computer instruction, showed a high performance in post-test and also in delayed-post test. Likely, Munger and Loyd (1989) support this finding that they found a significant relationship does exist between mathematics performance and attitudes toward technology. We can say that, based on the quantitative and qualitative results of this study; the dynamic geometry environment together with open-ended explorations has a positive effect on geometry performance. In addition based on the quantitative study, there was a significant gender difference with respect to computer attitude scale in favour of boys and this result was also supported by qualitative analyses of interviews. The result was consistent with the findings of other researchers (Koohang , 1989; Chen , 1986; Levin & Gordon , 1989; Massoud , 1991; Shashaani, 1993) that male students showed greater interest in the computer and its uses than females. Boys spend more time with computers than girls. In break times, generally the boys stayed in computer lab and continue to activities. In addition, boys were more willing to solve activities using computers compared with girls in the treatment. Geometer's Sketchpad (GSP) was a new program for the students of the experimental group, but boys were more eager to learn the software. Before the treatment when the students were given an instruction on how to use Geometer's Sketchpad (GSP), boys preferred to learn by trying and testing instead of asking questions to the researcher. Also, it was observed from the lessons video tapes analyses that girls were not as confident as boys when using computers. On the other hand, there were no significant gender difference was found with respect to geometry test. The result was consistent with Halpern (1986), Fennema (1974), Fennema and Carpenter (1981) and Stage, Kreinberg, Eccles, and Becker (1985) who reported that boys and girls did not differ in their mathematics and geometry performance during elementary school.

The results of this study show that GSP is an effective tool for independent inquiry and investigation in geometry in elementary school level. And this study supports the use of GSP to develop basic geometric knowledge and students' attitudes towards geometry (developing in attitudes towards geometry is said based on the three open-ended questions in CAS and interviews).

5.4 Dynamic Geometry Software

This study has also attempted to examine a variety of aspects that are associated with the use of dynamic software in mathematics classroom. It clearly demonstrates the instructional effectiveness of Geometers' Sketchpad as compared to the use of traditional construction tools. Being able to click with the use of a mouse and change the measurements of angles and segments helped the students to remember the results better than students who used a ruler and protractor to draw and redraw the same angles and segments. There are number of reasons for this conclusion. The reasons that are addressed are the novelty of the software and computers; the automaticity that the software provided; the visual aspect that the software provided; the interactivity of the software and the case of experimentation.

First of all, one influence was the novelty aspect regarding the use of a different type of software and the use of computers as a regular part of the classroom lesson. The sixth grade classes at this school have used dynamic software in geometry firstly. The computer lab was used for special project assignments, such as using a spreadsheet to plan a party or create a budget. If particular software programs were used, they were of the types that used logic or numeric games to provide practice in computational skills. For the experimental group students the computer lab was their mathematics classroom for two weeks. The software and the lessons derived from the software were directly tied into their classroom learning and covered topics that were new to them. They had not been previously involved in any similar program in their mathematics classes.

The second reason that the software proved to be a more effective tool than the construction tools was the obvious nature of its automaticity. The software program had several tools and operations that were automated, making the use of the software very efficient. The various measures that the software could determine illustrate part of its flexibility. The software program automatically calculated the measure of angles, sides, areas, and perimeters. In addition, as the drawings of the angles, sides, areas, and perimeters were stretched or shrunk by the user, the measurements changed in real time. These ties into a visual aspect that is discussed in the next paragraph, in which the deliberate changes made by the users caused a resulting change in the numerical measurement. The cause and effect relationship that this software provided gave the opportunity for students to make conjectures based on their observations. A second automated tool that was not as dependent on the dexterity of the student as the use of construction tools. There were several instances when the students in the tools group became frustrated using the compass, especially when drawing circles. Although there were no physically handicapped students in this project, it could be an important factor for using the software over the construction tools for those individuals that have coordination difficulties.

Thirdly, the visual demonstrations that were provided by the software and the accompanying lessons were more effective visually than the printed page. The ability to clearly visualize geometric models is an important first step in the problem solving process. The computer screen displayed figures formed by the software program that could be altered, measured, moved, stretched, and shrunk. The students could see these changes while they were making them. If a mistake was made in the manipulation, it was also clearly seen and understood by the user. The construction tools group drew their figures on a piece of white paper. It was not possible for them to move the figures without moving the paper, unless they erased them and redrew them. After several mistakes the paper sometimes became damaged and darker in color, so that it was difficult to see the figures. Because they were not as coordinated with the use of compasses and pencils as a more experienced person may be, this happened frequently in the tools group.

The interactive nature of the software relates to the visual component that was discussed in the previous paragraph. It is difficult to separate the two, since they rely so heavily on the visual learning process. Manipulatives are physical objects that are used in the mathematics classroom to assist visually in the development of the understanding of abstract concepts, and much research supports their use (Behr, 1976; Branch, 1973; Kennedy, 1986; Reys, 1971). They serve as useful modeling tools to assist the teacher in the representation of abstract ideas (NCTM, 1991). For example, sheets of transparent plastic can be used as manipulatives to represent planes, whereas sticks or rulers can be used to model lines and segments. These tools provide a visual representation of geometric ideas that help the students to understand how these ideas relate to each other. The models are somewhat limited, however, because they do not have all of the characteristics of the idea they are used to model. Since a sheet of transparent plastic has a definite length, width, and thickness, unlike a true plane, many students are confused when it is used to represent a plane. It is difficult for them to think in abstract terms of infinite length or infinite width because these terms have no relationship to the students' real world. A line or a ray that is drawn on the computer screen with this software does continue as far as they are able to scroll on the screen. There are no other limitations. It seems apparent that the interactive component of the geometry software used in this project not only replaces the need for standard manipulatives, but surpasses them.

Another example of the benefits of the software is that students can construct or observe previously constructed special shapes. As the students change the size of a particular angle, the number indicating the angles measure of degrees subsequently changes and can be easily observed. It allows the student to look at many special cases and several examples in a minimal amount of time. This interactive nature of the software provides an instant visual feedback, an important feature that is not available when a student has to stop and measure several angles when using a protractor, paper, and pencil. The student who is confirmed to the use of paper and protractor to measure several examples, and, while doing this, to also concentrate on the correct way to measure an angle, may be misdirected from the original conjecture of what he or she was trying to do. This is especially true for novices that are learning several new situations concurrently.

The software provided an easy way to allow for experimentation and conjecturing. One student, in the interview when asked what differences he noticed between the hands on tools and the software program, he said that “the computers let you experiment first.” In order to explore, however, they must first be given a chance to explore. One of the important features of Geometers' Sketchpad was that it facilitates the testing and making of conjectures (Clements & Battista, 1994). Students were able to draw for more diagrams, and more accurately, to support a generalization. These generalizations were performed in a self-directed learning type of environment. The software, along with the technology of the desktop computers, provided a one to one discovery, yet guided process that allows students to model and explore. In the past, students have accepted the textbook classification because it would take too much time to explore, to make tables, to conjecture, and to make sure that all possible cases would be investigated. The use of this software provided a way for this to happen without using a large amount of class time and would also give the students experience in the dynamics of the exploration process. Having students share in the exploration and conjecturing process will increase their involvement and participation in the mathematics classroom.

5.5 Implications and Suggestions for Further Research

The main aim of the geometry instruction is to develop students' spatial ability and visual awareness through the considerations of geometric shapes and interactions of these shapes (NCTM, 2000). Conjecturing, discovering, analyzing and reasoning should be the daily routine of geometry lessons and GSP is an important tool of this structure if it is used correctly in the classrooms. Classroom environment plays an important role in how students learn geometry. Shoenfeld (1989) claimed that student' beliefs of what geometry is really all about are determined by the daily practices done in the classrooms. Students might believe that success in geometry has more to do with speed and memorization than reasoning if students are only encouraged for quick algorithmic solutions. However, if teachers believe that geometry should be a sense making activity then conjecturing, discovering, analyzing and reasoning should be the daily routine of geometry lessons.

To achieve these purpose it will take enormous effort on the part of the education community, the reason is that it will require a re-training of teachers. Well-trained teachers can use computers to improve their student's attitudes, and they can coordinate computer lessons with classroom assignments, read reports to monitor student progress, create incentives, and use reports to diagnose and remediate individual student's skill deficiencies (Sherry, 1998). Teacher preparation in the use of technology can help ensure that teachers use technology to improve student achievement. The power of technology for student learning does not come from the presence of classroom computers, the real power of technology in education will come when teachers have been trained well and have captured the potential of technology themselves. Teachers must model the behavior students are expected to learn. In order to maximize the effectiveness of computer-based instruction, teachers must be given the time and training necessary to understand how to take advantage of its strengths. Teachers also need training in how to coordinate the use of computers with their regular classroom instruction. The trainings could be given in summer courses or workshops. In addition new graduated teachers should be informed about the dynamic geometry soft wares usage. It can be done by giving must courses about these dynamic soft wares before being a teacher.

Recommendation for Curriculum developers and Authors;

New curriculum developers added this statement: “dynamic geometry soft wares can be used” (Ministry of National Education, 2004) in some of the concepts of the geometry in the curriculum. In addition the authors did not mention dynamic geometry soft wares in the textbooks. Authors can introduce the dynamic geometry soft wares in the textbooks and can give activities based on the dynamic geometry environment. However a text should made the students use the motion features of the dynamic geometry software. For example, provide students a sketch displaying a collection of rectangles, all with different orientations and sizes. Rather than asking students to drag these shapes and resize them, a text might instead restrict students to using dynamic soft wares measurement tools to answering the question. “Do the given quadrilaterals satisfy the definition of a rectangle?” This idea ignores the power of dynamic geometry soft wares’ motion features. Therefore authors should prepare the activities based on the dynamic geometry soft wares’ motion features. In addition, authors who wish to make dynamic geometry a more central component of their texts will need to focus attention on several dynamic geometry related issues. From a terminology standpoint, text must adopt their definitions of geometric objects to reflect the nature of dragging. Also given what is already a growing diversity of dynamic geometry software programs or provide more generic directions that can be applied to any software package. Finally the teacher additions that accompany these texts should document some dynamic geometry related learning issues.

Recommendations for future research;

Based on the findings of this study, a number of possibilities for future research are available. Among the possibilities are:

- To investigate the students' gained spatial ability by the dynamic geometry environment. Spatial ability is important in geometry learning so it is meaningful to look how the spatial ability level is affected by dynamic geometry environment.
- Conduct this study for different concepts of geometry. It is needed to look students' success in different subjects which is given with dynamic geometry environment. It is important to look since if dynamic geometry environment is as affective as in different geometry concepts.
- Compare groups of students over one academic year. This would be important in terms of whether the students would show same willingness for dynamic geometry environment in one academic year or not. In addition, whether duration of the treatment for a longer period would affect the students' successes or not is also important to make more generalized conclusions about integrating dynamic geometry into the whole curriculum.

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APPENDIX A

GEOMETRY TEST

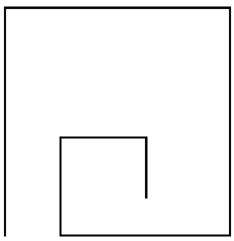
AD, SOYAD:
SINIF: NO: YAŞ: CİNSİYET:

GEOMETRİ TESTİ

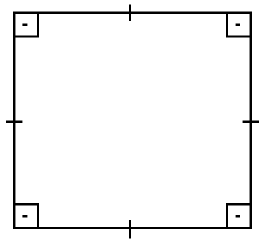
1. Aşağıdaki düzlemsel şekillerin çokgen olup olmadıklarını belirleyiniz.

Çokgen olanların adını yazınız;çokgen olmayanlar için ise açıklama yapınız.

Örnek:

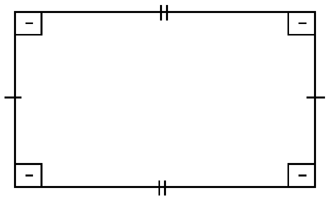


Kapalı şekil olmadığı için çokgen olamaz.



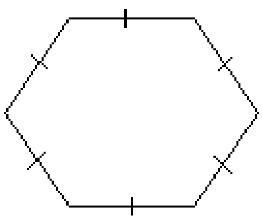
Kare (Dörtgen)

a)

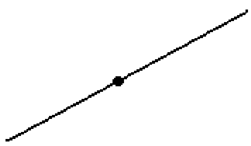


b)

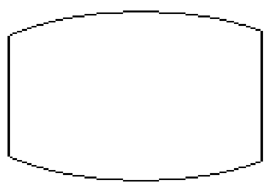
c)



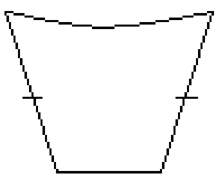
d)



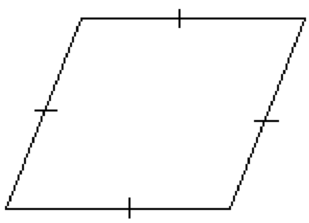
e)



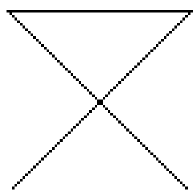
f)



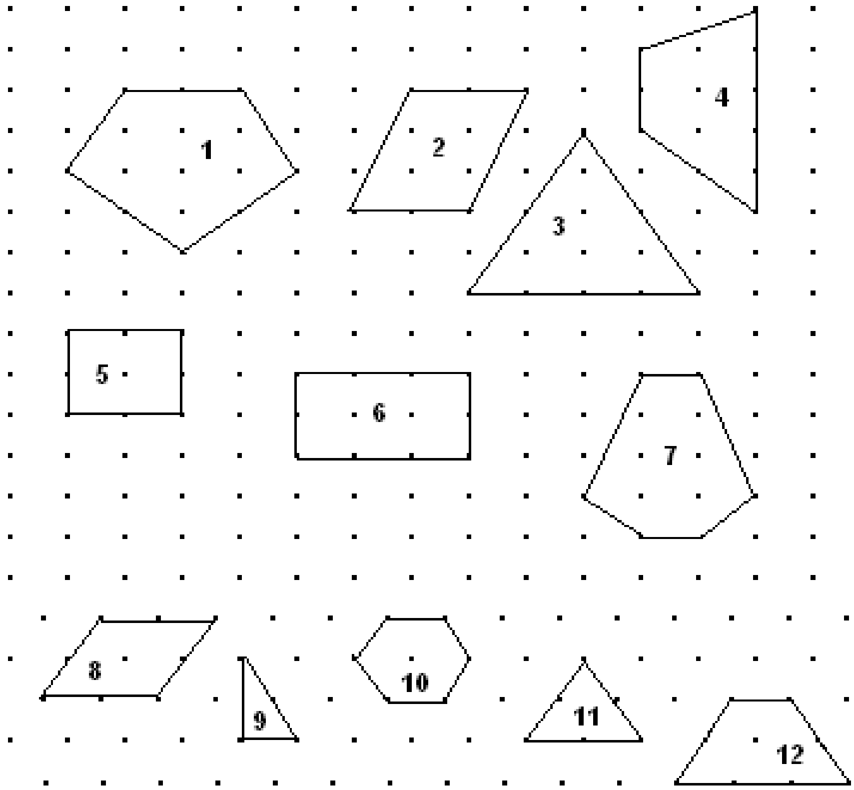
g)



h)

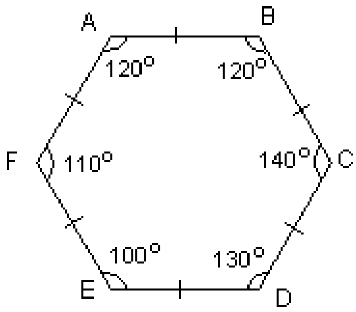


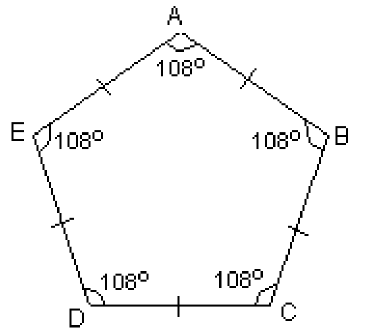
2. Aşağıdaki şekilleri, belirtilen özelliklere göre sınıflandırarak tabloyu doldurunuz.

