EFFECTS OF USING MANIPULATIVES ON SEVENTH GRADE STUDENTS' ACHIEVEMENT IN TRANSFORMATION GEOMETRY AND ORTHOGONAL VIEWS OF GEOMETRIC FIGURES

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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.

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ABSTRACT

EFFECTS OF USING MANIPULATIVES ON SEVENTH GRADE STUDENTS' ACHIEVEMENT IN TRANSFORMATION GEOMETRY AND ORTHOGONAL VIEWS OF GEOMETRIC FIGURES

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The purpose of the present study was to investigate the effects of using manipulatives on seventh grade students' achievement in transformation geometry and orthogonal views of geometric figures. This study also aimed to investigate students' views about using manipulatives.

The study was conducted in one elementary school in Keçiören district of Ankara in the Spring semester of 2012-2013 academic year. The study employed a static group pretest-posttest research design with 73 seventh grade students. Two classes, instructed by the researcher, were randomly assigned as experimental and control groups. Experimental group (EG) students interacted with manipulatives (unit cubes, symmetry mirror, and acetate paper) during the activities and control group (CG) students received regular instruction without using any manipulatives in activities. Achievement Test in Spatial Ability (ATSA), which was prepared by the researcher, was administered to students as pretest and posttest.

The results of the Independent Samples T-test showed that there was no statistically significant mean difference between EG and CG. The other findings of the study revealed that most of the students in the experimental group indicated their positive attitude toward using manipulatives in mathematics lessons.

Keywords: Manipulative, Geometric Figures, Transformation Geometry

ÖZ

SOMUT MATERYAL KULLANIMININ YEDİNCİ SINIF ÖĞRENCİLERİNİN DÖNÜŞÜM GEOMETRİSİ VE GEOMETRİK FİGÜRLERİN FARKLI YÖNLERDEN GÖRÜNÜMLERİ ÜZERİNDEKİ BAŞARILARINA ETKİSİ

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Bu çalışmanın amacısomut materyal kullanımının yedinci sınıf öğrencilerinin dönüşüm geometrisi ve geometrik figürlerin farklı yönlerden görünümleri üzerindeki başarılarına etkisini incelemektir. Bu çalışma aynı zamanda öğrencilerin materyal kullanımı hakkındaki görüşlerini incelemeyi de amaçlamıştır.

Bu çalışma 2012-2013 eğitim-öğretim yılının Bahar döneminde Ankara'nın Keçiören ilçesinde bir ilköğretim okulunda 73 öğrencinin katıldığı denkleştirilmemiş grup öntest-sontest araştırma deseni ile gerçekleştirilmiştir. Araştırmacının matematik öğretmeni olduğu iki sınıf deney (DG) ve kontrol (KG) grubu olarak rastgele atanmıştır. DG öğrencileri aktivitelerde materyaller (birim küp, simetri aynası ve asetat kağıdı) kullanırken, KG öğrencileri hiç bir materyal kullanmadan aktiviteleri tamamlamıştır. Araştırmacının geliştirdiği Uzamsal Başarı Testi, öntest ve sontest olarak uygulanmıştır.

Bağımsız örneklem T-testinin sonuçları DG ile KG öğrencilerinin sontest puanları arasında istatiksel olarak anlamlı bir fark bulunamadığını göstermiştir. DG öğrencilerinin çoğunun kullanılan materyaller hakkında pozitif düşüncelere sahip olduklarını ortaya çıkarmıştır.

Anahtar kelimeler: Somut Materyal, Geometrik Figürler, Dönüşüm Geometrisi

To My Wife Ayşe Gülçin ENKİ

&

To My Daughter Melis ENKİ

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LIST OF ABBREVIATIONS

ATSA: Achievement Test in Spatial Ability

CG: Control Group

EG: Experimental Group

ELE: Elementary Education

M: Manipulative

METU: Middle East Technical University

MONE: Ministry of National Education

N: Number

NCTM: National Council of Teachers of Mathematics

RI: Regular Instruction

SD: Standard Deviation

2D: Two Dimensional

3D: Three Dimensional

CHAPTER I

INTRODUCTION

1.1 Introduction

The overall aim of Turkish mathematics curriculum is to provide students specific mathematical knowledge, skills, and attitudes which might be required in current and later stages of their lives. The mathematics curriculum emphasized on conceptual learning, being fluent in operations, and development of students' problems solving skills (MONE, 2013) as a reflection of this aim. It was also stated that with the help of concrete experiences students can create mathematical sense and make abstraction and connections in which they are active participants of the process (MONE, 2005; 2013). The mathematics curriculum also gives importance on enhancing students' psychomotor skills by using concrete materials (such as algebra tiles and fraction strips), papers types (such as dot and isometric paper), and mathematical visuals (such as geometrical shapes, graphs, and charts) (MONE, 2013).

Research has showed that mathematics achievement and spatial ability are interrelated (Battista, 1994; Clements, 1998; Friedmen, 1992; Guay& McDaniel, 1977; Guzel&Sener, 2009; Hvizdo, 1992; Kayhan, 2005; Smith, 1964). Spatial ability is crucial for learning many topics in mathematics (Clements, 1998) and especially in geometry (Fennema&Tartre, 1985). The National Council of Teachers of Mathematics (NCTM) (2000) stressed the importance of spatial ability in mathematics education and emphasized enhancing students' spatial skills throughout learning activities where students have opportunities to draw, compare, and visualize the shapes in the geometry curriculum. By the change in elementary mathematics curriculum in Turkey in the middle of 2000s, several important spatial ability topics such as transformation geometry (translation, reflection, and rotation of planar figures), patterns, and tessellations were included into the elementary mathematics curriculum (MONE, 2005). After the revision of the curriculum in 2013, patterns and tessellations topics were removed. However, geometric figures topic was not revised and remained the same. Due to the recent change in the education system in Turkey, 7th grade mathematics is now a part of middle school mathematics while it was a part of the elementary school mathematics before. Both "elementary" and "middle" qualifiers are used in this thesis based on the resources used. "Middle" qualifier is used for referring to the current and future situations.

Mathematical concepts are most of the time abstract for students and they have difficulties in understanding many mathematical concepts. Therefore, the elementary mathematics curriculum which went through a major change (MONE, 2005) and a major revision (MONE, 2013) has emphasized the use of concrete materials in learning these concepts. Learning of these concepts should be supported by manipulation of the environment and by direct experience with constructive and sensory activities which include working with geoboards, pattern blocks and figures (Grande, 1986; Olkun&Knaupp, 1999). Since students' mathematical thinking and spatial ability can be improved by using spatial activities (Battista, 1994; Moses, 1977) and by practice and training (Lohman, 1993), it is important to investigate the effects of manipulative use on students' spatial ability in mathematics.

1.2 Manipulatives in the Mathematics Classroom

When students learn a topic via memorization, they have to depend on adults for the answer for any question (Moyer & Jones, 1998). On the other hand, there are evidences that young children learn mathematical concepts better when they are given chance to interact with concrete models (Battista, 1986; Clements & McMillen, 1996; Fennema, 1969; Parham, 1983; Suydam, 1986; Sowell, 1989). "Good manipulatives are those that aid students in building, strengthening, and connecting various representations of mathematical ideas" (Clements, 1999, p.49). Likewise Weiss (2006) defines manipulative as concrete representations of the objects which can be experienced by the senses. Hynes also defines manipulative as "concrete models that incorporate mathematical concepts, appeal to several senses and can be touched and moved around by students" (1986, p. 11). Fennema (1969) explained curriculum materials as textbooks, workbooks, and concrete or symbolic materials which are used by the teacher in learning process through instruction.

McClung (1998, p.2) defines three different types of manipulatives including, “dry models (using concrete objects or representations of objects), length models (using rods or number lines), and area models (using tiles or pictures)”. These tools actually should be used in the teaching-learning process and should be used by students as tools that enhance their mathematical conceptual learning and development (Moyer & Jones, 1998).

Mathematical concepts could often be very abstract for students and using manipulative materials will enable them to explore mathematical concepts in a concrete way. Manipulatives enable students to make connections between their own concrete sensory environment and more abstract levels of mathematics (McClung, 1998). The use of manipulative also enhances students’ attitude and intrinsic motivation. Students take opportunities with concrete manipulative to construct understanding and meaning. They gain positive attitude toward mathematics while understanding the concept and topics underlying a certain procedure (Moyer & Jones, 1998). Students should be sufficiently familiar with manipulative, otherwise using of them may not make any contribution to the learning process. Using manipulatives, on the other hand, creates additional work for the students and the teacher. Moreover, if students do not understand the purpose of using the manipulative, it turns into a distraction (Weiss, 2006).

1.3 Spatial Ability

The National Council of Teachers of Mathematics (2000) stresses the significance of spatial abilities in mathematics education and emphasizes the importance of developing students’ spatial abilities throughout the geometry curriculum. Students should experience different activities with drawing, transforming, visualizing, comparing, and classifying geometric shapes in order to develop their spatial ability (NCTM, 1989). Ben-Chaim et al. (1988) claimed that if appropriate materials are presented to students, their spatial ability can be improved via training. Although there are many studies in the literature related to spatial ability, there is no consensus on the terms and definitions used for spatial ability.

Spatial ability was defined by Lohman as “the ability to generate, retain, retrieve, and transform well-structured visual images” (1993, p.3). Linn and Petersen defined spatial ability as “representing, transforming, generating, and recalling symbolic, nonlinguistic information” (1985, p.1482). Another definition of spatial ability is constructing and manipulating mental representation of lines, shapes, relationships, and transformations (Clement, 1998). As these definitions suggest, spatial ability requires a considerable mental activity.

Lohman (1988), according to the results of a meta-analysis, asserted three factors of spatial ability as spatial visualization, the spatial orientation, and the spatial relations. However some researcher stated two major components of spatial ability, namely spatial orientation and spatial visualization (Battista, 1994; Clements, 1998; McGee, 1979). Clements defines spatial visualization as “understanding and performing imagined movements of two-and three dimensional objects” (1998, p.18) and defines spatial orientation as “understanding and operating on relationships between different positions, especially with respect to your own positions” (Clements, 1998, p.13). McGee defines spatial visualization as “ability of mentally rotate, manipulate, and twist two- and three-dimensional stimulus objects” and defines spatial orientation as “comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude to remain unconfused by the changing orientations in which a spatial configuration may be presented” (1979, p.896). While there are several definitions and approaches to the concept of spatial ability mentioned above, there is no single and exact definition and sub-definition of spatial ability. However, the common view of them is that spatial ability includes mental manipulation, rotation, or transforming of objects.Bishop (1980) and Tartre (1990) proposed that spatial ability is an important factor for learning geometry and integrating spatial ability and manipulation into learning activity could improve geometric learning.

1.4 Purpose of the Study and Research Questions

The purpose of the present study was to investigate the effects of using manipulatives on seventh grade students’ achievement in transformation geometry and orthogonal views of geometric figures. The effect of using manipulatives was investigated by means of pre-test and post-test control group design through conveniently selected participants. This study also aimed to investigate students' views about using manipulative by means of self-reported written reports.

In order to investigate the effects of using manipulatives on seventh grade students' achievement in spatial ability, the following research questions and hypotheses were formulated:

Research Question 1: Does the use of manipulatives influence seventh grade students' achievement in transformation geometry and orthogonal views of geometric figures as measured by the spatial achievement test?

