THE EFFECTS OF COMPUTER BASED INSTRUCTION ON SEVENTH GRADE STUDENTS' SPATIAL ABILITY, ATTITUDES TOWARD GEOMETRY, MATHEMATICS AND TECHNOLOGY

A THESIS SUBMITTED TO
GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

ŞEBNEM BOYRAZ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
THE DEPARTMENT OF
ELEMENTARY SCIENCE AND MATHEMATİCS EDUCATION

SEPTEMBER 2008

Approval of the Graduate School of Social Sciences

Prof. Dr. Sencer AYATA
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Prof. Dr. Hamide ERTEPINAR
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assist. Prof. Dr. Ayhan Kürşat ERBAŞ
Supervisor

Examining Committee Members

Assist. Prof. Dr. Ayhan Kürşat ERBAŞ (METU, SSME)

Assist. Prof. Dr. Yeşim Çapa AYDIN (METU, EDS)

Assist. Prof. Dr. Erdinç ÇAKIROĞLU (METU, ESME)

Dr. Mine IŞIKSAL (METU, ESME)

Dr. Bülent ÇETİNKAYA (METU, SSME)

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Şebnem BOYRAZ

Signature:

ABSTRACT

THE EFFECTS OF COMPUTER BASED INSTRUCTION ON SEVENTH GRADE STUDENTS' SPATIAL ABILITY, ATTITUDES TOWARD GEOMETRY, MATHEMATICS AND TECHNOLOGY

Boyraz, Şebnem

MS, Department of Elementary Science and Mathematics Education

Supervisor: Assist. Prof. Dr. Ayhan Kürşat Erbaş

September 2008, 144 pages

The aims of this study were to investigate the effects of two different methods of dynamic geometry based computer instruction on seventh grade students' attitudes towards geometry, attitudes toward mathematic and technology and spatial abilities compared to traditional textbook based instruction and to get the students' views related to the effects of computer based instruction on their learning.

The sample consisted of 57 seventh grade students from a private elementary school in Kayseri. The study was conducted in the 2006-2007 academic year, lasting 14 lesson hours (two weeks). The data were collected through spatial ability test, mathematics and technology attitude scale, geometry attitude scale, and interviews. The quantitative analyses were carried out by using multivariate covariance analyses. The results revealed that two different methods of dynamic geometry based computer instruction didn't have a significangt effect on students' spatial abilities compared to traditional textbook based instruction. The results also indicated that two different methods of dynamic geometry based instruction had a significant effect on students' attitudes toward geometry, mathematics and technology compared to traditional textbook based instruction. The results of the interviews indicated that computers created a dynamic learning environment which supported students' development and computers also helped students to explore mathematic in a far more meaningful way.

Keywords: Spatial ability, computer based instruction, dynamic geometry software, attitude toward mathematics and technology, and attitude toward geometry.

ÖZ

BİLGİSAYAR DESTEKLİ ÖĞRETİMİN YEDİNCİ SINIF ÖĞRENCİLERİN UZAMSAL DÜŞÜNEBİLME BECERİLERİNE, MATEMATİK, TEKNOLOJİ VE GEOMETRİYE KARŞI TUTUMLARINA ETKİSİ

Boyraz, Şebnem
Yüksek Lisans, İlköğretim Fen ve Matematik Alanları Eğitimi
Tez Yöneticisi: Y. Doç. Dr. Ayhan Kürşat Erbaş

Eylül 2008, 144 sayfa

Bu çalışma iki farklı bilgisayar destekli öğrenme ortamının, geleneksel öğretim yöntemiyle karşılaştırıldığında yedinci sınıf öğrencilerinin uzamsal düşünebilme becerilerine, geometriye, matematiğe ve teknolojiye karşı tutumlarına etkisini araştırmayı; öğrencilerin bilgisayarla öğrenmenin öğrenmeleri üzerine etkisine ilişkin görüşlerini almayı amaçlamıştır. Çalışmanın örneklemini Kayseri ilinde bir özel ilköğretim okulunda okuyan 57 yedinci sınıf öğrencisi oluşturmaktadır. Çalışma 2006–2007 öğretim yılında gerçekleştirilmiş, 14 ders saati (iki hafta) sürmüştür. Veri toplamak amacıyla, uzamsal düşünebilme becerisi testi, geometri, matematik ve teknoloji tutum ölçeği ve görüşmeler kullanılmıştır.

Elde edilen niceliksel veriler, yapılan çoklu kovaryans analizi ile incelenmiştir. Analiz sonuçlarına göre gruplar arasında uzamsal düşünebilme becerisi testinden alınan puanlara göre istatistiksel olarak anlamlı bir fark bulunmamıştır. Analiz sonuçlarına göre ayrıca gruplar arasında geometri, matematik ve teknoloji tutum ölçeklerinden alınan puanlara göre istatistiksel olarak anlamlı bir fark bulunmuştur. Öğrencilerin görüşmelerde ifade ettikleri düşüncelere göre, bilgisayarlar öğrencilerin gelişimin destekleyen dinamik bir öğrenme ortamı oluşturmuş ve öğrencilere matematiği daha anlamlı bir şekilde keşif etmelerine yardımcı olmuştur.

Anahtar Kelimeler: Uzamsal düşünebilme becerisi, bilgisayar destekli öğrenim, dinamik geometri yazımları, matematik ve teknolojiye karşı tutum, geometriye karşı tutum.

ACKNOWLEDGEMENTS

I would like to thank my supervisor Assist. Prof. Dr. Ayhan Kürşat Erbaş for his guidance, valuable comments and support in completing this dissertation.

I am thankful to Assist. Prof. Dr. Erdinç Çakıroğlu for his valuable comments during the pilot study.

I would like to thank teachers and students in Ted Kayseri College that participated in the study. A very deep sense of gratitude is extended to three teachers; Hayrullah Saykı and Mürüvet Alparslan and Aslıhan Orhan for their invaluable supports during the treatment.

I owe my thanks to Elçin for always being my friend in good and bad times.

I am thankful to Utku for his encouragement, support. He was always with me in hope from the beginning of this journey.

I want to express eternal gratitude to my mother Güler and father Tacettin Boyraz for their unconditional love and support .Special thanks are extended to my sisters' Şule and Çiğdem who have been a great source of support while I was performing this study. I would have never finished this dissertation without the love and support of them.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

ABBREVIATIONS	
SAT:	Spatial Ability Test
SOAT:	Spatial Orientation Ability Test
SVAT:	Spatial Visualization Ability Test
GAS:	Geometry Attitude Scale
MTAS:	Mathematics and Technology Attitude Scale
GSP:	The Geometer's Sketchpad Software
MOT:	Method of teaching
PREGAS:	Students' pretest scores on geometry attitude scale
POSTGAS:	Students' posttest scores on geometry attitude scale
PRESAT:	Students' pretest scores on spatial ability test
POSTSAT:	Students' posttest scores on spatial ability test
MANCOVA:	Multivariate analysis of covariance
ANCOVA:	Univariate analysis of covariance
Sig:	Significance
df:	Degree of freedom
N:	Sample size
α:	Significance level

CHAPTER 1

INTRODUCTION

Geometry has a great importance in people's life since 2000 BC and still maintains its importance. The National Council of Teachers of Mathematics (NCTM) reinforced the importance of geometry in their revised work *Principles and Standards for School Mathematics (2000)* and stated that "Geometry offers a means of describing, analyzing, and understanding the world and seeing beauty in its structures" (p. 309). Osserman (as cited in Brodie, 2004) also reinforced the importance of geometry for universe and stated that:

> All the centuries of progress of mapping the earth and with the mathematics associated with it allows us to think about mapping the universe and understanding the pictures that we come up with, to look out there you see the galaxies ... but you can't put them all together without the geometry to analyze what it is that you are seeing (p. 5).

Geometry is not only important to understand our geometric world or universe; it is also labeled as a basic skill in mathematics. Sherrard (as cited in Duatepe, 2004) states that geometry is significant for every student since; it is an important help for communication as geometric terms are used in speaking, it is faced in real life, it helps to develop spatial perception, learning geometry prepares students for higher mathematics courses and sciences and for a variety of occupation requiring mathematical skills, general thinking skills and problem solving abilities are facilitated by geometry, and studying geometry can develop cultural and aesthetic values.

Due to the importance of geometry, the factors affecting success in geometry are a topic of continuing discussion. One of the factors affecting geometry achievement is spatial skills which are ‘‘mental skills concerned with understanding, manipulating, reorganizing, or interpreting relationships visually’’ (Tartre, 1990, p. 216). Smit (1998) stress the importance of spatial skills and suggests that without spatial skills it would be difficult to exist in the world as one would not be able to communicate about position and relationships between objects, give and receive directions and imagine changes taking place in the position or size of shapes. Similarly, Lowrie (1994) argues that in order to interpret, understand and appreciate our inherently geometric world, spatial understanding is necessary.

Spatial ability is not just an important factor for daily life; it is also basic to higher level activities such as sophisticated mathematical thinking (Basham, 2007). As stated by Basham (2007) spatial ability has long been associated with success in educational tracks such as mathematics (Fennema & Sherman, 1977). Lord and Rupert (1995) state that spatial ability is a cognitive factor that has been linked to high performance in science and mathematics. Gardner (1993) suggests ‘‘it is skill in spatial ability which determines how far one will progress in the sciences” (p.192). Clement and Battista (1992) also assert that spatial thinking is essential to scientific thought; ‘‘it is used to represent and manipulate information in learning and problem solving’’ (p. 442).

Good spatial conceptualization is also a necessity for engineering as well as other math and science disciplines. Poorly developed spatial ability is considered as a cause of achievement difficulties in engineering disciplines. Medina et al., (1998) state that three-dimensional visualization skills are critically important for success in engineering careers since the engineer must be able to visualize how all of the components in the system work and fit together to be able to solve a complex problem. Towle et al., (2005) also note that such as the ability to correctly visualize three dimensional is essential skill for engineers.

More recently, guided by the thought that spatial ability is a factor that underlies mathematical aptitudes, researchers have attempted to discover the role that spatial ability plays in mathematics and geometry learning. Studies have shown the positive correlation not only between spatial ability and geometry, but also, more generally, between spatial ability and mathematics achievement at all grade levels (Clements & Battista, 1992; Fennema & Sherman, 1977; Guay & McDaniel, 1977; Lean &Clements, 1981).

Given the obvious role of spatial ability in mathematics education, the development of spatial ability has been a primary problem for the researchers and educators for many years. There is a wealth of publications that viewed that students' spatial ability can be improved through training (Battista et al., 1982; Einsenberg, 1999; Onyancha et al., 2007; Robihaux, 2003). However, few of them (Leong et al., 2002; Piburn et al., 2002) focused on the effects of computer based instruction on students' spatial abilities. There still a need to investigate the effects of technology on students spatial ability skills. The purpose of this study is to investigate the effects of two different methods of dynamic geometry based computer instruction on seventh grade students' spatial abilities, attitudes towards geometry, attitudes toward mathematic and technology compared to traditional textbook based instruction.

1.1 Main and Sub-Problems of the Study

P1. What are the effects of student centered and teacher centered dynamic geometry based computer instructions compared to traditional teaching on seventh grade students' attitudes toward geometry (as measured by the Geometry Attitude Scale) when students' pretest scores on Geometry Attitude Scale and the Spatial Ability Test are controlled?

P2. What are the effects of student centered and teacher centered dynamic geometry based computer instructions compared to traditional teaching on seventh grade students' spatial abilities (as measured by the Spatial Ability Test) when students' pretest scores on Geometry Attitude Scale and the Spatial Ability Test are controlled?

P3. What are the effects of student centered and teacher centered dynamic geometry based computer instructions compared to traditional teaching on seventh grade students' attitudes toward mathematics and technology (as measured by the Mathematics and Technology Attitudes Scale) when students' pretest scores on Geometry Attitude Scale, and the Spatial Ability Test are controlled?

P4. What are the students' opinions related to the effects of computer based instruction?

1.2 Hypotheses of the Study

The following hypotheses were tested to answer the research questions:

Null Hypothesis 1**:** There will be no significant mean difference between the groups on the population means of the collective dependent variables of the seventh grade students' posttest scores on Spatial Ability Test, Mathematics and Technology Attitude Test and Geometry Attitude Scale when students' pretest scores on Geometry Attitude Scale and Spatial Ability Test are controlled.

Null Hypothesis 2**:** There will be no significant mean difference between the groups on the population means of the seventh grade students' posttest scores on Geometry Attitude Scale Test, when students' pretest scores on Geometry Attitude Scale and Spatial Ability Test are controlled.

Null Hypothesis 3: There will be no significant mean difference between the groups on the population means of the seventh grade students' scores on Mathematics and Technology Attitude Test, when students' the pretest scores on, Geometry Attitude Scale and Spatial Ability Test are controlled.

Null Hypothesis 4: There will be no significant mean difference between the groups on the population means of the seventh grade students' posttest scores on Spatial Ability Test, when students' pretest scores on Geometry Attitude Scale and Spatial Ability Test are controlled.

1.3 Definition of the Important Terms

Spatial ability: Spatial ability is cognitive functions that make it possible for people to deal effectively with spatial relations, visual spatial tasks, and orientation of objects in space (Sjölinder, 1998). In the present study spatial ability score refers to the sum of the spatial visualization score and spatial orientation score.

Spatial visualization: Spatial visualization is the ability to manipulate an object in an imaginary 3-D space and create a representation of the object from a new viewpoint (Strong & Smith, 2001). In the present study spatial visualization ability score refers to the sum of paper folding test score and surface development test score.

Spatial orientation: Spatial orientation is the ability to imagine how a given object or set of objects would appear from a spatial perspective different from that in which the objects are shown (Lohman, 1979). In the present study spatial visualization ability score refers to the sum of card rotation test score and cube comparison test score.

The traditional instruction environment: It is based on a textbook approach, using chapters of a textbook related to topics. It is teacher-centered and involves lecturing and sometimes questioning. Generalizations, rules and definitions are given firstly as a top down approach, and then examples are provided. The students listen and take notes in their own places (Duatepe, 2004).

Computer based instruction: Computer-based instruction is defined as the delivery of instructional content by means of the computer to achieve learning goals through desired outcomes (Lowe, 2004, p.146).

1.4 Significance of the Study

It is a common perception that geometry is strongly associated with spatial and visual ability (Battista et al., 1982). Considering this link between spatial ability and geometry achievement, the development of spatial ability has been a primary problem for the researchers and educators for many years. Numerous studies (e.g., Ben-Chaim *et al.*, 1988; Olkun, 2003) have indicated that spatial ability can be improved through training if appropriate materials are provided. However, few of them (e.g., Leong et., 2002; Piburn et al .,2002) focused on the effects of computer based instruction on students' spatial abilities. There still occurs a need to understand how technology should be employed by teachers and students for improving students' spatial ability.

This study provides a framework for analyzing students' spatial ability and provides some insight into how particular technological tools may influence students' spatial ability. The study also investigates the role of the construction software and how it should be employed to get the most beneficial improvements in spatial ability.

Not only does this study address the effect of dynamic geometry environment on students' spatial ability, but it also looks at how dynamic geometry environments may influence students' attitudes toward geometry, mathematics and technology. Previous studies indicated that attitudes play an essential role in learning mathematics (Aiken, 1972) and using computers may lead to more positive attitudes in students. However there is little research to support such claims (Steen, 2002; Ganguli, 1992). The effect of dynamic geometry environments on students' attitudes toward geometry, mathematics and technology requires further study. The research provides insight into the effects of dynamic geometry environments on spatial abilities, attitudes toward geometry and mathematics and technology. The findings of the study have implications for designing instructional lessons and information derived from this study can serve as foundations for development of curricular considerations.

1.5 Assumptions of the Study

1. All tests were administered to the all classes under the same standard conditions.
2. The subjects of the study were sincere while responding to the test items and interview questions.
3. Students from different classes did not interact and communicate about the items of pre and post tests before administration of these tests.
4. The differences of implementers have no effect on the results of the study.

1.6 Limitations of the Study

The participants in the study were not randomly selected from any population and subjects were not also randomly assigned to classes, therefore it can't be assumed that the findings are applicable to other situations. The findings are limited to the sample of the study. The researcher implemented the treatment in both experimental groups. Therefore personal biases and enthusiasm may have influenced the results of the study.

Two teachers instructed the classes during the two-week unit of study. This is a limitation of the study since it might have had effects on the results of the study. To reduce this threat, the researcher provided lesson plans and worksheets to the teacher who instructed the control group to ensure as much as consistency in the teaching of unit.

As I was the sole researcher in the study, I selected the topic of transformation geometry and dynamic geometry based on my interests and experience as a teacher. Therefore, my own biases might have had an influence on the findings.

The duration of the study can be considered as a limitation of the study. Two weeks might not have been long enough to have an impact on students' spatial abilities, attitudes toward geometry and mathematics and technology.

CHAPTER 2

LITERATURE REVIEW

The literature related to the present study is reviewed in this chapter. For this purpose the review is organized into seven sections. In the first sections I attempted to give definitions and types of spatial ability. The second section reviews the literature about importance of spatial ability and the studies on spatial ability and mathematics learning. In the third section the studies attempting to develop spatial ability are presented. The forth and fifth section focuses on literature that provides an insight into the studies about dynamic geometry environments and geometry education. The sixth section reviews the literature about improving spatial ability by using dynamic geometry environments. A coherent summary of the reviewed literature is drawn in the last section.

2.1. Definitions of Spatial Ability, Spatial Visualization and Spatial Orientation

There are various definitions have been used to describe spatial ability, such as, spatial sense (NTCM, 1989), spatial thinking (Yakimanskaya, 1991), spatial skills (Tartre, 1990), spatial reasoning (Clements & Battista, 1992), spatial cognition (Sjölinder, 1998). Smith (1998) explains this variation by two reasons. First, spatial ability includes some processes which are non-verbal and which therefore are hard to describe with words. Second, there is not a consensus on what constitutes spatial ability.

Tartre (1990) defines spatial skills as ‘‘mental skills concerned with understanding, manipulating, reorganizing, or interpreting relationships visually’’ (p.216). Smith (1998) also defines spatial ability as the ability to solve problems involving shapes and spatial stimuli, by means of spatial reasoning such as mental imagery, imagined changes in rotation, orientation, and position, and visual recognition of particular spatial features. Carroll (1993) refers to spatial ability as the ability ‘‘in manipulating visual patterns as indicated by level of difficulty and complexity in visual stimulus material that can be handled successfully, without regard to the speed of task solution’’ (p.362). Lean and Clements (1981, p. 267) also refer to spatial ability as the ability to formulate mental images and to manipulate these images in the mind. Another definition of the spatial ability is given by Sjölinder (1998) as the cognitive functions that enable people to deal effectively with spatial relations, visual spatial tasks and orientation of objects in space.

There are several studies that spatial ability has been categorized into a few primary factors. While there is not an agreement on the numbers of factors, research has shown that general spatial ability can be thought of as being composed of two primary factors spatial orientation and spatial visualization (Bishop, 1980; Clements & Battista, 1992; Lohman, 1979; McGee, 1979).

Clements and Battista (1992) have defined spatial orientation as understanding and operating on the relationships between the positions of objects in space with respect to one’s own position. Lohman (1979) defines spatial orientation as the ability to imagine how a given object or set of objects would appear from a spatial perspective different from that in which the objects are shown. Smith and Strong (2001) support the definition of Lohman and suggest that spatial orientation is the ability to image a scene from different viewpoint. Velez et al., (2005) also define spatial orientation as ‘‘the ability to accurately estimate changes in the orientation of an object’’ (p. 2).

According to Tartre (1990) spatial orientation describes the tasks that require the subjects mentally readjust her or his perspective to become consistent with a representation of an object presented visually. Tartre states that spatial orientation tasks could involve organizing, recognizing, making sense out of visual representation, reseeing it or seeing it from a different angle, but not mentally move the object. McGee (1979) also suggests that spatial orientation involves the "comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude to remain unconfused by the changing orientation in which a spatial configuration may be presented and the ability to determine spatial orientation with respect to one's body" (p.897).

The other type of spatial ability is spatial visualization. Spatial visualization is defined by Clements and Battista (1992) as comprehension and performance of imagined movements of objects in two and three dimensional space. Another definition of the spatial visualization is given by Tartre (1990) as the ability to predict specified transformations of geometric figures. Tartre (1990) states that spatial visualization skills may in general indicate "a particular way of organizing thought in which new information is linked to previous knowledge structures to help make sense of the new material". Smith and Strong (2001) also define spatial visualization as the ability to manipulate an object in an imaginary 3-D space and create a representation of the object from a new point. McGee (1979) refers to spatial visualization as "ability to mentally manipulate, rotate, twist, or invert a pictorially presented stimulus objects" (p.893).

2.2. Spatial Ability and Mathematics Education

The literature contains a great deal of discussion about the possible relationship between spatial skills and mathematics. Furthermore, spatial skills have been found to be positively correlated with measures of mathematics performance (Battista, 1990; Clements & Battista, 1992; Fennema & Sherman, 1977) and noted as being a significant factor in specific areas of mathematics, such as geometry and in particular complex problems (van Garderen, 2006). Liedtke (1995) reinforce the importance of spatial ability for mathematics and states that "Spatial sense or imagery is an important part of geometry and important part of mathematics learning, since it is indispensable in giving meaning to our mathematical experience" (p.18). Tso and Liang (as cited in Christou et al., 2007) suggest that spatial abilities are important cognitive factors in learning geometry and incorporating spatial visualization and manipulation into learning activity could improve geometric learning. Wilson (1992) also stress the importance of the ability to visualize mathematical relationships and states that it is an essential part of many people's knowledge of mathematics and their facility in communicating ideas about mathematics.

From this perspective, The National Council of Teachers of Mathematics (2000) emphasize the importance of spatial abilities in mathematics education and recommend that mathematics instruction programs should pay attention to geometry and spatial sense so that all students, among other things, "use visualization and spatial reasoning to solve problems both within and outside of mathematics". Olkun (2003) also notes enhancing students' spatial abilities is one of the roles of geometric activities.

More recently, guided by the thought that spatial ability is a factor that underlies mathematical aptitudes, researchers have attempted to discover the role that spatial ability plays in mathematics learning. Studies have indeed shown the positive correlation not only between spatial ability and geometry, but also, more generally, between spatial ability and mathematics achievement (Bishop, 1980).

Kayhan (2005) conducted a study with 251 ninth-grade students to investigate the relationships between mathematics achievement, logical thinking ability and spatial ability. Kayhan used Spatial Ability Test and Group

Test of Logical Thinking to measure students' spatial ability and mathematics achievement. The results of the study indicated that there is a significant positive relationship between spatial ability and mathematics achievement and there is a significant positive relationship between spatial ability and logical thinking ability. The findings of Tai (2003) also support these findings. Tai conducted a study to investigate the effects of cognitive style and spatial ability on the logical thinking and problem solving abilities of students with regard to programming language. Study results indicated that students with high spatial ability scored significantly higher than those with low spatial ability in logical thinking ability. Delialioğlu (1996) also investigated the contribution of students' logical thinking ability, mathematical skills and spatial ability on achievement in secondary school physics. As a result of this study he also determined a significant and positive relationship between spatial ability and logical thinking abilities.

Spatial ability especially spatial visualization has been also cited as an important component in solving many types of mathematics problems (Booth & Thomas, 2000). McLeay (2006) stress out the importance of visualization ability for problem solving and suggests that one way to improve pupils' problem-solving ability is to encourage pupils to use imagery and visualization strategies. Ben-Chaim et al., (1988) also state that "visualization provides the learners with additional strategies potentially enriching their problem solving repertoire" (p. 51). The findings of a study conducted by van Garderen (2006) support this statement. Van Garderen undertook a study to investigate students' use of visual imagery and its relationship to spatial visualization ability while solving mathematical word problems. Students with learning disabilities (LD), average achievers, and gifted students in sixth grade participated in this study. Students were assessed on measures of mathematical problem solving, visual imagery representation, and spatial visualization ability. The findings revealed that use of visual images was positively correlated with higher mathematical word problem–solving performance and there was a significant and positive correlation between each spatial visualization measure and mathematical word problem-solving performance.

Similarly to van Garderen, Alias, Black & Gray (2003) conducted a study to test whether spatial visualization activities would affect problem-solving skills in structural design. There were 77 and 61 civil engineering students in the experimental and control group respectively. The two groups were equivalent with respect to age, gender proportion and academic ability. The experimental group was taught spatial skills prior to the learning of the subject, while the control group had their normal lectures. Two instruments, the Spatial Visualization Ability Test Instrument (SVATI) and the Structural Design Instrument (SDI) had been specifically designed for the study. It was found that the experimental group had a statistically significantly higher score on the structural design measure compared to the control group and that the effect was especially significant on the understanding of structural behavior. It was concluded that spatial visualization ability aids in the understanding of structural behavior and thus enhances problem solving in structural design.

Battista (1990) also investigated the role of spatial visualization plays in performance and gender differences in high school geometry. The sample of the study was 145 high school geometry students. A version of Purdue Spatial Visualization Test, knowledge of geometry and geometric problem solving test were administered to students. The results indicated that spatial visualization was an important factor in geometry achievement and geometric problem solving.

Just as spatial visualization, the role of spatial orientation skill in mathematics problems was also investigated. Tartre (1990) carried out a study with 97 10th grade students to explore the role of spatial orientation skill in the solution of mathematics problems and to identify possible associated gender differences. A spatial orientation test and 10th grade mathematics achievement test were used to measure students' achievements in this study. The students were asked to solve mathematics problems in individual interviews also. The results of the study suggested that spatial orientation skill appears to be used in specific and identifiable ways in the solution of mathematics problems. Tarte also noted that spatial skills may be a more general indicator of a particular way of organizing thought in which new information is linked to previous knowledge structures to help make sense of new material.

The results of the study of Lean and Clements (1981) didn't support other studies which suggest that it is desirable to use visual processes when attempting mathematical problems. They undertook a study with 116 engineering students. Students were given a battery of mathematical and spatial tests; in addition, their preferred modes of processing mathematical information were determined by means of an instrument recently developed. The results of the study revealed that students who preferred to process mathematical information by verbal-logical means tended to outperform more visual students on mathematical tests. The results also showed that spatial ability and knowledge of spatial conventions did not have a large influence on the mathematical tasks.

2.3 Improving Spatial Ability

Given the obvious importance of spatial ability in mathematics and science education, it is natural that the development of spatial ability has been a primary problem for the researchers and educators for many years. Smith (1998, p.8) stress the importance of finding ways of developing spatial ability and states ''Finding ways to develop spatial visualization skills from kindergarten through the 12th grade may serve to improve later performance in a variety of academic disciplines such as geometry, physics, and engineering''.

The National Council of Teachers of Mathematics (2000) also recommends that 2D and 3D spatial visualization and reasoning are core skills that all students should develop. Piburn et al., (2002) stated that spatial ability can be taught and practice with classification, pattern detection, ordering, rotation and mental manipulation of three-dimensional objects can improve spatial ability. Previous studies have viewed that students' spatial ability can be improved through training (Battista et al., 1982). However, which type of training provides the most beneficial improvements to spatial ability is not known.

Battista, Wheatley and Talsma (1982) investigated the effects of spatial ability, cognitive development, and their interaction on mathematics learning and to explore if geometry instruction of the type given in this study improves the spatial ability of preservice elementary teachers. The samples of the study were 82 preservice elementary teachers enrolled in four sections of a geometry course for elementary teachers. Students in the study participated in numerous classroom activities having spatial components such as paper folding, tracing, cut outs which made them familiar with the motion concepts. The Purdue Spatial Visualization Test was administered to each student for twice and the scores of students were significantly different. The results of the study revealed that The Spatial Visualization Test scores of students enrolled geometry course were significantly higher at the end of the semester than the beginning which was evidence that activities used in this course may improve students' spatial ability.