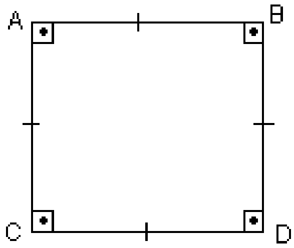


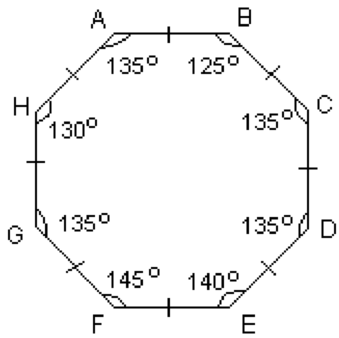
a) Paralel kenarı olan şekiller	
b) Üç kenarı olan şekiller	
c) Dört kenarı olan şekiller	
d) Beş kenarı olan şekiller	
e) Altı kenarı olan şekiller	

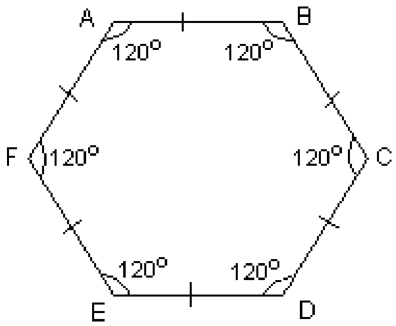
3. Aşağıdaki çokgenlerin kenarlarını ve açılarını inceleyerek düzgün çokgen olup olmadıklarını belirleyiniz ve şekillerin altında boş bırakılan yerlere yazınız.Düzgün çokgen olarak belirlediklerinizin ortak özelliklerini yazınız.











Düzgün çokgenlerin ortak özellikleri:

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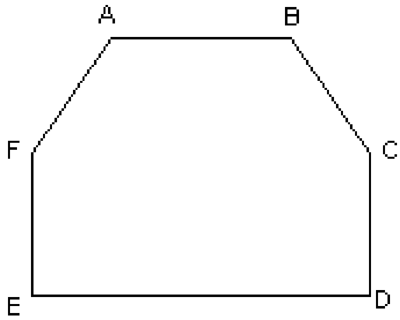
4. Aşağıdaki çokgenleri adlandırınız.

Düzgün çokgen olup olmadıklarını yazınız.



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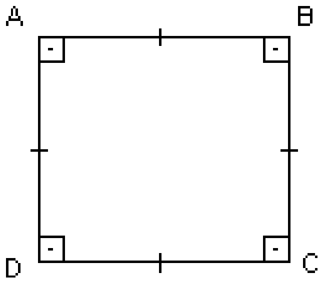

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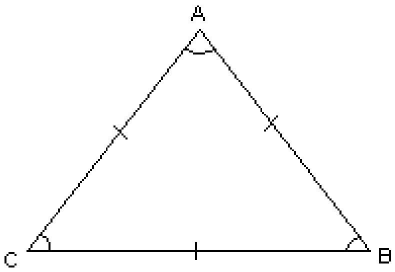

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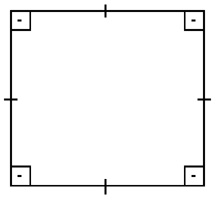
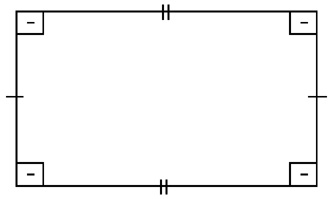
5. Aşağıdaki seçeneklerde verilen çokgenleri kendi aralarında karşılaştırarak benzer ve farklı özelliklerini yazınız.

a)





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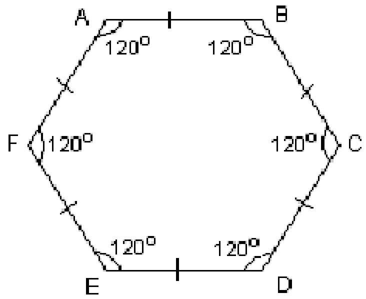
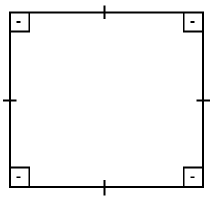
b)





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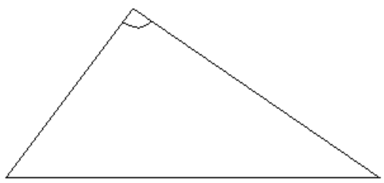
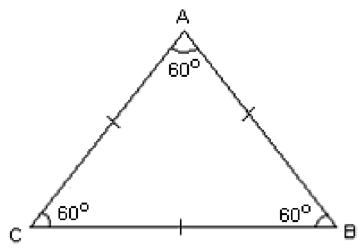
c)





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6. Aşağıdaki noktaları çokgen oluşturacak şekilde birleştiriniz. Çokgenleri adlandırınız.

7. Aşağıdaki seçeneklerin her birinde verilen özellikleri taşıyan dörtgenler çiziniz.

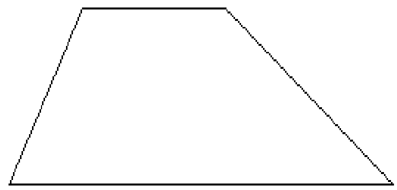
a) Kenarları birbirine dik olan dörtgen

b) En az iki kenarı paralel olan bir dörtgen

c) Kenar uzunlukları birbirine eşit olan bir dörtgen

d) Kenar uzunlukları birbirine eşit ve açıları dik olan dörtgen

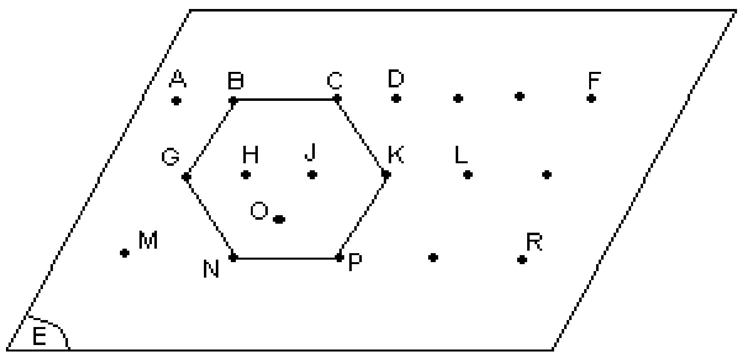
8.



Şekildeki yamuğun üzerinde aşağıda istenilen çizimleri yapınız.

a) Bir doğru parçası çizerek iki yamuk elde ediniz.
b) Elde ettiğiniz iki yamuğun birinden geçen bir doğru parçası çizerek bir paralel kenar ve bir üçgen elde ediniz.

9. Aşağıdaki düzlemde verilen altıgenin iç ve dış bölgesinde bulunan noktaların kümesini ayrı ayrı yazınız.



İç bölgesinde bulunan noktalar;

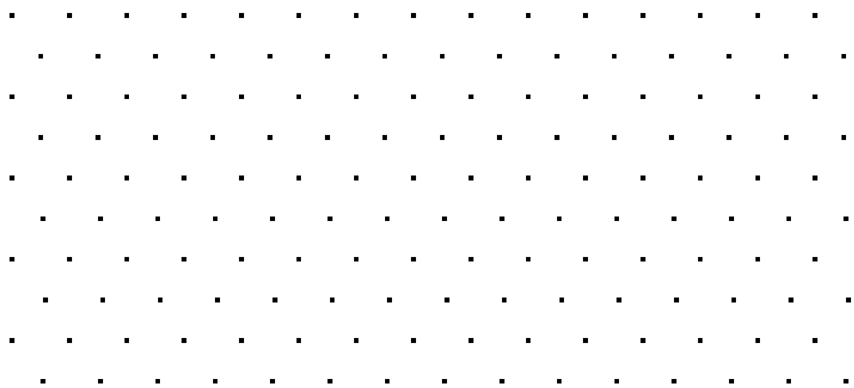
Dış bölgesinde bulunan noktalar;

10. Aşağıdaki noktalı bölüme , seçeneklerde istenilen çizimleri yapınız.

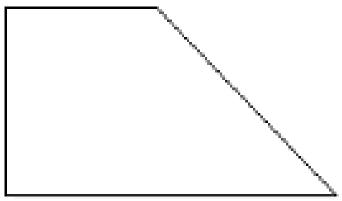
a) İç bölgesinde bir tane nokta bulunan bir altıgen

b) Kenarları boyunca üçer tane nokta , iç bölgesinde dört tane nokta bulunan bir üçgen

c) İç bölgesinde iki tane nokta bulunan bir eşkenar dörtgen

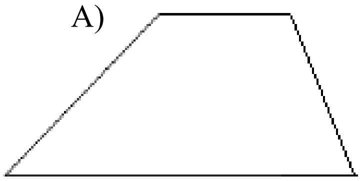


11.

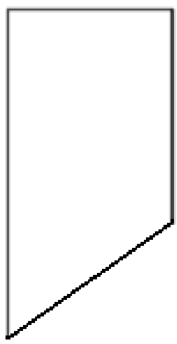


Aşağıdaki dörtgenlerden hangisi yandaki yamuğa eştir?

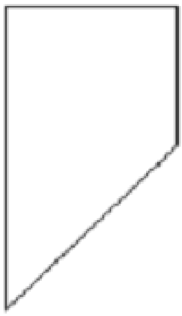
A)



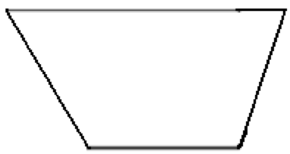
B)



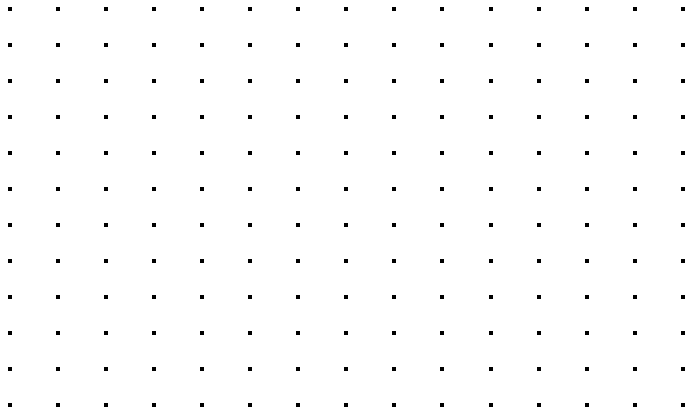
C)



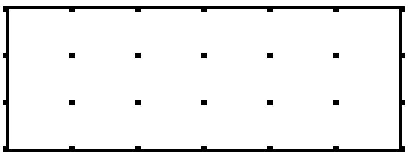
D)

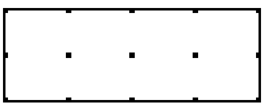


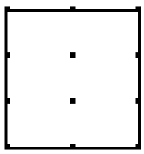
12. Aşağıdaki noktalı kâğıda birbirine eş , fakat farklı duruşlarda dört üçgen çiziniz.

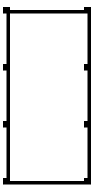


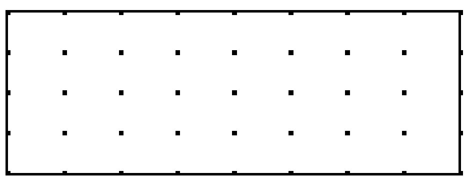
13. Aşağıdaki noktalı bölüme çizilmiş dörtgenlerden hangisi veya hangileri yandaki dikdörtgene benzerdir?



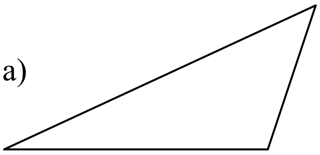
A) 

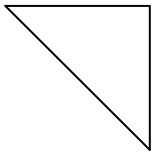
B) 

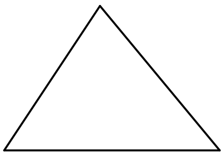
C) 

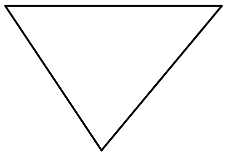
D) 

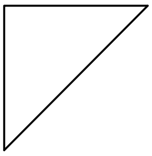
14. Aşağıdaki üçgenlerden eş olan çiftleri işaretleyiniz.