Null Hypothesis 1: There is no significant mean difference between posttest scores of groups in spatial achievement test who use manipulative and those who do not use manipulative.

Alternative Hypothesis 1: There is significant mean difference between posttest scores of groups in spatial achievement test who use manipulative and those who do not use manipulative.

Research Question 2: What are students' self-reported perceptions related to using manipulatives in mathematics lessons?

1.5 Definition of the Terms

Spatial Ability: Clements (1998) defined spatial ability as constructing and manipulating mental representation of lines, shapes, relationships, and transformations. In this study spatial ability will be considered as mental manipulation of objects in the concept of geometric shapes and transformation geometry. It will be measured by the Achievement Test in Spatial Ability (ATSA).

Spatial Visualization: "Ability of mentally rotate, manipulate, and twist two- and three-dimensional stimulus objects" (McGee, 1979, p.896).

Spatial Orientation: "Understanding and operating on relationships between different positions, especially with respect to your own positions" (Clements, 1998, p.13).

In the present study, achievement test was used to measure both spatial orientation and spatial visualization abilities of the 7th grade students. The activities and Achievement Test (ATSA) consisted of both spatial visualization and spatial orientation tasks which were 2D representation of 3D objects, isometric drawing, reflection, translating, and rotating.

Manipulative: "Concrete models that incorporate mathematical concepts, appeal to several senses and can be touched and moved around by students" (Hynes, 1986, p. 11). In this study manipulatives refer to unit cubes, symmetry mirror, and acetate paper.

1.6 Significance of the Study

Spatial ability is crucial for learning many topics in mathematics (Clements, 1998) and especially in geometry (Fennema&Tartre, 1985). Pittalis et al. (2007) revealed that spatial ability constitutes a strong predictor of students' performance in geometry and improvement in students' spatial ability may result in improvement of students' geometry performance. Therefore, several spatial ability topics such as transformation geometry (involves translation, reflection, and rotation of plane figures), patterns, and tessellations were integrated into the Turkish elementary mathematics curriculum in 2005 (MONE, 2005) and were maintained in the latest revision in 2013 (MONE, 2013). The elementary mathematics curriculum emphasized that active participation of students in the instructional process in which students created their own knowledge and learned by doing and experiencing things on their own was important (MONE, 2009). Many researchers have investigated the effects of treatments on spatial ability (Bayrak, 2008; Bayram, 2004; Ben-Chaim et al., 1988; Clements, 1998; Çakmak, 2009; Eryaman, 2009; Fennema&Tartre, 1985; Karaaslan et al., 2012; Olkun, 2003; Pittalis et al., 2007; Turgut, 2007; Werthessen, 1999; Yıldız&Tüzün, 2011; Yolcu&Kurtuluş, 2008) and their studies have shown that spatial ability could be improved by using appropriate treatments such as using manipulatives and visual treatment.

The overall aim of the Turkish National Education is to prepare students for life by developing their interest, abilities, knowledge, skills, and attitudes and enable them to have a profession that will make them happy (MONE, 2009). Students who have developed their spatial ability skills may enhance their future profession opportunities. Many studies also have shown that there is relationship between spatial ability and other disciplines such as medicine, engineering, chemistry, physics, and geology. Most of the areas of engineering, especially mechanical engineering, civil engineering and electric-electronic engineering require three-dimensional thinking ability (Olkun, 2003) which could be considered as spatial ability.

It is foreseen with this study that using manipulative will contribute students' spatial ability. Moreover, the findings of this study are expected to develop ideas for increasing students' spatial ability by using manipulatives and provide useful information for middle school teachers in planning learning activities. Also, it is believed that this study may contribute to the literature about the effect of manipulative use on enhancing students' spatial ability.

1.7 My Motivation for the Study

I am a mathematics teacher in one of the elementary schools in Ankara. I taught sixth, seventh, and eight grade levels through my teaching profession. There were some topics in mathematics such that every student enjoyed through lessons. Geometric figures and transformation geometry are such topics that students actively participate in the lessons. While introducing geometric figures topic, I introduced unit cubes to the students. These materials appealed their interest and made them concentrate on the topic. Afterward, I thought whether I could enhance their spatial ability with using manipulatives such as unit cubes, symmetry mirror, and acetate paper. By means of this study, I hope to find the answer of my question. Moreover, I believe that this study will contribute my teaching profession.

CHAPTER II

LITERATURE REVIEW

The purpose of the present study is to investigate the effects of using manipulatives on seventh grade students' spatial ability in the concept of geometric shapes and transformation geometry. In this chapter, literature review of the present study was presented. Specifically, this chapter consists of three sections; theoretical framework, spatial ability and related studies on using manipulative in spatial ability in mathematics education.

2.1 Theoretical Framework

The studies of Jean Piaget and Pierre M. van Hiele play important role in the improvement of teaching geometry (Fuys et al, 1988). Piaget and Inhelder (1956) suggested that a child's perception of space was constructed through social interaction and active participation with their environment. They stated four steps in cognitive progressing which were an individual's (i) maturation, (ii) social interaction, (iii) actions on the surroundings (either physical or mental), and (iv) the disagreement with disequilibrium and following resolution of the conflict by the processes of assimilation and accommodation. Piaget's Theory of Cognitive Development provided much contribution to the field of education (Ojose, 2008). In his theory, children's developmental stages were discussed and his works provided mathematics educators deep insight into how children learn mathematical concept and ideas (Ojose, 2008). Piaget (1973) examined the thinking patterns of children from birth through adolescence and described four stages of cognitive development: Sensorimotor Stage (birth to age 2); Preoperational Stage (ages 2 to 7); Concrete Operations Stage (ages 7 to 11); and Formal Operations Stage (age 11 onwards).

In sensorimotor stage, mental and cognitive development of infant starts by birth and continues through the appearance of language, approximately until 2 years. In this stage, children use their senses and motor skills to understand the world. They are able to find the object even if objects have been removed of their vision (Ojose, 2008). Additionally, ability of linking numbers to objects appears such as “one dog” or “two cats” in this stage (Piaget, 1977). Mathematical capacity of a child could be enhanced by encouraging safely without restricting them (Ojose, 2008).

In preoperational stage, there is an increase in language ability. Between ages 2 and 7 children gain symbolic thought, egocentric perspective, and limited logic. They can perform simple problem solving tasks with the materials such as blocks, sand, and water. In this stage, mechanisms of child’s thought processes can be accessed through conservation with him while child is working on the problem. In this stage child associates unrelated events, does not realize point of view, and does not have reverse operations. For example, a child who understands that adding three to five makes eight cannot perform the reverse operation of subtracting three from eight. Moreover, children’s perceptions are restricted in this stage and they might use one dimension such as height as a basis for his judgment of another dimension such as volume (Ojose, 2008).

A notable cognitive growth can be seen in concrete operations stage. Seriation and classification are two logical operations that children gain in this stage. Seriation is ordering objects according to their length, volume, or weight. Classification is grouping objects according to their properties. In this stage, the child starts organizing data into logical relationships and gains ability in managing data in problem solving situations. This happens only when concrete objects are presented. Piaget (1973) stated that mathematics involved actions and operations; therefore, understanding mathematics should begin with action. He suggested that this process should involve concrete exercises related to lengths, surfaces, numbers, and other topics in elementary school. At this stage, children gain sense of reversibility. In order to reinforce cognitive development, curriculum should provide specific educational experiences based on children’s developmental level and materials should also be within children’s level of understanding. Because children need concrete experiences at this stage, teachers should use manipulative such as pattern block, unit cubes, geoboards, tangrams, counters, and geometric shapes. Using materials also enhances mathematical confidence (Ojose, 2008).

In formal operations stage, child can construct his own mathematics by doing hypotheses and deducing possible consequences. The abstract thinking develops in this stage. Formal operational learners can solve the $x+3x=8$ without using any concrete manipulative. According to Piaget (1973), when a person arrives at the formal operational stage, the foundation for lifelong learning has been established (as cited in Ojose, 2008).

Similarly, van Hiele (1986) constructed a model that explained the stages of human geometric reasoning. The van Hiele model of geometric thinking appears similar in structure to Piaget's developmental stages, but the properties of these two models are different. Van Hiele (1958) stated that students should pass through five levels of thinking which were level 0, level 1, level 2, level 3, and level 4 and they cannot progress to the next level unless they have succeeded at the previous lower level.

At level 0 (Visual Level), students can identify, name, compare, and operate on geometric figures based on the form of the figures. At level 1 (Descriptive Level), students study figures in terms of their parts and relationships among those parts, and categorize figures according to their properties. At level 2 (Theoretical Level), students logically interrelate properties and rules they discovered by providing or tracking informal arguments. At level 3 (Formal Logic), students prove theorems deductively by building relationships among a web of theorems. At level 4 (Nature of Logical Law), students have a higher level of thinking and they are expected to establish theorems.

Level 2 is important for this study and deserves a focus (Van Hiele, 1958). At level 2, students logically order properties of concepts, construct abstract definitions, and state the necessity and sufficiency of a set of properties in determining a concept. The relationship between properties can be recognized, hierarchies can be constructed and the definitions can be understood, properties of geometric figures are deduced from others. For example, the student is able to see figure that a square is a rectangle; but a rectangle might not be a square. However, the importance of deduction cannot be understood at this level (Van Hiele, 1958). At this level properties are logically ordered such that one property precedes or follows from another property. However, the intrinsic meaning of deduction, that is, the role of axioms, definitions, theorems, and their converses in building relationship are not understood at this level. Van Hiele noted that providing students with information beyond their actual thinking level would not help them move to the next higher level. On the contrary, it will take them to a lower level. Van Hiele suggested that teachers should allow students to learn geometry by means of hands-on activities (Bayram, 2004)

In conclusion, while introducing geometry concept such as space, shapes, and figures to students, enhancing students' spatial thinking and ability is directly related to their cognitive development. Piaget (1973) stated that mathematics for students at concrete operational stage should be through discovery with concrete objects.

2.2 Using Manipulative in Teaching and Learning Mathematics

Teaching mathematics by using manipulative has a long history. Pestalozzi, in nineteenth century, suggested using of manipulative and manipulative took their part in mathematics classes in 1930s (Sowell, 1989). Between 1960s and 1970s researchers compared instructions with manipulative or pictorial materials and instructions without such materials (Sowell, 1989). With the publication of theoretical justification of their use by ZoltonDienes (1960) and by Jerome Bruner (1961), its importance increased (Sowell, 1989).

"Good manipulatives are those that aid students in building, strengthening, and connecting various representations of mathematical ideas" (Clements, 1999, p.49). Likewise, Weiss (2006) defines manipulative as concrete representations of the objects which can be experienced by the senses. Hynes also defines manipulative as "concrete models that incorporate mathematical concepts, appeal to several senses and can be touched and moved around by students" (1986, p. 11).