Lord (1985) also succeeded in improving the spatial ability of college students; he asked students to picture the cross-sectional slice of a three-dimensional shape and predicts the two-dimensional shape of the cut surface in his study. The experimental group used geometrical manipulative for 12 weeks of exercises in visualizing cross-sections. Lord found experimental group's post-tests scores against a control group showed significant difference.

Ben-Chaim, Lappan and Houang (1988) undertook an extensive study involving some 1000 students. Students were engaged manipulating concrete tasks with small cubes and to construct isometric drawings on grid paper for 3 weeks. A pre-test, posttest and retention test, using the Middle Grades Mathematics Project Spatial Visualization Test (MGMP SVT) were administered to these students and it was found that the students gained significantly from the training programs in spatial visualization tasks.

Similar to that of Ben-Chaim et al., Robihaux (2003) has shown that training with manipulative can facilitate improvement of spatial visualization skills. Robihaux undertook a qualitative study to examine the spatial visualization ability of an elementary education major interested in teaching middle school geometry. Results of the study indicated that spatial visualization ability does improve through participating in spatial activities periodically and the use of concrete objects and the opportunity to verbalize one's thought during activities helps in the development of this ability. The results also suggested that engaging one in spatial tasks once a week every other week over the course of one semester while verbalizing one's thought processes did improve one's spatial visualization.

There is also number of studies that indicated many different types of technology can be used also to improve students' spatial abilities (Leong et al., 2002; Piburn et al., 2002). These studies will be discussed in next sections.

2.4 Technology and Geometry Education

In recent years, the limitations of traditional approaches in the teaching and learning of geometry has been expressed (Rahim, 2002). Maragos (2004) argues these limitations and states that "in a traditional geometry course, students are told definitions and theorems and assigned problems and proofs; they do not experience the discovery of geometric relationships, nor invent any mathematics" (p. 2). Olive (1991) also stress the limitations of traditional approaches and states an inductive approach based on experimentation, observation, data recording and conjecturing would be much more appropriate for geometry education instead of traditional approach and such an approach will give students the opportunity to engage in mathematics as mathematicians not merely as passive recipients of others mathematical knowledge. Battista (2002) agrees with Olive and stress the importance of providing rich student-centered learning environments that gives students opportunities to develop their geometric thinking.

Nohda (1992) also notes that in mathematics, understanding cannot be generally being achieved without participation in the actual process of mathematics: in conjecture and the argument, in exploration and reasoning, in formulating and solving, in calculation and verification. Reys et al., (2006) agrees with Nohta and advocate that geometry is best learned in a hands-on active manner, one that should not rely on learning about geometry by reading from a textbook.

All the limitations of traditional educational approach led researchers to study on the development of alternative ways of teaching and learning geometry. As an alternative way to get over the problems which the teaching of geometry was faced in the past decades, technological environments have been created and computers were introduced into geometry education. Hughes (as cited in Robitaille et al., 1977) reinforced the importance of computers for mathematics education and stated that:

> The computer is almost certainly the most valuable aid we have acquired in the past few decades for teaching concepts of mathematics, but it will not make its maximum contribution until we have discovered the best techniques for using it (p. 26).

The importance of using technology in the teaching of mathematics has been advocated by the National Council of Teachers of Mathematics (NCTM) for many years (NCTM, 1989 & 2000). In *Principles and Standards for School*

Mathematics, NCTM (2000) states that "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (p.24). Nohda (1992) supports this statement and notes computer environments are ideal tools that support the implementation of the curricula, especially in mathematics. He defines calculators and computers as "fast pencil" that mathematical process can be made more useful and efficient with than with paper and pencil. Miwa (1992) also stress the powerful of computer at inquiry and discovery and states that the computer promotes students' mathematical activities to inquire into and discover mathematics, which is very important in mathematics education. He also notes that computer use enables students to widen their field of vision and enrich their understanding, and motivates students to practice discovery process. Clements and Sarama (2001) agreed with Miwa and stress that the computer can offer unique opportunities for learning through exploration, creative problem solving, and self-guided instruction.

A number of studies have been conducted that look at the impact of technology on students' geometry achievement (Hollebrands, 2003; Chan, Tsai and Huang, 2006). These studies concluded that use of technology in the mathematics classroom is beneficial in developing students' understandings of geometric concepts (Laborde, 2001).

Olkun, Altun and Smith (2005) investigated the possible impacts of computers on fourth-grade students' geometry scores and further geometric learning. The study used a pretest–intervention–posttest experimental design. Findings revealed that students who did not have computers at home initially had lower geometry scores. These findings suggest that it would be more effective to integrate mathematical content and technology in a manner that enables students to do playful mathematical discoveries. Olkun (2003) also conducted a study to compare the experiences of a group of learners using computer-based representations with another group using concrete manipulative. The results of the study revealed that both groups improved significantly, the computer group improved slightly more, with older pupils (fifth grade) benefiting more from the computer-based manipulative.

Hatfield and Kieren (1972) reported two studies with seventh- and eleventh grade students who learned to program a computer and used this skill in studying mathematics. The studies were conducted to examine if there is a differential effect of computer use on students of varying level of prior mathematic achievement and if there are areas where the use of the computer particularly contributes to or detracts from mathematics achievement. Both studies were conducted in a university for two years. Each year was treated as a separate experiment and in each year samples of students were randomly assigned to either a computer or non-computer group. In each topic the objectives and procedures were primarily influenced by the content sample and sequence of the regular textbook. The only planned difference in the treatments was that the computer classes wrote and processed computer programs involving the problems, concepts, and skills from the regular mathematics course while the non-computer classes did not use the computer or computer programs in the study of the same mathematical content. The results from these related studies lend support to computer programming as a facilitator in certain aspects of mathematics instruction. The grade seven studies indicated that even low, achievers can learn to successfully program mathematical problems. Yet the average and above-average seventh-grade achievers seemed to benefit relatively more from the computer treatment.

Martínez et al., (2005) conducted a study to evidence a model of sequence of instruction that incorporates Java applets to examine a kind of task that might support the development of geometrical intuition. The results of the study showed that dynamic geometry software facilitated some types of learning activities, for example, exploration and visualization, and can enhance some others, such as proof and proving.

Chan, Tsai and Huang (2006) conducted a study to find a way promotes learning and Van Hiele levels of geometric thought among elementary students. The study concerned applying Web-based learning with learner controlled instructional materials in a geometry course. The experimental group included thirty-five 3rd grade students and thirty-nine 6th grade students learned in a Web-based learning environment, and the control group, included thirty-four 3rd grade students and forty 6th grade students learned in a classroom. The results observed that the learning method accounted for a total variation in learning effect of 19.1% in the 3rd grade and 36.5% in the 6th grade. They also observed that the 6th grade students' ability to learn with computers and the Internet was sufficient to handle problems and promote their van Hiele levels of geometric thought.

Palmiter (1991) compared the performance of 78 university students taught calculus using a computer algebra system to the performance of students using paper-and-pencil computations. Students who were taught calculus using a computer algebra system had higher scores on a test of conceptual knowledge of calculus than the students taught by traditional methods. Students in the computer class also had higher scores on a calculus computational exam using the computer algebra system than students in the traditional class using paper and pencil.

Tutak and Birgin (2008) investigated the effects of the computer assisted instruction on students' geometry achievement at fourth grade geometry course. The experimental group was instructed by means of the computer assisted teaching materials, while the control group was instructed by traditional methods. The "Geometry Achievement Test" consisting of 20 multiple choice questions as pre-test and post-test. The results of this study showed that the computer-assisted instruction had a significant effect on the students' geometry achievement compared to the traditional instruction at fourth grade geometry course.

These studies highlight that computers are important tools for improving student's geometry achievement. Given the importance of integrating computers into content area teaching, there is clearly a need for further research investigating the effects of computer in geometry education. This study sought to further investigate the potentialities of the computers in developing students' spatial ability, attitudes toward geometry, mathematics and technology.

2.5 Computer Software and Learning of Geometry

In the last two decades some excellent dynamic geometry programs that support students in developing mathematics concepts were developed such as the Geometric Supposer (McCoy, 1991), Geometry Grapher (Choate ,1992), Geometer's Sketchpad (Hannafin, Burruss & Little, 2001), Cabri (Schumann & Green, 1994), Geometry Inventor (Roberts & Stephens, 1999). These programs allow users to construct 'classical' geometric objects such as points, segments, lines, circles etc., measure distances, angles, areas, and manipulate shapes on-screen. The programs let users to change the objects which are displayed on-screen dynamically by dragging and re-sizing them. Choate (1992) states that ''geometry software's provide exciting oppornuties for teaching geometry because they can be used to perform geometric experiments''. Maragos (2004) also notes that dynamic geometry software has a profound effect on classroom teaching and can help students *see* what is meant by a general fact.

It is thus the purpose of this study to consider the effectiveness of the use of one of these construction programs, namely the *Geometers' Sketchpad*, as a tool in developing students' spatial ability. *Geometer's Sketchpad* (Jackiw, 2001) is one of the interactive and dynamic computer program that all construction are performed by clicking on objects on the screen with the mouse and selecting appropriate operations from pull-down menus. The GSP can be used to help students to learn and understand geometrical concepts and principles (Bennett, 1994; Hollebrands, 2003; Nickell, 2007).

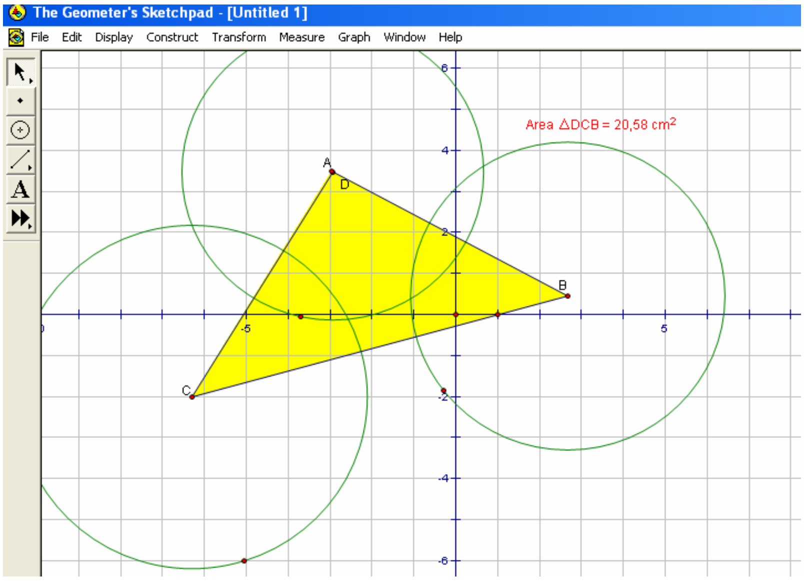


Figure 2.1: Geometer's Sketchpad Dynamic Software

Maragos (2004) states that *Geometer's Sketchpad* enables students to explore and understand mathematics in ways that are simply not possible with traditional tools. He also emphasize that *Sketchpad* encourages a process of discovery in which students first visualize and analyze a problem, and then make conjectures before attempting a proof. Furner and Marinas (2007) also states that the *GSP* software is an excellent interactive tool that allows students to create their own understanding of geometry and mathematical ideas in ways that are simply not possible with traditional tools. They also stress the importance of using hands on manipulative to construct students' own understanding of geometry and notes "the sketching software creates the bridge needed for children at a young age to connect their concrete understanding to more abstract mathematical ideas" (p. 86).

There are many elementary geometry concepts that could be explored using some fairly basic features of GSP. Finzer and Bennett (as cited by

Almeqdadi, 2000) state that students have many reasons for making a sketch with the GSP; “Their purpose may be to explore the behavior of a particular geometric figure, such as a rhombus, or to model a physical situation, such as a ladder leaning against a wall.They may want to make a beautiful pattern inspired by Navajo rug designs, or their goal may be an animation perhaps a Ferris wheel or a merry-go-round” (p. 2).

Research was carried out to study the impacts of dynamic geometry programme environments on students’ learning. Jones (2005) used data from a longitudinal study of 12-13 students’ use of dynamic geometry software, the focus of the analysis was on the interpretations the students make of geometrical objects and relationships when using this form of software. The analysis suggested that the students’ mathematical reasoning is shaped by their interactions with the software and the use of dynamic geometry software was appropriate for geometry education. Jones (2002) also reviewed a variety of dynamic geometry software research. The results of these researches also showed that dynamic geometry software can help students to explore, conjecture, construct and explain geometrical relationships.

Connor, Moss and Grover (2007) also investigated whether or not students made effective use of dynamic geometry software to explore the validity of a geometrical statement. Results indicated that reasoning based on prototypically constructed categories and difficulty correctly parsing mathematical statements, especially the ‘for all’ quantifier, interfered with the effective use of dynamic geometry software in justifying mathematical assertions.

The study of Hannafin, Burruss and Little (2001) examined teacher and student roles in a student-centered instructional geometry program using the Geometer's Sketchpad. The study was part of a larger project that included 2 seventh-grade teachers and their students. Grade 7 students worked for 2 weeks in their regularly scheduled mathematics class on activities that allowed them to explain on-screen relationships among geometric shapes. The class sessions and specific days were observed, students surveyed, and teacher and selected students interviewed. Findings revealed that students liked their new freedom, worked hard, and expressed greater interest in the subject material.

Hollebrands (2003) also conducted a study to investigate the nature of students' understandings of geometric transformations, which included translations, reflections, rotations, and dilations, in the context of the technological tool, *The Geometer's Sketchpad*. To investigate students' understandings of geometric transformations, the researcher conducted a teaching experiment in which she taught a seven-week instructional unit. The analysis suggested students' understandings of key concepts including domain, variables and parameters, relationships and properties of transformations were critical for supporting the development of deeper understandings of transformations as functions. Similarly to Hollebrands (2003), Almeqdadi (2000) conducted a study to investigate the effect of using the Geometer's Sketchpad (GSP) on students' understanding of some of the geometrical concepts. The students in the experimental group used the GSP software once a week and the book, while the students in the control group used only the book. Both groups took the same pretest and posttest, which was designed by the researcher. The results of the study indicated that there was a significant difference between the means of the students' scores on the posttest with favor to the experimental group. The results also indicated that there was more gain in the scores from the pretest to the posttest in the case of the experimental group.

Christou et al., (2003) also conducted a study to understand the way in which students can solve problems in the setting of a dynamic geometry environment, and how dynamic geometry environment provides opportunities for posing new problems. The results revealed that dynamic geometry software helped students to visually explore the problems and reflect on them. The results also showed that dynamic geometry environment can play a significant role in engendering problem solving and posing by bringing about surprise and cognitive conflict as students use the dragging and measuring facilities of the software. Similar to Christou, Nohda (1992) investigated the effects of dynamic geometry environment on students' problem solving abilities. He used an experimental group with the software of Cabri-Geometre and a control group with paper-pencil. The experimental group practiced with Cabri-Geometre and they solved problems by using it. On the other hand the control group solved the same problem without computer's results of the study indicated that there was no significant differences between groups.

Birgin, Kutluca and Gürbüz (2008) investigated the effects of computer-assisted instruction on students' achievement in "Coordinate Plane and Graphs of Linear Equation" at seventh grade mathematics curriculum. The experimental group was instructed by means of the computer assisted teaching materials using the "Spreadsheets" and "Coypu" software, while the control group was instructed by traditional methods. The results of this study showed that the computer-assisted instruction has more effective than the traditional instruction on students' achievement.

Işıksal and Aşkar (2005) carried out a study to investigate the effect of spreadsheet and dynamic geometry software on the mathematics achievement and mathematics self-efficacy of 7th-grade students. The study further examined the gender differences with respect to computer self-efficacy, mathematics self-efficacy and mathematics achievement. Two software programs, Excel and Autograph, were used in experimental groups separately, and a control group took traditional-based instruction without using any technological tools such as a computer or calculator. The "Mathematics achievement" test was used to assess the students' performance on mathematics. The "Mathematics self-efficacy" scale and the "Computer self-efficacy" scale were used in order to determine the self-efficacy expectation of the students with respect to mathematics and computers. Results revealed that the students in the Autograph group had the highest scores compared to other groups regarding mathematics achievement and mathematics self-efficacy. The results also revealed that boys had significantly higher scores with respect to computer self-efficacy. On the other hand, treatments seemed not to have any effect on gender regarding mathematics self-efficacy and mathematics achievement.

In the light of the superior geometry construction programs summarized abovethis study sought to employ *Geometers' Sketchpad* construction programme to improve students' spatial ability.

2.6 Technology and Spatial Ability

As discussed in previous sections technology has the potential to enhance student learning and provide students access to powerful geometric ideas and topics. One such topic is spatial abilities of students. Only a few studies have examined students' developing spatial ability while using technology. The results of these studies indicated that many different types of technology can be used to improve students' spatial abilities (Piburn et al., 2002).

A study of Clements et al., (1997) has viewed that students' spatial ability improved under instructional intervention. They studied a group of 23 third-grade students who were given pre- and posttest using the Wheatley Spatial Ability Test. Between the tests, students were taught a geometry unit using a *Tetris*™-like computer software that introduced area covering for rectangles using unit shapes that can be translated, rotated or reflected. The result indicated that students improved substantially, beyond a level measured in previous test-retest administration.

Similarly to Clements et al., Leong et al., (2002) investigated the impact of a computer software (Geometer's Sketchpad) *on* students' spatial abilities and on their concept formation of ideas within the domain of transformation geometry. Pre- and Posttests using the Wheatley Spatial Ability Test (WSAT) on three secondary two classes were administered. The results indicated that although the classes under this study were not significantly differentiated by the increases in the WSAT scores, it was noted that all these classes, irrespective of the mode of learning, registered significant gains in the WSAT scores, which is indicative of substantial improvement in their spatial ability.

Einsenberg (1999) also examined the effects of two software environments *HyperGami* and *JavaGami* on students' spatial abilities. A combination of assessment methods including children's drawings of two-dimensional folding nets, their verbal descriptions of polyhedral, and their performance on pre- and post- standardized tests of spatial visualization were discussed to examine the effect of the software and polyhedron building activities on students' spatial reasoning. The study showed that students have shown increases in sophistication in their verbal descriptions of shapes, in their renderings of folding nets of shapes, and in their performance on standardized tests of spatial thinking after their work with JavaGami or HyperGami.

Kosa, Baki and Güven (2007) carried out a study to investigate effects of dynamic geometry software Cabri 3-D on students' spatial skills. Research carried with two groups. In the first group implementations were carried with Cabri 3D during five weeks and the lessons at the second group were thought with traditional ways on blackboard. Purdue spatial visualization test was used as the pre-test to evaluate the students' spatial visualization skills. The results of the research showed that dynamic geometry software Cabri 3D is effective tool for developing students' spatial skills. The results also revealed that the students in experimental group enjoyed the 3D activities.

Onyancha et al., (2007) developed two tools for use in spatial ability training and they investigated the effect of these tools on the spatial ability and self efficacy of mechanical engineering freshmen in a comprehensive state university. One of two tools was Physical Model Rotator (PMR) which rotates a physical model of an object in synchronous motion with a model of the same object in CAD software and the other training tool was the Alternative View Screen (AVS) which provides the user of CAD software with both a solid model (including shading) and a line version view of the object. The students' spatial ability was determined using portions of the Purdue Spatial Visualization Test (PSVT). Students with poor spatial ability were identified and they were then trained over a four week period for one hour each week in the study. The effectiveness of the training tools was evaluated by comparing spatial ability test scores before and after training. The study found that all subjects who had poor spatial ability at the beginning of the semester showed some improvement at the end of the semester which was evidence that the newly developed training tools, the AVS and the PMR was effective at improving the spatial ability of students even when they are used over a relatively short period of time.

Virtual and Augmented Reality Learning Environment (VRLE) tools are also very useful for training spatial ability. The literature review shows these technologies were successfully used in a wide range of studies to examine different aspects of spatial behavior and skills (Hartman & Bertoline, 2005).

Kaufmann et al., (2005) conducted a study to investigate the potential of virtual reality (VR) and augment reality (AR) technologies on spatial ability. The aim of the study was to investigate whether spatial ability can be trained by an AR application and which aspects of spatial ability can be trained specially .Construct 3D which is a 3D geometric construction tool was used to design. The results indicated that all participants could improve their scores in the post test in the different spatial ability tests. Their findings indicated that augmented reality can be used to develop useful tools for spatial ability training. Kwon and Kim (2002) investigated the effects of virtual reality (VR) and augment reality (AR) technologies. All participants were 10th grade computer classes taught by mathematics teachers. All students were administered the Middle Grade Mathematics Project Spatial Visualization Test to obtain a baseline and background information on their skills. After Pretest was given, all students studied the software on the Web. A post test also was administered. The results of the study indicated that web-based instruction for spatial visualization was capable of improving the target skills and spatial visualization program using virtual reality was more effective than traditional methods.

Yeh and Nason (2004) also conducted a study to investigate two primary school students' construction of 3D geometry knowledge whilst engaged within a VRLE developed by the researcher. A design experiments research methodology was employed in this study. The participants in this phase or iteration of the design experiment were a Grade 6 student and a Grade 7 student. Findings of the study revealed that the 3D VR environment in VRMath provided users with the opportunity to operationalize both their spatial visualization and orientation abilities. Yun et al., (2006) also compared the effect of VGLS (Virtual Geometry Learning System) with that of the traditional teaching method in improving students' spatial ability. They selected two classes (total 106 students) in a middle school as experimental class and control class, and pre-tested their basic level of spatial ability. The VGLS was applied in the experimental class for four weeks while the traditional teaching method was applied in the control class. The result of the post-test showed that comparing with traditional teaching method, VGLS approach was more significant effective in the improving student's mental folding, unfolding as well as rotation ability of students, without obvious superiority in improving student's pattern recognition.

There are also studies that analyzed the potential of video games for improving the spatial skills of students. Miller and Kapel (1985) conducted a study carried with 7th and 8th grade students .A set of puzzle-type computer games were played by the experimental group. Students' spatial abilities were tested using Wheatley Spatial Test. The results showed that computer games played by students during the experiment had a positive effect on subjects' spatial skills.

All this finding opens up an avenue for research into effective approaches that can help to improve students' spatial abilities. This study is thus useful in its potential contribution to realize the effects of technology for improving students' spatial abilities.

2.7 Summary of Literature Review

Spatial skills are ''mental skills concerned with understanding, manipulating, reorganizing, or interpreting relationships visually'' (Tartre, 1990, p. 216). Spatial ability has been divided into two subdomains: spatial orientation and spatial visualization (Bishop, 1980; Clements & Battista, 1992; Lohman, 1979; McGee, 1979). Spatial orientation is the ability to imagine how a given object or set of objects would appear from a spatial perspective different from that in which the objects are shown (Lohman, 1979) and spatial visualization is the ability to manipulate an object in an imaginary 3-D space and create a representation of the object from a new viewpoint (Strong & Smith, 2001).

The literature contains a great deal of discussion about the possible relationship between spatial skills and mathematics. Spatial skills have been found to be positively correlated with measures of mathematics performance (Battista, 1990; Clements & Battista, 1992; Fennema & Sherman, 1977) and noted as being a significant factor in specific areas of mathematics, such as geometry and in particular complex problems (van Garderen, 2006). Given this obvious role of spatial ability in mathematics education, researchers have attempted to find ways to improve students' spatial ability. Previous studies have shown that students' spatial ability can be improved through training (Battista et al., 1982; Einsenberg, 1999; Onyancha et al., 2007; Robihaux, 2003). One of the ways to improve students' spatial ability is integrating computers into geometry education. Previous studies highlight that computers are important tools for improving student's spatial ability (Leong et al., 2002; Piburn et al., 2002). However there is little research to support such claims and which type of training with computers provide the most beneficial improvements to spatial ability is not known. This study is thus useful in its potential contribution to realize the effects of technology for improving students' spatial abilities. The study also investigates the role of the construction software and how it should be employed to get the most beneficial improvements in spatial ability.

CHAPTER 3

METHODOLOGY

This chapter discusses issues related to the methodology of the study such design of the study, sampling, instruments used in data collection, variables, procedures, teaching and learning materials, treatment, treatment verification and the analysis of the data collected.

3.1 Design of the Study

The quasi-experimental design was implemented in this study since the study do not include the use of random assignment of participants to both experimental and control groups (Fraenkel & Wallen, 1996). Following table summarizes the design of the study:

Table 3.1 Research Design of the Study

Groups	Pretests	Treatment	Posttest
Trt1	SAT GAS	Student centered dynamic geometry enviroment	SAT GAS MTAS
Trt2	SAT GAS	Teacher centered dynamic geometry environment	SAT GAS MTAS
CG	SAT GAS	Traditional teaching	SAT GAS MTAS

3.2 Population and Sample

Seventh grade is considered as an optimal time for the teaching of spatial visualization tasks (Ben-Chaim et al., 1988). Therefore, seventh grade students were chosen as sample in this study. The target population consists of all seventh grade private primary school students in Kayseri. Since it was difficult to select a random sample of individuals, convenient sample was used in this study. The sample was the seventh grade students in a private school in Kayseri where the researcher is a teacher. There were four seventh grade classes in the school and three of them namely 7-A, 7-B and 7-C were included in the sample. 7-A and 7-B which were taught by the researcher were identified as experimental groups (EG). While 7-A constituted Trt1 group, 7-B constituted Trt2 group. The other class 7-C constituted the control group (CG) for the study. The number of students involved in the study was 57. There were 18 students in Trt1 group, 20 students in Trt2 group and 19 students in the CG. The distribution of the subjects in the groups in terms of gender is given in Table 3.2.

Table 3.2 The distributions of the subjects in terms of gender

Gender	Groups							
	Trt1	%	Trt2	%	CG	%	Total	%
Female	11	55	10	55.5	10	52.6	31	54.3
Male	9	45	8	44.5	9	47.4	26	45.7
Total	20	100	18	100	19	100	57	100

3.3 Instruments

In order to gather data, three instruments were used in the study: Spatial Ability Test (SAT), Geometry Attitude Scale (GAS) and The Mathematics and Technology Attitudes Scale (MTAS).

3.3.1 Spatial Ability Test

Students' levels of spatial ability were assessed by Spatial Ability Test (SAT) which was a paper-pencil test. The SAT was developed by Ekstrom et al., (1976) and translated into Turkish by Delialioğlu (1996). The Spatial Ability Test (SAT) consisted of two sub-tests, spatial visualization ability test (SVAT) and spatial orientation ability test (SOAT). The score of the spatial ability test (SAT) was obtained by the summing the scores of SVAT and SOAT. The sample questions for each test are given in Appendix A.

The sub-tests of the SAT administrated for the study are:

Spatial Visualization Ability Test;

Spatial visualization ability test consists of two sub-tests: Paper Folding Test (PFT) and Surface Development Test (SDT). Both tests have two parallel parts; one was used for the pretest, one for the post test. A correction for guessing was used for scoring tests: the total test score is calculated according to the formula R - W/ (n-1), where R = the number right, W = the number wrong, and n = the number of response options for each item. The score of the spatial visualization ability test (SVAT) is obtained by the summation of the scores of PFT and SDT.

Paper Folding Test (PFT): It is a two-part test which each part consists of 10 multiple choice items. In each item, participants are shown an item on the left which depicts a folded of paper with holes punched and five item on the right.

Individuals are asked to select one of five drawings on the right that shows how the punched sheet on the left would appear when the piece of paper unfolded. Reliability measure as based on KR-20 coefficient was calculated as 0.73. Participants are given three minutes to solve 10 problems in each part in this test and given one point for every correct response. Since there are 20 questions, the maximum score of PFT is 20.