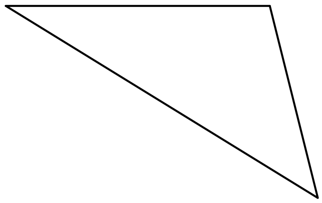
a) 

b) 

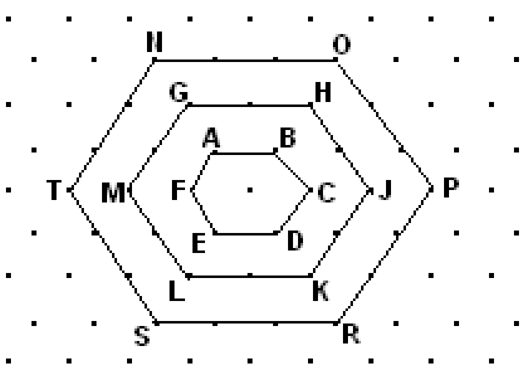
c) 

d) 

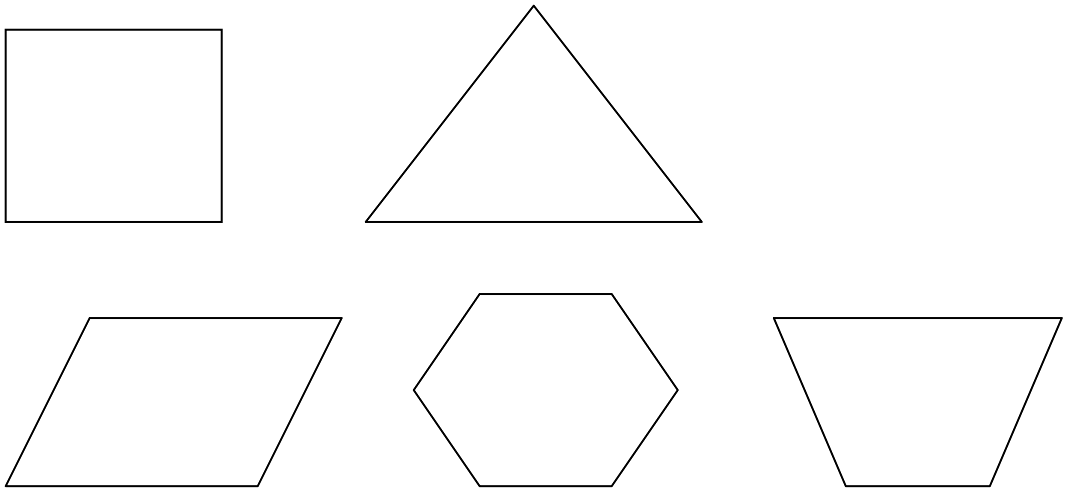
e) 

f) 

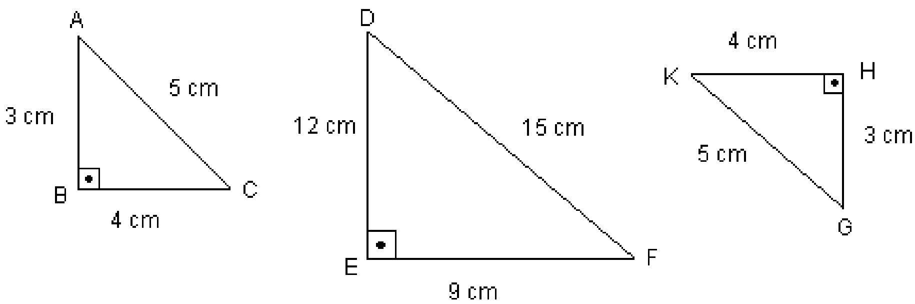
15. Aşağıdaki noktalı bölüme çizilmiş altıgenler arasındaki ilişkiyi sembol kullanarak gösteriniz.



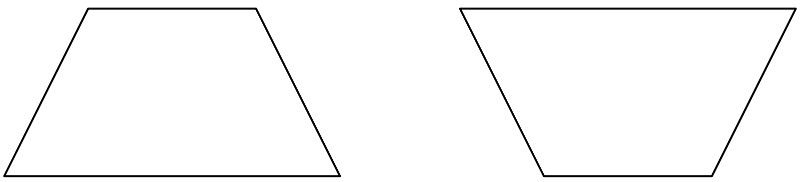
16. Aşağıdaki çokgenleri eş parçalara ayırınız.
Nasıl ayırdığınızı açıklayınız.



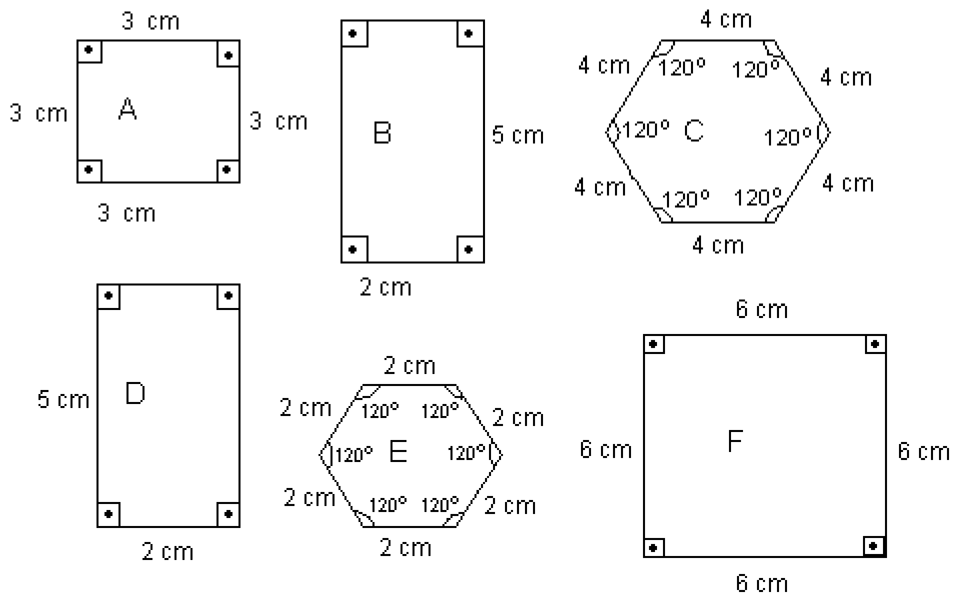
17. Aşağıdaki şekillerden eş ve benzer olanlarını belirleyiniz. Aralarındaki ilişkiyi sembol kullanarak gösteriniz.



18. Aşağıdaki iki yamuğun eş olup olmadığını nasıl belirlersiniz? Açıklayınız.



19. Verilenlere göre aşağıdaki çokgenlerden eş veya benzer olanları belirleyiniz.



Eş olan çokgenler	
Benzer olan çokgenler	

20. Aşağıdaki ifadelerden doğru olanların başına "D" , yanlış olanların başına "Y" yazınız.

a) .... Bütün çokgenlerde açı ve kenar bulunur.

b) .... Bütün çokgenlerde köşe vardır.

c) .... Kenar uzunlukları birbirine eşit olan çokgenler düzgün çokgenlerdir.

d) .... Dikdörtgen bir düzgün çokgendir.

e) .... Bir çokgenin dış bölgesi, üzerinde bulunduğu düzlemin; çokgenin kendisiyle iç bölgesi dışında kalan bölgedir.

f) .... Açı ölçüleri ve kenar uzunlukları birbirine eşit olan iki çokgen eştir.

g) .... Benzer olan çokgenler her zaman eştir.

h) .... Eş çokgenler aynı biçimde fakat farklı büyüklüktedir.

APPENDIX B

COMPUTER ATTITUDE SCALE (CAS)

AD, SOYAD	:	
SINIF	:	
NO	:	
YAŞ	:	
CİNSİYET	:	

GEOMETRİ DERSLERİNDE BİLGİSAYAR KULLANIMINA
KARŞI TUTUM ÖLÇEĞİ

Genel açıklama: Bu bir bilgi testi değildir ve bu nedenle hiçbir sorunun "doğru" yanıtı yoktur. Aşağıda yer alan sorularla bilgisayar ve bilgisayar ortamında yapmış olduğunuz geometri dersleriniz hakkındaki düşüncelerinizi almak istiyoruz. Her cümle için kendinize en uygun seçeneği işaretleyiniz.

1) Bilgisayar beni korkutuyor.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

2) Bilgisayar kullanma konusunda hiç iyi değilim.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

3) Bilgisayarla çalışmayı seviyorum.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

4) Bilgisayarlarla problemleri çözmek çekici gelmiyor.

A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım

D) Katılıyorum E) Kesinlikle katılıyorum

5) Bilgisayarlarla çalışmanın zevkli ve özendirici olduğunu düşünüyorum.

A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım

D) Katılıyorum E) Kesinlikle katılıyorum

6) Bilgisayarda geometri öğrenirken kendimi yalnız ve insanlardan uzak hissettim.

A) Hiç B) Çok nadir C) Bazen

D) Çoğu zaman E) Her zaman

7) Bilgisayarda çalışırken kendi kendime öğrenmeye çalışmaktan çok, kendimi yalnızca konuyu bitirmeye çalışırken buldum.

A) Hiç B) Çok nadir C) Bazen

D) Çoğu zaman E) Her zaman

8) Bilgisayarda geometri öğrenirken konu ile ilgili daha çok bilgi edindim.

A) Hiç B) Çok nadir C) Bazen

D) Çoğu zaman E) Her zaman

9) Bilgisayarda geometri öğrenirken konuyu anlamaktan çok bilgisayarı kullanmakla ilgilendim.

A) Hiç B) Çok nadir C) Bazen

D) Çoğu zaman E) Her zaman

10) Bilgisayarlı eğitimle çalışırken geometri konusuna uyum sağlamakta güçlük çektim.

A) Hiç B) Çok nadir C) Bazen

D) Çoğu zaman E) Her zaman

11) Bilgisayarlı eğitim, geometri öğrenirken kendimi rahatsız hissetmeme neden oldu.

A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım

D) Katılıyorum E) Kesinlikle katılıyorum

12) Bilgisayarlı eğitim, öğrencinin zamanını boşa harcıyor.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

13) Bilgisayarlı eğitim daha hızlı öğrenmemi sağladı.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

14) Bilgisayarlı eğitimden zevk aldım.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

15) Bilgisayar destekli eğitimle almış olduğum geometri konularına karşı duygularım çok olumluydu.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

16) Sıkıcı olabilecek konular bile bilgisayarlı eğitimle sunulduğunda ilginç olabilir.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

17) Bilgisayarlı eğitimle öğrendiğim konuyu göz önüne alırsak bilgisayarlı eğitimi geleneksel eğitime tercih ederim.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

18) Bilgisayar üzerinde verilen materyaller derse karşı olan ilgimi arttırdı.
A) Kesinlikle katılmıyorum B) Katılmıyorum C) Tarafsızım
D) Katılıyorum E) Kesinlikle katılıyorum

Aşağıda yer alan soruları bilgisayarlı ortamda yapmış olduğunuz geometri dersleriyle ilgili olarak yanıtlayınız.Lütfen nedenleri de belirtiniz.

1) Geometri öğrenirken bilgisayarlı eğitim sizlere ne şekilde yararlı oldu?

2) Bilgisayar destekli geometri dersine ne gibi değişiklikler önerebilirsiniz?

3) Geometride çalışmalarınızı etkileyen etkenler nelerdir? Bu etkenleri göz önüne alarak geometri dersine ne gibi değişiklikler önerebilirsiniz?

APPENDIX C

TEACHING MATERIALS IN THE EXPERIMENTAL GROUP

WORKSHEETS

Worksheet-1
**Ders : ** Geometri
**Konu : ** Üç nokta
<u>Etkinlik:</u>

1.Ekran üzerinde doğrudaş olmayan üç nokta belirleyiniz.

2.Bu noktaları adlandırınız.

3.Bu üç noktayı ikişer ikişer birleştirecek doğrular çiziniz.

4.Oluşan şekli açıklayınız.

5.Ekranı bir düzlem olarak kabul ederek, oluşan şeklin dış ve iç bölgesinin neresi olduğunu açıklayınız.

6.Ekran üzerinde rasgele noktalar belirleyiniz. Oluşan şekli hareket ettirerek belirlediğiniz noktaların hangi bölgede olduğuna karar veriniz.

Worksheet-2

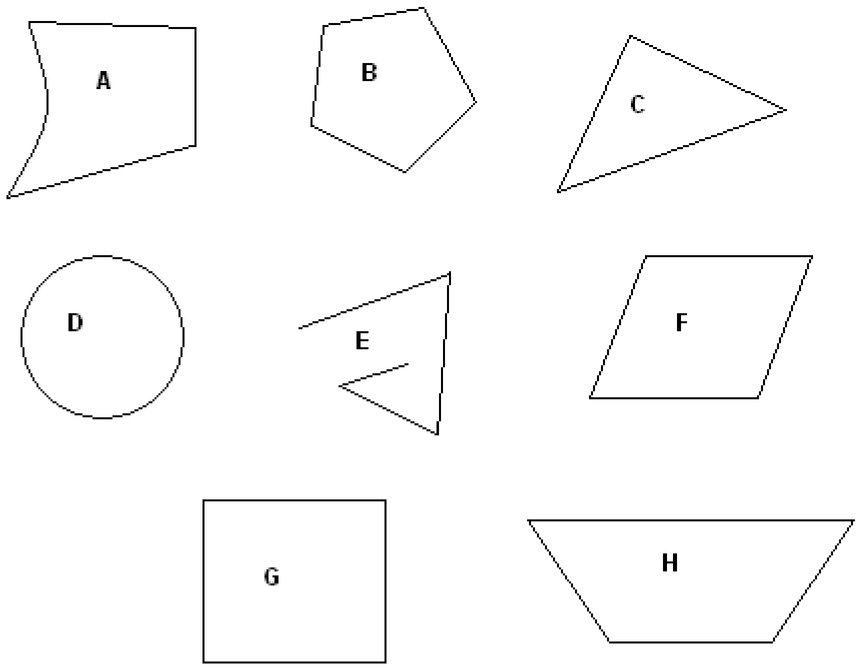
Ders : Geometri

Konu : Çokgen

- En az üçü doğrudaş olmayan noktaları birleştiren doğru parçalarının oluşturduğu kapalı düzlemsel şekillere çokgen denir.

<u>Etkinlik:</u>

1.Aşağıdaki şekillerden hangileri birer çokgendir?



Çokgen olanlar; ....

....

2.Sizlerde ekranınızda değişik çokgenler yaratınız.

3.Yarattığınız çokgenleri adlandırınız.

4.Yarattığınız çokgenlerin kenar, köşe ve açı sayılarını bulunuz.

<u>Sonuç;</u> Bulgularınıza göre çokgenlerin adlarıyla kenar, köşe ve açı sayıları arasındaki ilişkiyi açıklayınız.

....

....

Worksheet-3

Ders **:** Geometri

Konu **:** Düzgün çokgen

<u>Etkinlik:</u>

1. Masa üstünden GSP' de hazırlanmış düzgün çokgenler dosyasını açınız.
2. Gördüğünüz şekillerin açılarını ve kenar uzunluklarını ölçünüz.

Bulgularınızı aşağıdaki tabloya yazınız.