Fennema (1969) mentioned curriculum materials as textbooks, workbooks, and concrete or symbolic materials which are used by the teacher in learning process through instruction. Concrete materials can be used in for two purposes. First, they construct powerful connections among concrete situations, mathematical language, and mathematical notation. Second, concrete materials enable students be in action in the mathematics classroom (Swan & Marshal, 2010). In many studies, manipulatives were used as a teaching strategy; however, manipulatives are mathematical tools. These tools actually should be used by students as a tool enhancing their conceptual learning and development in mathematics (Moyer & Jones, 1998). There are evidences that young children learn mathematical concepts better when they are given chance for interacting with concrete models (Battista, 1986; Clements &McMillen, 1996; Fennema, 1969; Parham, 1983; Suydam, 1986). In other words, when learning environment was modified by teachers, children construct mathematical principles correctly. This manipulation can be through employing manipulative because mathematical concepts are often very abstract and using manipulative enables students to explore mathematical concepts in a concrete way. The use of manipulative also enhances students' attitude and intrinsic motivation. Students gain opportunities with concrete manipulative to construct understanding and meaning. They gain positive attitude toward mathematics while understanding the concept and topics underlying under a certain procedure (Moyer & Jones, 1998).

Clements & McMillan (1996, p.276-277) stated how teachers should select appropriate and effective manipulative. First of all, teachers should decide manipulatives for children's use. Additionally, selected manipulatives should allow children to use in their informal methods and should serve many purposes. While introducing a topic, teachers should use single manipulative rather than many different manipulatives. In many cases, computer manipulatives should be used when appropriate.

Sometimes it is not easy to use concrete materials in a correct way; rather, it is easy to misuse them (Swan & Marshal, 2010). Students should be sufficiently familiar with manipulative. Otherwise, using of them does not make any sense in learning process and creates additional work for teachers. Moreover, if students do not understand the purpose of the manipulative, it turns into a distraction (Weiss, 2006). Therefore, teachers should clearly communicate the purpose of using manipulative to the students.

The teachers who use manipulative in their classes for better understanding are actually helping their students who struggle with abstract symbols. Communicating with concrete models, such as manipulative, pictorial models, and symbolic representation enable students to enhance better understanding the process and mathematics (Moyer & Jones, 1998). Furthermore, the use of manipulative has important role in affecting students' motivation and attitude. However, in most classrooms manipulatives are far away from students or hidden in locked cabinets.

Teachers, generally, may be uncomfortable or unwilling for using manipulative materials or may be unfamiliar with them. Teachers feel that they lose control of students while students interact with manipulative materials. The reason why they feel like that is students see these materials as toys (Moyer & Jones, 1998). It is important that students see these materials in mathematics lessons frequently and are allowed to access them whenever they want in order for them not to see them as toys (Moyer & Jones, 1998). Materials should be available in student desk or somewhere in class for free access and students should be given chance to explore the use of them.

Students who use manipulative in mathematics lessons usually outperform than who do not; however, manipulative does not guarantee success (Clements, 1999; Thompson, 1994; Clements &McMillen, 1996). For example, McClung (1998) investigated the effect of manipulative on student achievement in a high school Algebra I classes and control group who did not use manipulative had higher mean score than experimental group who used manipulative. In this study, students' ages in both groups were between 14 and 16. According to Piaget (1973), concrete operational stage, this begins at age 7 and up to 12, is critical for using manipulative. In this stage the child starts to organize data into logical relationships and gains ability in manipulating data in problem solving situations.

Even if manipulative are crucial in learning mathematics, their physicality does not carry the meaning of the mathematical idea. Furthermore, meaning of concrete understanding does not always refer to physical objects (Clements, 1999; Thompson, 1994). Suydam& Higgins (1977) investigated whether using manipulative had effect on students' achievement in mathematics by analyzing the related research. They identified 23 studies comparing in which manipulative materials were used or were not used. These studies comprise first grade level to eight grade level and elementary school mathematics concepts from fractions to geometry topics. Two studies resulted in favor of lessons where manipulative were not used, eleven studies resulted in favor of lessons where manipulative were used and ten studies found no statistically significant difference between lessons in which manipulative were used and were not used. Approximately half of the studies resulted in favor of using manipulative. However, the same number of studies found no difference. When results of these studies were analyzed, in six of the ten studies which found no difference, manipulative-using groups had higher scores compared to no manipulative-using groups.

2.3 Definitions of Spatial Ability

Spatial ability is crucial for learning many topics in mathematics (Clements, 1998) and especially in geometry (Fennema&Tartre, 1985). The National Council of Teachers of Mathematics (2000) stressed the importance of spatial abilities in mathematics education and emphasized enhancing students' spatial skills throughout learning activities. Although there are many studies in the literature related to spatial ability, there is no consensus on the terms used for spatial ability.

Spatial ability was defined by Lohman as "the ability to generate, retain, retrieve, and transform well-structured visual images" (1993, p.3). Linn and Petersen define spatial ability as "representing, transforming, generating, and recalling symbolic, nonlinguistic information" (1985, p.1482). Another definition of spatial ability is constructing and manipulating mental representation of lines, shapes, relationships, and transformations (Clement, 1998). Linn and Petersen (1985) state that spatial ability is actually a combination of such skills as using map, dealing with geometry, and recognizing two dimensional representation of three dimensional figures. Olkun (2003) defines spatial ability as "mental manipulation of objects and their parts in 2D and 3D space" (p.8). While there are several definitions and approaches to the concept of spatial ability, the common view of them is that spatial ability includes mental manipulation of objects.

Underlying factors of the spatial ability has been an area of studies since the mid-1940s; however, these studies did not present a clear picture of the dimensions of this construct. When studies were investigated some terms appeared to address spatial ability such as spatial visualization, spatial orientation, spatial relations, spatial reasoning, visuo-spatial ability, spatial perception, and mental rotation. While some researchers accepted two dimensions of spatial ability, some accepted three or more dimensions. Two major components of spatial ability have been considered as spatial orientation and spatial visualization (Battista, 1994; Clements, 1998; McGee, 1979).

Battista (1994) defines spatial visualization as “comprehension and performance of imagined movements of objects in space” and spatial orientation as “understanding and operating on the relationships between the positions of objects in space with respect to one's own position” (p.87). While Clements (1998) defines spatial visualization as understanding and manipulating imagined movements of two and three dimensional objects, he defines spatial orientation as “understanding and operating on relationships between different positions, especially with respect to your own positions” (p.13). In this manner he deals with the terms maps, navigation, space, perspective, direction, location, and coordinates. Students should work with unit blocs to experience with “perspective”, identify the navigation idea as “directions” such as left, right, front, and back. Younger students should interact with coordinate reference system to develop their mental mapping system.

McGee (1979) defines spatial visualization as the ability of “mentally rotate, manipulate, and twist two- and three-dimensional stimulus objects” (p.896) and defines spatial orientation as “comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude to remain unconfused by the changing orientations in which a spatial configuration may be presented” (p.896). In another words, spatial orientation is ability to imagine an object from different perspectives.

In addition to these findings, McGee (1979) stated that Erkstorm, French, and Harman (1976) defined two sub-skills of spatial ability namely, spatial visualization and spatial orientation. Spatial visualization was defined as “an ability to manipulate or transform the image of spatial patterns into other arrangements” and spatial orientation was defined as “ability to perceive spatial patters or to maintain orientation with respect to object in space” (Ekstrom et al., 1976 as cited in McGee, 1979, p. 891). While orientation requires only mental rotation of the figure, visualization requires both rotation and serial operations. Moreover, while figure is perceived as a whole in orientation, it must be mentally restructured into components for manipulation in visualization (McGee, 1979).

In summary, there are several definitions of spatial ability and its factors in the literature. The purpose of this study is to investigate the effect of manipulative use on seventh grade students’ spatial ability in the concept of geometric shapes and transformation geometry. When analyzing spatial ability, many researchers have come to agreement of representing, transforming and manipulating of objects and their parts in the 2D or 3D space. Thus, definition of spatial ability by Clements (1998) will be employed for the purpose of this study.

2.4 Research Studies on Using Manipulative in Spatial Ability in Mathematics Education

With the reform in Turkey in 2003, the elementary mathematics curriculum program has changed and spatial ability was considered more important than before in the mathematic lessons (MONE, 2005; 2013). The instructional objectives in the new mathematics curriculum related to spatial ability contained drawing the images of point, line segment and other shapes under the translation on the plane, drawing the images of point, line segment and other shapes under the reflection on the plane, drawing two-dimensional views of three dimensional objects from different directions, and constructing three dimensional buildings given different two dimensional perspectives (MONE, 2013). It was also stated that unit cubes, symmetry mirror, isometric dot paper, squared paper, and other hands on materials should be used throughout the instruction.

Several studies have investigated students' spatial ability and many of them also investigated the effect of using manipulatives. These studies focused on the effect of visual treatments, dynamic computer software program, and concrete manipulative use on elementary and secondary school students' spatial ability skill. Mathematical manipulatives may include any kind of objects that is used in mathematics lessons to help students in understanding the concepts being taught (Rust, 1999). Considering this, studies on effect of using manipulatives on spatial ability or on spatial ability are briefly summarized below.

In a study Karaaslan et al. (2012) analyzed the 45 eleventh grade students' spatial ability skills with respect to their solutions for three dimensional geometry problems. Regardless of their ability level, students had difficulties with solving the geometry problems which had no figures. To overcome this problem, it was suggested that students should interact with concrete materials and visualization activity to solve the three dimensional geometry problems (Karaaslan et al., 2012).

In the study of Bayram (2004), the effects of concrete models on eighth grade students' geometry achievement and attitudes toward geometry were investigated in a private school in Ankara. One hundred and six eight grade students participated in this experimental study. There were one experimental and two control groups. While the experimental group received instruction with concrete models, control groups were instructed with traditional method and did not use any concrete models. Throughout the study control groups were taught in teacher-centered instruction and students worked individually but experimental group worked together as a group and shared their findings with their group member and other groups. Groups received 800 minutes instruction during four weeks. The Geometry Attitude Scale (GAS), Geometry Achievement Test (GAT), and open ended questions were used as instruments. Results of the study showed that in terms of geometry achievement score, while there was a statistically significant mean difference between students who received instruction with concrete models and those who received instruction with traditional method in favor of experimental group, there was no statistically significant mean differences between girls and boys. In terms of geometry attitude score, there was no statistically significant mean difference between experimental and control groups.

Eryaman (2009) investigated the contributions of spatial visualization and spatial orientation tasks regarding 2D representations of 3D objects and isometric drawing to the development of sixth grade students' spatial reasoning. The design of the study was first person inquiry one group pretest-posttest research design. There was no control group in this study. Researcher of the study was also the teacher of the participants. In this study unit cubes were used as manipulative. Twenty-four sixth grade students were participated in this study from the one private school in Ankara. Students received five class hours instruction throughout the study. In order to evaluate the effect of instruction, Achievement Test (AT) on 2D Representations of 3D Objects and Isometric Drawing was administered to the students before and after the task. Results showed that there was a statistically significant difference in students' spatial reasoning development between pre-test and post-test scores. Students had higher scores in post-test scores. Eryaman suggested that in order to develop students’ spatial reasoning, teachers should use visual activities supported by effective manipulative.

In another study, Bayrak (2008) investigated the effects of visual treatments on students’ spatial ability, spatial visualization, and spatial orientation. One group pretest-posttest research design was used. Participants of the study were 21 sixth grade students in Ankara. In this study participants received 10 weeks treatment five hours per each week. Spatial Ability Test and Spatial Problem Scale were used as instruments. Results showed that there was a statistically significant change in students’ spatial ability, spatial orientation, and spatial visualization scores across three time periods (pre-treatment, post-treatment and retention). Students’ test scores were significantly higher after the treatment than those before the treatment. Although their test scores were significantly lower after one month retention than post-test scores, their test scores were significantly higher than pre-test scores. It was also found that visual treatments had positive effects on students’ spatial cognitive process and their attitudes toward spatial ability problems.