(ii) Surface Development Test (SDT): It is a two-part test which each part consists of 12 multiple choice items. In the test drawings are presented of a solid form. Reliability measure as based on KR-20 coefficient was claculated as 0.80. Participants are asked to indicate how the piece of paper should be folded to make the solid form. Participants are given six minutes to solve 12 problems in each part in this test and given one point for every correct response. Since there are 12 questions, the maximum score of SDT is 60.

Spatial Orientation Ability Test;

Spatial orientation ability test consists of two sub-tests: Card Rotation Test (CRT) and Cube Comparison Test (CCT). Both tests have two parallel parts; one was used for the pretest, one for the post test. A correction for guessing was used for scoring tests: the total test score is calculated according to the formula R - W/ (n-1), where R = the number right, W = the number wrong, and n = the number of response options for each item. The score of the spatial orientation ability test (SOAT) is the summation of the scores obtained by CRT and CCT.

Card Rotation Test (CRT): It is a two-part test which each part consists of 10 questions with 8 items. In each item, there is a figure on the left and 8 item on the right. Participants are asked to determine if these 8 figures are either rotated versions of the item on the right or not. Reliability measure as based on KR-20 coefficient was claculated as 0.81. Participants are given three minutes to solve 10 questions in each part and given one point for every correct response. Thus an individual makes a total of 160 responses; the maximum score of the test is 160.

Cube Comparison Test (CCT): It is a two-part test which each part consists of 42 true-false items. In each item, there are two cubes and students are asked to indicate if the cubes could be rotated versions of each other. Reliability measure as based on KR-20 coefficient was claculated as 0.78. Participants are given three minutes in each part to solve 21 problems in each part of the test and given one point for every correct response. The maximum score of CRT is 42.

3.3.2 Geometry Attitude Scale

In order to determine students' attitudes toward geometry, The Geometry Attitude Scale (GAS) developed by Duatepe (2004) was used (see Appendix B). This scale is two-dimensional having 12 items. Five items (item numbers 3, 4, 5, 8 and 12) of the test represent negative statements such anxiety and seven items (item numbers 1, 2, 6, 7, 9, 10 and 11) represents positive statements such as enjoyment. Students are asked to rate statements by marking a five-point Likert scale with the alternatives of strongly disagree, disagree, uncertain, agree, and strongly agree. Negative statements are scored as 5, 4, 3, 2, and 1 and positive statements are scored 1, 2, 3, 4, and 5 in the order of alternatives. Since the sample size of the study was too small for performing a factor analysis (Gorsuch, 1983), the scale was used as one dimensional as it was used in Duatepe's study. The internal reliability estimate of the GAS was found to be .82 by calculating the Cronbach alpha coefficient. The possible maximum scores of the GAS are 60 and the minimum score of the scale is 12.

3.3.3 The Mathematics and Technology Attitudes Scale (MTAS)

In order to determine students' attitudes toward to learning mathematics with technology, The Mathematics and Technology Attitudes Scale (MTAS) developed by Barkatsas et al., (2007) was used (see Appendix C). The instrument consists of 20 items. It consists of five subscales: mathematical confidence [MC], confidence with technology [TC], attitude to learning mathematics with technology [MT], affective engagement [AE] and behavioral engagement [BE]. Students were asked to indicate the extent of their agreement with each statement, on a five-point scale from strongly agree to strongly disagree (scored from 5 to 1). A different but similar response set was used for the BE subscale. A five-point system was again used nearly always, usually, about half of the time, occasionally, hardly ever (scored again from 5 to 1). Since the sample size of the study was too small for performing a factor analysis (Gorsuch, 1983), the scale was used as one dimensional as it was used in original study. The internal reliability for each sections in the test found to be; MC, .85; MT, .87; TC, .78; BE, .73 and AE, .66 by calculating the Cronbach alpha coefficient. The maximum and minimum possible scores on any subscale were 20 and 4 respectively.

3.4 Variables

Variables of this study can be categorized as Independent Variable, Covariates and Dependent Variables.

3.4.1 Independent Variable

Independent variable of the study was the treatment being implemented.

3.4.2 Dependent Variable

Dependent variables of the study were; students' posttest score on spatial ability test (POSTSAT), geometry attitude scale (POSTGAS) and the scores of The Mathematics and Technology Attitudes Scale (MTAS).

3.4.3 Covariates

Covariates of this study were students' pretest scores on geometry attitude scale (PREGAS) and Spatial Ability Test (PRESAT).

3.5 Procedure

The aims of this study was to investigate the effects of two different methods of dynamic geometry based computer instruction on seventh grade students' attitudes towards geometry, attitudes toward mathematic and technology and spatial abilities compared to traditional textbook based instruction and to get the students' views related to the effects of computer based instruction on their learning. The study was conducted in mathematics courses designed to teach the topics of seventh grade geometry, involving reflection, translation and rotation symmetry and tessellation.

For this study, the Geometer's Sketchpad (GSP) software was used as a construction tool in EG, the EG learned transformation geometry topics with GSP, on the other hand the CG learned the topics in a traditional instruction environment which was based on a textbook approach using chapters related to Transformation Geometry from *İlköğretim Matematik 7* (Yıldırım, 2001) the adoptive text-book for the seventh grade students.

The lessons in EG were conducted by using the lesson plans, activity sheets and worksheets which were developed by considering the objectives of the seventh grade geometry suggested by Ministry of National Education. These lesson plans, activity sheets and worksheets were piloted on sixth grade students from the same school used in the main study during the first semester of 2006- 2007 academic year to test their appropriateness for the specified topics. The pilot study provided to gain experience about the lesson plans, activity sheets and worksheets and how to use them in the classroom effectively. The following conclusions and suggestions were taken into the consideration in order to revise the lesson plans after the pilot study;

- Teachers would do well to have a detailed instructional plan and to stick closely to it.
- A preparatory lab session would help students to gain confidence in the use of the software.
- Some of the students may not be able to complete all the tasks given the same amount of time in the lab sessions. More attention and encouragement could also be given to the slower pairs.

Upon the completion of piloting lesson plans, activity sheets and worksheets, they were ready to be used. The lesson plans and activity sheets are shown in Appendix D. A sample of a typical worksheet used in these sessions is also found in Appendix E.

Spatial ability test, geometry attitude scale, mathematics and technology attitudes scale were also piloted on sixth grade students from the same school used in the main study during the first semester of 2006- 2007 academic year to check the clarity of the questions, to make sure the adequacy of the test duration, to determine the difficulty of the questions and to decide the most suitable tests. It was concluded that some of the students had difficulties in understanding the instructions of the tests. More attention should be given to these students and instructions should be stated clearly with each class.

Upon the completion of piloting instruments, the three tests were used in this study. The SAT was administered to students as a pre and posttest to all of the classes. The time allotted for the SAT was 15 minutes each time. The tests were administered by the researcher to all of the students in their classrooms. Prior to administering the test, the researcher explained the purpose of the study and the directions. In addition, before administering each part of the SAT the students were given instructions about how to answer the part.

The geometry attitude scale was administered to all of the classes to determine their attitudes toward geometry. The time allotted for the administration of this scale was approximately 15 minutes each time. The GAS was administered as a pretest before the treatment to control differences between groups statistically on their prior attitudes toward geometry. It was administered as a posttest upon the completion of the treatment on geometry to determine the effect of method of teaching on students' attitude toward geometry.

The mathematics and technology attitudes scale (MTAS) was used to determine students' attitudes toward to learning mathematics with technology. This measuring tool was administered to all of the classes, allowing approximately 20 minutes controlling differences between groups statistically on their attitudes toward to learning mathematics with technology upon the completion of the treatment.

The students in all of the classes were taught the same mathematical content at the same place in the second term of the 2006-2007 academic years. Treatment period lasted 14 lesson hours. There were seven mathematics classes in each week and each lesson lasted 40 minutes. The EG was instructed by the researcher, the CG, however, was instructed by the classroom teacher. The teaching in CG was conducted in their regular classrooms while the Trt1 group was conducted in a computer lab and the Trt2 group in a classroom where a computer and projector were located.

Follow up interviews were conducted with seven students of Trt1 group and six students from the Trt2 group to get their views related to the effects of computer based instruction on their learning. The students were selected by taking into consideration; gender, their post geometry attitude score, mathematics and technology attitude score and their post spatial ability tests scores to have the best representative sample. Each interview was conducted individually in a quiet area of the school like an empty classroom and audio-taped. In order to increase the probability of honest responses, the interviewees were informed that their names and other personal information would be kept confidential and would not be used in the research report. Although there was no time limitation in then interviews, each individual interview lasted approximately 15 - 30 minutes. The interviewed students were posed the following questions:

- Does computer based instruction affect your learning? How?
- What was your role in the lessons? Is there any difference compared to regular lessons in the classroom?
- What was your teacher role in the lessons? Is there any difference compared to regular lessons in the classroom?
- Are there any negative effects of computer based instruction on your learning?
- Do you have any thoughts about the importance of using Computers in mathematics teaching?
- Did you have any problems with the software?

3.6 Treatment

While the EG learned transformation geometry topics with GSP, the CG learned them with traditional teaching as usual, in the treatment phase. The *GSP* was used as a common technological tool in Trt1 and Trt2. The manner of its use, however, differed among the two of the groups. The sequence of the treatment including topics covered and administration of the tests in classes is presented in Table 3.3. As seen from this table, instruction sessions lasted 14 lesson hours in all of the groups.

Table 3.3 The comparison of the classes in terms of topics covered, their orders and administration of the tests

Lesson	EG	CG
1	GAS pretest	GAS pretest
2	SAT pretest	SAT pretest
3	Translation symmetry (Lesson plan 1)	Translation symmetry
4	Translation symmetry (Lesson plan 1)	Translation symmetry
5	Translation symmetry Worksheet	Translation symmetry Worksheet
6	Reflection symmetry (Lesson Plan 2)	Reflection symmetry
7	Reflection symmetry (Lesson Plan 2)	Reflection symmetry
8	Reflection symmetry Worksheet	Reflection symmetry Worksheet
9	Rotation symmetry (Lesson Plan 3)	Rotation symmetry
10	Rotation symmetry (Lesson Plan 3)	Rotation symmetry
11	Rotation symmetry (Lesson Plan 3)	Rotation symmetry
12	Rotation symmetry Worksheet	Rotation symmetry Worksheet
13	Tessellation (Lesson Plan 4)	Tessellation
14	Tessellation (Lesson Plan 4)	Tessellation
15	Tessellation (Lesson Plan 4)	Tessellation
16	Tessellation Worksheet	Tessellation Worksheet
Table 3.3 Continued		
17	POSTSAT	POSTSAT
18	POSTGAS	POSTGAS
19	MTAS	MTAS

3.6.1 Treatment in the EG

Trt1 group was taught by the researcher during the treatment period. Of the 14 periods of the treatment duration, 5 were double-period sessions and 4 were single-period sessions. Lessons were held in the classroom in single-period sessions and in the lab where computers were located in double-period sessions. In the lab, students conjectured and explored geometry topics by using *GSP* software and students were given worksheets in the classroom sessions to ensure as much consistency as possible in the teaching of the unit.

The *GSP* was used as a tool for students' exploration and conjecturing in the Trt1. Students constructed images and changed the objects which are displayed on-screen dynamically by dragging and re-sizing them. In this learning environment students created their own understanding of transformation geometry. Students were active participants in learning process that they were imagining, communicating, exploring and expressing their ideas. On the other hand, the researcher acted as a facilitator to make students to develop transformation geometry concepts and guided them to reach targeted goals. Students were free to make observations, ask questions, and make conjectures in the lessons.

As the students in this class had no prior experience with the GSP, the students in this class were given a one-hour GSP preparatory course to make them familiar with the software.

At the lab sessions students were paired and they worked on the computers in pairs. In each lab section, pairs were given activity sheet contains instructions on which files to open and what objects to drag. The students followed the instructions, dragged the objects and observed the results of the movements on the screen. Students were actively involved in their learning process by dealing with activity sheets. A typical student-pair's display is shown in Figure 3.1.

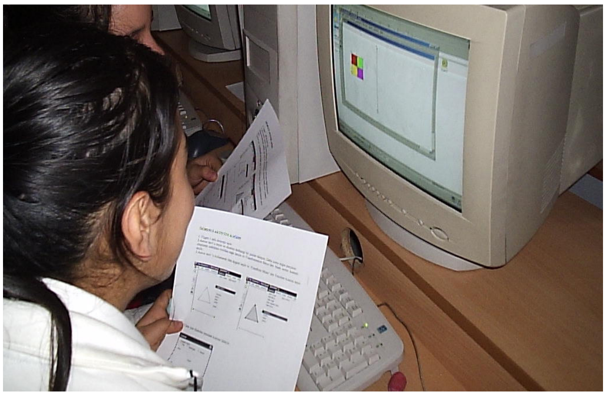


Figure 3.1. A typical student-pair's display in the Trt1

The experimental unit was organized into two one-week lessons. In these lessons students were introduced to the concept of translations, reflections, rotation and tessellation. They practiced translating, reflecting and rotating two-dimensional objects by using GSP and understood how translation, reflection and rotation worked. The first one-week consisted of 7 lessons which included concepts in reflections and translations. Lessons were carried out with the lesson plans 1 and 2. The first one week students did the activities that designed to have students demonstrate an understanding of translating or reflecting. Students discovered transformation patterns with computer applications and drew lines of symmetry on two-dimensional shapes. The second one-week also consisted of 7 lessons which included concepts of rotation and tessellation. Lessons were carried out with the lesson plans 3 and 4. The students did the activities which designed to have students perform, and describe rotations of 180º and clockwise and counterclockwise rotations of 90°, with the centre of rotation inside or outside .They created and analyses designs made by rotating a shape, or shapes, by 90º or 180º. Activities in tessellations addressed students to make quilt patterns by reflecting, translating, and/or rotating a shape, or shapes, by 90º or 180º.At the conclusion of each lab session students were encouraged to share their observations to the class. The lab sessions were followed by paper-and-pencil constructions and exercises in the classroom to review all they learned in lessons.

The Trt2 group was also taught by the researcher during the treatment period. All the lessons were conducted in the classroom where only a computer and a projector were located. Identical lesson plans were employed and identical worksheets were given in the Trt1 and the Trt2. But the construction software GSP was employed differently in two groups. While students could directly access the GSP and had hands-on experience with the software to explore the topics in the Trt1, students in the Trt2 couldn't directly access GSP. The teacher used GSP as a construction tool and manipulate the objects. In this class, direct instruction setting was applied. The students made observations while teacher was manipulating objects on the projected screen and they recorded the results of the activities presented on the screen. Since it was the teacher who used computer software to make conjectures on topics, the students in the Trt2 spent less time on the computer compared to the Trt1. Just like the Trt1, paper-and-pencil constructions and exercises were also given to students in the Trt2 to review all they learned in lessons.

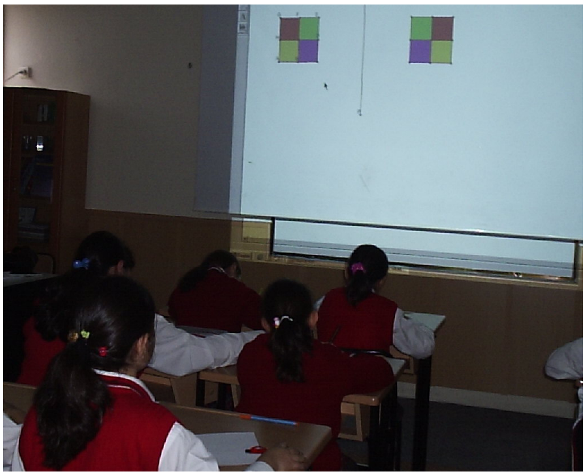


Figure 3.2. A display of projected screen in the Trt2

3.6.2 Treatment in the CG

Students in the CG were taught transformation geometry topics by traditional teaching approach. The traditional instruction environment was based on a textbook using chapters related to transformation geometry from *İlköğretim Matematik 7* (Yıldırım, 2001). The homework assignments were also given from this textbook. The author provided to teacher lessons plans and worksheets prior to and during the study. Students received identical worksheets with the other classes.

In this class generally, the teacher acted as an information giver and supplied knowledge to the students. Students were explained the concepts and given definition by the teacher and the teacher solved some examples on the blackboard by writing and drawing. Later the teacher allowed students to write them on their notebooks. The lessons were continued by solving questions in worksheets. The students in this group were passive receiver that they were just responsible for listening teacher, taking notes and solving the questions the teacher asked in their own places.

Figure 3.3. The traditional instruction environment in the CG

3.7 Data Analysis

3.7.1 Quantitative Data Analysis

As descriptive statistics, means and standard deviations were used to investigate the general characteristics of the sample.

The data gathered through the spatial ability test, mathematics and technology attitudes scale, and geometry attitude scale were analyzed by using Statistical Package for Social Sciences (SPSS) 15.0. Multivariate analyses of covariance (MANCOVA) procedure was employed to answer the research problems.

In order to compare the mean scores of the classes on attitudes toward geometry, mathematics and technology and achievement on spatial ability test and to reveal whether these differences are significant or not while controlling differences between groups for the pretest scores on attitudes toward geometry and spatial ability test, a MANCOVA was used.As the MANCOVA results only show significant differences between groups on the collective dependent variables, follow-up analyses of variance (ANCOVAs) were used to look at the effects of method of teaching on each dependent variable. In the analysis section, the probability of rejecting true null hypothesis (making Type 1-error) was set as .05 which is mostly used value in educational studies.

3.7.2 Qualitative Data Analysis

The conceptual framework of the study guided the qualitative analyses of data obtained from the students' interviews. The focus of the analyses was to investigate (a) how and why computer based instruction affected students' understanding of the topics of transformation geometry (b) reasons of changes in students' attitudes towards geometry, mathematic and technology.

The researcher used standardized open-ended semi-structured interviews. After the questions, follow-up questions were directed to deepen the interview responses. The analysis focused on the transcripts of 13 students taken from two experimental groups for whom extensive data are obtainable in an effort to answer the interview questions. The students were selected by taking into consideration; gender, their post geometry attitude score, mathematics and technology attitude score and their post spatial ability tests scores to have the best representative sample. 7 students from the Trt1 and 6 students from the Trt2 were selected as participants. After selecting the interview participants, each participant was interviewed in the same order by the researcher individually, going through the interview questions in order. The responses from participants were transcribed and coded to identify common responses of the students. Students' attitudes toward lessons were coded during the treatment and categorized as ''enjoy'' , ''like'' , ''interesting''. Students' attitudes toward learning experience were also coded during the treatment and categorized as ''hand-on'', ''visualization''.

3.8 Internal Validity

Internal validity refers to degree to which observed differences on the dependent variable are directly related to the independent variable not to some other (Fraenkel and Wallen, 1993). A list of possible threats to the internal validity of the study and how they were minimized or controlled were discussed in this section.

In this study students were not randomly assigned to the experimental and control group which can cause the subject characteristics threat to the study. Considering this fact, to remove subject characteristics threat students' previous geometry attitude and spatial ability scores were determined as potential extraneous variables to posttests. To minimize individual differences and satisfy group equivalency, these variables were put as a covariate set in MANCOVA analysis. The tests were administered to all groups in regular classrooms with similar conditions such as same size, same setting, etc. Therefore location threat was reduced by satisfying similar situations in three classes during the administration of the instruments. Furthermore, no outside events were notified that could influence the students' responses.

Mortality could not be a threat to the study since there were no missing data in all pretests and posttests. The researcher implemented the treatment in both experimental groups and it is a threat to internal validity since the characteristics, teaching ability, attitude or biases toward the treatment of the researcher might have an influence on the students' performance and attitude. For reducing this threat, the researcher avoided coaching the students towards the problems akin to those in the SAT.

Pretesting effect can be considered as a threat to this study. To reduce this threat, both groups were pretested and the pretest was treated as a covariate for the posttest analysis. Maturation might be also a threat to this study. However the length of the treatment was two weeks and both groups had the same time amount of time so if any maturation was occurred in subjects, it affected all of the classes.

3.9 External Validity

The participants of the study were seventh grade students in a private school in Kayseri. Since convenient sample was used in this study, the participants didn't constitute a sample of any larger population regarding external validity. However, the results presented in this study is limited with the sample of this study. Tests were conducted in regular classroom settings during the treatment that the conditions in all of three classes were more or less same and the size of the classes were around 20. The sitting arrangement and the lighting were also equal in three classes; therefore, the threats to ecological validity were not viable.

CHAPTER 4

RESULTS

This chapter is divided into four sections. The first section presents descriptive statistics of the data. The second and the third section present quantitative results and the qualitative results, respectively. The last one summarizes the research findings.

4.1 Descriptive Statistics

4.1.1 Descriptive Statistics of the Geometry Attitude Scale

The descriptive statistics related with the PREGAS and the POSTGAS appears in Table 4.1. As it is seen from the table, both the mean of the PREGAS and the POSTGAS of the Trt2 were higher than those of the Trt1 and the CG. The mean score of the Trt1 increased from 40.10 to 45.85 and the Trt2 increased from 45.72 to 49.50 whereas the CG showed a decrease of 2.85.

Table 4.1 Descriptive statistics related with the PREGAS and the POSTGAS

	Groups					
	Trt1		Trt2		CG	
	PREGAS	POSTGAS	PREGAS	POSTGAS	PREGAS	POSTGAS
N	18	18	20	20	19	19
Mean	40.10	45.85	45.72	49.50	43.79	40.94
Median	41	47.50	47.50	50.50	46	43.50
SD	11.68	10.40	9.26	7.05	8.10	8.33
Skewness	-.342	-.711	-.351	-.683	-.602	-.806
Kurtosis	-.486	.047	-.494	-.133	-.483	.636
Max.	18	22	26	33	26	22
Min.	60	60	59	59	54	55

In addition to the numerical descriptive statistics, clustered box plots were also performed. The clustered boxplots of the PREGAS and the POSTGAS appear in Figure 4.1. As seen from the figure, the median scores of the Trt1 and the Trt2 slightly increased from pretest to posttest while decreased in the CG. The range of the scores from PREGAS and POSTGAS for the Trt2 was smaller than the scores of the Trt1. Besides, the students of the Trt1 got the maximum score on POSTGAS.

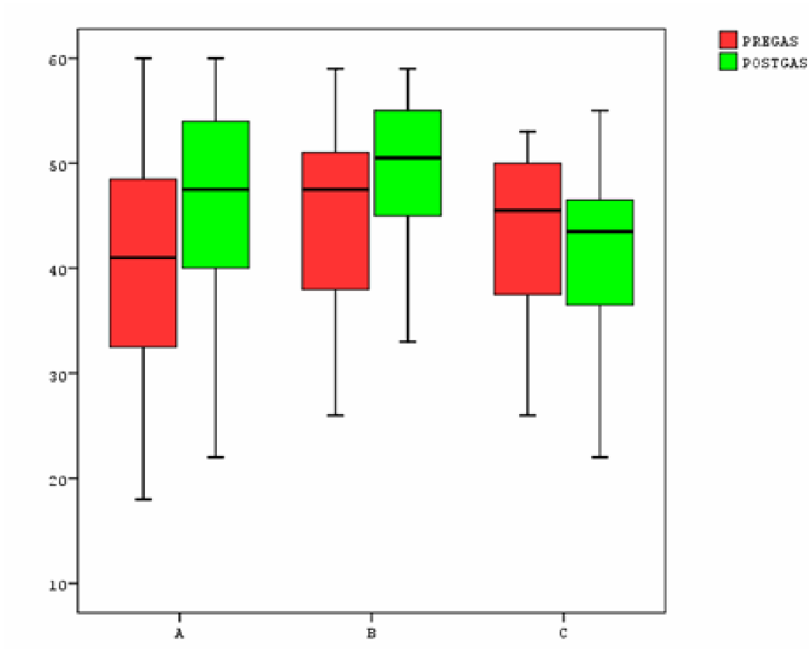


Figure 4.1 Clustered boxplot of the PREGAS and POSTGAS
(A indicates the Trt1, B indicates the Trt2 and C indicates the CG)

4.1.2 Descriptive Statistics of the Spatial Ability Test

The descriptive statistics related with the PRESAT and the POSTSAT appears in Table 4.2. The mean score of the Trt1 increased from 26.94 to 48.19 while the Trt2 increased from 42.28 to 60.47. An increase in mean scores was also observed for the CG from 26.32 to 35.84. According to the values, the mean score of the Trt1 showed an increase of 21.25 from pretest to posttest and the Trt2 had an increase of 18.19. The CG also showed an increase of 9.52.

Table 4.2 Descriptive statistics related with the PRESAT and the POSTSAT

	Groups					
	Trt1		Trt2		CG	
	PRESAT	POSTSAT	PRESAT	POSTSAT	PRESAT	POSTSAT
N	20	20	18	18	19	19
Mean	26.94	48.19	42.28	60.47	26.32	35.84
Median	27	49.63	44.25	61.38	18.75	39.25
SD	15.97	18.16	14.68	34.02	26.32	26.59
Skewness	-.098	-.408	-.548	-.602	1.207	.344
Kurtosis	-.579	-.666	-.312	-.221	-.483	-.636
Max.	59	86	67	113	96	100
Min.	1	22	14	-14	-11	-12

Figure 4.2 shows the clustered boxplots of the PRESAT and the POSTSAT. As it seen from the figure, the median scores of all groups increased from pretest to posttest. The maximum and the minimum and maximum scores on POSTSAT were gained by the students of the Trt2. There was a lower outliner in the PRESAT of the Trt2. One higher outliner appears in the POSTSAT of the CG.

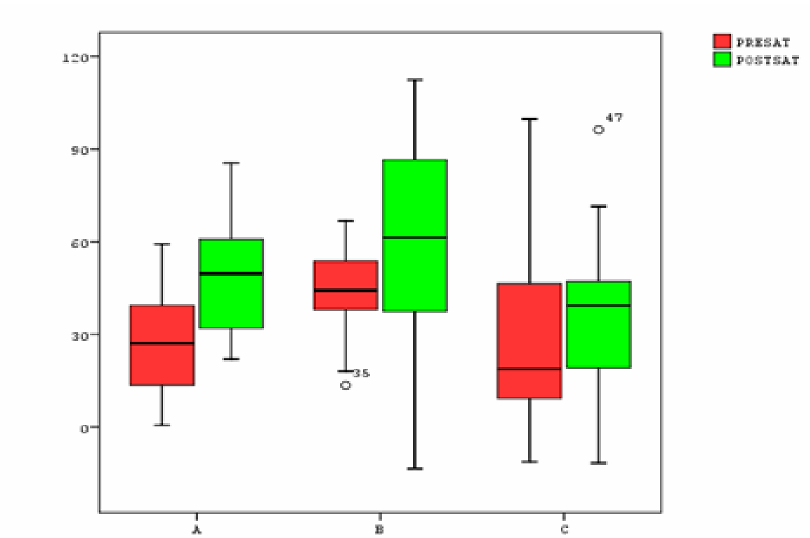


Figure 4.2 Clustered boxplot of the PRESAT and POSTSAT

(A indicates the Trt1, B indicates the Trt2 and C indicates the CG)

4.1.3 Descriptive Statistics of the Mathematics and Technology Attitudes Scale

The descriptive statistics related with the MTAS appears in Table 4.3. As it is seen from the table, the mean scores of the MTAS of the Trt1 and Trt2 were higher than those of the CG. The mean score of Trt1 is 84.65 and the mean score of Trt2 is 85.83. The mean score of the CG is 76.68.