	Kenar özellikleri	Açı özellikleri
1. şekil için		
2. şekil için		
3. şekil için		

<u>Sonuç;</u> Bulgularınıza göre düzgün çokgeni tanımlayınız.

Düzgün çokgen: ....

....

....

Worksheet-4

Ders : Geometri

Konu : Çokgenleri karşılaştırmak

Etkinlik:

1. Masa üstünden GSP' de hazırlanmış "Çokgenleri karşılaştırmak" dosyasını açınız.

2. Gördüğünüz çokgenlerin kenar uzunluklarını ve açılarını ölçerek sonuçları, aşağıdaki tablo üzerine yazınız.

	Kenar uzunlukları	Açı ölçüleri
1.Şekil		
2.Şekil		
3.Şekil		
4.Şekil		
5.Şekil		
6.Şekil		

3. Çokgenlerin kenar uzunluklarını ve açı ölçülerini kendi aralarında karşılaştırınız.

4. Düzgün olan ve olmayan çokgenleri belirleyiniz.

Düzgün çokgenler : ....

Düzgün olmayan çokgenler : ....

5. Düzgün olan ve olmayan çokgenleri nasıl belirlediğinizi açıklayınız.

Worksheet-5

**Ders : ** Geometri

**Konu : ** Kare ve dikdörtgen çizmek

<u>Etkinlik:</u>

1. Belli bir uzunlukta bir doğru parçası çiziniz.

2. Bu doğru parçasının uç noktasına doğru parçası ile aynı uzunlukta bir dikme indiriniz.
3. Diğer kenarları da aynı şekilde çizerek kare oluşturunuz.

4. Siz de aynı yöntemi kullanarak veya farklı bir yöntemle dikdörtgen çiziniz.Nasıl çizdiğinizi açıklayınız.

5. Masa üstünden GSP' de hazırlanmış paralel kenar dosyasını açınız.

6. Gördüğünüz şeklin açılarını ve kenar uzunluklarını ölçünüz.
Bulgularınızı aşağıya yazınız.

Kenar özellikleri	Açı özellikleri

Worksheet-6

Ders : Geometri

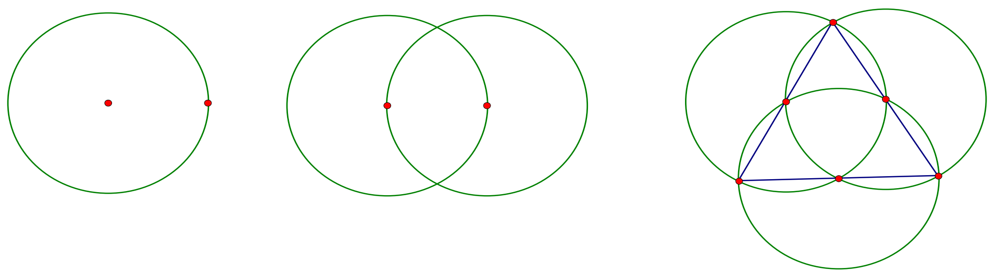
Konu : Çokgen çizmek

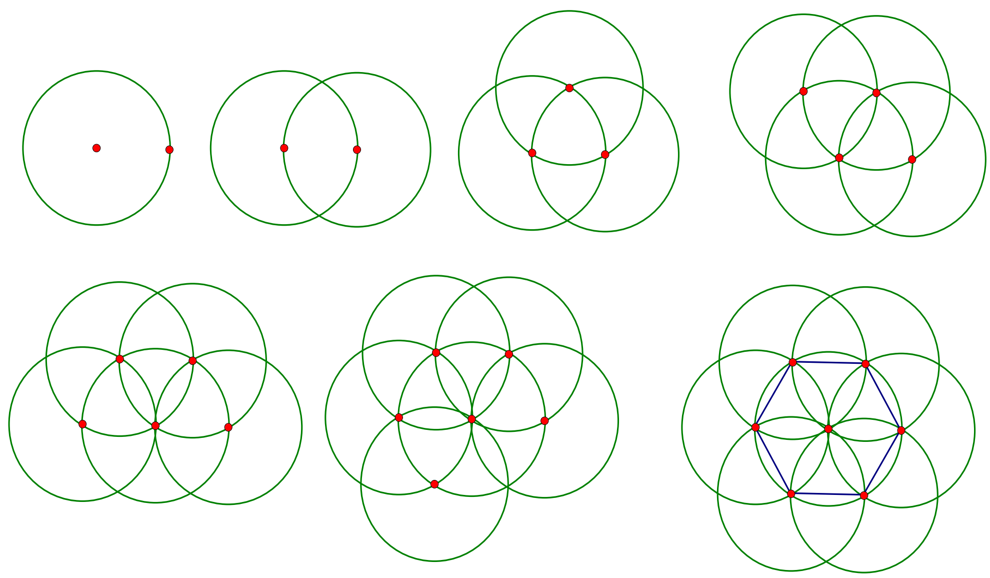
<u>Etkinlik:</u>

1.Aşağıda aşama aşama gösterilen çokgen çizimlerini, ekranınızda uygulayınız.

2.Oluşan çokgenlerin adlarını yazınız.

3.Oluşan çokgenlerin kenar ve açı ölçülerine bakarak düzgün çokgen olup olmadıklarına karar veriniz.





Worksheet-7

**Ders : ** Geometri

**Konu : ** Eşlik

<u>Etkinlik:</u>

1.Ekran üzerinde herhangi bir çokgen çiziniz.

2.Çizdiğiniz çokgeni ekran üzerinde kopyalayınız.

3.Oluşan çokgensel bölgeleri karşılaştırınız.

4.Elde edilen çokgensel bölgeler arasındaki ilişkiyi açıklayınız.

Worksheet-8

Ders **:** Geometri

Konu **:** Benzerlik

<u>Etkinlik:</u>

1. Masa üstünden GSP' de hazırlanmış " dikdörtgenler" dosyasını açınız.

2. Gördüğünüz her bir dikdörtgensel bölge numaralandırılmıştır.

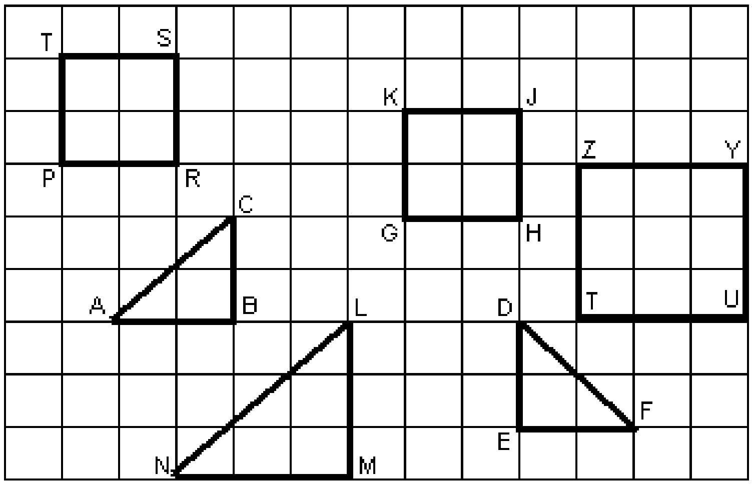
Numaralandırılan dikdörtgensel bölgelerin kenar ve açı özelliklerine bakarak
aralarında nasıl bir ilişki olduğunu açıklayınız.

3**.** Numaralandırılmış her bir dikdörtgensel bölge ile hepsini içine alan ABCD dikdörtgensel bölgesi arasında nasıl bir ilişki olduğunu açıklayınız.

Worksheet-9

Ders : Geometri

Konu : Eşlik ve Benzerlik



Yukarıdaki kareli bölümde ABC üçgeni DEF üçgenine, KJGH karesi TSPR karesine eştir. Eşlik için "≅" sembolü kullanılır.

Bu eşitlikler , $\overset{\triangle}{ABC} \cong \overset{\triangle}{DEF}$

KJGH dörtgeni ≅ TSPR dörtgeni biçiminde gösterilir.

ABC üçgeni LMN üçgenine, KGJH karesi TUYZ karesine benzerdir.Benzerlik için "~" sembolü kullanılır.

Bu benzerlikler; $\overset{\triangle}{ABC} \sim \overset{\triangle}{LMN}$

KJGH dörtgeni~TUYZ dörtgeni biçiminde gösterilir.

Etkinlik:

1. GSP' de hazırlanmış eş ve benzer üçgenler dosyasını açınız.
2. Verilen üçgenleri kareleri sayarak karşılaştırınız. Bu üçgenlerden eş veya benzer olanları belirleyiniz ve sembolle gösteriniz.

Eş olan üçgenler;

....

Benzer olan üçgenler;

....

Worksheet-10

**Ders : ** Geometri

**Konu : ** Eşlik ve Benzerlik

<u>Etkinlik:</u>

1.GSP' de hazırlanmış "Eşlik ve Benzerlik 2" dosyasını açınız.

2.Gördüğünüz çokgenleri adlandırınız.Çokgenlerin açı ölçülerini ve kenar uzunluklarını bularak, aşağıdaki tabloyu doldurunuz.

Çokgenin ismi	Açı ölçüleri (derece)	Kenar uzunlukları (cm)
ABCD yamuğu		
EFGH karesi		

3.Eş veya benzer olanları belirleyerek sembolle gösteriniz.

Eş olanlar	Benzer olanlar

4.Bulgularınıza göre, eşlik ve benzerlik arasındaki farklılıkları açıklayınız.

5.Eş olan iki şekil arasında benzerlik var mıdır? Açıklayınız.

6.ABCD yamuğu ile EFGH karesi arasında eşlik veya benzerlik olabilir mi?Açıklayınız.

Appendix D: Frequency and Percentage of Experimental Group and Control Group Students' Correct Answers in Pre-Test, Post-Test and Delayed-Post Test

Table D.1 Frequency and Percentage of Experimental Group and Control Group Students' Correct Answers in Pre-Test, Post-Test and Delayed-Post Test

	Experimental Group			**Control Group**		
	Pre-Test	**Post-Test**	**Delay-Test**	**Pre-Test**	**Post-Test**	**Delay-Test**
Q1a	46(69,69%)	66(100%)	56(84,84%)	44(64,70%)	60(88,23%)	32(47,05%)
Q1b expl.	10(15.15%)	32(48,48%)	31(46,96%)	14(20,58%)	18(26,47%)	13(19,11%)
Q1c	42(63,63%)	64(96,96%)	58(87,87%)	40(58,82%)	52(76,47%)	21(30,88%)
Q1d expl.	40(60,60%)	52(78,78%)	49(74,24%)	51(75%)	58(85,29%)	24(35,29%)
Q1e expl.	8(12,12%)	56(84,84%)	50(75,75%)	17(25%)	24(35,29%)	13(19,11%)
Q1f expl.	14(21,21%)	54(81,81%)	52(78,78%)	16(23,52%)	29(42,64%)	12(17,64%)
Q1g	36(54,54%)	65(98,48%)	40(60,60%)	34(50%)	56(82,35%)	24(35,29%)
Q1h expl.	6(9,09%)	43(65,15%)	41(62,12%)	8(11,76%)	22(32,35%)	10(14,70%)
Q2a	14(21,21%)	16(24,24%)	12(18,18%)	12(17,64%)	16(23,52%)	11(16,17%)
Q2b	24(36,36%)	64(96,96%)	42(63,63%)	26(38,23%)	52(76,47%)	26(38,23%)
Q2c	32(48,48%)	65(98,48%)	43(65,15%)	30(44,11%)	54(79,41%)	28(41,17%)
Q2d	43(65,15%)	66(100%)	46(69,69%)	41(60,29%)	56(82,35%)	31(45,58%)

Not: "expl." means explanation items.

Table D.1 (continued)

Q2e	34(51,51%)	64(96,96%)	39(59,09%)	36(52,94%)	58(85,29%)	29(42,64%)
Q3 expl.	10(15.15%)	60(90,90%)	58(87,87%)	16(23,52%)	32(47,05%)	29(42,64%)
Q4	15(22,72%)	58(87,87%)	36(54,54%)	13(19,11%)	21(30,88%)	15(22,85%)
Q5a expl.	2(3,03%)	15(22,72%)	14(21,21%)	5(7,35%)	8(11,76%)	6(8,82%)
Q5b expl.	2(3,03%)	16(24,24%)	15(22,72%)	6(8,82%)	10(14,70%)	7(10,29%)
Q5c expl.	1(1,51%)	11(16,66%)	11(16,66%)	4(5,88%)	6(8,82%)	5(7,35%)
Q6	43(65,15%)	46(69,69%)	34(51,51%)	41(60,29%)	44(64,70%)	24(35,29%)
Q7a	4(6,06%)	13(19,69%)	10(15.15%)	5(7,35%)	6(8,82%)	4(5,88%)
Q7b	3(4,54%)	14(21,21%)	9(13,63%)	3(4,41%)	4(5,88%)	3(4,41%)
Q7c	3(4,54%)	11(16,66%)	8(12,12%)	2(2,94%)	3(4,41%)	2(2,94%)
Q7d	2(3,03%)	10(15.15%)	6(9,09%)	1(1,47%)	3(4,41%)	1(1,47%)
Q8a	8(12,12%)	32(48,48%)	22(33,33%)	10(14,70%)	16(23,52%)	13(19,11%)
Q8b	10(15.15%)	43(65,15%)	27(40,90%)	7(10,29%)	22(32,35%)	14(20,58%)
Q9	6(9,09%)	60(90,90%)	35(53,03%)	6(8,82%)	35(51,47%)	19(27,94%)
Q10a	12(18,18%)	46(69,69%)	26(39,39%)	10(14,70%)	25(36,76%)	18(26,47%)
Q10b	16(24,24%)	34(51,51%)	32(48,48%)	14(20,58%)	18(26,47%)	12(17,64%)
Q10c	4(6,06%)	28(42,42%)	22(33,33%)	5(7,35%)	13(19,11%)	8(11,76%)
Q11	18(27,27%)	58(87,87%)	45(68,18%)	16(23,52%)	31(45,58%)	17(25%)

Not: "expl." means explanation items.