Çakmak (2009) investigated the effect of origami-based instruction on fourth, fifth and sixth grade students’ spatial ability. Study was conducted in one of the private schools in Eryaman, Ankara with 38 fourth, fifth, and sixth grade students. This was a one group pretest-posttest research design. In this research design, a single group was measured before and after the treatment. There were fifteen fourth grade students, nine fifth grade students and fourteen sixth grade students in this study. Because the sample size was small, researcher paid attention to each student. Study took 10 weeks for all gradesand each grades received instruction separately from other grade students. Data were collected with Spatial Ability Test which was a combination of “Test of Spatial Visualization in 2D geometry” and “Paper Folding Test” with 35 multiple-choice items. The result indicated that origami-based instruction had a positive effect on students’ spatial ability.

Turgut (2007) investigated the relationship between sixth, seventh, and eighth grade students’ spatial abilities, early childhood education and childhood logo experiences. MGMP Spatial Ability test was implemented to 1036 sixth, seventh and eighth grade students to collect data. It was found that students who had early childhood education and students who had childhood logo experiences performed better in spatial ability test than who had not early childhood education and childhood logo experiences. This result supported the idea that spatial ability is associated with individuals' academic environments to which they were exposed to. Moreover it was stated that spatial ability of children was positively affected by toys and plays in their learning environments.

Olkun (2003) provided activities for developing middle grade students' spatial ability with engineering drawing applications. In the activities, students built rectangular solids, and some figures like car, truck, and ship by using small cubes. At the end of the activities it was stated that spatial ability was important and could be improved through concrete experiences with geometrical objects.

Yolcu and Kurtuluş (2008) investigated the improvement in the spatial ability of sixth grade students by using concrete manipulative (unit cubes), a software, and worksheets. Participants of the study were 20 sixth grade students in a public elementary school in Eskişehir. Students were expected to visualize three dimensional structures, interpreting two dimensional drawings of three dimensional objects and find out the surface of the cube within geometrical objects. In this study, students' spatial ability was also supported with isometric drawing software program. After pretest and posttest were administered to the students, results indicated that there was a statistically significant difference in students' spatial ability between pretest and posttest scores in favor of posttest scores. It was stated that after the treatment students could more correctly find out the number of the cubes, visualize the three dimensional object, and more easily construct the three dimensional figures of given two dimensional drawing. Researcher also stated that the dynamic computer program had significant effect on students' visualization ability.

In another study conducted by Yıldız and Tüzün (2011), effects of using 3D virtual environments and concrete manipulative on spatial visualization and mental rotation abilities were investigated on 108 fifth grade students in a public school in Ankara. A quasi-experimental pre-test post-test research design was used. While experimental group used 3D virtual unit block simulation on the computer, control group used unit blocks as the concrete manipulative. Results of the study showed that while there was a significant increase in spatial visualization and mental rotation test scores of control group, only spatial visualization scores of experimental group increased. Also, it was indicated that there was no significant difference between groups in terms of spatial visualization and mental rotation test scores. Yurt and Sünbül (2012) suggested that using both virtual environment and concrete materials together would be more effective in enhancing students' spatial ability.

Ben-Chaim, Lappan and Houang (1988) investigated the effect of particular instruction including manipulative on middle grade students' spatial ability. Approximately 1000 students from 5th, 6th, 7th, and 8th grade classes were participant of the study. Three weeks instruction was implemented to students by 21 mathematics teacher. In the lessons, concrete activities in which unit cubes were used administered to the students. In the activities, first, students constructed "buildings" with cubes, then drew their two dimensional representations on the grid paper. Second, they created a "building" with unit cubes in which isometric drawings were given. Middle Grades Mathematics Project (MGMP) Spatial Visualization Test (SVT) which had thirty-two multiple choice items was administered to students. The test contained 10 different types of items and there were no time limitation for students to complete the test. The result of the study showed that all grade levels gained significant improvement from the instruction. Furthermore they concluded that grades 5 through 8 there was an increase in spatial ability with an increase in grade level.

Werthessen (1999) focused on the effect of instruction with hands on materials on gifted students' achievement in spatial ability. Nearly 105 fourth and fifth grade students were selected as participant. Two treatment and two comparison classes from each grade level received ten lessons through four weeks. Pretest and posttest were administered both groups. Students in treatment group were trained with exploration and construction of three dimensional figures by using Polydron materials which could be used to make cubes, prisms, pyramids, and more complicated polyhedra. Comparison group received routine mathematics instruction without using any concrete material. Result showed that training with hands on material in lessons had a positive effect on gifted students' spatial ability.

There were some studies resulting in having no significant effect of manipulative using on students' spatial ability (Boakes, 2009; Boyraz, 2008; Drickey, 2000; Eraso, 2007; Pleet, 1990). Drickey (2000) investigated the effectiveness of physical and virtual manipulative on middle school students' spatial reasoning skills. Quasi-experimental pretest-posttest non-equivalent control group research design was used. Two treatment groups, used physical and virtual manipulative respectively, were compared to a control group not using manipulative. Participants of the study were 219 sixth grade students. Three mathematics teachers taught geometry unit four weeks to the groups during instruction. Results of the study indicated no statistically significant differences between the groups in posttest scores. Researcher suggested longer treatment length, manipulative using during assessment and larger sample size for future research.

In the study conducted by Eraso (2007), a quasi-experimental pretest posttest research design was used to improve the tenth grade students' spatial visualization ability. Sixty-four tenth grade students participated in this study. Twenty-one students were in control group, twenty-two and twenty-one were in experimental groups. Geometer's Sketchpad and the Polydron manipulative were used in two experimental groups for teaching and learning the concept of solid geometry. The Purdue Spatial Visualization Test (PSVT) which was consisted of three parts with multiple choice questions about the visualization of rotations, views, and developments was used as the instrument to measure students' visualization abilities. Results of the study showed that there was no statistically significant mean difference between groups in terms of spatial visualization abilities due to having the same teacher in three groups. Moreover, it was stated by the researcher that six week instruction might not be sufficient for the treatment.

Boakes (2009) focused on the effect of origami based instruction on seventh grade students' spatial ability in geometry knowledge. Participant of the study was 56 seventh grade students. He used quasi experimental pretest-posttest research design in his study. While control group received traditional instruction, experimental group received origami based instruction in addition to traditional instruction. Duration of the study was one month and each group received 80 minutes instruction for every day. However, experimental group took origami instruction three days a week for 20-30 minutes prior to their normal instruction. A total of twelve origami based lessons were integrated into instruction. The data were collected through spatial ability tests (card rotation, paper folding, and surface development test) and NAEP geometry test. The results showed that there was no statistically significant mean difference between groups in paper folding and surface development test. However there was a difference between groups in card rotation test in the significant level of .005. Moreover, no significant mean difference was found between groups in terms of NAEP geometry test.

In another study Boyraz (2008) investigated the effect of geometry based computer instruction on seventh grade students' spatial ability compared to traditional textbook based instruction. The study was conducted with 57 seventh grade students in a private elementary school in Kayseri in the 2006-2007 academic school year. The study took 14 class hours in two weeks. The data were collected through spatial ability test and interviews. Result of the study showed that dynamic geometry based computer instruction didn't have significant effect on students' spatial ability compared to traditional textbook instruction.

Pleet (1990) investigated the effectiveness of using computer graphics and manipulative on transformation geometry concept and mental rotation skills of eighth grade students. Non-equivalent control group design was used in this study. There were two experimental group namely manipulative experimental group and computer experimental group and fourteen control groups. Eight mathematics teachers taught the groups throughout the study. Transformation Geometry Achievement Test (TGAT) designed by researcher with 20 multiple choice items and Card Rotation Test (CRT) with 20 multiple choice item were administered to groups as pretest and posttest. Time between pretest and posttest was three weeks. Results of the study showed that there was no significant mean difference between experimental and control groups in terms of TGAT and CRT test scores.

To sum up, while some of the studies showed that using manipulative had no effect on students' spatial ability (Boakes, 2009; Boyraz, 2008; Drickey, 2000; Eraso, 2007, Pleet, 1990), most of the studies indicated that spatial ability or its components should be improved through appropriate treatments (Bayrak, 2008; Ben-Chaim et al., 1988; Çakmak, 2009; Eryaman, 2009; Karaaslan, 2012; Olkun, 2003; Turgut, 2007; Werthessen, 1999; Yıldız&Tüzün, 2011; Yolcu&Kurtuluş, 2008). Moreover, researches showed that enhancement of spatial ability could be a result of activities in which appropriate manipulative were used. In other words, using manipulative plays a crucial role in improving spatial ability. Since spatial ability has been integrated into elementary mathematics curriculum recently, research studies were recently published and they were very limited in number.

2.5 Summary of the Literature Review

In summary, in the first part of the chapter, theoretical framework was given. According to Piaget (1973) and van Hiele (1986), while introducing geometry concepts such as space, shapes, and figures to students, enhancing students' spatial thinking and ability was directly related to their cognitive development. Piaget (1973) stated that mathematics for students at concrete operational stage should be through discovery with concrete objects. Then, in the second part, definitions of manipulatives and its uses in mathematics lessons were discussed. There was no consensus on the terms used for manipulatives but, its importance in mathematics education was common among researchers. Manipulatives were mathematical tools and they should be used by students as a tool enhancing their conceptual learning and development in mathematics. Mathematical concepts are often very abstract and using manipulative enables students to explore mathematical concepts in a concrete way. Additionally, there were evidence that the use of manipulative also enhanced students' attitude and intrinsic motivation toward mathematics lesson. Moreover, communicating with manipulatives, pictorial models, and symbolic representation enabled students to enhance better understanding the process and mathematics. Also, students who use manipulative in mathematics lessons usually outperform than who do not; however, manipulative does not guarantee success. In the third part of the chapter, definition of spatial ability and its components were discussed. Among the researchers, there was no common definition of spatial ability and number of components changes between two and three. In the present study, spatial ability consisted of both spatial visualization and spatial orientation. Spatial ability is crucial for learning many topics in mathematics (Clements, 1998) and especially in geometry (Fennema&Tartre, 1985). The National Council of Teachers of Mathematics (2000) stressed the importance of spatial abilities in mathematics education and emphasized enhancing students' spatial skills throughout learning activities. With the reform in Turkey in 2003, the elementary mathematics curriculum program has changed and spatial ability was considered more important than before in the mathematic lessons (MONE, 2005; 2013). Several studies have investigated students' spatial ability and many of them also investigated the effect of using manipulatives. Literature review showed that spatial ability of an individual could be improved with the help of manipulatives and additional visual treatments. Yet, the number of the studies in Turkey was so few and the design of the previous studies was limited. In other words, there were no control groups in most. In this manner, this study was to investigate the effect of using manipulative on students' spatial ability with pretest-posttest research design.

CHAPTER III

METHOD

In this chapter research design of the study, sampling procedures, data collection methods and instrument, treatment, data analysis, assumptions and limitations and lastly internal and external validity of the study were explained in detail.