Table 4.3 Descriptive statistics related with the MTAS

	Groups		
	Trt1	Trt2	CG
	MTAS	MTAS	MTAS
N	20	18	19
Mean	84.65	85.83	76.68
Median	88.00	88.00	78.00
SD	10.378	6.973	10.177
Skewness	-.939	.536	-.064
Kurtosis	-.082	-.180	-.534
Max.	100	94	95
Min.	62	70	59

Figure 4.3 shows the clustered boxplots of the MTAS. As it can be seen in Figure 4.3, the median of MTAS for the Trt2 is higher than the Trt1 and the CG. The maximum score was gained by the students of the Trt1 whereas the minimum score was gained by the students of the CG. Only one lower outliner was detected in the MTAS of the Trt1.

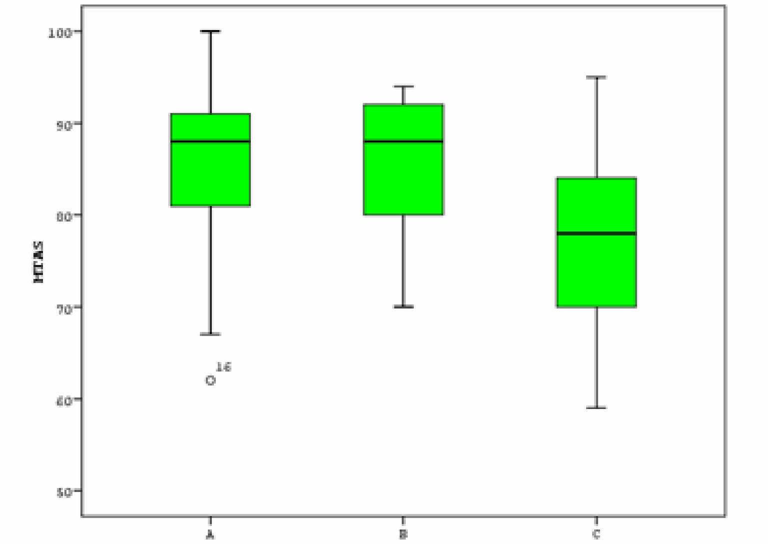


Figure 4.3 Boxplot of the MTAS

(A indicates the Trt1, B indicates the Trt2 and C indicates the CG)

4.2 Quantitative Results

4.2.1 Missing Data Analyses

There were no missing data in all pretests and posttests.

4.2.2 Determination of Covariates

Three independent variables namely; gender, the PRESAT and the PREGAS were set as possible confounding variables of this study. In order to determine which of these should be considered as covariates in MANCOVA, the correlations between the predetermined independent variables and dependent variables were calculated.The correlations and their significance appears in Table 4.4.

Table 4.4 Correlation coefficients between independent and dependent variables and their significance for the MANCOVA comparing posttests scores

Correlation Coefficients

	POSTGAS	POSTSAT	MTAS
GENDER	-.126	.059	-.125
PREGAS	.700**	.401**	.269*
PRESAT	.217	.538*	-.050

Correlation is significant at the .05 level (2-tailed).

Table 4.4 shows that all of the preset covariates have significant correlations with at least one of the dependent variables except gender of the students. Therefore the gender was discarded from the covariates set, and the other two independent variables were determined as covariates of the MANCOVA comparing posttests scores. In analysis of MANCOVA there are five underlying assumptions that need to be verified. These assumptions are normality, multicollinearity, and homogeneity of regression, equality of variances and independency of observations.

4.2.3 Assumptions of MANCOVA

In analysis of MANCOVA there were five underlying assumptions that need to be verified. These assumptions are normality, multicollinearity, and homogeneity of regression slopes, equality of variance and independence of observations.

To verify normality assumption, skewness and kurtosis values were examined. These values of scores on POSTGAS, POSTSAT, and MTAS were in almost acceptable range (between -2 and +2) for a normal distribution (Kunnan, as cited in Hardal, 2003) as indicated in Table 4.1, 4.2, 4.3.

The Box's test of equality of covariance matrices revealed that the observed covariance matrices of the dependent variables were equal across groups and thus the multivariate normality assumption was validated, Box's M = 22.16, $F(12, 11686) = 0.63$, $p > .05$.

The correlation between covariates was checked for multicolilinearity assumption. The results indicated that, the correlations between covariates were .352 which is smaller than .80. Therefore the assumption of multicollinearity was satisfied.

Homogeneity of regression slopes assumption was assessed through syntax using the MANOVA program. The test of the pooled covariates by the treatment showed that there was no interaction between the covariates and the treatment ($p > .05$.).

To determine the equality of variances assumptions, equality of variances was controlled by Levene's Test of Equality. Table 4.5 shows the results of this test. As it is seen from Table 4.5, all F values were found non-significant. This indicates the error variances of the dependent variable across groups were equal.

Table 4.5 Levene's test of equality of error variances for the MANCOVA comparing posttest scores

	F	df1	df2	Sig.
POSTGAS	1.803	2	51	.175
MTAS	.928	2	51	.402
POSTSAT	2.289	2	51	.112

Independency of observations assumption was also checked. To validate this assumption the researcher observed groups during the administration of all pre and post tests. The observations indicated that all subjects did all tests by themselves.

4.2. 4 Inferential Statistics

In this part the findings of the analyses related to the hypotheses will be presented. Hypotheses related to the first question were:

Null hypothesis 1: There will be no significant mean difference between the groups on the population means of the collective dependent variables of the seventh grade students' posttest scores on Spatial Ability Test, Mathematics and Technology Attitude Test and Geometry Attitude Scale when students' pretest scores on Geometry Attitude Scale and Spatial Ability Test are controlled.

In order to test the first hypothesis, data were analyzed by using multivariate analysis of covariance (MANCOVA). The results of this analysis are presented in Table 4.6.

Table 4.6 Multivariate tests results for the MANCOVA comparing posttest scores

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Eta Squared	Observed Power
Intercept	.193	65.325	3	47	.000	.807	1.00
PRESAT	.381	25.455	3	47	.000	.619	1.00
PREGAS	.393	24.216	3	47	.000	.607	1.00
MOT	.540	5.654	6	94	.000	.265	.99

As it is seen from the table, significant main effects were detected between the groups (Wilk's $\Lambda = .540$, $p = .000$). This means that statistically significant differences were identified between groups on the collective dependent variables of the POSTGAS, the POSTSAT and the MTAS. Therefore, the first null hypothesis was rejected which means that there was a significant mean difference between groups on the collective dependent variables of the POSTGAS, the POSTSAT and the MTAS.

Null Hypothesis 2: There will be no significant mean difference between the groups on the population means of the seventh grade students' posttest scores on Geometry Attitude Scale Test, when students' pretest scores on Geometry Attitude Scale and Spatial Ability Test are controlled.

Null Hypothesis 3**:** There will be no significant mean difference between the groups on the population means of the seventh grade students' scores on Mathematics and Technology Attitude Test, when students' pretest scores on, Geometry Attitude Scale and Spatial Ability Test are controlled.

Null Hypothesis 4**:** There will be no significant mean difference between the groups on the population means of the seventh grade students' posttest scores on Spatial Ability Test, when students' pretest scores on Geometry Attitude Scale and Spatial Ability Test are controlled.

To test the null hypotheses 2, 3, and 4 separate univariate analyses of covariance (ANCOVA) were then carried out on each dependent variable in order to test the effect of the method of teaching. Table 4.7 presents the results of the ANCOVA.

Table 4.7 Tests of between-subjects effects

Source	Dependent Variable	Type III Sum Of Squares	df	F	Sig.	Eta Squared	Observed Power
PRESAT	POSTGAS	124.061	1	3.761	.058	.071	.477
	MTAS	219.527	1	2.915	.094	.056	.388
	POSTSAT	16360.17	1	55.516	.000	.531	1.000
PREGAS	POSTGAS	2291.578	1	69.473	.000	.586	1.000
	MTAS	562.979	1	7.475	.009	.132	.764
	POSTSAT	855.573	1	2.903	.095	.056	.386
MOT	POSTGAS	703.361	2	10.662	.000	.303	.947
	MTAS	1465.753	2	9.731	.000	.284	.999
	POSTSAT	1305.365	2	2.215	.120	.083	.576
Error	POSTGAS	1616.269	49				
	MTAS	3690.546	49				
	POSTSAT	14440	49				
Total	POSTGAS	4568.833	53				
	MTAS	5516.815	53				
	POSTSAT	43283.49	53				

As it is seen from the table, there was a statistically significant difference between the groups with respect to posttest scores of the GAS ($F = 10.662$, $p < .001$). So the null hypothesis 2 was rejected. From Table 4.7, it can also be revealed that, there was a statistically significant difference between the groups with respect to scores of the MTAS ($F=9.731$, $p < .001$). The null hypothesis 3 was rejected. Null Hypothesis 4 was failed to reject since there was no significant mean difference on the dependent variable posttest scores of POSTSAT ($F = 2.215$, $p =.120$).

4.2.5 Follow-up analyses

Post Hoc Analyses consisted of pairwise comparisons was conducted for each dependent variable to find which methods of teaching had better results. For each dependent variable Bonferroni test was used as pairwise comparison (Multiple comparisons). Table 4.8 shows Bonferroni test results for the POSTGAS across the groups.

Table 4.8 Pairwise Comparisons of POSTGAS scores of students

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Trt1	Trt2	-.889	1.985	1.000	-5.809	4.031
	CG	7.842*	1.969	.001	2.961	12.722
Trt2	Trt1	.889	1.985	1.000	-4.031	5.809
	CG	8.731*	2.129	.000	3.452	14.009
CG	Trt1	-7.842*	1.969	.001	-12.722	-2.961
	Trt2	-8.731*	2.129	.000	-14.009	-3.452

As it is seen from the table, there was no significant mean difference between the Trt1 (M=47.63) and the Trt2 (M=48.52). On the other hand, there was a significant mean difference between the Trt1 and the CG (M=39.79) and between the Trt2 and the CG.

Table 4.9 shows Bonferroni test results for the MTAS across groups. According to the results, there was no significant mean difference between the Trt1(M=85.25) and the Trt2 (86.15). But, there was a significant mean difference between Trt1 and the CG (M=73.75) and between the Trt2 and the CG.

Table 4.9 Pairwise Comparisons of MTAS scores of students

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Trt1	Trt2	-.902	2.999	1.000	-8.337	6.533
	CG	11.507*	2.975	.001	4.133	18.882
Trt2	Trt1	.902	2.999	1.000	-6.533	8.337
	CG	12.410*	3.218	.001	4.433	20.386
CG	Trt1	11.507*	2.975	.001	-18.882	-4.133
	Trt2	12.410*	3.218	.001	-20.386	-4.433

Table 4.10 shows Bonferroni test results for the POSTSAT across groups. According to the results, there was no significant mean difference between the Trt1(M=53.33) and Trt2 (M=48.16) and between the Trt1 and the CG (M=40.94). Similarly there was no significant mean difference between the Trt 2 and the CG.

Table 4.10 Pairwise Comparisons of POSTSAT scores of students

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Trt1	Trt2	5.164	5.933	1.000	-9.542	19.871
	CG	12.384	5.884	.121	-2.203	26.971
Trt2	Trt1	-5.164	5.933	1.000	-19.871	9.542
	CG	7.220	6.365	.786	-8.558	22.998
CG	Trt1	-12.384*	5.884	.121	-26.971	2.203
	Trt2	-7.220*	6.365	.786	-22.998	8.558

4.3 Qualitative Results

Subjects were labeled Xi, where X indicates the treatment group and i the student. The audio-recorded responses of the students can be seen in Turkish in Appendix F.

4.3.1 Students' Opinions related to the Effect of Computer Based Instruction on Their Learning

In order to the get the students' opinions related to the effect of computer based instruction on their learning, they were asked the question of "Does computer based instruction affect your learning? How? " The interview results showed that all of the interviewees agreed that computers helped them to learn geometry easily and they understood geometry better.

Some of the students stated that computers created a dynamic learning environment which supported their development. Computers provided students opportunities to construct and manipulate geometric figures displayed on-screen dynamically which helped students to explore mathematic in a far more meaningful way. The students mentioned benefits of dynamic learning environment as follows:

> Using computers in learning mathematics was like having my own personal tutor guiding me. We could construct geometrical figures on screen and save them for future use. Computer made geometric figures dynamic we couldn't do by using a pencil or paper (A1).

> It would be so boring if we studied these topics on blackboard. We wouldn't be that active and we wouldn't understand the topics that well. I think I learnt very fast and easily because I was very active on learning process, I constructed objects and dragged them myself (A3).

> Computers enabled us to construct geometrical figures quickly and computers presented geometrical figures that we constructed in a dynamic and interesting way (A4).

> We could create and manipulate points and lines on the screen. Using computers made lessons more interactive (A6).

If we studied these topics on the blackboard as usual, that would be really hard for us to understand. For example if we tried to rotate objects on the blackboard that would be really difficult and I don't think I would understand rotation symmetry that well. But it was so easy to rotate objects by computer (B2).

I can't understand topics that well when only teacher explained it but, I learnt these topics very well because I was active in learning process by measuring, forming, discussing, thinking, doing, explaining (A2).

The students of the Trt1 stated that their learning was very meaningful for them since they discovered the topics themselves instead of memorizing properties and definitions that teacher said. They also stated that the use computer allowed them to have independent practice and they actively participated in learning process. On the other hand the students of the Trt2 indicated that they would learn much better if they had hands on experience with the computer instead of watching the objects on projected screen which were constructed by the teacher.

I really learnt the topics very well. We construct the objects ourselves, dragged them. I think that it would be waste of time if we studied these topics in the classroom in a traditional way. Because it would really take time to draw these objects (A4).

We constructed everything on computer it was like we were the creators. Computers allowed us to continuously learn from their mistakes (A7).

Projected computer images contributed my understanding of the key concepts of the course. But I think it would be much better for us if we had these experiments by ourselves (B3).

I didn't understand everything I watched on projected screen, I think I would understand much better if I had hands on experience with computer instead of just watching (B4).

I learn the topics much better when it is represented in a visual way. But I think that we could learn much better if we had hands on experience with computer instead of just watching the objects that represented on the projected screen (B5).

We could construct the geometric objects ourselves that would be much more interesting (B6).

Most of the students indicated that computers provided them a visual representation which helped them to understand geometry concepts better. They mentioned that computer helped them to visualize the geometric concepts in a fun and engaging way. They also indicated that computers allowed them visual representations that are often impossible to show with pen and paper.

I think the ability of visualization is important for geometry and working with computer in mathematic lessons helped us to use our visualization abilities and we could learn easily (A1).

We actually just solve problems and equations in mathematics lessons. But using computers allowed us to visualize the objects and the use of visualization made learning much easier (A6).

I don't actually understand mathematics well, it is like a brunch of numbers and I can't visualize what is going on really. But computer presents mathematics in a visual way that i can understand much better (A7).

I think it is much easier to understand geometric concepts, if they are visual and computer allows us to visualize the shapes (B1).

It is easier to understand math with computer because we can see the shapes visual and the computer shows things that is difficult to imagine (B2).

The use of visualization in learning mathematical concepts simplifies the concept. I think visualization enhanced our learning process (B3).

Students stated that their learning was much more meaningful for them than something which their teacher explains or exists out there in books. They stated that since all information represented visually they didn't need to memorize anything that they have learned and they could easily remember what they have learned.

I think that we have little understanding of what we are doing when we memorize mathematics topics. I have great difficulty trying to remember the things I memorized. But this time I didn't need to memorize anything, I think that I will have no difficulty remembering what I have learnt (A1).

Studying mathematics was just memorizing for me before, but I think that I didn't memorized anything this time; I have learnt the topic really (A2).

I don't remember any topic well we studied last year but I think that I will have no difficulty remembering what I have learnt in the lessons we used computers (A5).

Generally I have to study the topics over and over to learn well and it is very boring for me. But this time I didn't have to study that much, it was very easy and fun to learn. I really learnt the topics well and I don't think I will forget them (A7).

If we studied these topics in classroom as general that would be very boring and I think we would just memorize them instead of learning (B4).

Students mentioned that studying geometry with computer was very exciting and interesting for them. Some students mentioned that they had fun while learning in lessons. They also stated that they were much more attentive to the mathematics lessons. Computers introduced students to exciting ways of learning math and made students find math more enjoyable. Students liked the freedom provided by computers to do experiments.

> It was very exciting to learn geometry with computer; I think I learnt much better than before. I think that it was the same for everyone and we were all much more attentive in these lessons (A2).
>
> I really enjoyed learning math on the computer. Before this I could never make myself pay attention in order to learn. Using computers helped me concentrate and stay focused (A3).
>
> It was the best week in mathematics lessons for me because we used a computer software program to learn geometry. I think it was very interesting. That would be really cool to learn geometry always with computer (A5).
>
> It was a bit weird to study geometry with computer at first but I really had fun. It was really interesting and cool to study geometry only with computer without using paper and pencil. I think that it was the best topic we studied till now (B1).
>
> I didn't even think that these lessons would be that interesting for me. I liked very much learning geometry with computers; I think I really learnt the topics. I wish we could always study with computers (B4).

Some students mentioned that computer based instruction helped them to realize their potentials of being successful in geometry. The overall positive attitudes toward geometry were reflected in the students' comments. Students also stated that they gained confidence in themselves. Computer helped students to gain confidence in their self-initiated investigations and findings. Students' attitudes towards math were positively affected by the use of computer that they were more willing to participate in the class and offer answers to questions.

If you had asked me before what mathematics was, I would properly say that it was a torture. Now it is one of my favorite lessons. I am really surprised to realize that there are enjoyable ways to learn mathematics (A2).

Geometry was difficult for me before now I think that it is not that much difficult and I can be successful in geometry. I realized that geometry can be fun (A3).

I don't have problems with studying lessons in classroom but it was much better when we had lessons in the computer lab. I was very happy and really willing to attend the class when we had lessons there. I don't participate in class much in general because I don't really understand the topics but I could understand what we studied with computers (A4).

It was very different to construct objects on computer .I don't like geometry much at all but I really enjoyed these lessons was able to solve problems before but it was never interesting for me and it was a bit difficult also. Now I think geometry is not that difficult (A5).

I have to admit that I was very nervous about using computers to learn geometry because I am not much of a math person. But I have found that I have been doing so much better than I had expected. I noticed that there are some topics that I like in geometry (A6).

I always had to try hard to be successful in mathematics, but this time there was no need to try that hard. It was interesting to learn that topic. I learnt that I can be successful in mathematics and ı think that there are very enjoyable topics in mathematics (A7).

Some of our friends were afraid of geometry, they were afraid of being failed now I think that the way they think has changed and they feel much more confidence about themselves. I think that confidence is very important to learn geometry because we make mistakes if we don't have confidence and we can't learn the topics as much as we are expected (B1).

I thought that it was a very difficult topic for me before learning it with computers. Now I think that it is very easy and I think that I really learnt that topic (B2).

I was more willing to participate in the class when we had lessons with computer because I knew that it would be fun. I think that I really learnt the topics we studied. It was very easy for me to learn (B3).

I realized that there are mathematics topics that I can enjoy. Mathematics was just numbers for me before and it was really boring for me .Now I think that geometry is fun (B4).

There were just formulas in mathematics before. It was so boring to memorize them all for me. But in these lessons there was nothing boring. I think that I could enjoy the other topics also we had studied them with computers also (B5).

In order to the get the EG students' opinions related to software used in computer activities, they were asked the question of "How confident do you feel with using computers, starting programs, experimenting with a new program's functions etc.? Did you have any problems with the software? "

Most of the students responded that they felt fairly comfortable about using computers. Only two of the students said that they felt a little uneasy in using computers. Some of the students mentioned that they were not reliable access to computers because of some technical problems such as slow bandwidth. Some students also mentioned that it was a bit difficult to construct geometric objects with software because it was the English version of the software and they couldn't understand easily what to do.

I feel confident doing mathematics on computer (A2).

> It was a bit frustrating to use such software for learning mathematics at first. But now I feel less anxious about using computers when learning geometry (A3).

> I had only basic knowledge in computers before these lessons now I can use such software and I feel quite confident (A4).

> It was quite helpful for us but it was a bit hard to catch up the activities for me because of I didn't have so much experience using computers (A5).

> Computers were too old and sometimes we really had to try to make it work. If we didn't have such problems, using this software would be much easier (A6).

> It was a bit boring for me that it was the English version, but our teacher explained all we needed (A7).

In order to the get the students' opinions related to the role of computers in mathematics education, they were asked the question of "Do you have any thoughts about the importance of using Computers in mathematics teaching?" Most of the students indicated that technology and computers are as an important part of teaching mathematics because computers are motivator for them what makes math more interesting. Some students mentioned that they believe that integrating computers will engage them in their learning and lead to a better understanding of the content. Most of the students also indicated that using computers in the mathematics education would be very enjoyable for them. Only one student stated that using technology in the mathematics classroom was not that important.

> Technology and computers are very important part of this century. I think that they should be part of mathematics education also. I would like to study all subject in geometry with computers. It was so enjoyable for me (A4).

I think that computers should be part of mathematics education because they really lead us to a better understanding of the mathematics contents. We can do many new things so quickly, so carefully that is why preferred using computers (A6).

I think that computers make mathematics more interesting because it's very colorful and exciting. I think that would be great if we studied all mathematics topics by computers (A7).

Computers are motivators for us because we love getting on the computer. We see mathematics lessons as being fun and something exciting and new when we study with computers (B1).

I would much rather to learn geometry using computers instead of classical teaching methods. Computers allow us to get away from our desks for a while. Computers actually make learning mathematics enjoyable and exciting (B3).

I don't think that it would be so useful for us if we used computers in learning other topics. I think that it is very useful only for us in learning geometry topics (B4).

I think that we can learn much better if we use computers in mathematics topics but maybe it can be boring too. Because we would get used to it. Normally we study mathematics tonics on blackboard and it is very boring that is why we liked that much learning topic with computers because it was new and interesting (B5).

I don't think that using computers in mathematics education is that important. I would much rather learn geometry topics in traditional methods. I think that I can learn much better in that way (B6).

In order to get the EG students' views related with the negative aspects of computer based instruction on their learning; they were asked "Is there any negative effects of computer based instruction on your learning?" All of the interviewees expressed that there is no negative point for them.

4.3.2 Students' Opinions related to the Role of Students in Computer Based Instruction Environment

In order to get the students opinions related to the role of students in computer based instruction, they were asked the question of "What was your role in the lessons? Is there any difference compared to regular lessons in the classroom?"

Students emphasized that they were more active in their learning process in these lessons considering regular lessons. All students stated that they felt free to imagine, communicate and express their ideas. Students also stated that they were free to make observations, ask questions, and make conjectures in the lessons.

> In the past, we were just sitting in our desks and listening our teacher. We were not independent on our learning process. Using computers helped us to become independent learner. We did more independent work (A1).

> Generally our teacher explains the topics and we just note on our notebook. But in these lessons I felt so free; I draw the objects I wanted. Computers provided a break from classroom routine (A3).

> It was like I was the teacher. In fact everyone was like his or her own teacher. I think it is much better because we should be more active in our learning process (A5).

> Normally we just note what teacher wrote on blackboard, we try to solve the problems and sometimes we solve them on the blackboard. But in these lessons

> I was so active that I did much more than just listing and taking notes (B2).
> Normally it is a torture to sit, listen and take notes in last hours of school time and I got really boring. But I had fun even in last hours in these lessons (B3).

The students of the Trt1 also mentioned that they liked a lot in studying in pairs. Some of them mentioned that it was very helpful and fun for them to study in pairs. Working in pairs promoted maximum participation from all students. Pair work also promoted cooperative skills, such as listening and communication skills. Only one of the students stated that she didn't like pair work since she didn't have opportunity to do activities much because of her partner.

> Normally we just sit in our desks and listen to teacher, we don't talk each other or we don't share or discuss ideas. But in these lessons we worked in pairs it was really fun. Pair work was useful also because we discuss and helped each other while working on the computer tasks (A1).

> It was really fun that I did everything with my friend. We helped each other and it helped me to understand easier (A3).

> I didn't like working in pairs much. Because I didn't have enough time to work on the computer. I think it would be much better if I had studied alone (A4).

> We worked in pairs and it was not we often do. Generally we just listen to teacher and don't interact with each other much. But in these lessons we exchanged our ideas, we tried to do all activities together (A5).

> We used to interact with our teacher in the past; in fact we just interact with our teacher. But in these lessons we studied in pairs. We helped and corrected each other's mistakes (A7).

4.3.3 Students' Opinions related to the Role of Teacher in Computer Based Instruction Environment

In order to the get the students opinions related to the role of teacher in computer based instruction, they were asked the question of "What was your teacher role in the lessons? Is there any difference compared to regular lessons in the classroom?"

The students of the Trt1 stated that teacher didn't act as an information giver as usual. According to them the teacher played the role of a guide and partner in their learning. On the other hand, the students of the Trt2 stated that the teacher's role didn't change much.

> In the past teacher was telling the concepts and writing on the board. But in the lessons we did in computer lab, teacher didn't explain the subjects, she just guided and helped us to learn (A1).

> In the past teacher was telling everything and it was really boring for me but in these lessons teacher just helped us we did everything (A2).

> We did everything on computer but I think we can't be that successful without guidance of our teacher (A3).

> Teacher didn't tell much as before, just guided us. We didn't interact with the teacher as much as before. She guided me through the activities, but didn't tell me what to do (A5).

> In these lessons teacher didn't need to explain the topics, we did everything ourselves. The teacher does a little less teaching. She tried us to learn but it was not like before (A6).

> Instead of explaining concepts and modeling solutions, she let us come our own conclusions, she helped us when we got stuck, listened our conversations, tried to prod us right direction to finish the tasks (A7).

> I don't that think the role of teacher has changed much. She was active again but she asked more questions to us and she tried to make us understand the topics (B1).

> In the past teacher was explaining the topics. In these lessons teacher didn't explain the topics directly as much before she asked us more questions than usual and gave us clues to reach the answers (B2).

> I think that teacher was more active in these lessons than usual. Teacher did everything on the computer, asked us questions about the objects on the screen. Teacher helped us to understand the topics by asking questions (B3).

> Teacher constructed all objects on computer but she didn't explain everything as usual, she asked questions and tried to make us our own conclusions (B5).

One of the students mentioned that he was learning much better when teacher explain the topics instead of guiding students.

> Normally teacher was explaining the topics and I prefer that because I think I learn much better in that way (B6).

4.4 Summary of the Results

4.4.1 Summary of Descriptive Statistics

The descriptive statistics including sample size, mean, standard deviation, minimum and maximum scores, skewness and kurtosis reported the demographics of the sample. According to the results related to all of the instruments, the students of the Trt1 and the Trt2 which were taught by computer based instruction had the higher scores comparing the students of the CG which were taught by traditional instruction.

4.4.2 Summary of Inferential Statistics

Statistical analyses of quantitative data concerning performance in SAT, attitudes towards geometry and mathematics and technology were summarized in this part in relation to each of the hypothesis guiding the study.

- There was a significant mean difference between groups on the population means of the collective dependent variables of the seventh grade students' posttest scores on Spatial Ability Test, Mathematics and Technology Attitude Test and Geometry Attitude Scale when students' pretest scores on Geometry Attitude Scale and Spatial Ability Test are controlled.
- There was a significant mean difference between groups on the population means of the seventh grade students' posttest scores on Geometry Attitude Scale Test, when students' pretest scores on Geometry Attitude Scale and Spatial Ability Test are controlled.
- There was a significant mean difference on the population means of the seventh grade students' scores on Mathematics and Technology Attitude Test, when students' pretest scores on, Geometry Attitude Scale and Spatial Ability Test are controlled.
- There was no significant mean difference between groups on the population means of the seventh grade students' posttest scores on Spatial Ability Test, when students' pretest scores on Geometry Attitude Scale, and Spatial Ability Test are controlled.
- There was no significant mean difference between the POSTGAS

scores of the Trt1 and the Trt2. On the other hand, there was a significant mean difference between the Trt1 and the CG, and between the Trt2 and the CG.