Table D.1 continued

Q12	9(13,63%)	34(51,51%)	23(34,84%)	11(16,17%)	18(26,47%)	16(23,52%)
Q13a	7(10,60%)	42(63,63%)	29(43,93%)	7(10,29%)	24(35,29%)	15(22,05%)
Q13d	11(16,66%)	58(87,87%)	44(66,66%)	13(19,11%)	27(39,70%)	18(26,47%)
Q14	58(87,87%)	66(100%)	46(69,69%)	59(86,76%)	65(95,58%)	61(89,70%)
Q15	2(3,03%)	58(87,87%)	39(59,09%)	1(1,47%)	12(17,64%)	9(13,23%)
Q16 expl.	2(3,03%)	16(24,24%)	14(21,21%)	6(8,82%)	8(11,76%)	7(10,29%)
Q17	1(1,51%)	42(63,63%)	26(39,39%)	2(2,94%)	11(16,17%)	6(8,82%)
Q18 expl.	9(13,63%)	38(57,57%)	36(54,54%)	14(20,58%)	19(27,94%)	16(23,52%)
Q19	5(7,57%)	56(84,84%)	35(53,03%)	6(8,82%)	18(26,47%)	11(16,17%)
Q20a	16(24,24%)	62(93,93%)	36(54,54%)	18(26,47%)	32(47,05%)	21(30,88%)
Q20b	14(21,21%)	60(90,90%)	44(66,66%)	12(17,64%)	29(42,64%)	19(27,94%)
Q20c	20(30,30%)	64(96,96%)	43(65,15%)	17(25%)	22(32,35%)	19(27,94%)
Q20d	12(18,18%)	58(87,87%)	35(53,03%)	10(14,70%)	23(33,82%)	16(23,52%)
Q20e	6(9,09%)	37(56,06%)	21(31,81%)	8(11,76%)	15(22,05%)	12(17,64%)
Q20f	10(15.15%)	40(60,60%)	25(37,87%)	13(19,11%)	24(35,29%)	16(23,52%)
Q20g	4(6,06%)	32(48,48%)	18(27,27%)	4(5,88%)	14(20,58%)	8(11,76%)
Q20h	7(10,60%)	36(54,54%)	28(42,42%)	9(13,23%)	13(19,11%)	11(16,17%)

Not: "expl." means explanation items.

APPENDIX E

GEOMETRY TEST PILOT STUDY

Geometry Test Pilot Study Interview Results

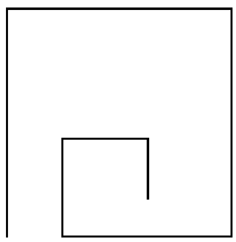
The results related to each question on polygons, regular polygons, congruency and similarity are interpreted and presented separately. The interview transcripts and interview results are given.

Interviewer, high level, middle level and low level students labeled as I, H, M and L respectively.

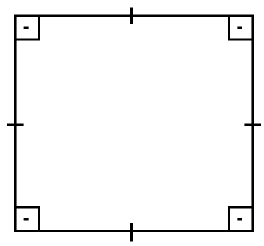
GEOMETRY TEST

1. Decide that which of the figure or figures polygons are. Write the name of the polygons; explain your reason for the figures which are not polygons.

Example:

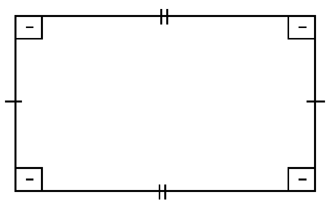


The figure is not close so it can not be a polygon.

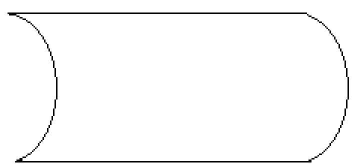


Square (quadrilateral)

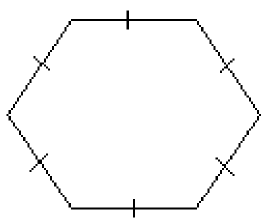
a)



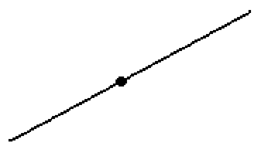
b)



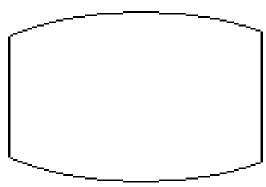
c)



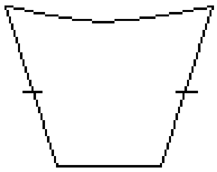
d)

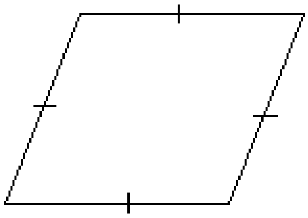


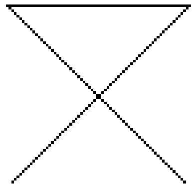
e)



f) g) h)







Polygon is a simple closed curve composed of line segments (Musser and Trimpe, 1994) or polygons are figures formed by joining segments at their endpoints, if the segments do not intersect at any other points (Bank, Posamentier and Bannister, 1972).The segments become the sides of the polygon.

Student H gave the answer that all the figures except d are polygons, when she was asked why they are polygons, she give an answer as:

H: They have three or more than three angles and sides. A is polygon, c is a polygon and also g is polygon.

I: What about other figures?

H: except d, they must be polygons because there are angles and sides.

It is seen from her explanations that she does not seem to know that polygons compose of lines and an angle is formed by rotating a ray about its end points. She did not differentiate the intersect lines at figure h.

Student M was aware of the fact that polygons are composed of lines. But like student H she did not recognize that figures h could not be a polygon because of the intersecting lines.

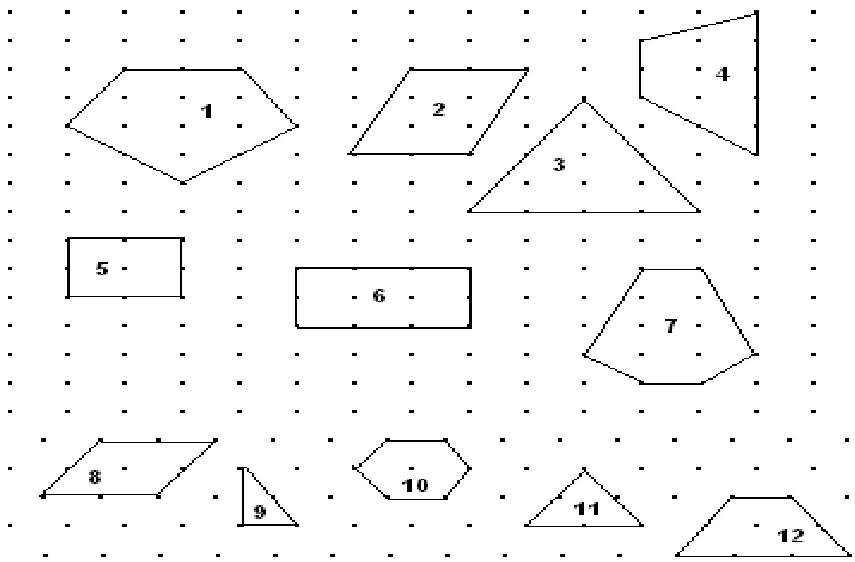
M: I can not remember the definition of polygon. A, c and g are polygons because they are formed by lines, b, e and f is not because its side is not a line. D is a line not a polygon. I do not have decision for h.

Student L responded that except d, all the figures are polygons. His support connected to the sides.

L: Polygon must have more than three or more than four sides; the figure does not need to be regular. I think except d, all shapes are polygons.

Like defined before, closed curve composed of line segments and joining line segments at their end points without intersecting at any other points are critical attributes for classifying. Here all students did not consider the attribute, the segment do not intersect at any other points other than its end points. Students H and L also did not consider another attribute; polygons are formed by line segments. It is apparent that the students' concept image on polygons includes only some attributes of the definition of polygons.

2. Classify the figures based on the properties that are given and fill the table.



a) The figures with parallel sides	
b) The figures with three sides	
c) The figures with four sides	
d) The figures with five sides	
e) The figures with six sides	

All students gave the same answer; they found the figures with three, four, five and six sides by counting the sides however they only write 2 and 8 in the part of the figures with parallel sides.

I: Why do you write only 2 and 8 in the part of the figures with parallel sides?

H: Because these figures are parallelogram and they have parallel sides.

I: is square or rectangle a parallelogram?

H: no

I: why they are not parallelograms?

H: since they have right angles

I: Do you know the definition of a parallelogram?

H: A figure that has parallel sides.

I: Which sides are parallel?

H: Both pairs of opposite sides.

I: OK, how can you differentiate a rectangle or square from a parallelogram? Also rectangle and square has parallel sides.

H: I do not know

Student M and L gave the similar answers.

As seen from the above extracts, students think that only parallelograms have parallel sides. In addition they think that rectangles and squares are not parallelograms. Rectangle is defined to be a quadrilateral with four right angles. Square is also a rectangle, having congruent sides (Musser and Trimpe, 1994).

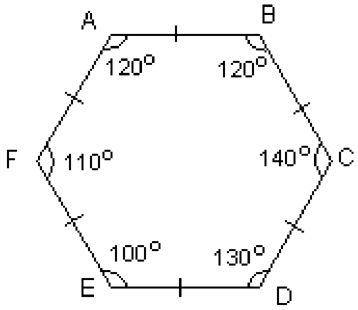
I: Why do you think that rectangles and squares can not be parallelograms?

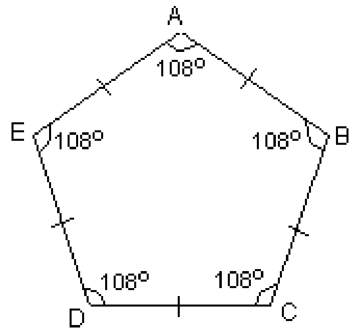
M: They must be different as their names are different.

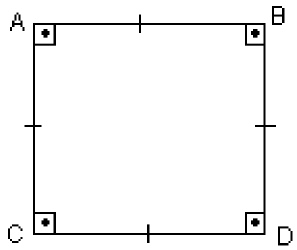
This indicates that assigning different names to the concepts prevents students to connect relation among concepts. Also students thought that parallelograms do not have right angles and parallelograms' sides are not equal. These are the non-critical properties of the parallelograms. Based on these non-critical attributes they think that rectangles and squares can not be a parallelogram.

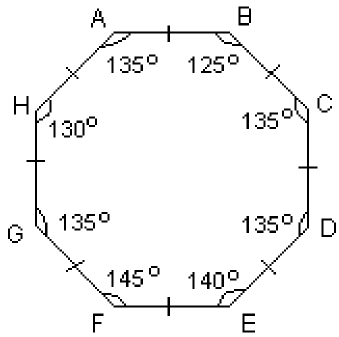
It is seen that non-critical properties and assigning different names to the concepts causes prototypes.

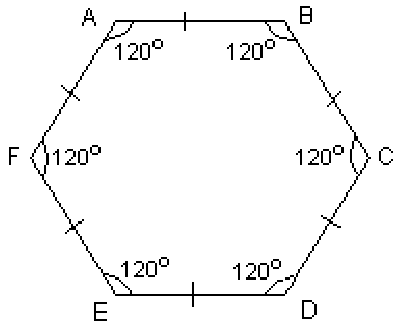
3.Decide the regular polygons by examining the measures of edges and angles and write regular or not regular under the figures. Write the common properties of regular polygons.











The common properties of regular polygons:

....
....
....

Regular polygon is a polygon in which all sides are equal and all angles are equal.

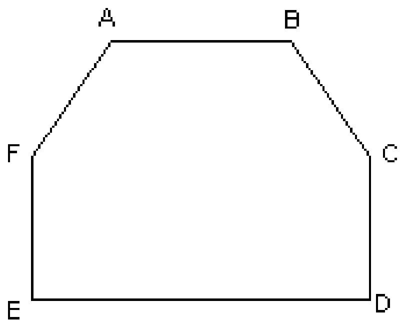
Student H and M answers are true. They write regular or not regular under the polygons truly and they write in the common properties part that regular polygons have equal sides and equal angles. However, student L write regular polygons under each polygon and he only write equal sides under the common properties part.

I: Is there any common property for regular polygons?

L: No, it is enough that their sides are equal in order to be regular in polygons.

As seen above student L did not think the angles congruency while defining the regular polygons.

4. Write the name of the polygons and write that these polygons are regular or not.



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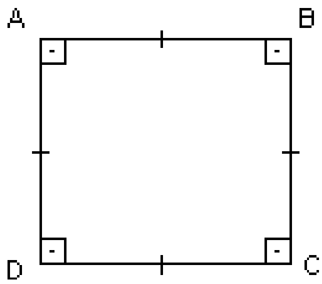

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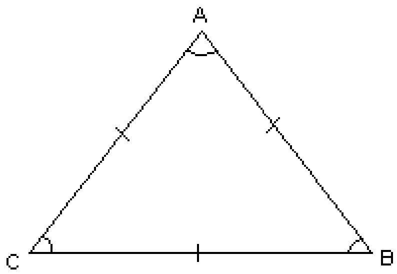

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Student H, M and L give the correct answers. However student M has a difficulty in naming the first polygon.

I: How do you write their names to the polygons?

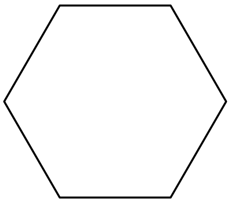
M: According to their number of sides.

I: Why do not you write the name of the first polygon?

M: It has six sides but our teacher did not draw a hexagon like that, It does not resembles a hexagon

I: How your teacher draw a hexagon can you draw for me?

M:

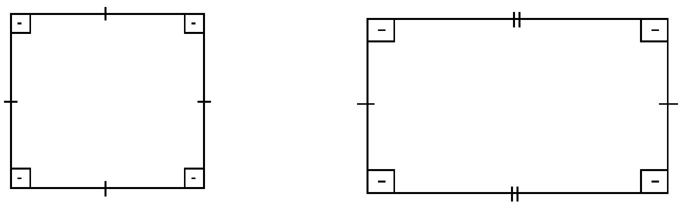


Student M did not write the name of the first polygon.

It is seen that more weighted examples are so important in geometry instruction. The reason is that in classes while naming the polygons always regular polygons are drawn on blackboards.

5. Write the similar and different properties of the polygons in each choice by comparing them.

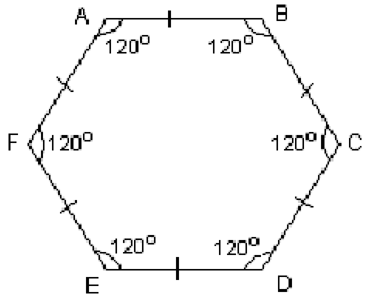
a)

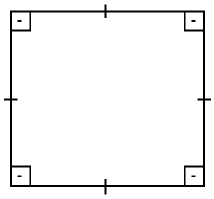


....