3.1 Research Design of the Study

The purpose of the present study was to investigate the effects of using manipulatives on seventh grade students' achievement in transformation geometry and orthogonal views of geometric figures.In addition, it was aimed to investigate students' views about using manipulative by means of self-reported written reflections. In this study, both quantitative and qualitative methods were used to examine research questions. For quantitative part, present study employed a static-group pretest-posttest design because two intact classrooms which were already formed at the beginning of the 2012-2013 school year were used as the experimental and control group (Fraenkel&Wallen, 2006). Therefore, randomization of the students was not possible. In this study, two already existing groups were used as the experimental group and the control group. The study was conducted in the 7^{th} grade classes of a conveniently selected public school in Ankara. The treatment in the study was use of manipulatives in the mathematics classroom and, it was considered as the independent variable. The dependent variable was students' post-test scores in Achievement Test in Spatial Ability (ATSA)which was prepared by the researcher. For qualitative part, second research question was examined by self-reported reflection papers. Table 3.1 summarizes the research design where EG represents experimental group, which received instruction with "Manipulatives" (M); CG represents the control group, which received "Regular Instruction" (RI), the measuring instrument T1 represents Achievement Test in Spatial Ability Test (ATSA), which was administered as pre-test and post-test.

Table 3.1 Research Design of the Study

Group	Pre-test	Treatment	Post-test
EG	T1	M	T1
CG	T1	RI	T1

There were four 7th grade classes in the school and the researcher was the mathematics teacher of two of them. The experimental and control groups in the study were randomly assigned among these two 7th grade classes which the researcher was teaching. In other words, researcher was the mathematics teacher of both experimental and control groups.

3.2 Sampling

Target population of this study was all seventh grade students in Ankara. Accessible population was all seventh grade students in Keçiören. This study was conducted one of the elementary schools in Keçiören district of Ankara in the Spring semester of 2012-2013 academic year. The school was conveniently selected as the researcher was working in this school at the time of the study. There were four seventh grade classes in this school and 73 seventh grade students from two classes were participants of this study. The classes were heterogonous in terms of student achievement and these two classes' mathematics achievement level was similar. In order to verify this similarity, students' 6th grade mathematics lesson scores were obtained and independent sample t-test was conducted. Table 3.2 shows independent sample t-test results of groups.

Table 3.2 Independent Sample T-Test Results of Groups’ 6th Grade Mathematics Lesson Scores

	Experimental Group		Control Group		t value
	Mean	SD	Mean	SD	
Mathematics Scores	2.38	1.40	2.50	1.36	-0.401

$p>0.05$

The results showed that there was no significant mean difference between groups in terms of mathematics achievement level in the 6th grade. Students were mostly from low socio-economic status families and their ages were between 11 and 12. The distribution of the subjects in terms of gender in the experimental and control group was given in the Table 3.3.

Table 3.3 Subjects of the Present Study

	Experimental Group	ControlGroup	Total
Girls	20	19	39
Boys	17	17	34
Total	37	36	73

3.3 Context of the Study

The school was located in Keçiören district of Ankara but it was far from the center of Keçiören and Ankara. Most of the families emigrated from the rural areas of Black Sea Region and their socio economic status was very low. There were nearly 1500 students in this school at the time of the study and 490 of them were middle school students. There were 47 teachers in this school at the time of the study and three of them were mathematics teachers. One of them was a temporary mathematics teacher with a degree in physics education who was the instructor of the fifth grade classes; the other teacher was a twenty years experienced mathematics teacher and was the instructor of the sixth and seventh grade classes. The third teacher was the researcher who was a five years experienced mathematics teacher and the instructor of the seventh and eighth grade classes.

Because the researcher was also a mathematics teacher in this school, his views and informal interviews with other colleagues about using manipulatives in mathematics lessons was stated in this section. Mathematics course books published by the Ministry of National Education (MONE) were used in the mathematics lessons and teachers followed the MONE's mathematics curriculum. Teachers were expected to use materials to make mathematics instructions more effective (MONE, 2009), however mathematics teachers other than the researcher in the school stated that there were insufficient number of materials in the school, therefore they mostly employed direct instruction in their teaching. Moreover, they stated that when they used materials for one or two times, students have played with them as if they were playing a game. Because classrooms were populated in this school (with average class sizes of 40), they could not handle this situation and using manipulative in the lessons was ineffective in the mathematics lessons. The school had unit blocks, pattern blocks, symmetry mirror, base ten blocks, and geometry boards at the time of the study. However, they were insufficient in number. Because teachers had negative experience with materials, they did not use them. It can also be said that teachers mostly used direct instruction in their lessons most of the time. In the study, this type of teaching was referred as regular instruction.

The researcher was also the mathematics teacher of these two classes, experimental and control groups, one year before the study in the sixth grade. These two classes used unit cubes, isometric and squared paper, and made isometric drawing in the topic of geometric shapes in the sixth grade. In other words, both experimental and control group members used unit cubes as manipulative in the mathematics lessons one year before the present study and they were familiar with unit cubes and isometric drawing. It can be said that they had gained adequate pre-requisite knowledge of using manipulatives in the sixth grade.

3.4 Data Collection Methods and Instruments

3.4.1 Achievement Test in Spatial Ability

The data for this study was collected through Achievement Test in Spatial Ability (ATSA) which was a paper-pencil test for evaluating spatial ability in the concept of geometric figures and transformation geometry. The test was prepared by the researcher by reviewing the related literature and considering the related objectives in the Elementary Mathematics Curriculum (MONE, 2009). The objectives in the Elementary Mathematics Curriculum related to geometric shapes and transformation geometry were given in Table 3.4. These objectives guided the experimental and control group instructional activities and the pretest and the posttest which were used in this study.

Table 3.4 Objectives in the Seventh Grade Mathematics Curriculum

Geometric Shapes
1. Draw the 3D buildings made of unit cubes onto the isometric dot paper.
2. Draw 2D views (top, front, and sides) of 3D buildings made of unit cubes.
3. Construct views of the 3D buildings with the unit cubes and draws them on the isometric dot paper when drawings of 2D views are given.
Transformation Geometry
1. Explain reflection.
2. Explain translation.
3. Draw shapes by rotating them with specified angle and around a point in the plain.

Mathematics teachers' and mathematics education researchers' opinions were obtained before the pilot study to gain construct-related validity evidence for the instrument and the instrument was revised based on these experts' opinions. ATSA was implemented before the treatment as the pre-test and after the treatment as the post-test. The test consisted of 3 multiple choice items and 10 open-ended questions. Because the students' thinking, drawing, translating, reflecting, and rotating processes were important complex abilities, open-ended question type was preferred to observe their answers and thinking processes. Pilot study of the instrument was conducted in two eighth grade classes consisting of 55 eighth grade students in the same elementary school in 40 minutes. Students' answers were coded as "1" if their answers were correct and coded as "0" if their answers were wrong. Missing values were also coded as "0". Since the difficulty of all the items was assumed equal, Kuder-Richardson 21 formula was used to calculate reliability coefficient. The reliability coefficient was calculated as .71 for the pilot study, which could be considered as high (Fraenkel&Wallen, 2006). In the main study, reliability coefficient was calculated as 0.83 for the pretest and as 0.86for the posttest, which were considered as high.One of the questions in the Achievement Test consists of four objectives therefore; maximum score that a student could get from ATSA was 16.

3.4.2 Reflection Paper

Students were asked to write a reflection paper to express their opinions and views about the activities, instruction, and manipulatives they used after the treatment was completed. In the reflection paper, students were asked to make comments about drawings they did in the activities and manipulatives they used which were unit cubes, symmetry mirror, and acetate paper. Moreover, students were asked whether using manipulatives helped them to understand the topic better. Reflection papers also asked students to write their suggestion, opinions, and difficulties they faced through activities. After the researcher read the reflection papers, the researcher conducted a class discussion session with the experimental group students and encouraged them to express their views about use of manipulatives freely. The researcher did not address a specific student; rather he told them that their views were important in order to understand the effectiveness of the manipulatives so that they will be used in the coming years. Therefore, their true views were extremely valuable to improve the implementation. Students shared their positive and negative views and this enabled the researcher to have better interpretations of participants' viewpoints and opinions

3.4.2.1 Data Analysis, Reliability and Validity Issues regarding Students' Reflections

In the qualitative part of the study, 37 students' (in experimental group) reflection papers were analyzed after the treatment was completed. Their responses for four questions were carefully read twice, emerging common issues were identified among the data, and these were considered as coding categories (Bogdan&Biklen, 2006). Students' attitudes toward using manipulatives in mathematics lesson were categorized as "enjoy", "like" and "entertaining". Data were carefully screened once more by employing these coding categories.

The lack of a second coder and an inter-coder agreement process presented a serious limitation for the study. However, the focused nature of the reflection papers and the researchers' field notes during the study in the experimental group resulted in a considerable agreement. Peer review was conducted throughout the study and through the analysis of the findings. The researcher discussed his implementation, observation, conversations with the students in order to clarify their experiences, and also data analysis process with his supervisor throughout the study for the peer-review process (Cresswelll, 2007). Moreover, because he was the mathematics teacher of the students in both control and experimental groups for the past two years, he had been in these classrooms for a long time and had a trust relationship with the students in both classes as a result of his prolonged engagement (Cresswell, 2007). Therefore, the findings from students' reflections could be considered as representing their true attitudes.

3.4.3 Treatment

The treatment in this study was activities designed and implemented by the researcher. Activities were administered to 73 seventh grade students in the Spring Semester of 2012-2013 academic year. Both experimental and control groups were taught by the researcher throughout the study. The researcher was the actual mathematics teacher of both experimental and control group classes. While experimental group interacted with manipulatives such as unit cubes, symmetry mirror and acetate paper during the activities, control group did not use any manipulatives in activities. The activities were prepared by the researcher by reviewing the related literature and considering the relatedobjectives in the Elementary Mathematics Curriculum (MONE, 2009). Mathematics teachers' and mathematics education researchers' opinions were obtained before the study and classroom activities were revised according to their opinions. Activities were performed in four lessons in each week throughout three weeks. Duration of the treatments was mentioned in the seventh grade curriculum of Elementary Mathematics Curriculum as 12 class hours. Each group received six activities throughout the treatment. These activities were designed to enhance students' spatial ability. Three of them were related to geometric shapes and the other three were related to transformation geometry. Table 3.5 presents the description of activities in experimental and control group classes. Treatment in both experimental and control group were explained in detail below.