- There was no significant mean difference between the POSTSAT scores of the groups.
- There was no significant mean difference between the MTAS scores of the Trt1 and the Trt2 while there was a significant mean difference between Trt1 and the CG and between the Trt2 and the CG.

4.4.3 Summary of the Qualitative Data

Summing up the interview results briefly, it can be argued that students' opinions related to the computer based instruction were positive. Students stated that computers created a dynamic learning environment which supported their development and computers helped them to explore mathematics in a far more meaningful way. The students mentioned that their learning was very meaningful for them since they discovered the topics themselves instead of memorizing properties and definitions that teacher said. Using computers gave students a visual way to explore and understand geometry which students frequently find difficult. Most of the students indicated that computers provided them a visual representation which helped them to understand geometry concepts better.

Students also mentioned that studying geometry with computer was very exciting and interesting for them. The use of computer affected students' attitudes towards mathematics very positively that most of the students stated that they were more willing to participate in the class and offer answers to questions. Computer based instruction also helped students to realize their potentials of being successful in geometry.

Concerning with the role of the teacher, students of the Trt1 stated that the teacher didn't act as an information giver as usual. According to them the teacher played the role of a guide and partner in their learning. On the other hand, the students of the Trt2 stated that the teacher's role didn't change much. Concerning their role, students emphasized that they were more active in their learning process in these lessons considering regular lessons. All students stated that they felt free to imagine, communicate and express their ideas. The students of the Trt1 also mentioned that they liked a lot in studying in pairs. Some of them mentioned that it was very helpful and fun for them to study in pairs. Working in pairs promoted maximum participation from all students.

Most of the students stated that they felt fairly comfortable about using computers. Only two of the students said that they felt a little uneasy in using computers. Some of the students mentioned that they were not reliable access to computers because of some technical problems.

CHAPTER 5

DISCUSSION AND IMPLICATIONS

This chapter is divided into five sections. The first section presents the discussion of the results. Implications and recommendations for further studies are given in the second and third sections respectively.

5.1 Discussion

The aims of this study were to investigate the effects of two different methods of dynamic geometry based computer instruction on seventh grade students' attitudes towards geometry, attitudes toward mathematic and technology and spatial abilities compared to traditional textbook based instruction and to get the students' views related to the effects of two different methods of dynamic geometry based computer instruction on their learning, awareness of themselves, the role of the teacher and students.

Findings of the study confirm that two different methods of dynamic geometry based computer instruction have a positive effect on geometry attitude compared to traditional teaching. According to the results, the mean score of the Trt1 (which was based on student centered dynamic geometry computer instruction) increased from 40.10 to 45.85 and the Trt2 (which was based on teacher centered dynamic geometry instruction) increased from 45.72 to 49.50 whereas the CG (which was based on traditional teaching) showed a decrease of 2.85.

The result shown here adds support to the previous studies that indicated that computer based instruction effect students' attitudes toward mathematics positively (Ganguli, 1992; Robitaille et al., 1977; Steen, 2002). The overall positive attitudes toward geometry were also reflected in the students' comments. During the observations students maintained high level of interest towards lessons that they were more willing to participate in the class and offer answers to questions. This finding supports the findings of Ganguli (1992) who found that students in the computer enhanced class demonstrated stronger motivation for doing mathematics than in similar courses where the technology was not incorporated into the learning process. This finding also supports the statement of Curtis (2006), she stated that when students experience a different learning environment from the traditional teaching, it can have a positive impact on student attitudes.

The reason for the positive effect on attitude can be explained by the exciting and interesting learning environment that was created by using computers. The enjoyment in the lessons reflected in the students' comments during the interviews. Most of the students mentioned that studying geometry with computer was very exciting and interesting for them. Some of the students also mentioned that they had fun while learning in lessons and that they were much more attentive to the mathematics lessons. From the classroom observations, it can be implied that computers introduced students to exciting ways of learning math which made students find math more enjoyable and students' attitudes toward geometry has been effected positively. This observation supports that of Reed (1996) who found that students' enjoyment was a ride effect stemming from students' positive attitude.

Findings of the study also confirm that two different methods of dynamic geometry based computer instruction have a positive effect on mathematic and technology attitude compared to traditional teaching. Students' attitudes toward mathematic and technology were slightly more positive for the Trt1 and the

Trt2 (M = 84.65, M = 85.83) than for the CG (M = 76.68) for the same unit of study. The results of this study support the findings of previous studies which showed that experience with computer has a positive effect on attitudes toward mathematics and technology (Paltimer, 1991; Sanchez, Ursini, & Orozco, 2004).

Interviews with students also shed insight on participants' interest in math and their attitudes toward the integration of mathematics and technology. Students' comments reflected their attitudes toward technology: "I really enjoyed learning math on the computer."; "I think that would be great if we studied all mathematics topics by computers."; "We see mathematics lessons as being fun and something exciting and new when we study with computers". Considering these statements, it can be concluded that experience with computers had a positive effect on students' attitudes toward using computers in mathematics education. This finding supports the findings of previous studies (Havill, Hashim & Alalawi, 2004; Ocak, 2006) who found positive correlation between and students' attitude and experience on the program.

Findings of the study confirm that the method of teaching has no significant effects on Spatial Ability. However, all the classes in this study made improvement in their SAT scores. According to the values, the mean score of the Trt1 showed an increase of 21.25 from pretest to posttest and the Trt2 had an increase of 18.19. The CG also showed an increase of 9.52. The result shown here adds support to the numerous studies that indicated that spatial ability can be improved through training (Battista et al., 1982; Ben-Chaim et al., 1988; Einsenberg, 1999; Onyancha et al., 2007; Robihaux, 2003).

According to the results, the Trt1 and the Trt2 made substantial improvement in SAT scores considering the scores of the CG. The results here strengthen the cause of employing the computers (as was in the Trt1 and the Trt2) to improve students' spatial abilities. The result shown here adds support to the numerous studies that indicated that technology can be used also to improve students' spatial abilities (Clements et al., 1997; Kwon & Kim, 2002; Leong et al., 2002; Piburn et al., 2002; Rafi et al., 2006).

Several reasons may account for the positive effect of computer based instruction on spatial ability test scores. One of the reasons for the positive effect of computers on spatial ability can be stemmed from the visual representation that computers provided. Visualization is a basic component in learning and teaching geometry and the importance of visualization in the teaching of mathematics is recognized by researchers (Harnish, 2000; Bishop, 1994; Gutiérrez, 1996). In this study, using computers provided students a visual way to explore and understand transformation geometry topics. Students could see visual representations on the screen which is often impossible to show with pen and paper. This finding supports that of Reed (1996) who found that computers help students to visualize concepts in geometry. Most of the students also indicated that computers provided them a visual representation which helped them to understand geometry concepts better during the interviews.

Another reason for the positive effect of computer based instruction on spatial ability test scores can be self-efficacy beliefs of the students which are considered as a factor that is effective in the students' learning about mathematics concepts (Cantürk & Başer, 2007). The previous studies showed that the learning of mathematics is influenced by a pupil's mathematics-related beliefs, especially self-confidence (Bachman, 1970; Hannula et al., 2004). This finding also was validated with students' interview responses that claim computer based instruction helped them to realize their potentials of being successful in geometry and they gained confidence in themselves. Findings from the interviews in this study suggested that computer based instruction had positive effects on students' self efficacy beliefs and their confidence. Computer helped students to gain confidence in their self-initiated investigations and findings. This findings support the findings of Sivin-Kachala and Bialo (2000) who found that computer based instruction had positive effects on student attitudes toward learning and on student self-concept. This findings also similar to the findings of Towle et al., (2005) who found self efficacy is directly correlated with spatial ability and self efficacy of students improved after using computer software.

Considering the mean scores of the Trt1 and Trt2, it can be concluded that the Trt1 which was based on centered student centered dynamic geometry computer instruction made much more significant improvement considering the Trt2 which was based on teacher centered dynamic geometry computer instruction. Considering the result of the mean scores, allowing the students to explore figures, via conjecturing and testing of their conjectures by using the *GSP* as was done in the Trt1 appeared to have enabled the students to form better in spatial ability test. This finding supports the suggestions of Reys, Suydam, Lindquist and Smith (2006) that geometry is best learned in a hands-on active manner. Furner and Marinas also state that students today are motivated to learn when activities are presented in a dynamic hands-on engaging manner.

Findings from the interviews also appear to suggest that having hands-on experience effected students' motivation and learning. Some of the students of the Trt1 stated that their learning was very meaningful for them since they discovered the topics themselves instead of memorizing properties and definitions that teacher said. They also stated that the use computer allowed them to have independent practice and they actively participated in learning process. This finding support the findings of Hannafin, Burruss, and Little (2001) who found that students enjoyed having personal control over their learning and that they equated being in charge with having fun. On the other hand the students of the Trt2 indicated that they would learn much better if they had hands on experience with the computer instead of watching the objects on projected screen which were constructed by the teacher.

Another reason of the difference between mean score of two groups can be pair work. The students of the Trt1 worked in pairs during the study and working in pairs could also facilitate learning. Interview feedback showed that, students had positive attitudes toward working in pairs. Some of the students mentioned that it was very helpful and fun for them to study in pairs. Working in pairs promoted maximum participation from all students. Pair work also promoted cooperative skills, such as listening and communication skills.

5.2 Implications

There is a positive correlation between spatial ability and mathematics achievement at all grade levels (Clements & Battista, 1992; Fennema & Sherman, 1977, Guay & McDaniel, 1977; Lean &Clements, 1981). Due to this correlation, teachers should be aware of the importance of spatial ability and be aware of the fact that it can be developed over a period if appropriate material is used just as computers (Battista et al., 1982; Ben-Chaim et al., 1988; Robihaux, 2003).

Curriculum developers should pay attention to the development of the spatial ability and geometry curriculum should be designed to develop spatial ability of students. Curriculum developers should also take the effectiveness of computer based instruction on developing spatial ability and should take into consideration during curriculum development process. The involvement of computers in mathematics curriculum will accordingly make teachers give more importance to computer based instruction.

Teachers should have knowledge of how technology can influence their students' understanding of the mathematics and attitudes; they also should understand how to use technology and how to select appropriate software. There is a need to provide classroom teachers with opportunities to develop teaching methods for computer integration. Courses for teachers might be designed to help them gain competency of "teaching with computers".

Preservice teacher training programs should also involve a course to inform prospective teacher about the benefits of computer based instruction and how to integrate computers to mathematics education. Thus, the prospective teachers can use computers throughout their undergraduate years and at the time of becoming a teacher; the prospective teachers can integrate computers into their job more easily.

Students should have the opportunity to use computer software to gain the knowledge and skills to use them appropriately .Students should take time to be familiar with constructions software (Pokay & Tayeh, 1997). In this purpose, it can be suggested that the time period of "computer" courses may be increased so that K-12 students could be able to interact with computers more.

The government should provide schools of education with larger technology budgets. Technology resources (hardware, software, and Internet access) should be provided in every school. In this context, it can be suggested that at least one computer with Internet access should be provided in every classroom. In addition to the supply of resources, technical support should be provided to schools and teachers to use these resources effectively.

One further implication can be suggested for the mathematics textbooks and other teaching materials. The mathematics textbooks for elementary students are lacking activities that help developing spatial abilities. Authors of mathematics education books should include concrete activities that help developing spatial ability in the textbooks.

5.3 Recommendations for Further Studies

Considering the high correlation between mathematics achievement and spatial ability (Clements & Battista, 1992; Fennema & Sherman, 1977; Guay & McDaniel, 1977; Lean &Clements, 1981) continued research that further specifically examines development of spatial ability is recommended to determine if it may improve.

Spatial ability is a cognitive factor that has been linked to high performance in science achievement as well as mathematics achievement (Lord and Rupert, 1995). Further research is recommended to examine the effects of spatial ability on science achievement.

Although there is some indication that students' gender difference is linked to their spatial ability, very few studies have investigated gender differences on spatial ability (Alias, Black, & Gray, 2002; Battista ,1990). It is strongly recommended that more studies should be conducted on effects of gender differences on spatial ability.

Computer based instruction can be implemented to every topic in mathematics. Transformation geometry topics were chosen for this study, however it is strongly recommended to use this instruction method in other topics of geometry.

The Geometry Attitude Scale and The Mathematics and Technology Attitude Scale were used as one dimensional scale in this study. It is strongly recommended to determine factorial structure of the scales in further studies.

In this study, convenience sampling was used. Thus, it can be stated that the results of the study were limited. Regarding this issue, new studies can be replicated using random sampling methodologies. A replication of this current study could be also done for a longer time and with a larger sample.

REFERENCES

Aiken, L. R. (1972). Research on attitudes toward mathematics. *Arithmetic Teacher*, 229-234.

Alias, M., Black, T. R., & Gray, D. E. (2002). Attitudes towards sketching and drawing and the relationship with spatial visualization ability in Engineering Students. *International Education Journal, 3*(3), 1-12.

Alias, M., Black, T. R. & Gray, D. E. (2003). Relationship between Spatial Visualization and Problem Solving in Structural Design-*World Transaction on Engineering and Technology Education*, *2*(2), 273-276, UICEE, Monash University.

Almeqdadi, F. (2000). The Effect of Using the Geometer's Sketchpad (GSP) on Jordanian Student's Understanding of Geometrical Concepts. Jordon: Yarmouk University.

Bachman, A. M. (1970). The relationship between a seventh-grade pupil's academic self-concept and achievement in mathematics. *Journal for Research in Mathematics Education, 1*(3), 173-179.

Barkatsas, A. (2007). A New Scale for Monitoring Students' Attitudes to Learning Mathematics with Technology (MTAS). *Computers and Education*, *48*(2), 285-300.

Basham, L. K. (2007). The effects of 3-D dimensional CADD modeling software on the development of spatial ability of ninth grade technology discovery students. Unpublished Ph.D. dissertation, Louisiana: Louisiana State University.

Battista, M. T. (1990). Spatial visualization and gender differences in high school geometry. *Journal for Research in Mathematics Education, 21*(1), 47-60.

Battista, M. T. (2002). Learning geometry in a dynamic computer environment*; Teaching Children Mathematics,* 8(6), 333-339.

Battista, M. T., Wheatley, G. H. & Talsma, G. (1982). The importance of spatial visualization and cognitive development for geometry learning in preservice elementary teachers. *Journal for Research in Mathematics Education, 13*(5), 332-340.

Ben-Chaim, D., Lappan, G. & Houang, R. T. (1988). The effect of instructions on spatial visualization skills of middle school boys and girls. *American Educational Research Journal, 25*(1), 51-71.

Bennett, D. (1994). *Exploring geometry with The Geometer's Sketchpad.* Key Curriculum Press.

Birgin, O., Kutluca, T., & Gürbüz, R. (2008). The Effects of Computer Assisted Instruction on the Students' Achievement in Mathematics at Seventh Grade. [Online] http://ietc2008.home.anadolu.edu.tr/ietc2008/170.doc [2008,September 09].

Bishop, A. J. (1980). Spatial abilities and mathematics education – a review. *Educational Studies in Mathematics, 11*, 257-269.

Booth, R. D., Thomas, M. O. (2000) Visualization in mathematics learning: arithmetic problem-solving and student difficulties. *Journal of Mathematical Behavior*, *18*(2), 169-190.

Brodie, J. H. (2004). Background Factors Affecting Success in Geometry.[On-line] http://handle.uws.edu.au:8081/1959.7/12566 [2008, July 09].

Cantürk, B., & Başer, N. (2007).The development of Self-Efficacy Scale toward Geometry. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *33*, 68-76.

Carroll, J. B. (1993).Human cognitive abilities: A survey of factor-analytic studies. Cambridge, England: Cambridge University Press.

Chan, H., Tsai, P., & Huang, T.Y. (2006). Web-based Learning in a Geometry Course. *Educational Technology & Society*, *9* (2), 133-140.

Christou, C., Mousoulides, N, Pittalis, M, & Pitta-Pantazi, D. (2003). Problem solving and posing in a dynamic geometry environment. *Proceedings of the 6th International Conference on Technology in Mathematics Teaching*, 125-132.

Christou, C., Jones, K., Pitta-Pantazi, D., Pittalis, M., Mousoulides, N., Matos, J.F., Sendova, E., Zachariades, T., &Boytchev, P. (2007), Developing student spatial ability with 3D software applications. Paper presented at the *5th Congress of the European Society for Research in Mathematics Education (CERME)*, Larnaca, Cyprus, 22-26 Feb 2007.

Choate, J. (1992). Using Construction Programs in the Teaching of Geometry, in J.P. Becker & T. Miwa (Eds.), Proceedings of the US-Japan Seminar on Computer Use in School Mathematics. (ERIC Document Reproduction Service No. ED 351203)

Clements, D. H., & Battista, M. T. (1992). Geometry and spatial reasoning. In Grouws D.A. (Ed.), *Handbook of research on Mathematics Teaching and Learning*, (pp. 420-463). New York: Macmillan.

Clements, D. H., Battista, M. T., & Sarama, J. (2001), Logo and Geometry: JRME monograph number 10. Reston, Va.: National Council of Teachers of Mathematics.

Clements, D. H., Battista, M. T., Sarama, J., & Swaminathan, S. (1997). Development of students' spatial thinking in a unit on geometric motions and area. *The Elemantary School Journal, 98*(2), 171-186.

Connor, J., Mossy, L. & Groverz, B. (2007). Student evaluation of mathematical statements using dynamic geometry software. *International Journal of Mathematical Education in Science and Technology*, *38* (1), 55–63.

Curtis, M. K. (2006). Improving student attitudes: A study of a mathematics curriculum innovation. Unpublished PhD dissertation, Manhattan: Kansas State University.

Delialioğlu, Ö. (1996). Contribution of students' logical thinking ability, mathematical skills and spatial ability on achievement in secondary school physics, unpublished master's thesis, Ankara: METU.

Duatepe, A. (2004). The effects of drama based instruction on seventh grade students' geometry achievement, Van Hiele geometric thinking levels, attitude toward mathematics and geometry. Unpublished PhD dissertation, Ankara: METU.

Eisenberg, A. (1999).An Educational Program for Paper Sculpture: A Case Study in the Design of Software to Enhance Children's Spatial Cognition.PhD dissertation, Colorado: University of Colorado, USA.

Fennema, E., & Sherman, J. (1977). Sex-related differences in mathematics achievement, spatial visualization and affective factors, *American Educational Research Journal*, *14*, 51-71.

Fraenkel, J.R., & Wallen, *N.E. (1993). How to design and evaluate research in science education. (3rd Ed.).* NY: McGraw-Hill.

Furner, J. M., & Marinas, C.A. (2007). Geometry Sketching Software for Elementary Children: Easy as 1, 2, 3. *Eurasia J. Math., Sci. & Tech. Ed.*, *3*(1), 83-91.

Ganguli, A. B. (1992). The effect on students' attitudes of the computer as a teaching aid. *Educational Studies in Mathematics, 23*, 611-618.

Gardner, H. (1993). *Frames of mind: The theory of multiple intelligences* (10th anniversary Ed.) New York: Basic Books.

Gorsuch, R. L. (1983). *Factor analysis* (2nd Ed.). Hillsdale, NJ: Erlbaum.

Guay, R.B., & McDaniel, E. (1977). The relationship between mathematics achievement and spatial abilities among elementary school children, *Journal for Research in Mathematics Education, 8*, 211-215.

Gutiérrez, A. (1996). Visualization in 3-dimensional geometry: In search of a framework, *Proceedings of the 20th PME Conference. 1*, 3-19.

Hannafin, R. D., Burruss J. D., Little C. (2001). Learning with Dynamic Geometry Programs: Perspectives of Teachers and Learners. *The Journal of Educational Research*, *94*(3), 132-147.

Hannula, M. S., Maijala, H., & Pehkonen, E. (2004). Development of Understanding and Self-confidence in Mathematics; Grades 5-8. *International Journal for Mathematics Teaching and Learning* (October 12).

Hardal, O. (2003).The effects of hands-on activities on students' achievement and attitudes towards physics. Unpublished master dissertation, Ankara: METU.

Harnisch, D. L. (2000). *Importance of mathematical visualization: I can see what you mean now*. Presentation as part of Symposium entitled: Moving K-12 Teachers into 21st Century Technology: Building the educational grid for pre-service training. Paper presented at the Society for Information Technology and Teacher Education (SITE), San Diego.

Hartman, N. W., Bertoline, G. R. (2005).Spatial Abilities and Virtual Technologies: Examining the Computer Graphics Learning Environment. Ninth International Conference on Information Visualization (IV'05), pp. 992-997.

Hatfield, L. L., & Kieren, T. E. (1972). Computer-assisted problem solving in school mathematics. *Journal for Research in Mathematics Education*, *3*, 99-112.

Havill, D., Hashim , W. B., & Alalawi, S. (2004).Optimizing computer-based developmental math learning at an Arabic women's university.*International Journal for Mathematics Teaching and Learning* (October 12).

Hollebrands, K. (2003). High school students' understandings of geometric transformations in the context of a technological environment. *Journal of Mathematical Behavior, 22*(1), 55-72.

Huk, T., Steinke, M., & Floto, C. (2003). The Influence of Visual Spatial Ability on the Attitude of Users towards High-Quality 3D-animations In Hypermedia Learning Environments. *Proceedings of E-Learn, 1038* -1041.

Isiksal, M. and Askar, P. (2005) The effect of spreadsheet and dynamic geometry software on the achievement and self-efficacy of 7th grade students. *Educational Research, 47*, 3, 333-350.

Jackiw, N. (2001). The Geometer's Sketchpad (Version 4) [Software]. Berkley, CA: Key Curriculum Press.

Jones, K. (2002). Research on the use of dynamic geometry software: implications for the classroom. *Micro Math*, *18*(3), 18-20 & 44-45.

Jones, K. (2005), The Shaping of Student Knowledge with Dynamic Geometry Software. Paper presented at the *Computer Assisted Learning Conference 2005* (CAL05), Bristol, 4-6 April 2005.

Kaufmann, H., Steinbügl, K., Dünser, A., Glück, J. (2005) General Training of Spatial Abilities by Geometry Education in Augmented Reality. *Annual Review of CyberTherapy and Telemedicine: A Decade of VR, 3*, 65-76.

Kayhan, B. (2005). Investigation of high school students' spatial Ability. Unpublished Masters Dissertation, Ankara: METU.

Kosa, T., Baki, A., & Güven, B. (2007). Using Dynamic Geometry Software Cabri-3D to improve students' spatial Skills. [Online] http://matserv.pmmf.hu/cadgmewebproceedings/index.htm [2008, September 09].

Kwon, N., Kim, S., Kim, Y. (2002). Enhancing Spatial Visualization through Virtual Reality on the Web: Software Design and Impact Analysis. *Journal of Computers in Mathematics and Science Teaching, 21(1), 17* -31.

Laborde, C. (2001). Integration of technology in the design of geometry tasks with Cabri-geometry. *International Journal of Computers for Mathematical Learning*, *6*, 283–317.

Lean, G., & Clements, M. A. K. (1981). Spatial ability**,** visual imagery, and mathematical performance. *Educational Studies in Mathematics*, *12*, 267-299.

Leong, Yew Hoong & Lim-Teo, Suat Khoh. "Effects of *The Geometer's Sketchpad* on Spatial Ability and Achievement in Transformation Geometry among Secondary Two Students in Singapore." *Proceedings of Second East Asia Regional Conference on Mathematics Education*, Vol. II*,* eds. Douglas Edge and Yeap Ban Har (Singapore: EARCOME2/SEACME9, 2002): 433-439.

Liedtke, W. (1995). Developing Spatial Abilities in The Early Grades. *Teaching Children Mathematics,* 12-18.

Lohman, D. F. (1979). *Spatial ability: A Review and Reanalysis of the Correlational Literature* (Tech. Rep. No. 8). Stanford, CA: Aptitude Research Project, School of Education, Stanford University. (From Diezmann, C. M., Watters, J.J. (2000). Identifying and Supporting Spatial Intelligence in Young Children, *Contemporary Issues in Early Childhood, 1*(3), 45-60)

Lord, T. (1985). Enhancing the visuo-spatial aptitude of students. *Journal of Research in Science Teaching, 22*(5), 395-405.

Lord, T. R., & Rupert, J. L. (1995). Visual-spatial aptitude in elementary education majors in science and math tracks, Journal of Elementary Science Education, *7*, 47-58.

Lowe, J. S. (2004). A theory of effective computer-based instruction for adults. Ph.D.Thesis. Louisiana: Louisiana State University.

Lowrie, T. (1994). *Developing talented children's mathematical ability through visual and spatial learning tasks.* Australian Association for Research in Education.

Maragos, C. (2004). Building educational scenarios with "Sketchpad". [Online]. http://hermes.di.uoa.gr/edugames/sketchpad/ScetchPad.pdf. [2008, July 21].

Martínez, M. J., Martínez, S., Bárcena, F. B., & Rodríguez, S. T.(2005). ICT in Mathematics Education:geometry problem solving with applets. [On-line] http://www.formatex.org/micte2005/402.pdf [2008, August 12].

McCoy, L. P. (1991). The effect of Geometry Tool Software on High school geometry achievement. *Journal of Computers in Mathematics and Science Teaching,* 10 (3), 51-57.

McGee, M. G. (1979) Human Spatial Abilities: Psychometric Studies and Environmental, Genetic, Hormonal, and Neurological Influences. *Psychological Bulletin*, 86(5), 889-918.

McLeay, H. (2006). Imagery, spatial ability and problem solving. *Mathematics teaching incorporating micromath,* 195, 36-38.

Medina, A. C., Gerson, H. B. P., &. Sorby, S. A. (1998). Identifying Gender Differences in the 3-D Visualization Skills of Engineering Students in Brazil and in the United States. Proceedings of the International Conference for Engineering Education.

Miller G. G. , Kapel D. E. (1985).Can Non-Verbal, Puzzle Type Microcomputer Software Affect Spatial Discrimination and Sequential Thinking of Skills of 7th and 8th Graders?.*Education* 106 , 160–67.

Miwa, T. (1992). An Overview of Computer Use for Mathematical Problem Solving in Japanese Schools, in J.P. Becker & T. Miwa (Eds.), Proceedings of the US-Japan Seminar on Computer Use in School Mathematics. (ERIC Document Reproduction Service No. ED 351203)

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author

Nickell, J. (2007).Useful Online and Teacher Production Tools of The Geometer's Sketchpad. *Mathematics Teacher*, 100(8), 565–67.

Nohda, N. (1992). A Study of Problem Solving with Cabri-Geometry in Secondary School Mathematics, in J.P. Becker & T. Miwa (Eds.), Proceedings of the US-Japan Seminar on Computer Use in School Mathematics. (ERIC Document Reproduction Service No. ED 351203)

Ocak, M. (2006). The relationship between gender and students' attitude and experience of using a mathematical software program. *Turkish Online Journal of Distance Education*, 7(2), 11.

Olive, J. (1991). Logo programming and geometric understanding: An in-depth study. *Journal for Research in Mathematics Education,* 22, 90-111.

Olkun, S. (2003) Making connections: Improving spatial abilities with engineering drawing activities, *International Journal of Mathematics Teaching and Learning*, 1-10.

Olkun, S., Altun, A. & Smith, G. G. (2005). Computers and 2D geometric learning of Turkish fourth and fifth graders. *British Journal of Educational Technology, 36*(2), 317-326.

Onyancha, R., Towle, E. & Kinsey, B. (2007). Improvement of Spatial Ability Using Innovative Tools: Alternative View Screen and Physical Model Rotator [Online] http://www.icee.usm.edu/icee/conferences/asee2007 [2008, June 2].