....

b)

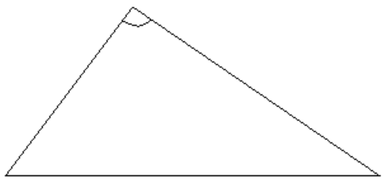


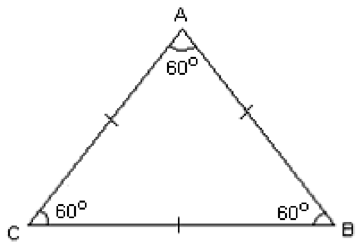


....

....

c)





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While the students comparing the polygons they only compare their sides and angles. None of them write they are regular or not regular polygons. They only compare according to the given drawings and their statements are not clear.

6. Join the points in order to form polygons. Write the name of the polygons.

Student H and M join the points and name the polygons truly. However student L could not join the points for heptagon. He joins like figure E.1;

Figure E.1 Student L’s drawing for the question 6 in geometry test

I: Is this a polygon?

L: Yes

I: What is the name of this polygon?

L: octagon

As seen above, like defined before, closed curve composed of line segments and joining line segments at their end points without intersecting at any other points are critical attributes for classifying polygons. Here student L did not consider the attribute, the segment do not intersect at any other points other than its end points.

7. Draw the quadrilaterals according to the properties that are given in each choice.

a) A quadrilateral with perpendicular sides.

b) A quadrilateral with at least one pair of the sides are parallel.

c) A quadrilateral with equal sides.

d) A quadrilateral with perpendicular and equal sides.

All students draw the same quadrilaterals, rectangle for a, parallelogram for b, rhombus for c and square for d.

We can see the critical attributes clearly in this question.

Quadrilateral and four right angles are the critical attributes for a rectangle.

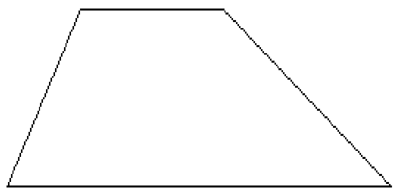
Quadrilateral, four right angles and all sides equal are the critical attributes for a square.

All sides equal are the critical attributes for a rhombus.

Quadrilateral and parallel opposite sides are the critical attributes for a parallelogram.

It can be said that critical attributes have important effects on geometry instruction.

8.



Perform the wanted drawings in the choices on this trapezoid.

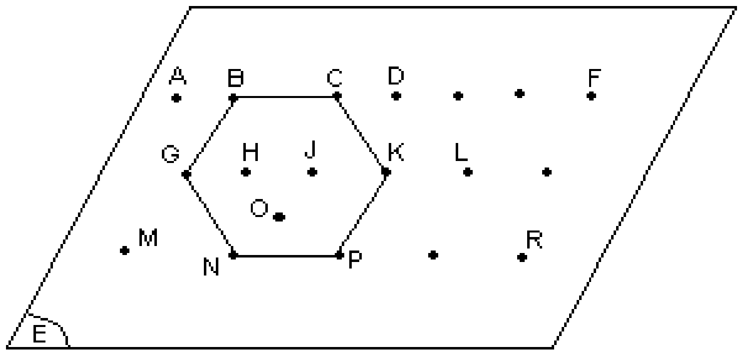
c) Draw a line segment in order to obtain two trapezoids.

d) Draw a line segment which goes through the one trapezoid that you draw in order to obtain one parallelogram and one triangle.

All students can draw only a line segment in order to obtain two trapezoids however none of them can draw a line segment which goes through the one trapezoid that they draw in order to obtain one parallelogram and one triangle.

When I ask them why do not you draw a line segment which goes through the one trapezoid that you draw in order to obtain one parallelogram and one triangle? They said that they could not imagine.

9. Write the points which are in interior and exterior region of the hexagon given in the plane.



The points which are in interior region;

The points which are in exterior region;

All the students write the points; B, C, K, P, N and G in the interior region part.

I: What are the regions that a polygon divides on a plane?

H: Interior and exterior region of a polygon.

I: Is there any other region?

H: No

The other students gave the same answers too.

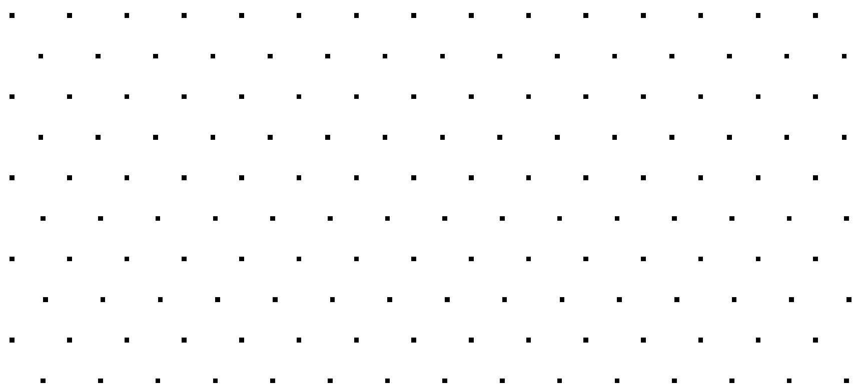
The answers given on this question show that interior and exterior regions are connected with the shapes not the shapes itself. The reason is that interior and exterior regions are more weighted examples.

10. Perform the wanted drawings in the pointed region.

a) Hexagon which has one point in its interior region.

b) Triangle which has four points in its interior region and three points on each of the sides.

c) Rhombus which has two points in its interior region.



Student H can only draw all the figures that are wanted in the choices. Her drawings are given in figure E.2.

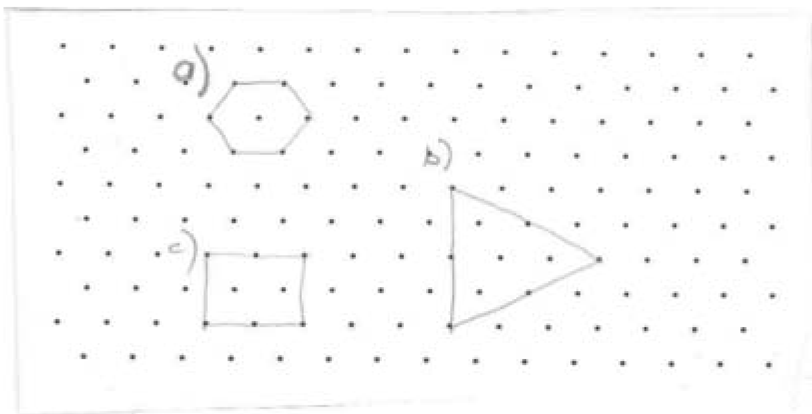
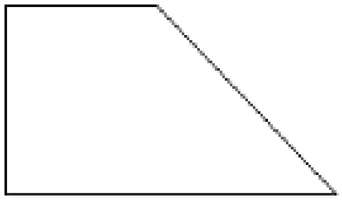


Figure E.2 Student H’s drawing for the question 10 in geometry test

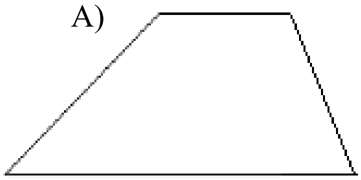
Student M and L can only draw a hexagon which has one point in its interior region.

11.

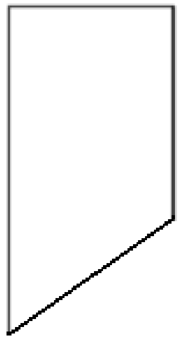


Which quadrilateral is congruent to the trapezoid that is given?

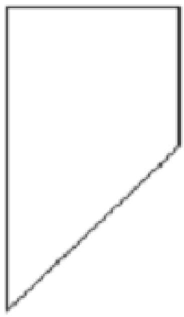
A)



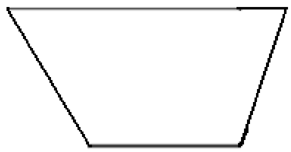
B)



C)



D)



Student H and L used their rulers in order to find the congruent quadrilateral to the given trapezoid. They give true answer based on the measurement of sides.

I: What are the needed properties in order to be congruent for shapes?

M: Their sides should be equal

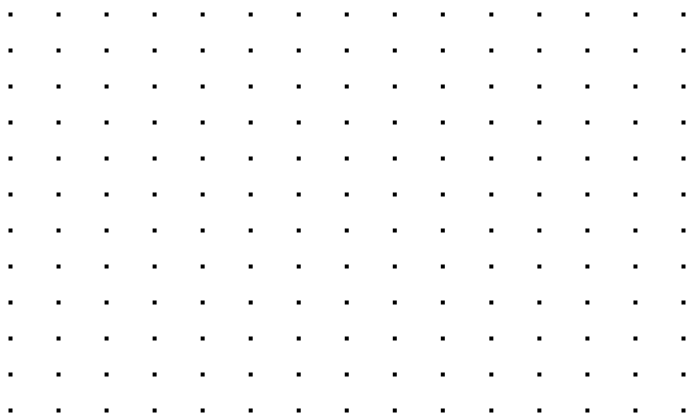
I: Is it enough to be congruent?

M: Yes

Student H gave the similar answer too.

Student L marked the wrong choice, he said that a) is the congruent one, when I asked the reason he said that it seemed congruent to the trapezoid. He did not give any explanation.

12. Draw four triangles which have different positions and congruent to each others in the pointed region.



All the students could draw different positions of a triangle. However they did not give much attention to the congruency of the length of the sides in their drawings. The reason might be that equal sides are shown in lessons by putting similar signs on these sides without using ruler.

Student M drawing is given in figure E.3:

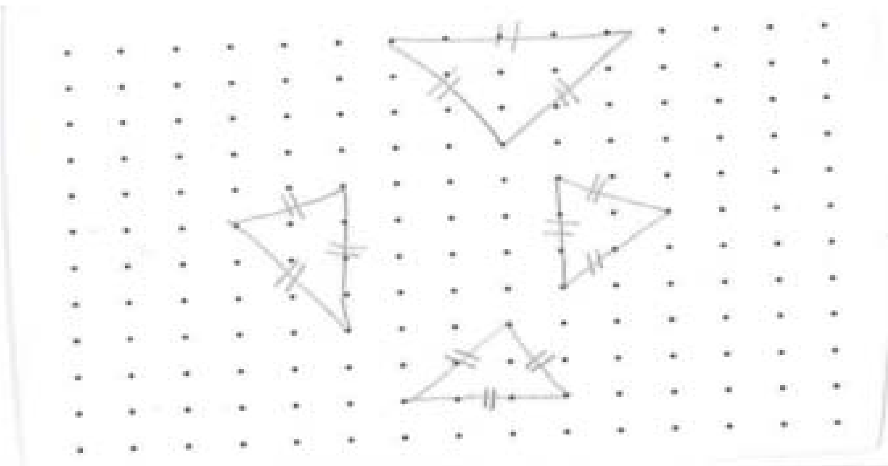
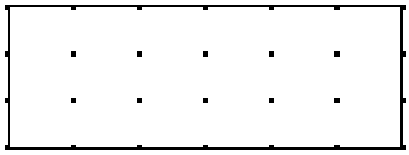


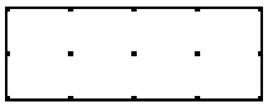
Figure E.3 Student M’s drawing for question 12 in geometry test

13.

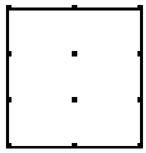


Which quadrilateral or quadrilaterals is similar to the given quadrilateral?

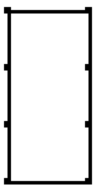
A)



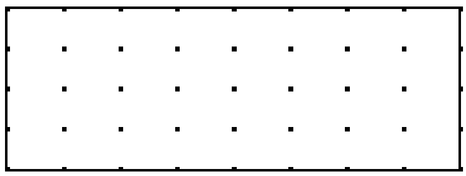
B)



C)



D)



Student H and M marked the true choices which are A and D.

However student L marked all the choices.

I: Are all the quadrilaterals is similar to the given quadrilateral?

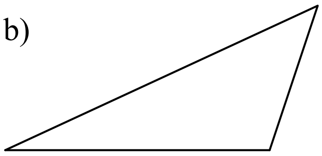
L: Yes

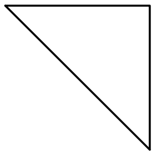
I: Can you say me the definition of similarity?

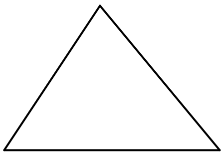
L: Figures with the same shape but not necessarily the same size.

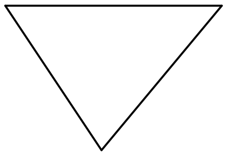
As seen from the explanation that he thought all the figures with the same shape can be similar. He does not think any proportion about the size.

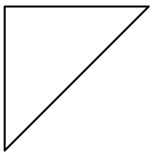
14. Match the triangles which are congruent.

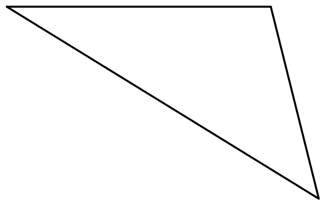
b)


b)


c)


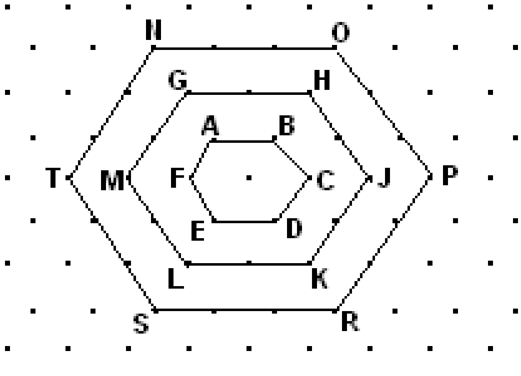
d)


f)


f)


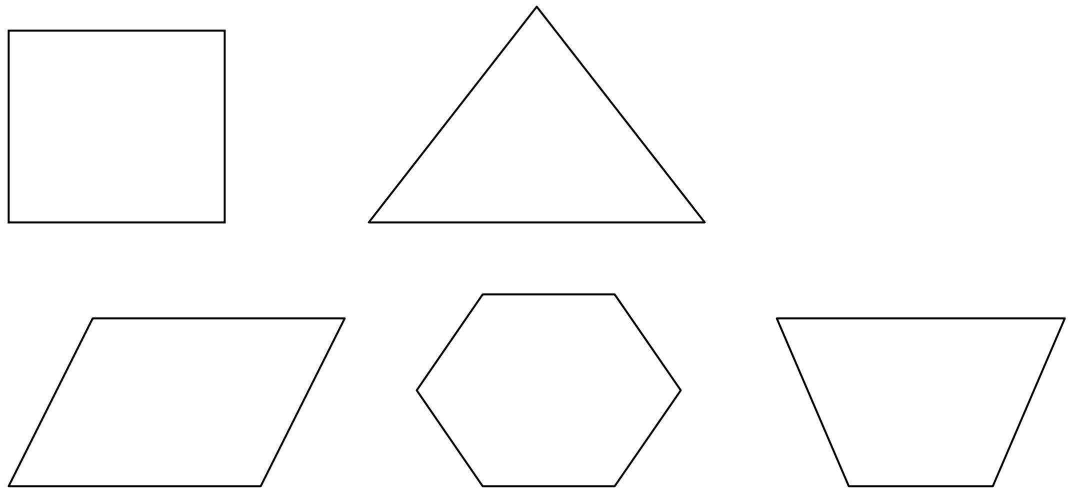
All the students match the triangles which are congruent easily.