Table 3.5 Description of the Activities in Experimental and Control Group Classes

Activity	Experimental Group	Control Group
1) Drawing 3D structures onto isometric paper	Build the structure with unit cubes then draw it onto isometric dot paper.	Draw 3D structures of unit cubes onto isometric dot paper without interacting any manipulative
2) Drawing 2D views of 3D structures onto squared paper	First built the 3D structure with unit cubes and then draw their 2D (top, front and sides) views on squared paper. Then draw 2D views of 3D structures without using the unit cubes	Draw 2D views (top, front, and sides) of 3D structures without using any manipulative

Table 3.5 Continued

Activity	Experimental Group	Control Group
3) Isometric drawing of given orthogonal views	Form the 3D structure by using the unit cubes and then draw the 3D views of the created model in the isometric dot paper	Draw the 3D structure of given 2D views onto isometric dot paper without using any manipulative
4) Drawing reflection	Use symmetry mirror to see the reflection then draw it to the isometric or squared paper	Draw reflection of images of planar shapes on the isometric or squared paper without using any manipulative
5) Drawing translation	Use acetate paper to see the translation then draw it to the isometric or squared paper	Draw translation of shapes without using acetate paper
6) Drawing rotation	Draw shapes by rotating them with specified angle and around a point in the plain by using acetate paper	Draw shapes by rotating them with specified angle and around a point in the plain without using acetate paper

3.4.3.1 Experimental Group Treatment

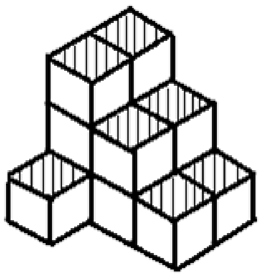
Before beginning each activity, objectives of each lesson was explained in detail to the students. Afterwards, the researcher distributed the activity sheets and manipulatives (to only experimental group) to the students which they needed to use in each activity. He wanted them to read the instructions carefully written on activity sheets and to ask any questions if they had. If there were any questions, he answered the questions and made a demonstration (to only experimental group) about how to use manipulatives before the each activity. After the demonstration, he let them start working on tasks. While they were working on the tasks, he observed students and took some notes for where in the activity and how they had difficulties.

3.4.3.1.1 First Activity

First activity was about drawing the 3D structures of small cubes onto the isometric dot paper which was a prerequisite objective from the fifth grade. *Figure 3.1* represents a task in the first activity.

Figure 3.1 Perspective Drawing

In this activity, students' ability of drawing 3D structures onto isometric dot paper was developed through a warm up activity. Before beginning the activities, the researcher explained the objectives of the lesson and what he expected from students do throughout the lesson. He asked them whether they heard about isometric dot paper and unit cubes before. In the 6^{th} grade, students made some activities about 3D drawing of structures on isometric dot paper using unit cubes. Hence, almost all of the students said that they had an idea about the isometric dot paper and unit cubes from last year. Afterwards, he distributed the activity sheets, isometric dot papers, and unit cubes to the students. He wanted them to read the instructions carefully written on activity sheets and to ask any questions if they had. Some students asked whether they had to use unit cubes while drawing 3D of structures and the researcher answered that they did not have to use them, but if they had any difficulties it was better to use them. Before beginning the activities, he made a demonstration about how to make drawing on isometric dot paper. After the demonstration, he let them to start doing tasks. While they were doing the tasks, he started to observe students. In the first part of the activities while some students were using unit cubes, some students were not using them. When he asked why they did not use them, they answered they could do activities without using unit cubes. However, some students preferred to use unit cubes in the activities. In the second part of the first activity, students tried to estimate the number of cubes in a structure. *Figure 3.2* shows a task in the second part of the first activity.



.... birim küpten oluşmuştur

*Figure 3.2*Cube Counting

In this part, students were expected to construct the structure with unit cubes and then count the total number of the cubes in the structure. According to the researcher's observations, some students tried to count unit cubes without constructing the structure with unit cubes. However, they had difficulties while counting the cubes or gave wrong answers to the questions. Therefore, they decided to use unit cubes and answered to questions by using them.

3.4.3.1.2 Second Activity

Second activity was drawing 2D views (top, front and sides) of 3D structures of small cubes which was a prerequisite objective from the sixth grade. *Figure 3.3* shows a task in the second activity.

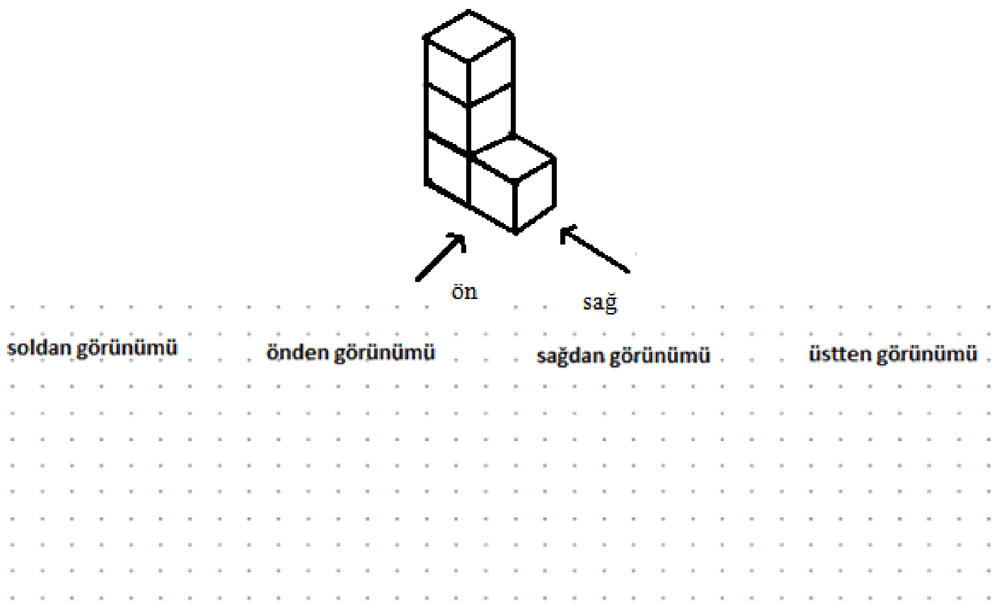


Figure 3.3 Drawing Orthogonal Views

In this activity, students were expected to build the 3D structure with unit cubes and then draw their 2D views on squared paper. In this activity, almost all of the students constructed the 3D structured with unit cubes then drew 2D views of 3D structures. In the second part of the second activity, students were expected to decide at least how many unit cubes was needed to make cube in a given structure. There were structures constructed with unit cubes and students were to add extra unit cubes to make a cube model. After doing one or two examples, some students answered without using any unit cubes. They understood the key point and gave answer only by counting the cubes.

3.4.3.1.3 Third Activity

Third activity was isometric drawing of given orthogonal views. *Figure 3.4* shows a task in the third activity.

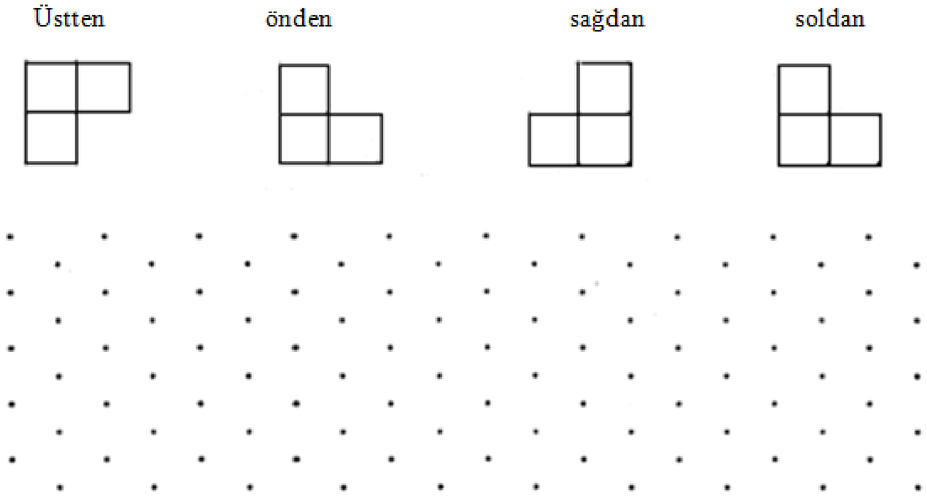


Figure 3.4 Isometric Drawing of Given Orthogonal Views

In this activity, 2D drawings of 3D structures from the top, front, and sides (left, right and front) view were distributed to students with activity sheets. Students were asked to form the 3D structure by using the unit cubes and then draw the 3D views of the created model in the isometric dot paper. In this activity, students had some difficulties with constructing the structure at the beginning, but after the first one, they were able to construct the structures. However, when the structures were getting complex, they had difficulties with isometric drawing of structures they formed. First, they had to form the structure with unit cubes correctly, and then they had to draw 3D views of created model isometric dot paper.

3.4.3.1.4 Fourth Activity

Fourth activity was drawing reflection of images of planar shapes on the isometric or squared paper. *Figure 3.5* shows a task in the fourth activity.

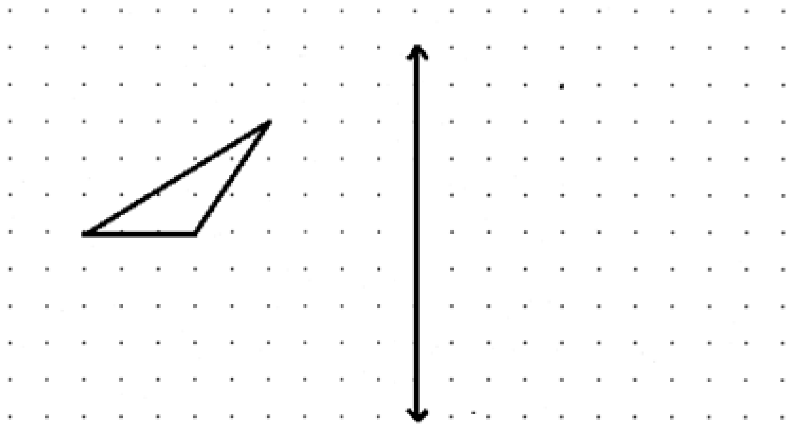


Figure 3.5 Drawing Reflection

Before beginning the activity, symmetry mirror was introduced to students and they were asked if they had any idea about how to use it. Almost all of the students had an idea about how to use it, because they had an experience from 6th grade. In this activity, images were drawn onto activity sheets before and students used symmetry mirror to see the reflection, then drew it to the isometric or squared paper.

3.4.3.1.5 Fifth Activity

Fifth activity was making translation. Students were expected to make translation onto coordinate plane through x or y axis by using acetate paper. Every students were given two acetate papers and coordinate plane was drawn on every acetate paper before by the researcher. Some students know acetate paper but they did not any idea about how to use it in activities. Simple demonstration was made by the researcher and students started to doing task. In this activity, planar shapes were drawn onto activity sheets before and students were asked to draw these shapes onto one of the acetate papers. By moving this acetate paper according to instruction in the activity sheet, students were expected to see new position of shapes in coordinate plane with the help of other acetate paper and students were expected to realize translation.

3.4.3.1.6 Sixth Activity

Sixth activity was drawing rotation. In this activity planar shapes were drawn onto activity sheets before and students were asked to draw these shapes onto acetate paper. Each student was given two acetate papers again and coordinate plane was drawn on every acetate paper before by the researcher. By translating one of the acetate papers according to directions in the activity sheet, students were expected to make rotation by specified angle and around the origin in the coordinate plane.

3.4.3.2. Control Group Treatment

In the control group, students did not use any manipulative like unit cubes, symmetry mirror, or acetate paper, but they only used isometric dot or squared paper. Before beginning each activity, the researcher explained the objectives of each lesson to students and what he expected from them to do throughout the lessons. Afterwards, he distributed the activity to the students. He wanted them to read the instructions carefully written on activity sheets and to ask any questions if they had. If there were questions, he answered the questions before each activity and let them start doing tasks. While they were doing the tasks, he observed students and took some notes for where in the activity and how they had difficulties. The instruction conducted in the control group class was described below.