Palmiter, J. R. (1991). Effects of computer algebra systems on concept and skill acquisition in calculus. *Journal for Research in Mathematics Education*, *22,* 151-156.

Piburn, M. D., McAuliffe, C., Reynolds, S. J., Birk, J. P., Leedy, D. E., McAuliffe, C.M., & Johnson, K. J. (2002).The Hidden Earth:Visualization of Geologic Features and their Subsurface Geometry. Paper presented at the annual meeting of the National Association for Research in Science Teaching.

Pokay, P. A., & Tayeh, C. (1997). Integrating technology in a geometry classroom: Issues for teaching, *Computers in the Schools*, *13*(2), 117-123.

Rahim, M. H.(2002). A Classroom Use of Geometer's Sketchpad in a Mathematics Pre-Service Teacher Education program [On-line] http://math.unipa.it/~grim/Jrahaim [2008, August 12].

Rafi, A., Samsudin, K. A., & Ismail, A. (2006). On Improving Spatial Ability Through Computer-Mediated Engineering Drawing Instruction. *Educational Technology & Society*, 9 (3), 149-159.

Reed, E. K. (1996). Grade 11 students' understanding of circle geometry in a computer environment. Unpublished Masters dissertation, Simon Fraser University, Canada.

Reys, R E., Lindquist, M. M., Lambdin, D. V., Smith, N. L., & Suydam, M. N. (2006). *Helping children learn mathematics (8th Ed).* Boston, MA: John Wiley & Sons Publishing, Inc.

Roberts, D. L., & Stephens, L. J. (1999). The effect of the frequency of usage of computer software in high school geometry. *The Journal of Computers in Mathematics and Science Teaching, 18*(1), 23-30.

Robihaux, R. R. (2003). The Improvement of Spatial Visualization: A Case Study, *Journal of Integrative Psychology,* 4, 10-41.

Robitaille, D.F., Sherrill, J.M., & Kaufman, D.M. (1977). The effect of computer utilization on the achievement and attitudes of grade nine mathematics students. *Journal for Research in Mathematics Education, 1*, 26-32.

Sanchez, J. G. Orozco Hormaza, M. Ursini, S.(2004) Attitudes towards mathematics and mathematics taught with computers: Gender differences [Online] http://www.emis.de/proceedings/PME28/SO/SO015_Sanchez.pdf [2008, June 20].

Schumann, H., Green, D. (1994).*Discovering geometry with a computer - using Cabri Géomètre*, London, Chartwell-Bratt.

Sjölinder, M. (1998). Spatial Cognition and Environmental Descriptions. In Exploring Navigation: Towards a Framework for Design and Evaluation of Navigation in Electronic Spaces. Ed. Nils Dahlbäck. SICS Technical Report T98:01, March 1998, ISSN: 1100-3154, ISRN: SICS-T-98/01-SE.

Sivin-Kachala, J. & Bialo, E. R. (2000). *2000 Research Report on the effectiveness of technology in schools (7th ed).* Washington, DC: SIAA.

Smit, S. (1998). An introduction to geometry through shape, vision and position. Unpublished manuscript, Stellenbosch: University of Stellenbosch.

Smith, G. G. (1998). Computers, computers games, active control and spatial visualization, strategy. Unpublished Ph.D. dissertation, Arizona: Arizona State University.

Smith, R., Strong, S. (2001). Spatial Visualization: Fundamentals and Trends in Engineering Graphics. *Journal of Industrial Technology ,* 18(1),1-13.

Steen, D. K. (2002).Analyzing the impact of web-based geometry applets on first grade students. Unpublished PhD dissertation, Nebraska: University of Nebraska.

Tartre, L. A. (1990). Spatial orientation skill and mathematical problem solving, *Journal for Research in Mathematics Education,* 21(3), 216-229.

Tai, D. W. S., Yu, C. H., Lai, L. C. & Lin, S. J. (2003). A study on the effects of spatial ability in promoting the logical thinking abilities of students with regard to programming language. *World Transactions on Engineering and Technology Education UICEE,* 2(2), 251-26.

Towle, E., Mann, J., Kinsey, B., O'Brien, E. J., Bauer, C. F., & Champoux, R. (2005). *Assessing the self-efficacy and spatial ability of engineering students from multiple disciplines*. Proceedings of ASEE/IEEE Frontiers in Education Conference, October 19-22, Indianapolis, IN.

Tutak, T., Birgin, O. (2008). The Effects of Computer Assisted Instruction on the Students' Achievement in Geometry. [Online] http://ietc2008.home.anadolu.edu.tr/ietc2008/208.doc [2008, September 09].

Wilson, J. W. (1992). Mathematical visualization in problem solving facilitated by computers, in J.P. Becker & T. Miwa (Eds.), Proceedings of the US-Japan Seminar on Computer Use in School Mathematics. (ERIC Document Reproduction Service No. ED 351203)

Van Garderen, D. (2006). Spatial visualization, visual imagery, and mathematical problem solving of students with varying abilities. Journal of Learning Disabilities, 39, 496-506.

Velez, M., Silver, D., & Tremaine, M. (2005). Understanding visualization through spatial ability differences. In *Proceedings of the IEEE Visualization 2005 Conference* (VIS 2005; pp. 511–518). New York: IEEE.

Yakimanskaya, I. S. (1991). *The Development of Spatial Thinking in School Children* ("Soviet Studies in Mathematics Education"vol.3). (N.T.C.M.: Reston, USA).

Yıldırım, H. (2001*). İlköğretim Matematik 7*: Ankara. Yıldırım Yayınları.

Yeh, A., & Nason, R. (2004). *Towards a semiotic framework for using technology in mathematics education: the case of learning 3D geometry*. Paper presented at the International Conference on Computers in Education.

Yun, H. X., Yi , L. (2006).The Experiment of Improving Students' Spatial Ability by Using VGLS.ICAT ,467-473.

APPENDICES

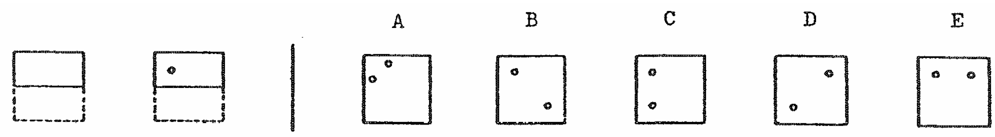
APPENDIX A

SAMPLE QUESTIONS OF SAT

Paper Folding Test

Kâğıt Katlama Testi

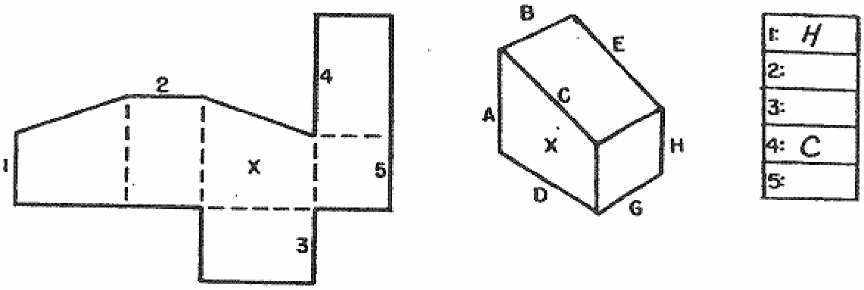
Bu testte bir parça kâğıdın katlanıp açılmasını hayal etmeniz gerekmektedir. Tüm problemlerde katlamalar dikey çizginin solunda yapılmaktadır.Ayrıca kâğıt hiç bir yöne çevrilmemekte sadece katlanmaktadır.Doğru cevabın kâğıdın tamamen açıldıktan sonraki deliklerin yerini gösteren seçenek olduğunu unutmayınız.



Surface Development Test

Yüzey Oluşturma Testi

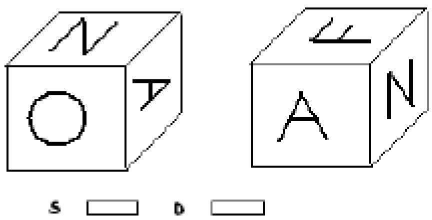
Bu testte bir parka kağıt katlanarak değişik cisimler hayal etmeniz istenmektedir. Aşağıdaki şekillerden soldaki şekil noktalı çizgili yerlerden katlandığında sağdaki cisim oluşmaktadır.Katlamayı hayal ederek numaralı köşelerin hangi harflere denk geldiğini bulunuz ve en sağdaki kutunun içine yazını



Cube Comparison Test

Küp Karşılaştırma Testi

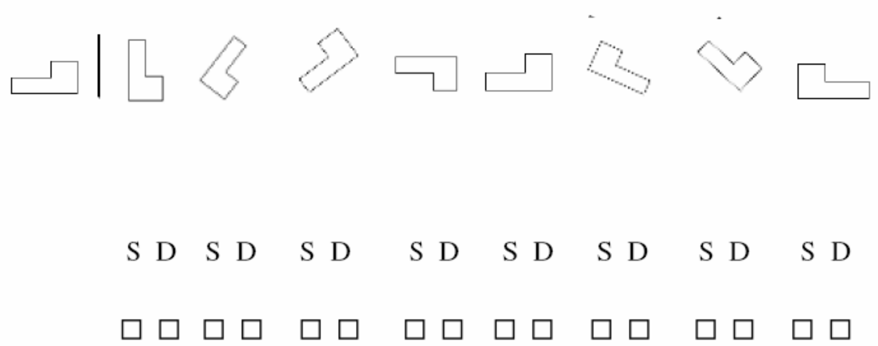
Bu testteki tüm problemlerde üzerlerinde harf, rakam veya şekil bulunan 6 yüzü (alt yüz, üst yüz ve dört yanı) olan küpler verilmiştir ve küplerin birbirlerinin aynı olup olmadığını bulmanız istenmektedir.Eğer küpler aynı ise şeklin altındaki S (Sabit), Farklı ise D (Değişik) şıklarını işaretleyiniz.



Card Rotation Test

Kart Çevirme Testi

Bu test şekiller arasındaki farkı görebilme yeteneğinizi ölçmek için geliştirilmiştir. Bu testte yapmanız gereken dikey çizginin solundaki şekille sağındaki sekiz şekli karşılaştırıp aynı olup olmadıklarını tespit etmektir. Sağdaki şekillerden herhangi birisi soldakiyle aynı ise şeklin altındaki S (Sabit), Farklı ise D (Değişik) şıklarını işaretleyiniz.



APPENDIX B

GEOMETRY ATTITUDE SCALE

GEOMETRİYE YÖNELİK TUTUM ÖLÇEĞİ

Bu ölçek sizin geometri ile ilgili düşüncelerinizi öğrenmek için hazırlanmıştır. Cümlelerden hiçbirinin kesin cevabı yoktur. Her cümleyle ilgili görüş, kişiden kişiye değişebilir. Bunun için vereceğiniz cevaplar kendi görüşünüzü yansıtmalıdır. Her cümleyle ilgili görüş belirtirken önce cümleyi dikkatle okuyunuz, sonra cümlede belirtilen düşüncenin, sizin düşünce ve duygunuza ne derecede uygun olduğuna karar veriniz. Cümlede belirtilen düşünceye;
Hiç katılmıyorsanız, Hiç Uygun Değildir
Katılmıyorsanız, Uygun Değildir,
Kararsız iseniz, Kararsızım,
Kısmen katılıyorsanız, Uygundur
Tamamen katılıyorsanız, Tamamen Uygundur seçeneğini İşaretleyiniz.
Ad-soyad :

	Tamamen ıygundur	Uygundur	Kararsızım	Uygun değildir	Hiç uygun değildir
1. Okulda daha çok geometri dersi olmasını istemem.					
2. Matematikte diğer konulara göre geometriyi daha çok severek çalışırım.					
3. Matematikte en çok korktuğum konular geometri konularıdır					
4. Geometri dersinde bir tedirginlik duyarım.					
5. Geometri dersinde gerginlik hissetmem.					
6. Geometri konuları ilgimi çekmez					
7. Geometriyi seviyorum.					
8. Geometri dersinde kendimi huzursuz hissediyorum.					
9. Geometri sorularını çözmekten zevk almam.					
10. Geometri çalışırken vaktin nasıl geçtiğini anlamıyorum.					
11.Matematiğin en zevkli kısmı geometridir					
12. Geometri dersi sınavından çekinmem					

APPENDIX C

MATHEMATICS AND TECHNOLOGY ATTITUDE SCALE

MATEMATİK VE TEKNOLOJİYE YÖNELİK TUTUM ÖLÇEĞİ

Bu ölçek bir bilgi testi değildir ve bu nedenle hiçbir sorunun ‘‘doğru cevabı’’ yoktur. Aşağıda yer alan sorularla Geometer-Sketchpad yazılımı ile yapmış olduğunuz dersleriniz hakkındaki fikirleriniz öğrenilmek istenmektedir. Verilen yargı cümlelerini okuyarak kendi düşüncenizi en iyi yansıtan yalnız bir seçeneği işaretleyiniz.

Adı , Soyadı:

Sınıfı: No: Yaş : Cinsiyet : (E) (K)

	Hemen hemen hiç	Ara sıra	Yaklaşık yarı yarıya	Genellikle	Hemen hemen her zaman
1. Matematikte zor konsantre olurum.					
2. Öğretmenin sorduğu sorulara cevap vermeye çalışırım.					
3. Hata yaptığımda onları düzeltene kadar çalışırım.					
4. Eğer bir problemi çözmeyi başaramazsam, çözmek için başka fikirler denemeye devam ederim.					
5. Bilgisayar kullanmakta başarılıyımdır.					
6. VCR, VCD, DVD, MP3 ve cep telefonu gibi teknolojik aletleri kullanmakta başarılıyımdır.					
7. Birçok bilgisayar sorununu çözebilirim.					
8. Okul için gerekli olan herhangi bir bilgisayar programını iyice öğrenebilirim.					
9. Beynim matematiğe iyi çalışır.					

	Kesinlikle katılmıyorum	Katılmıyorum	Emin değilim	Katılıyorum	Kesinlikle Katılıyorum
10. Matematikten iyi notlar alabilirim.					
11. Matematikteki zorluklarla başa çıkabileceğimi biliyorum.					
12. Matematikte kendime güveniyorum					
13. Matematikte yeni şeyler öğrenmeye ilgi duyuyorum.					
14. Matematikte emeğinizin karşılığında ödüllendirilirsiniz.					
15. Matematik öğrenmek eğlencelidir.					
16. Matematik sorularını çözdüğüm zaman bir çeşit memnuniyet hissederim.					
17. Matematik için bilgisayar yazılımları/programları kullanmayı seviyorum.					
18. Matematikte bilgisayar yazılımları/programları kullanmak, fazladan sarf edilen zaman, emek ve efora değer.					
19. Bilgisayar yazılımları/programları kullanıldığı zaman matematik daha ilginç hale gelebilir.					
20. Bilgisayar yazılımları/programları matematiği daha iyi öğrenmeme yardım edebilir.					

APPENDIX D

LESSON PLANS

DERS PLANI 1

HEDEF 1: Öteleme hareketini kavrayabilme.
D1. Öteleme hareketini açıklar.
D2. Ötelemede şeklin duruşunun, biçiminin ve boyutlarının aynı kaldığı anlar.
D3. Bir şeklin öteleme sonunda oluşan görüntüsünü inşa eder.
Süre: 3 ders saati
Materyal: Geometer's Sketchpad programı yüklü bilgisayarlar, kalem ve öğrenciler için aktivite sayfası.
Grup: Her bilgisayar için 2 kişilik öğrenci grupları oluşturulur.
Alt yapı: Öğrencilerin bilgisayar okuryazarlığına sahip olması gerekmektedir.

GİRİŞ ETKİNLİKLERİ:

Öğretmen öğrencilere çevrelerinde ne tür yer değiştirme hareketlerini gözlemlediklerini sorar. Yer değiştirme hareketinde konum değiştiren nesnelerin doğrultu ve yönlerinin nasıl değiştiği konusunda öğrencilerin fikirleri alınır. Öğrencilere kayak sporu hakkında sorular sorulur, bu sporu yaparken yapılan yer değiştirme hareketini açıklamaları istenir.

GELİŞTİRME ETKİNLİKLERİ:

Öğretmen sınıfı bilgisayar çalışması için 2'şer kişilik gruplara ayırır ve her birine aktive ile ilgili çalışma kâğıtları verir. Öğrenciler ile birlikte aktiviteler gerçekleştirilir

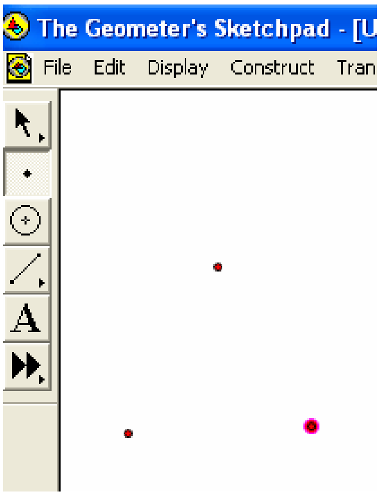
SONUÇ ETKİNLİKLERİ:

1.Öğrencilerden Ötelemeyi tanımlamaları istenir.

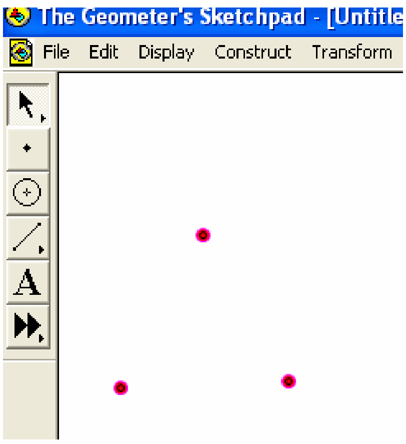
2. Ötelenmiş cismin şekil, alan özelliklerinin değişmediği vurgulanır.

ÖĞRENCİ AKTİVİTE KAĞIDI

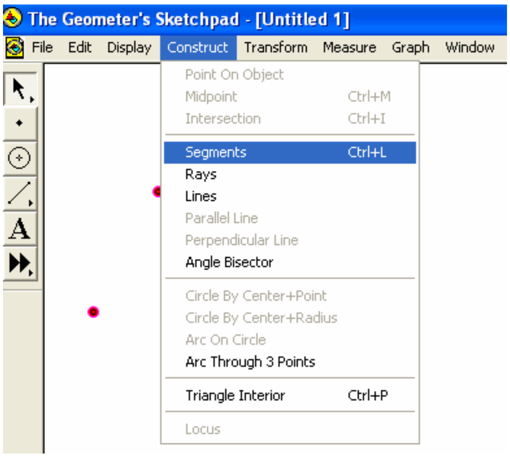
1. Point Tool kullanarak şekilde gösterildiği gibi 3 tane nokta (üçgen oluşturacak şekilde) belirleyiniz.



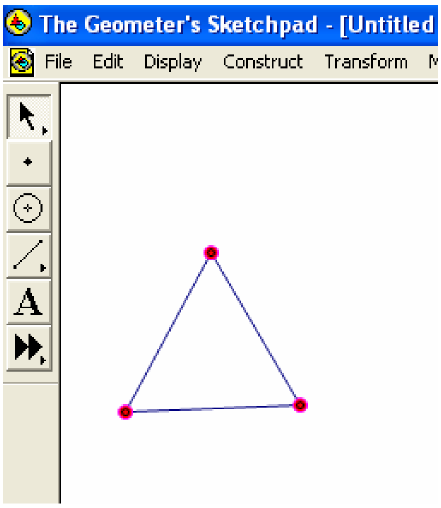
2. Arrow Tool' u (sol kısım 1.) seçin ve ekranı herhangi bir yerine tıklayın. Ardından belirlediğiniz tüm noktaları şekildeki gibi seçin.

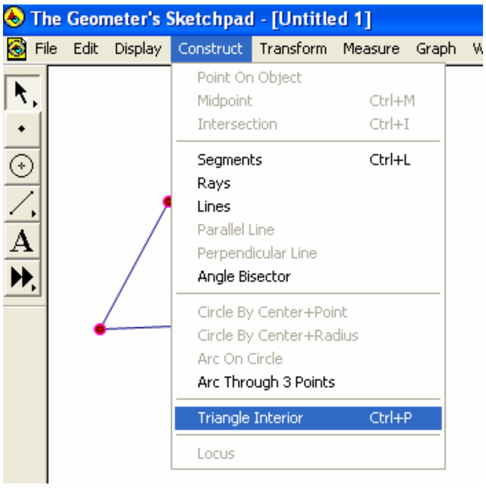


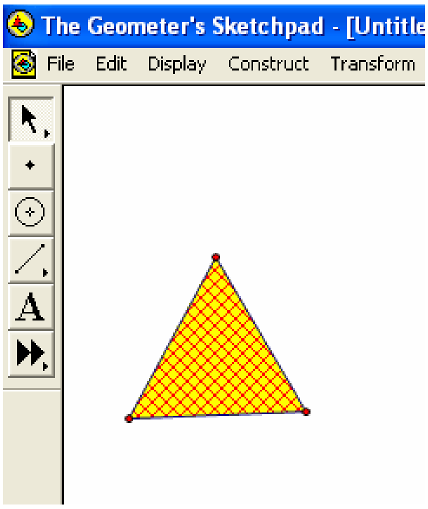
3.Construct Menu (Ekranın üst kısmında 4.) seçin ve açılan pencereden Segments'i seçin.



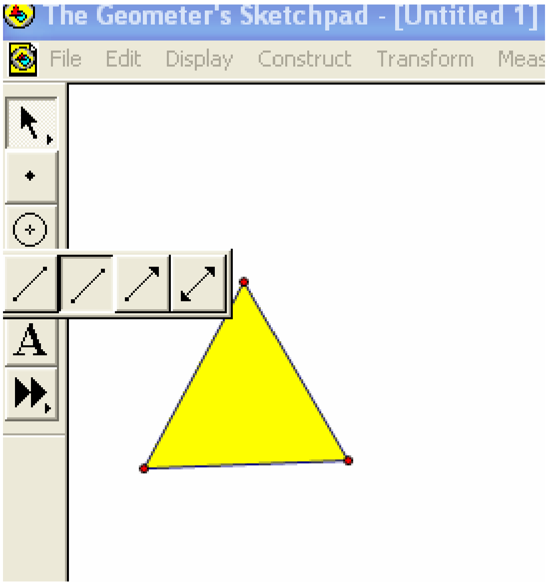
4. Üçgeniniz oluştu şimdi ekranda her hangi bir yere tıklayın. Daha sonra üçgeninizi oluşturan noktaları seçin ve Construct Menu'den İnterior kısmını seçin.





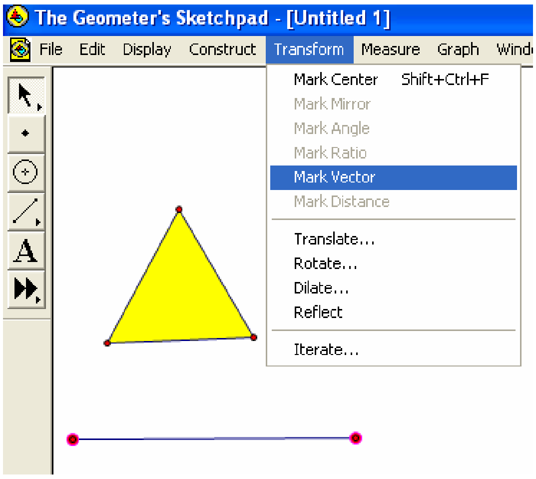


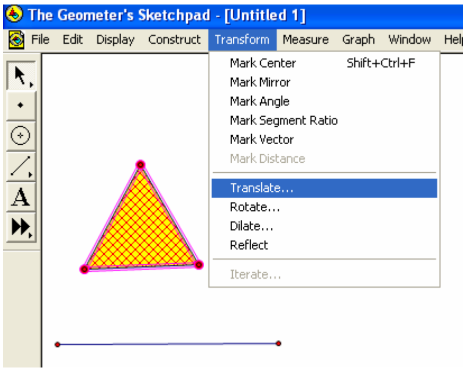
5.Ekranın herhangi bir yerine tıklayın. Segment Tool'u kullanarak üçgeninizin altına bir doğru parçası çizin.



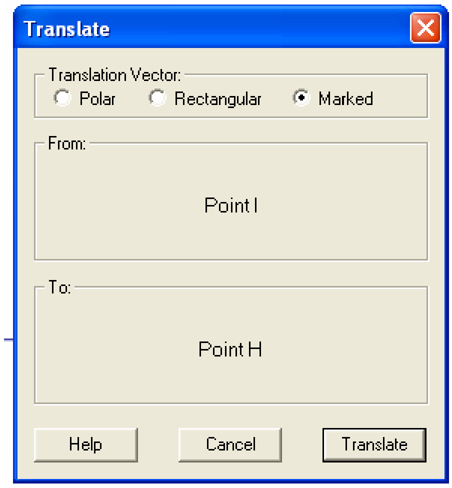
6.Arrow Tool'u seçin ve ekranın herhangi bir yerine tıklayın. Daha sonra doğru parçasını oluşturan noktaları (soldan sağa)seçin ve Transformation Menu'den Mark vector kısmını seçin.

7.Arrow Tool 'u kullanarak tüm üçgeni seçin ve Transform Menu' den Translate kısmını seçin





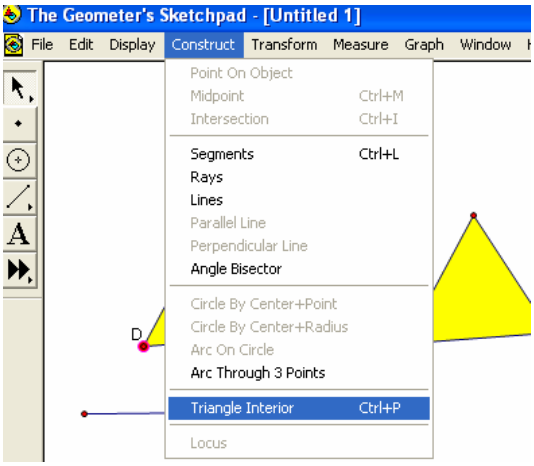
8.Çıkan yeni ekrandan Translate kısmını tıklayın.

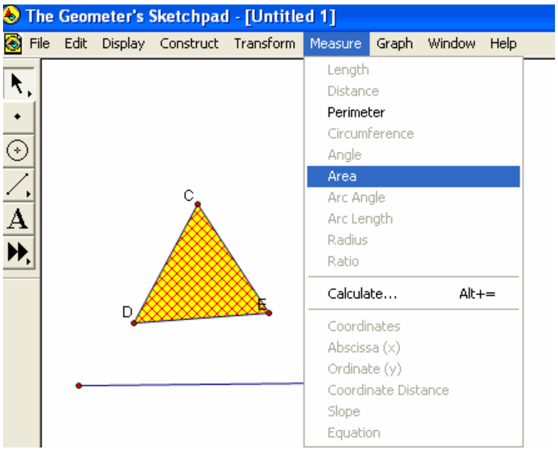


9.Ne olduğunu açıklayın. Orijinal üçgeninizle ikinci üçgeniniz arasındaki benzerlikler ve farklılıklar nelerdir?

10.Daha önce oluşturduğunuz doğru parçasının başlangıç ve bitiş noktalarını Arrow Tool kullanarak seçin ve doğru parçasını uzatın, ne gibi değişiklikler oldu?

11.Üçgeninizi oluşturan noktaları Arrow Tool kullanarak seçin. Construct Menu'den triangle interior' u seçin. Ardından Measure Menu' den Area' yı seçerek üçgeninizin alanını hesaplayın.





12.Aynı işlemleri ikinci üçgen içinde yapın, Neler fark ettiniz?

DERS PLANI 2

HEDEF 1: Yansıma hareketini kavrayabilme

D1. Yansıma hareketini açıklar.