15. Present the relationship between hexagons that are drawn with using symbol.



All the students say that they are similar to each other however none of them remember the symbol of the similarity.

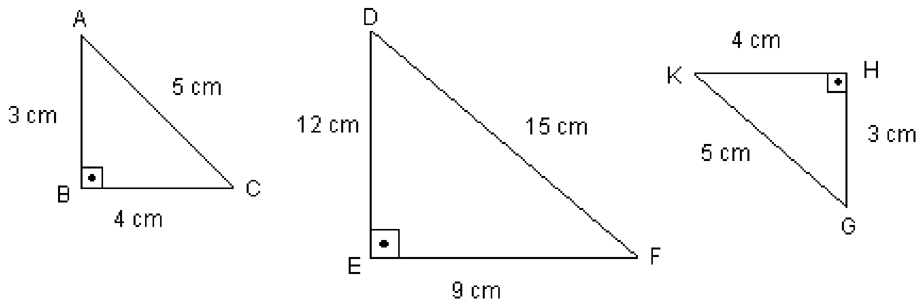
16. Divide the polygons to equal parts. Explain how you divide to equal parts.



Students can divide the polygons to equal parts by using their rulers. Only student H also measures the angles of the parts that she divided. However they did not explain. When I said that please explain how you can divide the equal parts. All of them answer like they are equal how I can explain.

It is apparent that although the students know and draw, they have a language problem when explaining the form. Their visual representations are more powerful than explaining.

17. Decide which figures are similar and which figures are congruent. Present the relationship with using symbol.



They showed with arrows which figures are similar and which figures are congruent also write similar and congruent on the arrows but none of them used symbols of congruency and similarity. Also all of them did not write similar between ABC triangle and KHG triangle.

I: Are not ABC triangle and KHG triangle be similar?

H: No, they are congruent

The answer of the student H is given in figure E.4;

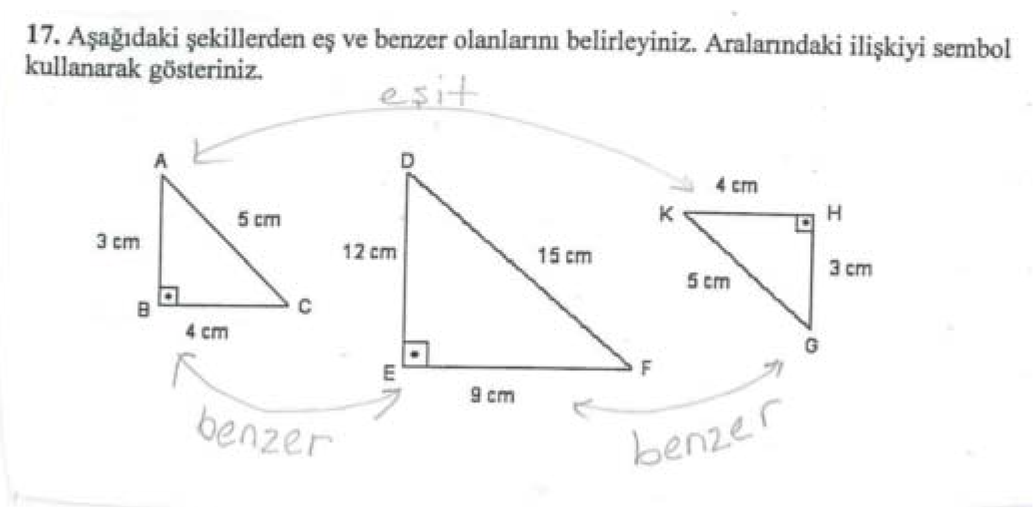
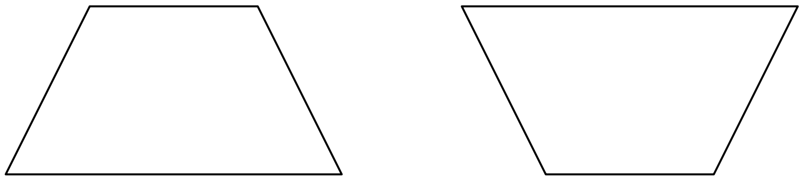

17. Aşağıdaki şekillerden eş ve benzer olanlarını belirleyiniz. Aralarındaki ilişkiyi sembol kullanarak gösteriniz.

Figure E.4 Student H's answer for question 17 in geometry test

As seen from the answers, they thought that congruent figures can not be similar.

18. How can you decide these trapezoids are congruent or not? Explain.



Student H wrote that by measuring its sides and angles. However student M and L wrote only by measuring its sides.

I: What about the angles, do not you measure them?

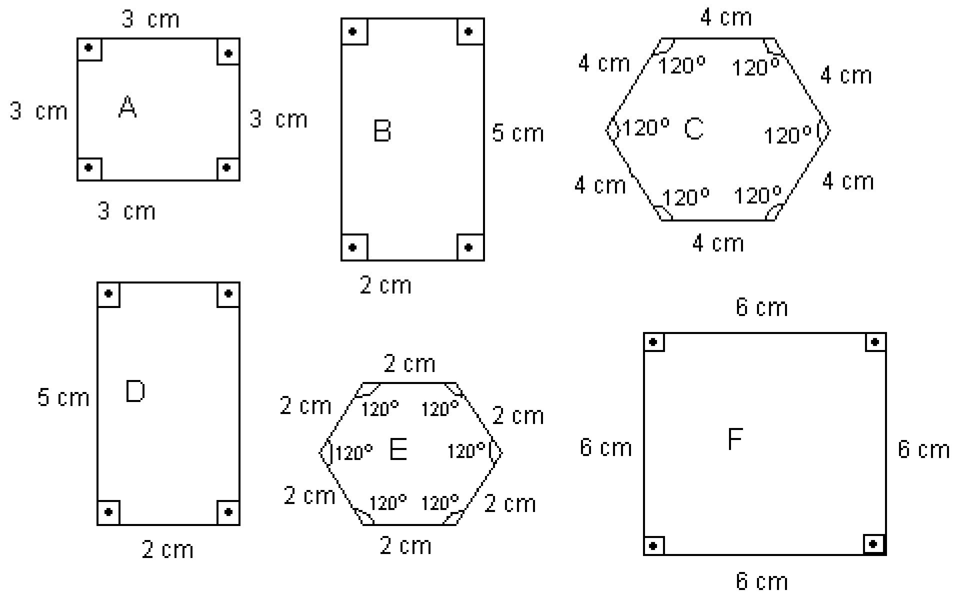
L: It is not need to be since if the sides are equal then the angles must be equal.

I: How can you decide this opinion?

L: in class, always it is true.

It can be said that students extracted some conclusions for themselves from the more weighted examples that are given in the classes.

19. Decide which polygons are similar and which polygons are congruent.



Polygons that are congruent to each others	
Polygons that are similar to each others	

All the students write the congruent and similar ones but none of them write congruent pairs to the similar part. As it is explained before, they thought that congruent figures can not be similar.

20. Write "T" in front of the true statement and Write "F" in front of the false statement

i) .... All polygons have angles and sides.

j) .... All polygons have vertexes.

k) .... The polygons which have equal sides are regular polygons.

l) .... Rectangle is a regular polygon.

m) .... The exterior region of a polygon is the region which is on the plane and outside of the interior region of it and itself.

n) .... The polygons which have equal angles and sides are congruent to each other.

o) .... The similar polygons are congruent too.

p) .... The congruent polygons are in the same form but have different magnitude.

Student L wrote T to the part C except this all the students gave the true answers. Student L wrote T to the part C since he thought that the polygons which have equal sides are regular polygons.

The Discussion and Conclusion of the Pilot Study of Geometry Test

The results of pilot study show that geometrical concepts are mainly acquired by means of figures. In addition it can be said that assigning different names to the concepts, prototypes and the non-critical properties of the concepts have an important effect on geometrical thinking.

Forming hierarchical relationships between different types of quadrilaterals is important for developing connections between shapes and their properties. De Villiers (1998) claimed that an advantage of hierarchical definition for a concept is that all theorems proved for that concept then automatically apply to its special cases. It is obvious that these difficulties occur since the importance of hierarchical classification is not applied in classes effectively. The hierarchical order should be in the sequence of parallelogram, rhombus, rectangle, and square.

Also we can say that naming the concepts differently excite erroneous conclusions based on these data. This handicap students to connect relationship among geometric shapes and also explains students' resistance to hierarchical relations among quadrilaterals.

This result confirm with those of Wilson (1983), Burger and Shaugnessy (1986), Hershkowitz (1989), Matsuo (2000) who claimed that students do not distinguish between two concepts of the geometric figures based on their differences and similarities.

The results of this study also suggest that students perceive the figures differently when the figure's orientation is changed. This finding is consistent with those of Prevost (1985) who reported that students include irrelevant properties when orienting the figure. Drawing regular figures in teaching are likely to have affected students' learning.

The results also show that more weighted drawn figures are central to learning geometry. More weighted figures, called prototypes have been found to be important in conceptual learning. These findings confirm the findings of Hoffer (1983) whom provided evidence that the shape and the self attributes of the prototype are the criterion for prototypical judgment. A new harmony between the figural and the conceptual aspects should be constructed when we think the geometry from the figural concept view.

While understanding the polygons, regular polygons, congruency and similarity, the comparison of these three levels deduced not much difference. This displayed that assigning different names to the concepts, prototypes, non-critical properties of the concepts are common problems among all level of students.

APPENDIX F

SUMMARY DESCRIPTIONS FOR THE SIX LEVELS OF PROFICIENCY IN MATHEMATICS IN PISA (PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT) TESTS

Summary descriptions for the six levels of proficiency in mathematics in PISA tests

At Level 1, students can answer questions involving familiar contexts where all relevant information is present and the questions are clearly defined. They are able to identify information and to carry out routine procedures according to direct instructions in explicit situations. They can perform actions that are obvious and follow immediately from the given stimuli.

At Level 2, students can interpret and recognize situations in contexts that require no more than direct inference. They can extract relevant information from a single source and make use of a single representational mode. Students at this level can employ basic algorithms, formulae, procedures or conventions. They are capable of direct reasoning and making literal interpretations of the results.

At Level 3, students can execute clearly described procedures, including those that require sequential decisions. They can select and apply simple problem-solving strategies. Students at this level can interpret and use representations based on different information sources and reason directly from them. They can develop short communications reporting their interpretations, results and reasoning.

At Level 4, students can work effectively with explicit models for complex concrete situations that may involve constraints or call for making assumptions. They can select and integrate different representations, including symbolic ones, linking them directly to aspects of real world situations. Students at this level can utilize well-developed skills and reason flexibly, with some insight, in these contexts. They can construct and communicate explanations and arguments based on their interpretations, arguments and actions.

At Level 5, students can develop and work with models for complex situations, identifying constraints and specifying assumptions. They can select, compare, and evaluate appropriate problem-solving strategies for dealing with complex problems related to these models. Students at this level can work strategically using broad, well-developed thinking and reasoning skills, appropriately linked representations, symbolic and formal characterizations, and insight pertaining to these situations. They can reflect on their actions and can formulate and communicate their interpretations and reasoning.

At Level 6, students can conceptualize, generalize, and utilize information based on their investigations and modeling of complex problem situations. They can link different information sources and representations and flexibly translate among them. Students at this level are capable of advanced mathematical thinking and reasoning. These students can apply this insight and understanding, along with a mastery of symbolic and formal mathematical operations and relationships, to develop new approaches and strategies for attacking novel situations. Students at this level can formulate and precisely communicate their actions and reflections regarding their findings, interpretations, arguments, and the appropriateness of these to the original situations. (OECD, 2004)

Table F.1 Summary of descriptions of six levels of proficiency on the mathematics/space and shape scale in PISA tests

Level	General competencies students should have at each level	Specific tasks students should be able to do
1	Solve simple problems in a familiar context using familiar pictures or drawings of geometric objects and applying counting or basic calculation skills	– Use a given two-dimensional representation to count or calculate elements of a simple three-dimensional object
2	Solve problems involving a single mathematical representation where the mathematical content is direct and clearly presented; use basic mathematical thinking and conventions in familiar contexts	– Recognize simple geometric patterns – Use basic technical terms and definitions and apply basic geometric concepts (*e.g.,* symmetry) – Apply a mathematical interpretation of a common-language relational term (*e.g.,* “bigger”) in a geometric context – Create and use a mental image of an object, both two- and three-dimensional – Understand a visual two-dimensional representation of a familiar real-world situation – Apply simple calculations (*e.g.,* subtraction, division by two-digit number) to solve problems in a geometric setting

Table F.1 (continued)

3	Solve problems that involve elementary visual and spatial reasoning in familiar contexts; link different representations of familiar objects; use elementary problem solving skills (devising simple strategies); apply simple algorithms	– Interpret textual descriptions of unfamiliar geometric situations – Use basic problem–solving skills, such as devising a simple strategy – Use visual perception and elementary spatial reasoning skills in a familiar situation – Work with a given familiar mathematical model – Perform simple calculations such as scale conversions (using multiplication, basic proportional reasoning) – Apply routine algorithms to solve geometric problems (*e.g.,* calculate lengths within familiar shapes)
4	Solve problems that involve visual and spatial reasoning and argumentation in unfamiliar contexts; link and integrate different representations; carry out sequential processes;	– Interpret complex text to solve geometric problems – Interpret sequential instructions and follow a sequence of steps – Interpretation using spatial insight into non–standard geometric situations – Use a two–dimensional model to work with 3-D representations of unfamiliar geometric situation

Table F.1 (continued)

4	apply well-developed skills in spatial visualization and interpretation	– Link and integrate two different visual representations of geometric situations – Develop and implement a strategy involving calculation in geometric situations – Reason and argue about numeric relationships in a geometric context – Perform simple calculations (*e.g.,* multiply multi-digit decimal number by an integer, apply numeric conversions using proportion and scale, calculate areas of familiar shapes)
5	Solve problems that require appropriate assumptions to be made, or that involve working with assumptions provided; use well-developed spatial reasoning, argument and insight to identify relevant information and to interpret and	– Use spatial/geometrical reasoning, argument, reflection and insight into two- and three-dimensional objects, both familiar and unfamiliar – Make assumptions or work with assumptions to simplify and solve a geometrical problem in a real-world setting, *e.g.,* involving estimation of quantities in a real-world situation, and communicate explanations – Interpret multiple representations of geometric phenomena – Use geometric constructions

Table F.1 (continued)

5	link different representations; work strategically and carry out multiple and sequential processes	– Conceptualize and devise multi-step strategies to solve geometrical problems – Use well-known geometrical algorithms but in unfamiliar situations, such as Pythagoras' theorem, and calculations involving perimeter, area and volume
6	Solve complex problems involving multiple representations and often involving sequential calculation processes; identify and extract relevant information and link different but related information; use reasoning, significant insight and reflection; and generalize results and findings, communicate solutions and provide explanations and argumentation	– Interpret complex textual descriptions and relate these to other (often multiple) representations – Use reasoning involving proportions in non-familiar and complex situations – Show significant insight to conceptualize complex geometric situations or to interpret complex and unfamiliar representations – Identify and combine multiple pieces of information to solve problems – Devise a strategy to connect a geometrical context with known mathematical procedures and routines – Carry out a complex sequence of calculations, for example volume calculations or other routine procedures in an applied context, accurately and completely – Provide written explanations and arguments based on reflection, insight and generalization of understanding

APPENDIX G

THE ANALYSIS OF THE LESSONS VIDEO TAPES

The study yielded 10 hours and 40 minutes of videotape data. This appendix describes the process involved in shaping the raw footage into organized, thematic strands. Central to this task were two considerations: How should the videotape data is coded into a corresponding paper format? In doing so, what level of detail should be extracted? And In deciding which mathematical episodes to include in this study, what criteria should be used to select noteworthy events?