In the first activity, students drew 3D structures of unit cubes onto isometric dot paper without interacting any manipulative. In the second part of the first activity, they counted the unit cubes in the structure without using any manipulative. Second activity was drawing 2D views (top, front, and sides) of 3D structures of small cubes, which was a prerequisite objective from the sixth grade. In this activity, 3D structures were given in activity sheet and students did not use any manipulative. Third activity was isometric drawing of given orthogonal views. In this activity, 2D drawings of 3D structures from the top, side (left and right), and front view were distributed to students with activity sheets. Students were not provided any unit cubes that they would use in this activity. Fourth activity was drawing reflection of images of planar shapes on the isometric or squared paper. In this activity, students did not use symmetry mirror and only drew the reflection on the isometric or squared paper. Fifth activity was making translation. Students made translation onto coordinate plane without using acetate paper. Sixth activity was drawing rotation. In this activity planar shapes were drawn onto activity sheets before and students were asked to make rotation without using acetate paper.

3.5 Data Analysis

In this study, both quantitative and qualitative research methodologies were used. In order to answer first research question quantitative data analysis, to answer the second research question qualitative data analysis methods were used.

Quantitative research methodologies were used to analyze data through SPSS 18 program. A rubric was used for evaluating students' responds. In the rubric correct and wrong answers were written and students' answers were coded as "1" if their answers were correct and coded as "0" if their answers were wrong. Missing values were also coded as "0". One of the questions in the ATSA consists of four objectives therefore; maximum score that a student could get from ATSA was 16. Both descriptive and inferential statistics were employed for the study. In descriptive statistics, mean scores and standard deviation of the pretest and posttest scores and frequency of pretest scores were calculated. In inferential statistics, T-test was used to test whether there was any significant mean difference between groups who used manipulative and who did not. To check the normality assumptions of T-test, Kolmogorov-Smirnov, skewness and kurtosis, and histograms statistics were run.

In order to answer second research question students' reflection papers were read and their responses were categorized. Most occurring responses indicating attitudes formed the coding categories and their responses were analyzed by identifying chunks of data that could be categorized through the derived codes.

3.6 Assumptions and Limitations

The main assumptions of the study were stated here. The participating students were able to understand and interpret the items truly. Moreover, all students answered the measuring instruments accurately and sincerely. The implementation of the treatments in experimental and control group was completed as intended and the administration of the tests was completed under standard conditions.

There were several limitations to the study. The participants of the study were not selected randomly. Therefore, the sample might not be fully representative of the population and the generalizability of the findings is limited. In this study, manipulatives were used during the instruction but not during the assessment. It could be the case that the findings of the study would have been different if assessment was conducted with manipulatives. The results were limited with the data provided by the students. Furthermore, the length of the treatment was three weeks. Longer treatment was not feasible for this study as the period of the content was defined by the National Curriculum and teachers had obligation to follow the curriculum. Experimental and control group classes used unit cubes, isometric and squared paper, and made isometric drawing in the topic of geometric shapes in the sixth grade. In other words, both group members used unit cubes as manipulative in the mathematics lessons one year before the present study and they were familiar with unit cubes and isometric drawing. They had gained adequate pre-requisite knowledge of using manipulatives in the sixth grade and that could affect their responses to the tests. In addition, the teacher was also the researcher of the study. This may be regarded as limitation because researcher knew the purpose of the study and might have unintentionally emphasized certain points in the experimental group throughout the instruction.

3.7 Internal and External Validity of the Study

In this section internal and external validity of the study are discussed.

3.7.1 Internal Validity

Internal validity of a study means that observed differences on the dependent variable should directly be related to the independent variable rather than another unaccounted variable (Fraenkel&Wallen, 2006). In this section, the internal validity threats for the presented study were evaluated.

History: There might be external unplanned events occurring during the course of the study which might be responsible for the responses of subjects instead of the treatment. These unplanned or unexpected events are referred as history threat (Fraenkel&Wallen, 2006). In the study, unplanned or unexpected events which might have affected students' responses or the implementation in both control and experimental groups were not observed. In lecturing hours, it was forbidden for students to leave the class which was a rule set by school administration. Therefore, any disruptive or unexpected behavior was eliminated. The researcher informed the school administrators about the study and kindly asked them to inform him beforehand if the instruction in any of the experimental and control groups would be disrupted. Since the researcher was also a teacher of the school, he also knew the events taking place at school before the implementation and he did not experience any unexpected event before the implementation.

Maturation: A maturation effect occurs when changes in the dependent variable are due to naturally occurring internal processes rather than to the intervention itself (Fraenkel&Wallen, 2006). Time between pretest and posttest was three weeks. Therefore maturation was not a threat.

Testing: In an experimental study, data are collected through a period of time. If the improvement in posttest scores compared to pretest scores is not due to the intervention, but to the use of the pretest, this is called testing threat (Fraenkel&Wallen, 2006). In order to reduce testing threat the time between pretest and posttest was set as three weeks.

Location: The location where data were collected or intervention was carried out might create unaccounted results and this is called location threat (Fraenkel&Wallen, 2006). In this study all groups were in identical classrooms, they had same opportunities, same books, same class environments, and the same teacher. Therefore, there was no location threat.

Mortality: If the subjects drop out the study at any time of the data collection process, this is called mortality or loss of subject (Fraenkel&Wallen, 2006). This was one of the most difficult threats to control. One student was absent during the pretest and one student was absent during the posttest in experimental group. Two students in control group were absent during the posttest. These four students' scores were not included in the evaluation process. The sample size was large enough to minimize the effect of subject loss.

Subject Characteristic: Selection of students for a study may cause unintended differences in groups which might be related to the variables to be studied. This situation is called subject characteristic threat or selection bias (Fraenkel&Wallen, 2006). In the study all the participants were at the same age and they were from families with similar socio-economic status. Moreover, classes were heterogonous with respect to ability level. Therefore, there was no selection bias.

Implementation: The person who implements the treatment group and/or the control group instruction might have personal bias for one in favor of the other. This might result in superior performance of students who were taught by that method and this is called implementation threat (Fraenkel&Wallen, 2006). The instructor was also the researcher of present study and taught one control and one experimental group and he tried to ensure an unbiased approach in each group by following the lesson plans. Implementation threat was reduced in this way.

Attitude of Subjects: Students in the experimental group might feel that they are receiving special treatment and therefore may have improved scores even when the treatment is not effective in reality. This is called Hawthorne effect (Fraenkel&Wallen, 2006). In this study, students in the experimental group were made to believe that the treatment was just regular part of the instruction. However, certain parts of the implementation might have been communicated to the students in the control group because of being in the same school and students in the control group might have felt undervalued and show poor performance. This situation might be a threat to internal validity. To eliminate this effect, control group was treated with manipulatives after the study.

Instrumentation: If the nature of the instrument and scoring procedure is changed in some way, then that is called instrument decay (Fraenkel&Wallen, 2006). Multiple choice items and essay type questions were used in data collection procedure. In order to control instrument decay in scoring of essay type questions, a rubric was constructed and scoring was performed by using the rubric for all students. Data collector was the researcher who implemented the instruction in both experimental and control groups. The students knew the researcher who was their teacher, therefore, they did not have much reaction to the researcher during the implementation and data collector characteristic threat was reduced.

3.7.2 External Validity

External validity of the study refers to "the extent to which the results of a study can be generalized from a sample to a population" (Fraenkel&Wallen, 2006, p. 108). External validity can be evaluated in terms of population generalizability and ecological validity.

While target population of this study was all seventh grade students in Ankara, accessible population was all seventh grade students in Keçiören. The school was conveniently selected as the researcher worked in this school at the time of the study. Selected sample size and representativeness of sample did not provide population generalizability due to non-random sampling. However, generalizations can be done for the subjects having the same characteristics with the subjects of the present study.

"Ecological validity refers to the degree to which the results of a study can be extended to other settings or conditions" (Fraenkel&Wallen, 2006, p. 106). The research was conducted in regular classroom settings in a public middle school. The school was located in Keçiören, Ankara. There were nearly 1500 students in this school at the time of the study and 490 of them were middle school students. There were 23 classrooms and 12 of them belonged to middle school students. In each classroom there were approximately 42 students. Classrooms were crowded which made it difficult to conduct effective instruction. The classes were heterogeneous in terms of student achievement and students' academic level is too low. They were mostly from low socio-economic status families. Mostly regular instruction was used in the lessons. The results of the study can be generalized to similar settings and conditions.

CHAPTER IV

RESULTS

In previous chapters, theoretical background of the study, general review of the previous studies and methodology of present study were introduced. In this chapter, descriptive and inferential statistics will be reported and results will be explained in detail.

4.1 Descriptive Statistics

There were 37 students in the experimental group and 36 students in the control group in the present study. Each student was implemented the Achievement Test on Spatial Ability Test (ATSA) which included 13 questions as the pretest before the treatment and as the posttest after the treatment. One of the questions in the Achievement Test consisted of four objectives therefore; maximum score that a student could get from ATSA was 16. Table 4.1 shows the descriptive statistics of both groups in ATSA.

Table 4.1 Descriptive Statistics of Pretest and Posttest Scores in ATSA for Both Groups

	Experimental Group		Control Group	
	Pretest (out of 16)	Posttest (out of 16)	Pretest (out of 16)	Posttest (out of 16)
N	37	37	36	36
Minimum	0	2	1	0
Maximum	14	16	14	16
Mean	6.32	9.38	6.78	9.14
Standard Deviation	3.70	4.00	3.53	4.26

As seen from the Table 4.1, control group students' mean score in pretest (Mean= 6.78, SD=3.53) was higher than experimental group students' mean score in pretest (Mean= 6.32, SD=3.70). However, experimental group students' mean score in posttest (Mean= 9.38, SD=4.00) was higher than control group students' mean score in posttest (Mean=9.14, SD= 4.26). Moreover, maximum scores of posttest were higher than maximum scores of pretest for both groups. Additionally, posttest scores were higher than pretest scores for both groups.

4.2 Inferential Statistic

In this study, there was one independent variable as treatment (use of manipulative) and one dependent variable as posttest scores. Independent Sample T-test was used and hypotheses were tested at the 0.05 level of significance.

4.2.1 Effects of Using Manipulative on Students' Achievement in Spatial Ability

The first research question was "Does the use of manipulatives influence seventh grade students' achievement in transformation geometry and orthogonal views of geometric figures as measured by the achievement test?" To investigate the research question, independent sample T-test was conducted. Before conducting the analysis, assumptions were checked and reported in the following sections.

4.2.1.1 Assumptions of T-Test

Pallant (2007) stated that before conducting the analysis, assumptions for independent sample T-test which were level of measurement, independence of observations, and normality of the dependent variable should be checked.

4.2.1.1.1 Level of Measurement

Pallant (2007) explained level of measurement as "each of these approaches assumes that the dependent variable measured at the interval or ratio level, that is, using a continuous scale rather than discrete categories" (p. 197). In this study, dependent variable was the Achievement Test scores and it was a continuous variable.

4.2.1.1.2 Independence of Observations

Pallant (2007) explained the independence of observations as “the data must be independent of one another, that is, each observation or measurement must not be influenced by any other observation or measurement” (p.197). In this study it was assumed that the measurement did not influence each other.