D2. Bir şeklin yansıma sonunda oluşan görüntüsünü inşa eder.

Süre: 3 ders saati

Materyal: Geometer's Sketchpad programı yüklü bilgisayarlar, kalem ve öğrenciler için aktivite sayfası.

Grup: Her bilgisayar için 2 kişilik öğrenci grupları oluşturulur.

Alt yapı: Öğrencilerin bilgisayar okuryazarlığına sahip olması gerekmektedir

GİRİŞ ETKİNLİKLERİ:

Öğretmen öğrencilere çevrelerinde ne tür yansıma hareketlerini gözlemlediklerini sorar. Yansımanın nasıl oluştuğunu açıklamalarını ister.

GELİŞTİRME ETKİNLİKLERİ: Öğretmen sınıfı bilgisayar çalışması için 2'şer kişilik gruplara ayırır ve her birine aktive ile ilgili çalışma kâğıtları verir. Öğrenciler ile birlikte aktiviteler gerçekleştirilir.

SONUÇ ETKİNLİKLERİ:

1.Öğrencilerden yansımayı tanımlamaları istenir.

2. Yansımış cismin şekil, alan özelliklerinin değişmediği vurgulanır.

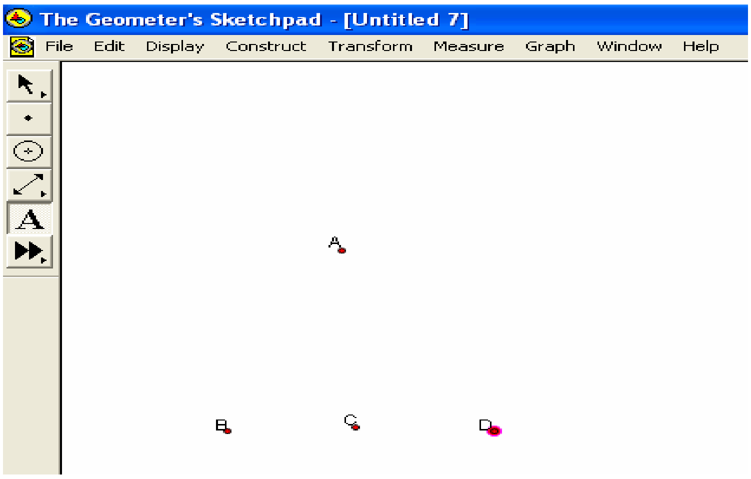
3.Orijinal cisim ile yansıyan cismin doğruya olan uzaklıklarının eşit olduğu vurgulanır.

4.Bazı şekillerin birden fazla simetri eksenleri olabileceği vurgulanır.

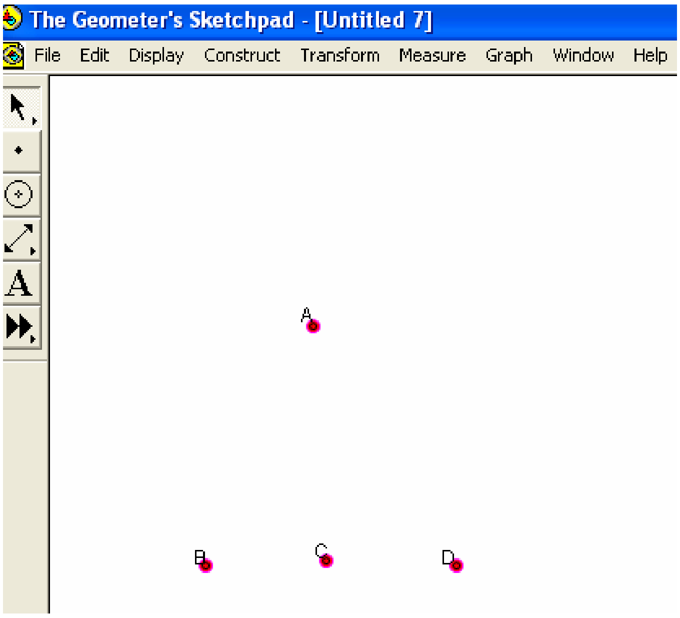
ÖĞRENCİ AKTİVİTE SAYFASI

1. Point Tool kullanarak şekilde gösterildiği gibi 4 tane nokta (üçgen oluşturacak şekilde 3 tanesi tabanda) belirleyiniz. Ardından Text Tool kullanarak **(A)** noktaları yukarıdaki noktadan başlayarak saat yönünün tersine

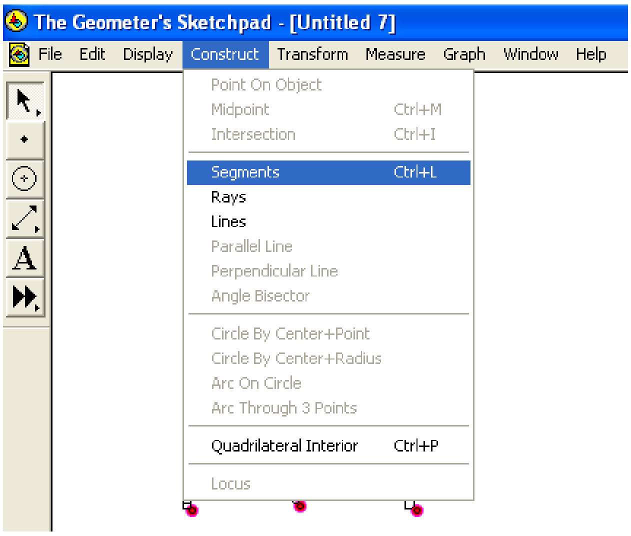
harflendiriniz.



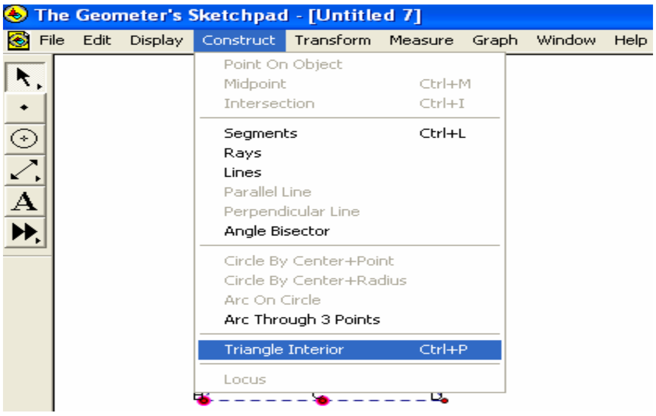
2. Arrow Tool' u (sol kısım 1.) seçin ve ekranı herhangi bir yerine tıklayın. Ardından belirlediğiniz tüm noktaları şekildeki gibi seçin.



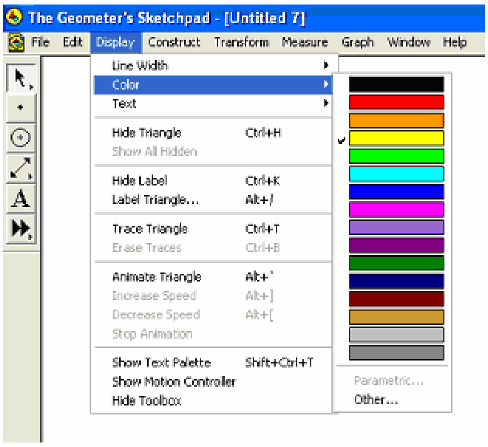
3. Construct Menu (Ekranın üst kısmında 4.) seçin ve açılan pencereden Segments'i seçin



4. Arrow Tool'u seçip ekranın herhangi bir yerine tıklayın. Daha sonra yine Arrow Tool kullanarak sırasıyla A,B ve C noktalarını seçin ardından Construct Menu'den Triangle İnterior kısmını şekildeki gibi seçin.

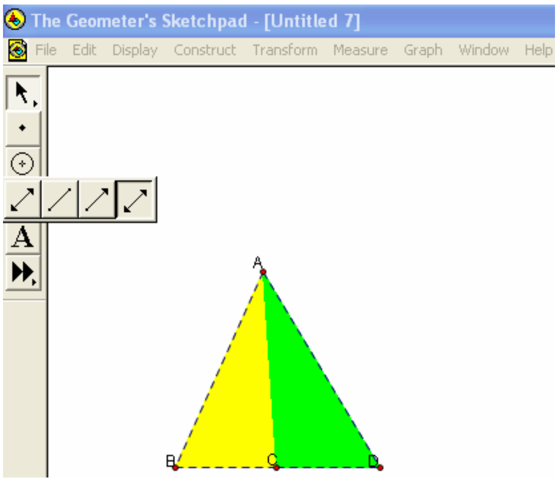


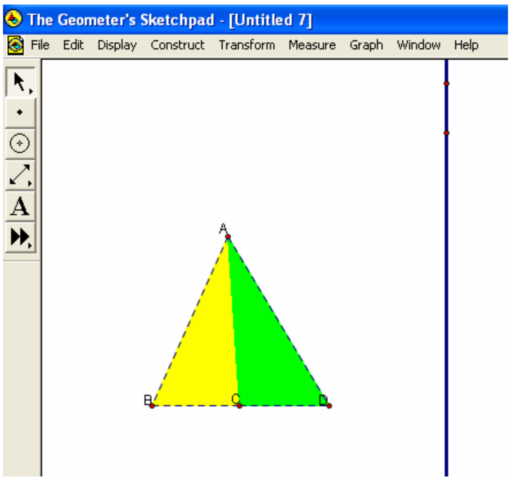
5. Display bölümünden color kısmını açın ve istediğiniz rengi seçin



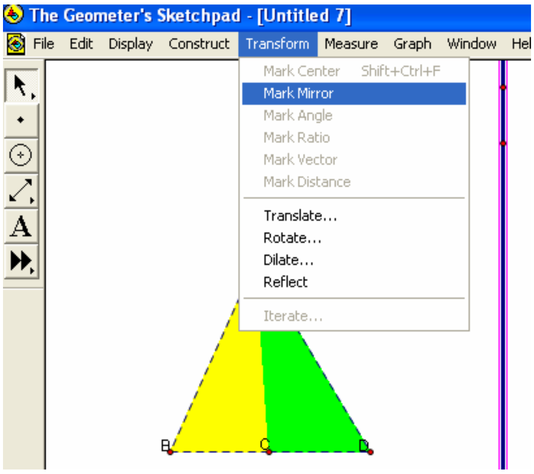
6. Arrow Tool'u kullanarak öncelikle ekranın herhangi bir yerine tıklayın. Bu sefer sırasıyla A, D, C noktalarını seçin ve 4. ve 5. adımlarda yaptıklarınızı tekrarlayın.(Construct Menu'den Triangle İnterior kısmını şekildeki gibi seçin ardından Display bölümünden color kısmını açın ve istediğiniz rengi seçin)

7.Segment Tool' u kullanarak üçgeninizin sağ tarafına bir doğru çizin.

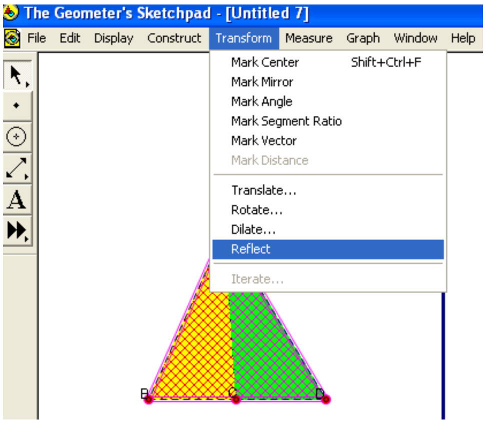




8.Arrow Tool'u kullanarak çizdiğiniz doğruyu seçin ve ardından Transform Menu'den Mark Mirror kısmını seçin.

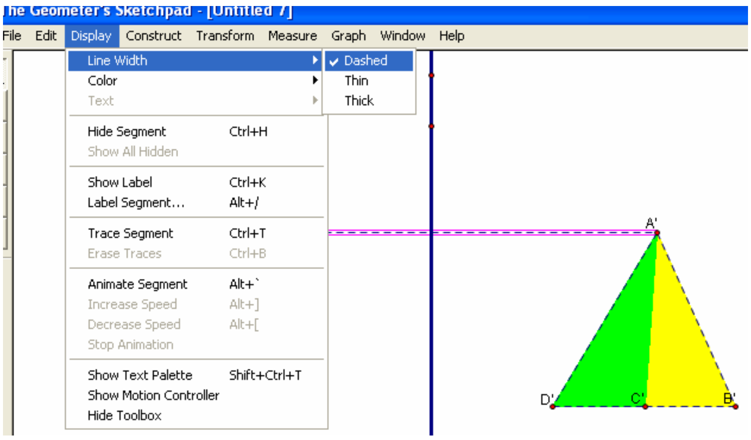


9. Arrow Tool' kullanarak üçgeninizin tamamını seçin ve ardından Transform Menu'den Reflect kısmını seçin.



10. Ne olduğunu açıklayın.

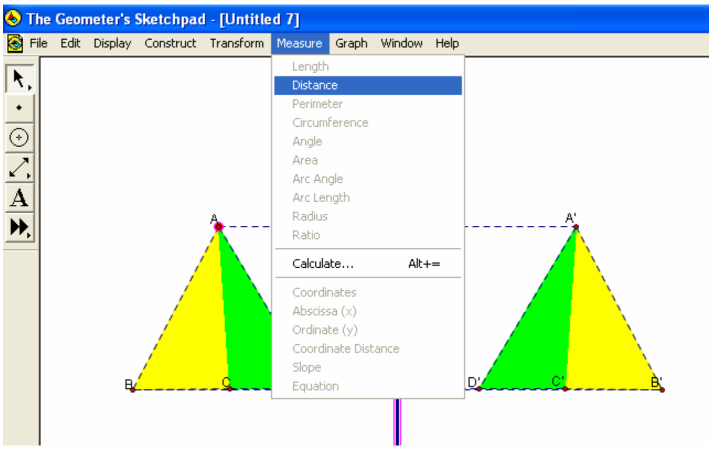
11. Oluşan yeni üçgeninizin de noktalarını isimlendirin. A ve A’ noktalarını Arrow Tool kullanarak seçin, ardından Construct Menu’den Segments kısmını seçin. Daha sonra Display Menu’den Line Width kısmını seçin ve Dashed bölümü işaretleyin. Bu işlemi B ve B’ noktaları ile D ve D’ noktaları içinde tekrar edin.



12.Çizmiş olduğunuz doğruyu seçin ve ileri geri hareket ettirin. Neler gözlemlediniz?

13.Üçgeni oluşturan noktalardan birini seçin ve ileri geri hareket ettirin. Neler gözlemlediniz?

14.Arrow Tool kullanarak A noktasını ve doğruyu seçin ve Measure Menu' den distance kısmını seçin. Böylece seçtiğiniz noktanın doğru parçasına olan uzaklığını bulacaksınız.



15. Aynı işlemi A' noktası içinde ve sonuçları karşılaştırın.

16. Bu işlemi diğer noktalar içinde gerçekleştirin. Neler gözlemlediniz?

17. Çizmiş olduğunuz doğru parçasının başlangıç veya bitiş noktalarından birini seçin ve ileri geri hareket ettirin. Neler gözlemlediniz?

DERS PLANI 3

HEDEF 1: Dönme hareketini kavrayabilme.

D1. Dönme hareketini açıklar.

D2.Düzlemde bir nokta etrafında ve belirtilen bir açıya göre şekilleri döndürerek çizimini yapar.

Süre: 4 ders saati

Materyal: Geometer's Sketchpad programı yüklü bilgisayarlar, kalem ve öğrenciler için aktivite sayfası.

Grup: Her bilgisayar için 2 kişilik öğrenci grupları oluşturulur.

Alt yapı: Öğrencilerin bilgisayar okuryazarlığına sahip olması gerekmektedir

GİRİŞ ETKİNLİKLERİ:

Öğretmen öğrencilerden saatlerinin de bulunan akrep ve yelkovanının bağlı olduğu pimin etrafındaki hareketi yorumlamalarını ister ve akrep ve yelkovanının bağlı olduğu pimin dönme hareketinin merkezi olduğu keşfettirilir. Günlük yaşamdan dönme hareketine örnekler verilemesi istenir. Rüzgârgülü vb.

GELİŞTİRME ETKİNLİKLERİ:

Öğretmen sınıfı bilgisayar çalışması için 2'şer kişilik gruplara ayırır ve her birine aktive ile ilgili çalışma kâğıtları verir. Öğrenciler ile birlikte aktiviteler gerçekleştirilir.

SONUÇ ETKİNLİKLERİ

1.Öğrencilerden dönme hareketini tanımlamaları istenir.

2. Döndürülen şeklin biçim ve boyutunun değişmediği, ancak şeklin duruşunun ve yerinin değiştiği vurgulanır.

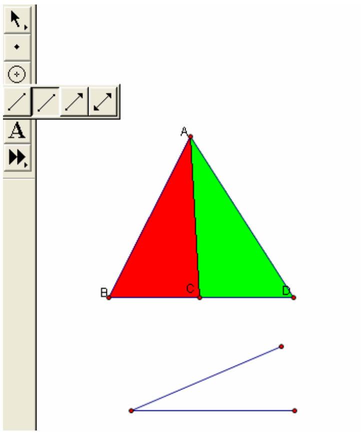
3.Çeyrek dönmenin 90° lik dönme, yarım dönmenin 180° lik dönme olduğu vurgulanır.

4. 180° lik dönmenin merkezil dönme (noktaya göre simetri) olduğu açıklanır.

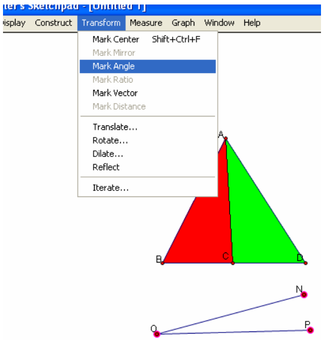
5. Bir şekil kendi merkezi etrafında döndürüldüğünde 360° den küçük açılı dönmelerde en az bir defa kendisi ile çakışıyorsa bu şeklin dönme simetrisine sahip olduğu vurgulanır.

ÖĞRENCİ AKTİVİTE KÂĞIDI

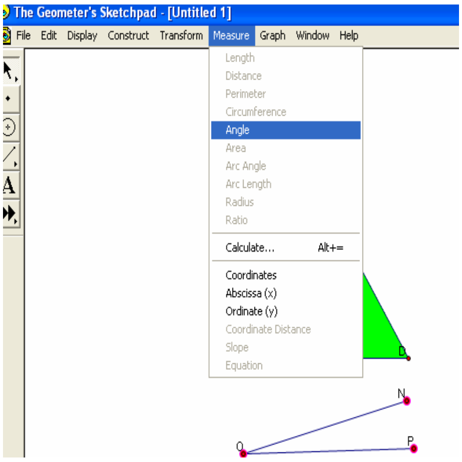
1. Point Tool kullanarak şekilde gösterildiği gibi 4 tane nokta (üçgen oluşturacak şekilde 3 tanesi tabanda) belirleyiniz. Ardından Text Tool kullanarak **(A)** noktaları yukarıdaki noktadan başlayarak saat yönünün tersine harflendiriniz.
2. Arrow Tool' u (sol kısım 1.) seçin ve ekranı herhangi bir yerine tıklayın. Ardından belirlediğiniz tüm noktaları şekildeki gibi seçin.
3. Construct Menu (Ekranın üst kısmında 4.) seçin ve açılan pencereden Segments'i seçin.
4. Arrow Tool'u seçip ekranın herhangi bir yerine tıklayın. Daha sonra yine Arrow Tool kullanarak sırasıyla A,B ve C noktalarını seçin ardından Construct Menu'den Triangle İnterior kısmını seçin.
5. Display bölümünden color kısmını açın ve istediğiniz rengi seçin
6. Arrow Tool'u kullanarak öncelikle ekranın herhangi bir yerine tıklayın. Bu sefer sırasıyla A, D, C noktalarını seçin ve 4. ve 5. adımlarda yaptıklarınızı tekrarlayın.(Construct Menu'den Triangle İnterior kısmını şekildeki gibi seçin ardından Display bölümünden color kısmını açın ve istediğiniz rengi seçin)
7. Segment Tool'u kullanarak üçgeninizin alt kısmına şekildeki gibi bir açı çizin.



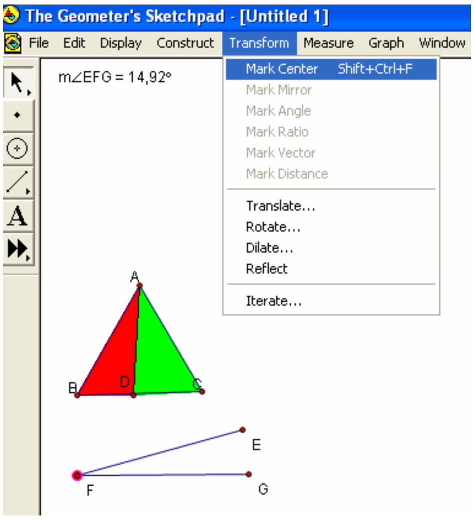
8. Açınızı oluşturan harfleri açının okunuş kuralını dikkate alarak Text Tool kullanarak sırasıyla harflendirin. Ardından yine okunuş kuralını dikkate alarak açıyı oluşturan noktaları seçin ve Transfor Menu'den Mark Angle kısmını seçin



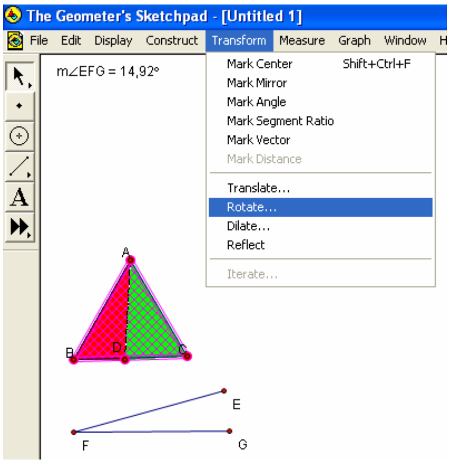
9. Tekrar okunuş sırasını dikkate alarak açıyı oluşturan noktaları seçin ve Measure Menu'den Angle kısmını seçin. Böylece açınızın ölçüsünü bulacaksınız.



10. Açının başlangıç noktasını seçin ardından Transform Menu’den Mark Center kısmını işaretleyin.



11.Üçgeninin tamamını seçin ve Transform Menu’den Rotate kısmı seçin.Açılan yeni pencereden Rotate kısmını tıklayın .



12. Neler gözlemlediniz? İlk üçgen ile oluşan ikinci üçgen arsında nasıl bezerlikler var?

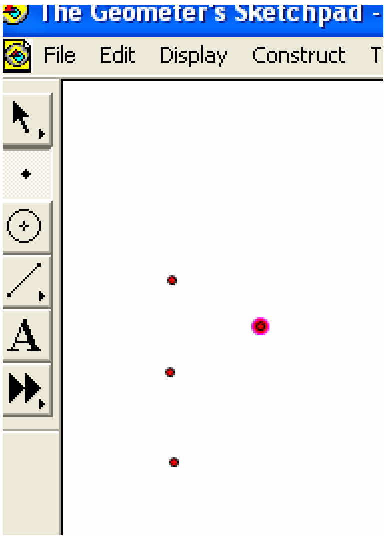
13. İlk üçgen ile oluşan ikinci üçgen arsında nasıl bezerlikler var?

14 Açınızın bitiş noktalarından birini seçerek ileri geri hareket ettirin. Neler gözlemlediniz?

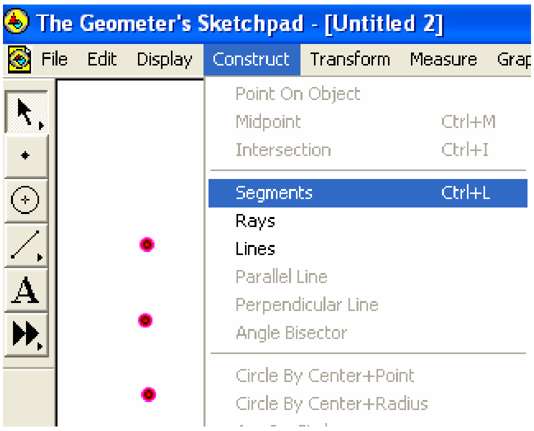
15.Üçgeninizi 90,180 ve 360 derece döndürün. Neler gözlemlediniz?

AKTİVİTE 2

1. Ekranınıza şekildeki gibi 4 tane nokta (3'ü üçgen oluşturacak şekilde) oluşturun.

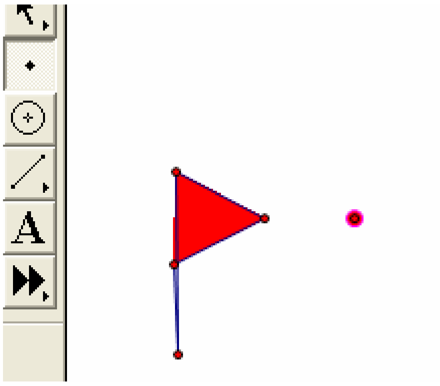


2. Noktalarınızın hepsini (3'ü üçgen oluşturacak şekilde) seçin ve ardından Construct Menu'den Segments kısmını seçin.

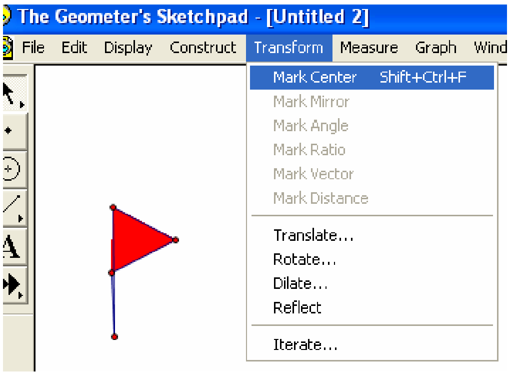


3.Üçgen oluşturan noktaları seçip ilk önce Construct Menu'den Triangle İnterior kısmını ardından Display Menu'den colour kısmını seçerek üçgeninizi istediğiniz renge boyayın.

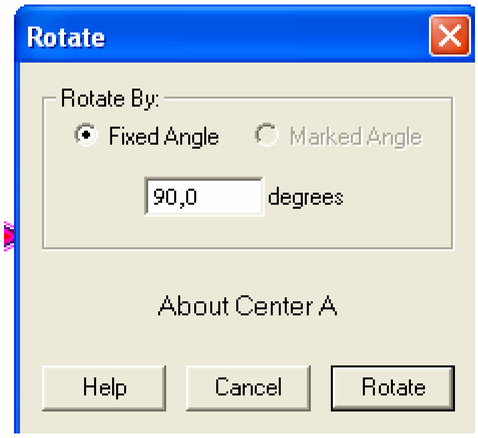
4. Oluşan Bayrak şeklinin sağ tarafına şekildeki gibi nokta belirleyin.



5. Son belirlediğiniz noktayı seçin ve ardından Transform Menu'den Mark Center kısmını işaretleyin.

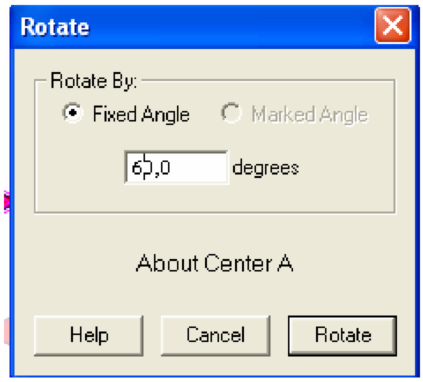


6. Bayrağınızın tamamını seçin ardından Transform Menu kısmından Rotate kısmını seçin. Açılan yeni pencere açı kısmının 90 derece olduğundan emin olun.