The discussion that follows addresses these areas of concern. The appendix G concludes by contrasting this analysis technique to an alternative method proposed by Schoenfeld (1985).

Transferring the video-taped lessons Into Paper Format

At the heart of the study are the words spoken by students. Transcribing speech into written form provides the researcher with a convenient medium for subsequent analysis. If words alone, however, are the only events recorded, certain pieces of data are likely to be lost. These include pauses in speech, tone of voice, and facial expressions.

The inadequacy of word-by-word transcriptions was particularly acute in this study. Nearly all of the conversations between students and researcher centered on the actions occurring on a computer screen in the experimental group. Typical of written transcripts was this line spoken by students: "You see, we need to move point A. You see, over here..., it's X that does this... We've got this...And so far, I can move this."

From the start, it is known that bringing meaning to the lessons transcripts required a second level of transcription; one of a pictorial nature. As it is viewed the tapes, it is needed a way to capture the geometric activity that accompanied students' words.

Practically speaking, It could not be drawn every image that appeared on screen. Students reconfigured their geometric constructions hundreds, perhaps thousands, of times during the computer based lessons, whether it was dragging a point slightly to the left, or adding and then deleting new elements to their picture.

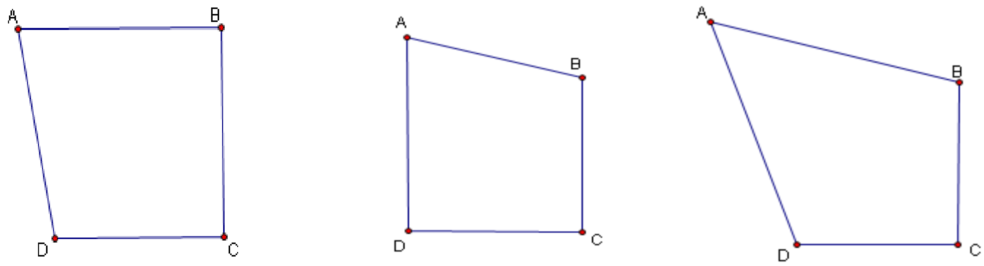
Film directors face a similar challenge when projecting their concept of a film beyond the words in a script. The art of story boarding: allows them to communicate visual aspects of a motion picture in a concise fashion. Each storyboard depicts a key frame of a scene, condensing the action into snapshot images.

It was decided that a storyboarding approach could suit the materials well. On the second viewing of the videotapes, it was drawn rough pictures to represent those geometric configurations that it was thought best captured the actions transpiring on screen. For those pictures that required further clarification, it was written the worksheets, the names of the menu and toolbar items used in the activity underneath each picture. It was also added bracketed explanatory notes into the text of students' words to clarify the meaning of unclear or vague expressions.

One example of the storyboarding technique appears in Chapter IV of this study. In the excerpt below, one student describes why his quadrilateral ABCD is not a rectangle. Appearing by them selves, the words are rather cryptic:

> *Student: Well, it's not exactly a rectangle, but if you move point A out, then D has to come out with it. If you move point A up, B has to come. If you move point A diagonal, then they [points B and D] have to go up and to the side.*

With just three accompanying snapshots (Figure G.1), however, the meaning of "out," "up," and "diagonal" becomes clearer.



“out” “up” “diagonal”

Figure G.1: Three storyboard images

Shortcomings of a Storyboard Approach

For the storyboard method in order to be effective, it is known that the transcripts and storyboards would need to stand on their own as a meaningful account of the lessons. With the hand-drawn sketches complete, it is put the work aside and then returned to the data with fresh eyes.

As reading the students' words and viewed the accompanying pictures, it is known that on one level, the experiment was a success, it could be reconstructed the sequence of geometric actions that occurred during the experiment. At the same time, though, something had been lost. The exact nature of this loss remained unclear until viewing the tapes again.

The storyboards presented freeze-frame views of the actions occurring onscreen. In Storyboard 1, point A might be in the top right corner of the screen. In Storyboard 2, the same point might now be in the lower left corner. How it moved from one location to another was not indicated.

In many instances, the details behind this change of location were either uninteresting or simple: point A moved from one corner to the other by being dragged in a straight line. Yet sometimes, the movement involved was more intriguing and could not be represented strictly through pictures. Just as tone of voice could be a clue to one's thoughts, so could, it is realized the speed and nature of one's mouse movements onscreen.

It was decided on a case-by-case basis whether the storyboards and written transcriptions required additional descriptive commentary. If the descriptions became too long, it simply flagged the corresponding videotape excerpt as something that it would need to be watched rather than annotate.

What Counts as a Noteworthy Event?

With the descriptive coding complete, it was begun to consider a broad question: How did students perform on tasks in worksheets? The answer to this question depended on the lens that applied to the data. If it was chosen to focus on whether students knew the technicalities of each Sketchpad command and menu item, there were minor mistakes to report. These included:

- Students did not hold down the "Shift" key when trying to select more than one object on screen.

- In trying to create points that traveled along lines, students mistakenly constructed the points before the lines.

From a software design perspective, such observations could be valuable (indeed the newest version of Sketchpad eliminates the need for the "Shift" key and for creating lines before points). But these findings seemed bland in light of this study's goal to uncover those areas of students' geometric thinking that were shaped by the dynamic geometry software.

While much of our students' work was routine in nature, there were excerpts of videotape, some spanning no more than a minute, others longer where students performed a certain action or gave a verbal description that clearly surprised the researcher. These were places where students' ideas did not fit either the "normal" approach or a predictable misstep (such as the bulleted items above). Confrey (1991) describes the value of finding such occurrences:

"Seldom are students' responses careless or capricious. We must seek out their systematic qualities which are typically grounded in the conceptions of the student... Frequently when students' responses deviate from our expectations, they possess the seeds of alternative approaches which can be compelling, historically supported and legitimate if we are willing to challenge our assumptions... It is at points of contact, at moments of discrepancy, that we have the highest probability of gaining insight into another person's perspective. (p. 122)"

Readers of this study will find that nearly all of the data excerpted throughout this work fits the general criteria below:

- The students' work is unorthodox. While neglecting to hold down the "Shift" key would not be a great surprise to anyone familiar with the software, the methods employed by students were not predictable prior to conducting the study.

- The students' work is clever. This is not to say their methods were always productive. But in all cases, students approached their constructions in entirely reasonable ways.

- The geometric ways of thinking involved are specific to dynamic geometry software. Uncovering hidden paths, describing objects in terms of movement metaphors, and finding alternative ways to build a square all depend on the tools made available by the software.

In choosing examples that conformed to these criteria, the challenge, working from Confrey's perspective described above, was to chronicle the unforeseen and sensible use of Sketchpad, as compared to its misuse.

This goal was aided by the style of the study. As researcher with experience using the software, students were comfortable enough with Sketchpad so that students' tiny missteps did not affect their study.

Developing the Interpretations

At this stage in the analysis process, it is known which lessons excerpts would be developed into narratives. It is envisioned each narrative as consisting of three parts. First, it would be described for the reader the "normal" manner in which a particular construction could be accomplished with Sketchpad. Then, it would be offered a student's method, highlighting the ways in which it differed from the norm. Finally, it would be analyzed the student's work, attempting to uncover the merits of her/his reasoning.

This entire interpretive process was shaped by an admonition of Confrey (1993) similar to the one that was quoted previously:

"…when interpreting data, the researcher must demonstrate his/her own willingness to examine his/her own assumptions and challenge the validity of those assumptions...one can come to see how frequently what is labeled as student's inadequacy is really the result of our own inflexibility in considering alternative perspectives. (p. 6)

This study provides an example of this approach. It would have been easy to dismiss the work of some students as incorrect ways of building a square. Instead, it is found aspects of their work that while problematic, still displayed ingenuity.

Sharing the Interpretations

Having developed the theories of students' motivations, it is needed a way to validate the findings. To gain feedback and alternative perspectives, researcher wants help from the one mathematic teacher who is the friend of a researcher.

For the first few meetings together, researcher did not bring videotapes. Rather, researcher sat with her colleague at a computer and introduced her to the features of Sketchpad. When she developed some familiarity with the software, researcher presented her with the various items from the worksheets and allowed her to explore and then recreate them on her own.

At this stage, researcher was ready to share the videotapes. For each excerpt, researcher first allowed her colleague to view the tapes without any interruption. However, in places where she needed a brief clarifying comment, researcher paused or rewound the tape to offer an explanation. Researcher then assumed the role of her in the computer lab as researcher asked her colleague to analyze what she saw and heard on the tapes. The questions of most interest in nearly all cases were, "What do you think students are trying to accomplish here? What ideas are guiding their exploration/construction? Do their ideas seem reasonable?"

This process gave way to discussions in which researcher shared, defended, and, reworked her own interpretations of the video data. Through this collaboration, researcher was able to provide support to her theories as well as consider new possibilities and themes suggested by her colleague.

An Alternative Approach

One of the more detailed descriptions of lessons analysis techniques appears in Schoenfeld's Mathematical Problem Solving (1985). It is instructive to consider his approach as a means of highlighting where (and why) researcher pursued a different course. Similar to dynamic geometry study, Schoenfeld's study focus on geometry, though of the paper and pencil variety. He provides transcripts of the sessions along with illustrative pictures. But there the similarity ends.

Schoenfeld's interest lies in charting the cognitive strategies of students. For these purposes, he describes six problem-solving categories: Read, Analyze, Explore, Plan, Implement, and Verify. Each sessions is parsed into a timeline showing which category best describes students' behavioral any given moment. Particular attention is paid to junctures where students switch from one strategy to another. With this coding, the larger scope and progression of a student's work assume priority over specific incidents:

"At the risk of flogging a dead horse, I wish to stress that... matters of detail...are virtually irrelevant. A coding scheme should highlight major decisions" (p.289).

Because the coding stays general in nature, Schoenfeld maintains that the process of analyzing a study can be remarkably standardized, even for those without graduate training. He says, "A team of undergraduate coders can be trained to parse the protocols with accuracy and reliability" (p. 315).

Schoenfeld's broad coding allows him to address issues of meta cognition- specifically, "the overall quality of the students' monitoring, assessing, and executive decision making" (p.310). Sometimes the quality can be low, leading students on "wild goose chases" or to choosing "ill-chosen approaches" (p. 282).

There is a definite appeal to Schoenfeld's analysis technique. It introduces some of the reliability found in quantitative methods into qualitative work. It does not force to reconsider the researcher methods of solving mathematical problems. Researcher accepts that Schoenfeld's method may yield more uniformity than her approach. But researcher also maintains that this technique overlooks as much as it finds.

APPENDIX H

PERSONAL INTERVIEW PROTOCOL

Personal Interview Questionnaire

What you say is totally confidential. No one will know what you tell me. Please feel free to be totally honest, regardless of how you feel. This is a survey about your opinions. There are no wrong or right answers. I need to know who you are to track your answers to your test for this study.

Student number

1. What did you like most about your experiences using the Geometers' Sketchpad?
2. What did you like least about your experiences using the Geometers' Sketchpad?
3. Did you like working with the computers to perform constructions?
4. Why or why not?
5. Do you think that you had to concentrate more in your class sessions using the computers than you normally would without the computers?

6. If so, in what ways? Indicate all that apply (yes or no).

    Understanding the software

    Understanding geometric ideas

    Understanding constructions

    Trying to understand the directions to perform activities

    Other (explain)

7. When you had an opportunity to use the "hands-on" tools (compass, ruler, paper, pencil), what differences did you notice between the two methods?
8. Which method did you prefer, computers or "hands-on" tools to perform constructions?
9. Why?
10. What was the most difficult part of doing the geometric activities and construction when using
    a. the compass, ruler, and pencil?
    b. Geometers' Sketchpad?
11. What was the easiest part of doing the geometric activities and constructions when using
    a. the compass, ruler, and pencil?
    b. Geometers' Sketchpad?
12. Would you recommend other students to have the same experience using Geometers' Sketchpad?
13. Why or why not?
14. Do you think that you know more about geometry than before?

15. If yes, do you think: that you learned more because of using Geometers' Sketchpad?

16. Why or why not?

17. Do you think that working with Geometers' Sketchpad improved your understanding of geometry?

18. If yes, in what way?

- Easier to manipulate the lines, points, angles
- Easier to perform the constructions
- Easier to understand the relationships between lines, points, angles
- Easier to visualize the relationships
- Other (explain)

19. What do you think your grade for geometry test will be?

20. Is this higher, lower, or the same than you normally get in mathematics?

21. How do you rate your technology skill level?

22. If low, do you think that your skill level hindered you in your 'work?

    If high, do you think that your skill level gave you an advantage in your work?

23. Do you have anything else that you want to mention about this study?