7. Rotate işlemini 2 kez daha gerçekleştirin. Neler gözlemlediniz?

8. Dönme açısını 60 derece olarak ayarlayın. Neler gözlemlediniz?



DERS PLANI 4

HEDEF 1: Örüntü oluşturabilme.

D1. Öteleme, yansıma ve dönüşüm simetrilerini kullanarak süslemeler yapar.

Süre: 4 ders saati

Materyal: Geometer's Sketchpad programı yüklü bilgisayarlar, kalem ve öğrenciler için aktivite sayfası.

Grup: Her bilgisayar için 2 kişilik öğrenci grupları oluşturulur.

Alt yapı: Öğrencilerin bilgisayar okuryazarlığına sahip olması gerekmektedir.

GİRİŞ ETKİNLİKLERİ:

Ders kitabındaki fotoğraflar inceletilerek el sanatları ile kültür arasındaki ilişki vurgulanır. El sanatlarındaki motifler inceletilerek öğrencilerin düşünceleri alınır.Motifler üzerindeki simetrik şekillere dikkat çekilerek örüntü oluşturma konusunda ön bilgi verilir.

GELİŞTİRME ETKİNLİKLERİ:

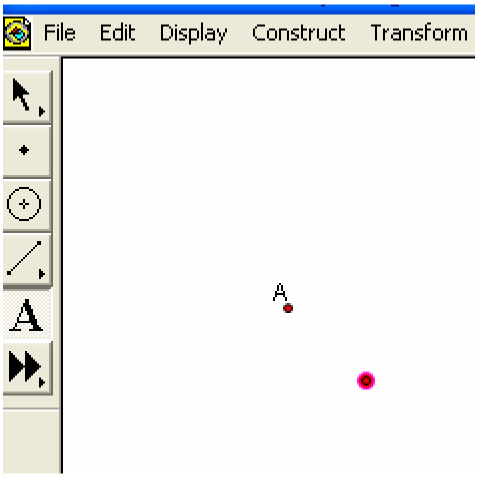
Öğretmen sınıfı bilgisayar çalışması için 2'şer kişilik gruplara ayırır ve her birine aktive ile ilgili çalışma kâğıtları verir. Öğrenciler ile birlikte aktiviteler gerçekleştirilir.

SONUÇ ETKİNLİKLERİ:

1.Öğrencilere nasıl örüntü oluşturabilecekleri sorulur.

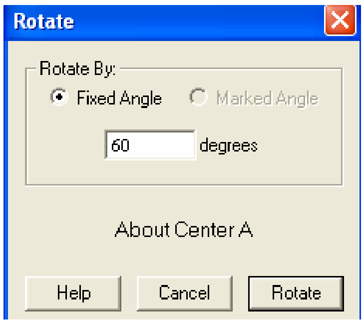
ÖĞRENCİ AKTİVİTE SAYFASI

1.Ekrana şekilde gösterildiği gibi 2 tane nokta belirleyin.



2. A noktasını seçin ve Transform Menu'den Mark Center kısmını seçin.

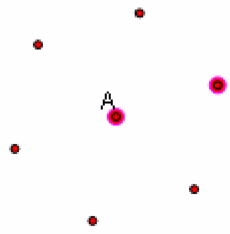
3. 2.noktayı seçin ve ardından Transform Menu'den Rotate kısmını seçin. Açılan yeni pencerede açı yerine 60 dere yazın.



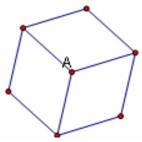
.

4. Bu işlemi 4 kez daha gerçekleştirin.

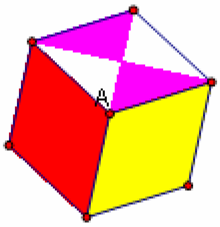
5. Oluşan şekillinizde bulunan A noktasını ve sağındaki noktayı şekildeki gibi seçtikten sonra Construct Menu'den segment kısmını seçin.



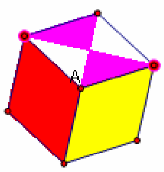
6. Bu işlemi A noktası ile birer nokta atlayarak tüm noktalar ile (küp oluşturacak şekilde) gerçekleştirin.



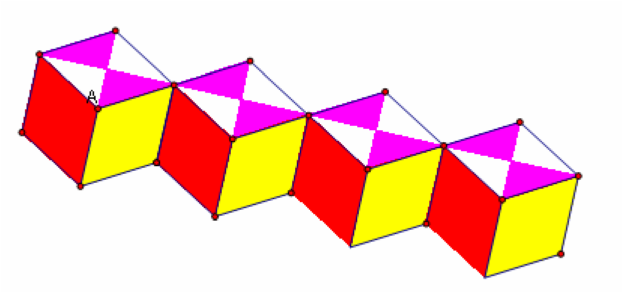
7. Küpün kenarlarını oluşturan karelerin noktalarını seçin ve Construct Menu'den İnterior kısmını seçin. Ardından Display Menu'den Colour kısmını seçerek kareleri istediğiniz renklere boyayın.



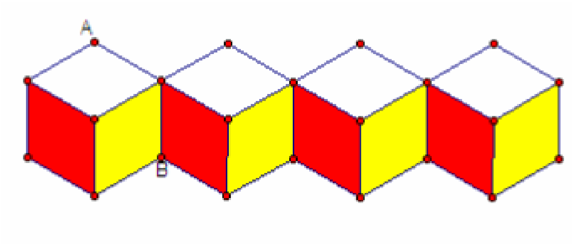
8. Küpün en üst kısmındaki karenin köşegenlerini şekildeki gibi seçin ve ardından Transform Menu'den Mark Vector kısmını seçin.



9. Küpün tamamını seçin ve ardından Transform Menu’den Translate kısmını işaretleyin. Bu işlemi bir kaç kez daha gerçekleştirerek şeklinizin ötelenmiş halini oluşturun. Neler gözlemlediniz?



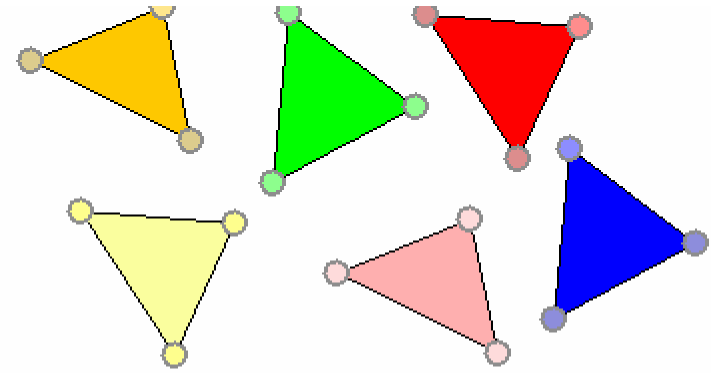
10. Orjinal küpünüzün köşelerini şekildeki gibi seçin.(A VE B)ve Transform Menu’den Mark Vector kısmını seçin. Bütün küpleri seçin ve Transform Menu’den Translate kısmını işaretleyin. Bu işlemi bir kaç kez daha gerçekleştirerek şeklinizin ötelenmiş halini oluşturun. Neler gözlemlediniz?



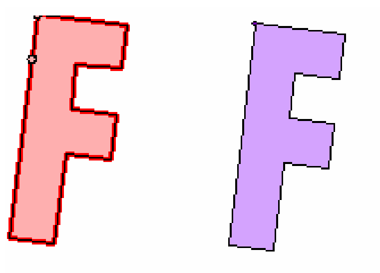
APPENDIX E

SAMPLE OF WORKSHEETS

1. Aşağıdaki şekildeki üçgenlerden her biri kendisinin ötelenmiş hali ile bir çift oluşturmuştur. Buna göre bu üçgen çiftlerini bulun.



2.



Yukarıda F harfi ile ötelenmiş hali verilmiştir. Buna göre iki şekil arasında nasıl farklar vardır?

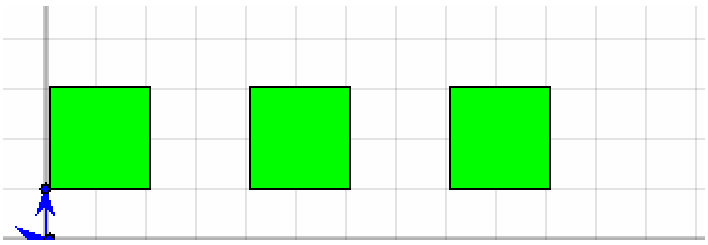
A) İkinci F daha büyüktür.

B) İkinci F daha küçüktür.

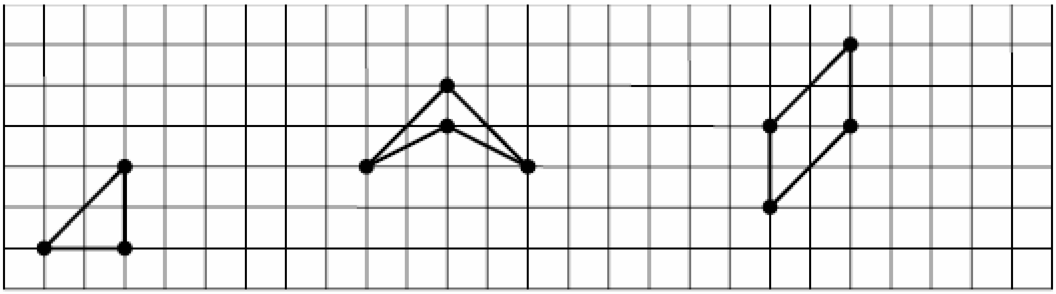
C) Birinci F daha büyüktür

D) Boyutları arasında fark yoktur.

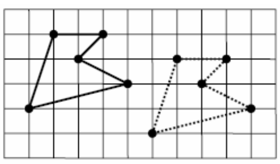
3.Şekildeki kare kaç birim ötelenmiştir?

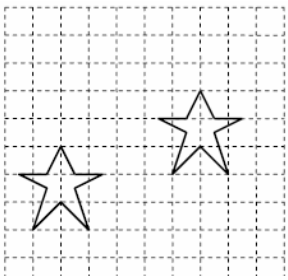


4. Aşağıdaki şekillerin her birini 4 birim sağa öteleyin.



5. Aşağıdaki şekiller kaç birim ötelenmiştir açıklayın.





APPENDIX F

TURKISH EXCERPTS FROM INTERVIEW WITH STUDENTS

(SAYFA 64)

Matematik öğrenirken bilgisayarları kullanmak kendi özel öğretmenimin olması gibiydi. Geometrik şekilleri bilgisayar ekranında oluşturabildik ve onları daha sonra kullanmak için saklayabildik. Bilgisayar geometrik şekillerin kalem ve kâğıtla yapamayacağız şekilde hareketli olmasını sağladı (A1).

Eğer bu konuları tahtada işleseydik bence çok sıkıcı olurdu. Ayrıca biz şimdi olduğumuz kadar aktif olmayacaktık ve konuyu bu kadar iyi anlamayacaktık. Bence konuyu hızlı ve kolay öğrendim çünkü öğrenme süresince çok aktiftim, şekilleri kendim oluşturup, değiştirdim (A3).

Bilgisayarlar geometrik şekilleri hızlı bir şekilde oluşturmamızı sağladı ve bizim oluşturduğumuz şekilleri hareketli ve ilginç bir şekilde bize gösterdi (A4) .

Nokta, doğru gibi şekiller oluşturup onları hareket ettirebildik. Bilgisayar kullanmak dersleri çok daha aktifleştirdi (A6).

(SAYFA 65)

Bu konuları eğer normalde olduğu gibi tahtada işleseydik, bizim için anlaması çok zor olacaktı. Mesela şekilleri tahtada döndürmeye çalışsaydık bu gerçektenden zor olurdu ve dönme simetrisini anlamazdık bence. Ama bilgisayarda şekilleri döndürmek çok kolaydı (B2).

Konuları sadece öğretmen açıkladığında çok iyi anlamıyorum ama bu konuyu iyi öğrendim çünkü tartışarak, yaparak ve açıklayarak öğrenme süresince aktif oldum (A2).

Projeksiyonda gördüğümüz şekiller benim konunun temelini anlamamı sağladı. Ama bence eğer kendimiz bilgisayarda yapabilseydik bizim için çok daha iyi olurdu (B3).

(SAYFA 66)

Projeksiyonun yansıttığı her şeyi çok iyi anlayamadım. Bence sadece izlemek yerine biz bilgisayarda kendimiz yapsaydık çok daha iyi anlardım (B5).

Konular görsel bir şekilde sunulduğunda daha iyi anlıyorum ama bence sadece projeksiyonda yansıtılan şeyleri izlemek yerine kendimizde bilgisayarla bir şeyler yapsaydık çok daha iyi öğrenebilirdik. Şekilleri kendimiz oluşturabilirdik ve bu çok daha ilginç olurdu (B6).

Bence görsellik geometri için çok önemli ve bilgisayarla ders işlemek görsel zekâmızı geliştirmemize yardımcı oldu ve kolaylıkla öğrenebildik (A1).

Matematik derslerinde problemler ve denklemler çözüyoruz. Ama bilgisayarla ders işlemek şekilleri görsel olarak canlandırmamızı sağladı ve görselliği kullanınca öğrenmek çok daha kolay oldu (A6).

Matematiği çok iyi anlamıyorum aslında, sadece sayılarda ibaret gibi geliyor ve aslında ne olduğunu gözümde canlandıramıyorum. Ama bilgisayarlar matematiği görsel bir şekilde sunuyor ve ben çok daha iyi anlıyorum (A7).

Bence görsel olduğunda geometriyi anlamak çok daha kolay oluyor ve bilgisayarlar şekilleri görsel olarak görmemizi sağlıyor (B1).

Bilgisayarla matematiği anlamak çok daha kolay çünkü şekilleri görsel olarak görüyoruz ve bilgisayar bize hayal etmesi zor şeyleri gösteriyor (B2).

(SAYFA 67)

Matematik konularını öğrenirken görselliği kullanmak konuları basitleştiriyor. Görsellik öğrenme sürecimizi geliştirdi (B3).

Bence matematik konularını ezberlediğimizde aslında ne yaptığımızı çok az anlıyoruz. Ezberlediğim şeyleri hatırlamak benim için çok zor. Ama bu sefer hiç bir şeyi ezberlemek zorunda kalmadım ve öğrendiğim şeyleri hatırlamakta zorluk çekmeyeceğim (A1).

Matematik çalışmak benim için daha önce sadece ezberlemekti, ama bu sefer hiçbir şeyi ezberlemek zorunda kalmadım, konuyu gerçekten öğrendim (A2).

Geçen sene işlediğimiz konuları hatırlamıyorum ama bilgisayarla işlediğimiz bu derslerde öğrendiklerimi hatırlamakta zorluk çekmeyeceğim bence (A5).

Genelde konuları tekrar tekrar çalışırım iyi öğrenmek için ve bu çok sıkıcı. Ama bu sefer o kadar çok çalışmak zorunda kalmadım, öğrenmek eğlenceli ve kolaydı. Bence konuları gerçekten iyi öğrendim ve unutacağımı sanmıyorum (A7).

Eğer bu konuları normalde olduğu gibi sınıfta işleseydik çok sıkıcı olacaktı ve öğrenmek yerine sadece ezberleyecektik bence (B4).

(SAYFA 68)

Geometriyi bilgisayarla öğrenmek çok ilginçti, bence önceye göre çok daha iyi öğrendim. Bence bu herkes için öyleydi, hepimiz bu derslerde çok daha aktiftik (A2).

Matematiği bilgisayarda öğrenmek gerçekten çok hoşuma gitti. Önceden öğrenmek için dikkatimi hiç toplayamıyordum. Bilgisayar kullanmak konsantre olmama ve öle kalmama yardım etti (A3).

Bu hafta matematik derslerindeki en iyi haftamdı çünkü geometri öğrenmek için bir bilgisayar programı kullandık. Geometri öğrenmek için hep bilgisayar kullanmak gerçekten çok hoş olurdu (A5).

İlk başta geometri derslerinde bilgisayar kullanmak biraz garipti ama gerçekten eğlendim. Kâğıt kalem kullanmadan sadece bilgisayarla geometri öğrenmek gerçekten ilginç ve hoştu (B1)

Bu derslerin benim için bu kadar ilginç olacağını düşünmemiştim bile. Geometriyi bilgisayar kullanarak öğrenmek gerçekten çok hoşuma gitti, konuları gerçekten öğrendim bence. Keşke hep bilgisayarla ders işleyebilsek (B4).

(SAYFA 69)

Daha önce bana matematik nedir diye sorsanız muhtemelen işkence derdim. Şimdi ise sevdiğim derslerden biri. Matematik öğrenmek için eğlenceli yollar olduğunu gördüğüme gerçekten çok şaşırdım (A2).

Önceleri geometri benim için zordu ama şimdi o kadar zor olmadığını düşünüyorum. Bence ben geometride başarılı olabilirim. Geometrinin eğlenceli olabileceğini fark ettim (A3).

Dersleri sınıfta işlemekle ilgili bir sıkıntım yok ama dersleri bilgisayar laboratuarında işlemek bence çok daha iyiydi. Dersleri orda yaptığımda mutluydum ve derse katılmak için gerçekten istekliydim. Normalde derslere çok katılmıyorum çünkü konuları çok iyi anlamıyorum ama bilgisayarla işlediğimiz konuları anladım (A4).

Şekilleri bilgisayarda oluşturmak gerçekten çok ilginçti. Geometriden aslında o kadar hoşlanmam ben ama bu derslerden hoşlandım. Önceden de problemleri çözebilirdim ama bu benim için ilginç değildi ve bazen de zordu. Şimdi Geometrinin o kadarda zor olmadığını düşünüyorum (A5).

İtiraf etmem gerek, ilk başlarda geometri öğrenmek için bilgisayar kullanmak konusunda endişeliydim çünkü ben pek matematik insanı değilim. Ama sonra umduğumdan çok daha iyi yaptığımı fark ettim. Geometride sevebileceğim konular olduğunu fark ettim (A6).

Matematikte başarılı olabilmek için hep çok çaba sarf etmem gerek, ama bu sefer o kadar çaba sarf etmeme gerek yoktu. Bu konuyu öğrenmek gerçekten çok ilginçti. Matematikte başarılı olabileceğimi öğrendim ve bence matematikte zevkli konularda var (A7).

Bazı arkadaşlarımız geometriden korkuyorlardı, başarısız olmaktan korkuyorlardı bence şimdi onların düşünceleri değişti ve kendilerine daha çok güveniyorlar. Bence geometride güven çok önemli çünkü kendimize güvenmesek hata yaparız ve konuları beklendiği kadar iyi öğrenmeyiz (B1).

(SAYFA 70)

Bilgisayarla öğrenmeden önce bu konunun benim için çok zor olduğunu düşünüyordum. Şimdi bence kolay ve gerçekten bu konuyu öğrendim (B2).

Bilgisayarla yaptığımız derslerde derse katılmak için çok daha fazla istekliydim çünkü eğlenceli olacağını biliyordum. İşlediğimiz konuları gerçekten öğrendiğim bence. Benim için öğrenmek kolaydı (B3).

Matematikte sevebileceğim konular olduğunu fark ettim. Daha önce matematik benim için sadece sayılardan ibaretti ve gerçekten çok sıkıcıydı. Şimdi ise geometrinin eğlenceli olduğunu düşünüyorum (B4).

Önceleri matematik sadece formüllerden ibaretti. Ama bu derslerde sıkıcı hiç bir şey yoktu. Bence eğer diğer konuları da bilgisayarla işlemiş olsaydık onlardan da hoşlanabilirdim (B5).

Bilgisayarda matematik işlemek konusunda kendimi emin hissediyorum (A2).

(SAYFA 71)

Başlarda böyle bir programı kullanmak biraz ürkütücüydü ama şimdi geometri öğrenirken bilgisayar kullanmak konusunda daha az gerginim (A3).

Derslerden önce bilgisayar kullanmak için temel bilgim vardı şimdi ise böyle bir programı kullanabiliyorum ve kendimi gayet emin hissediyorum (A4).

Bizim için oldukça yaralıydı ama aktivitelere yetişmek biraz zordu benim için çünkü bilgisayar kullanımı konusunda tecrübeli değilim (A5).

Bilgisayarlar çok eskiydi ve bazen çalışsın diye gerçekten uğraşmak zorunda kaldık. Bu tarz problemler olmasaydı, programı kullanmak çok daha kolay olurdu (A6).

Programın İngilizce olması biraz sıkıcıydı, ama öğretmen bizim için gerekli her şeyi açıkladı (A7).

Teknoloji ve bilgisayarlar bu yüzyılın önemli parçaları. Bence matematik eğitiminde olmalılar. Geometrideki tüm konuları bilgisayarla işlemek hoşuma giderdi. Benim için gerçekten eğlenceliydi (A4).

(SAYFA 72)

Bence bilgisayarlar matematik eğitimin bir parçası olmalı çünkü gerçekten matematik konularını daha iyi anlamamı sağladı. Bilgisayarla yeni şeyleri çok çabuk ve dikkatli bir şekilde yapabiliriz bu yüzden bilgisayar kullanmayı tercih ederim (A6).

Bence bilgisayarlar matematiği çok daha ilginç yapıyor çünkü çok renkli ve heyecanlı. Matematikteki her konu bilgisayarla işlesek bence harika olurdu (A7).

Bilgisayarlar bizi motive ediyor çünkü bilgisayarla uğraşmayı seviyoruz. Bilgisayarla işlediğimiz zaman matematik derslerini eğlenceli, heyecanlı ve yeni buluyoruz (B1).

Geometriyi klasik şekilde öğrenmektense bilgisayarla öğrenmeyi tercih ederim. Bilgisayarlar kısada olsa sıralarımızdan uzaklaşmamızı sağladı.Bilgisayarla matematik öğrenmeyi zevkli ve heyecanlı yapıyor (B3).

Bence başka konuları öğrenmek de bilgisayar kullanmak bizim için o kadar yararlı olmaz. Bence sadece geometri konularında bizim için yararlı (B4).

Bence matematik derslerinde bilgisayar kullanırsak daha iyi öğrenebiliriz ama aynı zamanda sıkıcıda olabilir. Çünkü alışırız. Normalde matematik konularını tahtada işliyoruz ve çok sıkıcı bu yüzden konuları bilgisayarla öğrenmekten bu kadar çok hoşlandık, çünkü bilgisayarlar yeni ve ilginç (B5).

Matematik derslerinde bilgisayar kullanmanın o kadar önemli olduğunu düşünmüyorum Ben geometri konularını geleneksel yollarla öğrenmeyi tercih ederim. Bu şekilde çok daha iyi öğreniyorum bence (B6)

(SAYFA 73)

Geçmişte, biz sadece sıramızda oturuyorduk ve öğretmenimiz dinliyorduk. Öğrenme sürecimizde bağımsız değildik Bilgisayarları kullanmak daha bağımsız olmamızı sağladı. Daha çok bağımsız iş yaptık (A1).

Genelde öğretmenimiz konuları anlatır ve biz defterimize yazarız. Ama bu derslerde kendimi çok özgür hissettim, istediğim tüm şekilleri kendim çizdim. Bilgisayarlar sınıfın alıştığımız ortamından çıkmamızı sağladım (A3).

Sanki öğretmen bendim. Aslında sanki herke kendi öğretmeniydi. Bence bu şekilde çok daha iyi çünkü öğrenme süresince çok daha aktif olarak katılmalıyız (A5).

(SAYFA 74)

Normalde biz sadece öğretmenin tahtaya yazdığı şeyleri not alıyoruz, problemleri çözmeye çalışıyoruz ve bazen de problemleri tahtada çözüyoruz. Ama bu derslerde o kadar aktiftim ki sadece oturup not almaktan çok daha fazlasını yaptım (B2).

Normalde okulun son saatlerinde sırada oturup, not almak bir işkence ve ben gerçekten çok sıkılıyorum. Ama bu sefer son saatlerde bile eğlendim (B3).

Normalde biz sadece sıramızda otururuz ve öğretmeni dinleriz, birbirimizle konuşmayız ya da düşüncelerimizi tartışıp, paylaşmayız. Ama bu derslerde çift halinde çalıştık ve gerçekten eğlenceliydi. Çift olarak çalışmak faydalı çünkü bilgisayarda çalışırken birbirimizle tartıştık, birbirimize yardım ettik (A1).

Her şeyi arkadaşımla birlikte yapmak gerçekten eğlenceliydi. Birbirimize yardı ettik ve bu benim daha iyi anlamamı sağladı (A3).

Çift halinde dersi işlemekten çok hoşlanmadım. Çünkü bilgisayarda çalışmaya yeterli zamanım olmadı benim. Bence yalnız olsaydım çok daha iyi olurdu (A4).

Çift halinde çalıştık ve bizim çok sık yaptığımız bir şey değil. Genellikle biz sadece öğretmeni dinleriz ve birbirimizle iletişim kurmayız çok fazla. Ama bu derslerde fikirlerimizi paylaştık, tüm aktiviteleri birlikte yapmaya çalıştık (A5).

Geçmişte öğretmenle iletişim içinde olmaya alışkındık, aslında sadece öğretmenizle iletişim kuruyoruz biz. Ama bu derslerde çift halinde çalıştık. Birbirimize yardım ettik ve hatalarımızı düzelttik (A7).

(SAYFA 75)

Geçmişte öğretmen konuları anlatıyordu ve tahtaya yazıyordu. Ama bu derslerde bilgisayar laboratuarındaydık, öğretmen konuları açıklamadı, bizi yönlendirdi ve öğrenmemize yardımcı oldu (A1).

Geçmişte her şeyi öğretmen anlatıyordu ve bu benim için gerçekten çok sıkıcıydı ama bu derslerde öğretmen sadece yardım etti, her şeyi biz kendimiz yaptık (A2).

Biz her şeyi bilgisayarda yaptık ama bence öğretmenin yönlendirmesi olmadan bu kadar başarılı olamayız (A3).

Öğretmen çok fazla anlatmadı sadece bizi yönlendirdi. Eskiden olduğu kadar çok iletişim kurmadık onunla. Aktiviteler sırasında bizi

yönlendirdi ama ne yapılacağını söylemedi (A5).
Bu derslerde öğretmen konuları açıklamadı, biz her şeyi kendimiz yaptık. Normalden daha az öğretti. Yine öğrenmemiz için uğraştı ama önceden olduğu gibi değildi (A6).
(SAYFA 76)
Öğretmenimiz konuları anlatmak ve çözüm yollarını göstermektense, kendi kendimize anlamamıza izin verdi, tıkandığımız zaman yardımcı oldu, bizi dinledi ve bizi doğru yola yönlendirdi (A7).
Ben öğretmenin rolünün çok fazla değiştiğini düşünmüyorum. Yine aktifti ama daha fazla soru sordu ve konuları anlamamızı sağlamaya çalıştı (B1).
Geçmişte öğretmen konuları açıklıyordu. Bu derslerde her şeyi direk olarak öğretmen açıklamadı eskiden olduğu gibi, normalden daha fazla soru sordu bize ve cevapları bulmamız için ipuçları verdi (B2).
Bence öğretmen bu derslerde normalden daha aktifti. Herşeyi bilgisayarda o yaptı, bize ekrandaki şekiller hakkında sorular sordu. Sorular sorarak konuyu anlamamıza yardım etti (B3).
Tüm şekilleri bilgisayarda öğretmen oluşturdu ama normalde olduğu gibi her şeyi açıklamadı, bize sorular sordu ve kendi yorumlarımızı yapmamıza yardım etti (B5)
Normalde öğretmen konuyu açıklıyordu, ben bu yolu daha çok tercih ediyorum çünkü bence bu şekilde daha iyi öğreniyorum (B6).