4.2.1.1.3 Normality

This assumption assumes the normal distribution of the population from which the samples were selected for parametric techniques. Violation of this assumption could not cause any major problem if the sample size is large enough (such as 30+) (Pallant, 2007). In this study sample size were bigger than 30 for both groups and scores were normally distributed. In order to check this assumption, Kolmogorov-Smirnov Test, skewness and kurtosis values, and histograms were examined. Table 4.2 presents the result of Kolmogorov-Smirnov Test result.

Table 4.2 Result of Kolmogorov-Smirnov Test

	Statistic	df	Sig.
Pretest	0,098	73	0,080
Posttest	0,093	73	0,194

As seen from the Table 4.2, significance value for both tests as 0. 080 and 0.194 indicate normal distribution. In addition to result of Kolmogorov-Smirnov Test above, skewness and kurtosis values were both test were gathered.

Table 4.3 Result of Skewness and Kurtosis Values of Pretest and Posttest of Achievement Test

	Std. Deviation	Skewness	Kurtosis
Pretest	3.60	.044	-.718
Posttest	4.10	-.161	-.710

Skewness and kurtosis values should be between +2.0 and -2.0 for the evidence of normal distribution (Pallant, 2007). As it can be seen from the Table 4.3, the skewness and kurtosis values were between 0.44 and -0.718 which were the evidence of normal distribution. Moreover, histograms with normal curves supported the normality assumption for pretest and posttest scores of ATSA. *Figure 4.1* shows the histogram of pretest scores of Achievement Test.

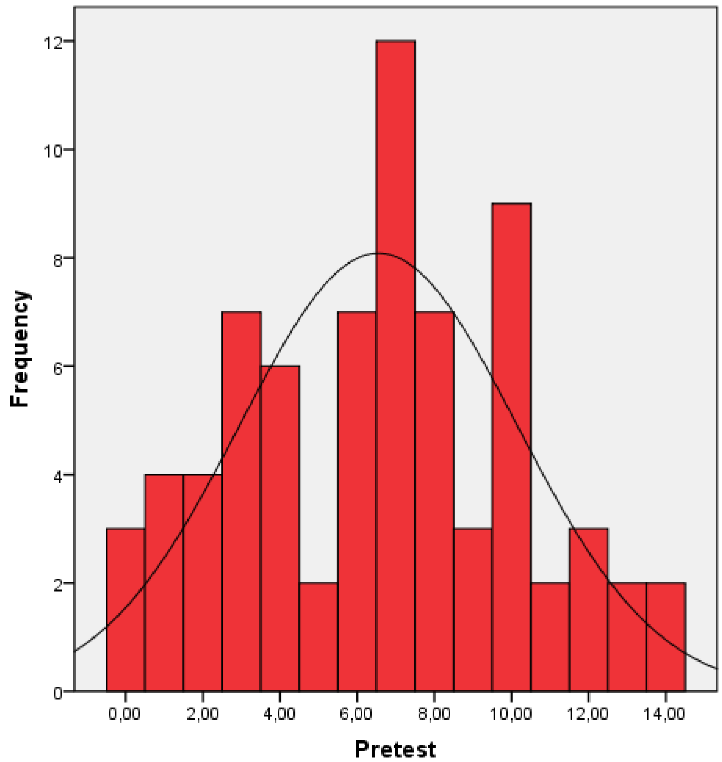


Figure 4.1 Histogram of Pretest Scores of Achievement Test

*Figure 4.2*shows the histogram of posttest scores of Achievement Test.

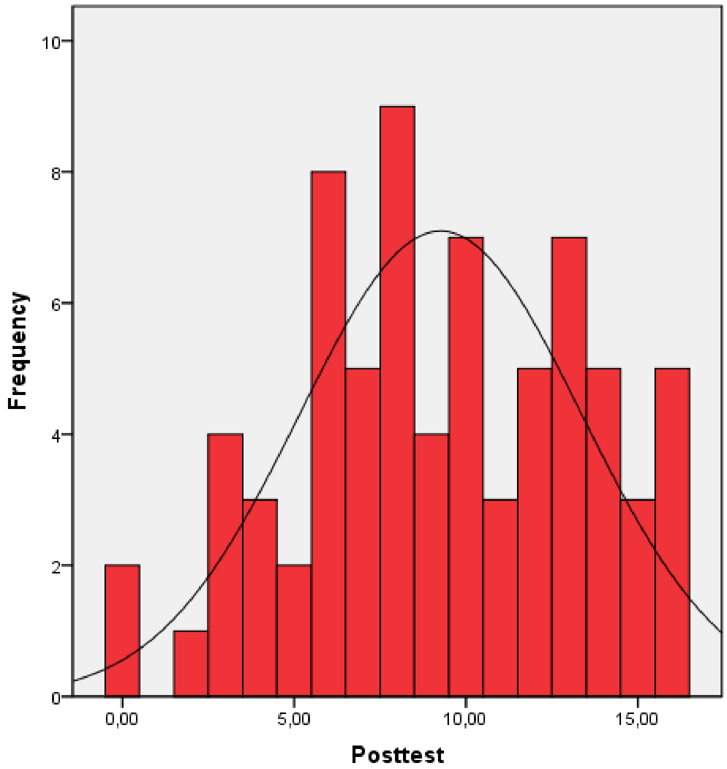


Figure 4.2 Histogram of Posttest Scores of Achievement Test

4.2.1.1.4 Homogeneity of Variances

This assumption assumed that samples were obtained from population of equal variances, that is, scores for each of the groups is similar (Pallant, 2007). In order to support this assumption, Levene's Test of Equality of Error Variances was analyzed and this test showed homogeneity of variances assumption was not violated ($p= .769$).

4.2.1.2 T-Test Results

The first research question was "Does the use of manipulatives influence seventh grade students' achievement in transformation geometry and orthogonal views of geometric figures as measured by achievement test?" For the first research question the following hypothesis was tested:

Null Hypothesis 1: There is no significant mean difference between posttest scores of groups in spatial achievement test who use manipulative and those who do not use manipulative.

In order to test the hypothesis, independent sample t-test was performed.

4.2.1.2.1 The Results of Pretest Scores of ATSA

To investigate whether there was a significant mean difference between the experimental group and control group before the treatments in terms of pretest scores in Achievement Test in Spatial Ability (ATSA), independent sample t-test was conducted. The results were presented in Table 4.4.

Table 4.4 Result of T-Test of Pretest Scores

	Experimental Group		Control Group		t value
	Mean	SD	Mean	SD	
ATSA	6.32	3.70	6.78	3.53	-0.535

$p>0.05$

As seen from the Table 4.4, there was no statistically significant mean difference between groups who received instruction with manipulatives and who received regular instruction in terms of pretest scores. Therefore, pretest scores were not taken as covariate. In order to test the hypotheses whether there was significant mean difference in achievement test scores between students who used manipulative and those who did not use manipulative, independent t-test was used.

4.2.1.2.2 The Results of Posttest Scores of ATSA

After the treatment, AchievementTest (ATSA) was administered to the subjects as posttest and independent sample T-test results of posttest scores were given in the Table 4.5 with respect to treatment.

Table 4.5 Result of T-Test of Posttest Scores in Terms of Treatment

	Experimental Group		Control Group		t value
	Mean	SD	Mean	SD	
ATSA	9.38	4.00	9.14	4.26	0.248

$p>0.05$

As seen from the Table 4.5 there was no statistically significant mean difference between the groups who received instruction with manipulative and who received regular instruction in terms of posttest scores.

4.2.2 Students' Opinions about Manipulatives Used in Activities

The second research question was "What are the students' self-reported written reflections related to using manipulatives in mathematics lessons?" To investigate the research question, experimental group students' self-reports were obtained with reflection papersafter the study was completed. They were asked to write their opinions for whether using unit cubes in geometric shapes activities (counting cubes, drawing 3D buildings made of unit cubes onto the isometric dot paper, drawing 2D views (top, front and sides) of 3D buildings made of unit cubes and constructing views of the 3D buildings with the unit cubes and draws them on the isometric dot paper when drawings of 2D views are given) helped them to understand the topic easily, whether using symmetry mirror helped them to comprehend reflection, and whether using acetate paper helped them to understand translation and rotation in transformation geometry. In this section, results of questions mentioned above will be given.

4.2.2.1 Students' Opinions about Using Unit Cubes in Activities

Results of students' reflections showed that almost all of the students thought that using unit cubes in activities helped them to understand the topic easily. Twenty-nine out of 32 students expressed that interacting with unit cubes helped them completing the tasks in the activities easily. They benefited the unit cubes in validating their responses, enhancing their learning, visualizing shapes, and drawing as reflected in the following quotes:

> "Unit cubes helped me to crosscheck my solutions and helped me to draw easily."
>
> "Constructing 3D geometric shapes with unit cubes made me to see the construction easily and I drew their all 2D views on the isometric dot paper easily."
>
> "I could make drawing without using unit cubes before but [unit cubes] reinforced my learning."
>
> "In easy activities I did not used them but when the activities were difficult I needed to use."
>
> "I could not understand the topic before but after using unit cubes I realized I could do. I recommend everybody to use it."

Some of the students who expressed positive experiences also commented on more affective components such as enjoyment:

> "Using these materials increased my love and motivation for this course; it was enjoyable."
>
> "Especially I enjoyed the sound of cubes a lot while dealing with them."
>
> "The activities in which we used unit cubes are more enjoyable and more informative than normal instruction."

Three students stated that using unit cubes did not contribute much to completing the tasks much. They even expressed that the activities including unit cubes were boring:

> "It did not help me because I could do the activities without using them. Also I can clearly say that I did not like this topic."

> "It is boring with unit cubes. Doing the task directly onto the paper is easier."

Students' written reflections revealed that they mostly benefited unit cubes in the activities in terms of the cognitive support they provided. They also enjoyed working with unit cubes in the mathematics class. However, for some students, their effect in completing the tasks was not much significant.

4.2.2.2 Students' Opinions about Using Symmetry Mirror in Activities

According to students' explanations using symmetry mirror had positive effect on their understanding the reflection topic. Twenty-nine out of 32 students stated that using symmetry mirror helped them to understand the topic. Symmetry mirror provided students with a visual aid in drawing the reflection, a confirmation tool for their responses or ideas, and a better understanding of the reflection concept:

> "Using symmetry mirror helped us in this topic. I know how and where to use it."

> "It was the first time I used the symmetry mirror. From now on I trust myself in the reflection concept. It helped me to understand topic easily and it was easy to keep in mind."

> "Before I used it, I could make mistake while making reflection. After using it, I understood how it worked and I did not need to use it anymore. It helped me a lot."

> "With the help of symmetry mirror I learnt to make reflection according to axis in the coordinate plane."

"While using the symmetry mirror, there is no possibility to have an incorrect solution because I can control my answer."

"Without making any drawing I can see the reflection of the image on the other side."

It was also entertaining to work with symmetry mirror for some students. They mentioned that they enjoyed working with the mirror:

"I know the symmetry mirror before but by using it again I learnt the topic better. It was entertaining."

"Reflection is easy but I think that symmetry mirror is useful and enjoyable."

However, one student addressed a difficulty in using symmetry mirror:

"Symmetry mirror is a nice tool for students who use their right hand. Because I use my left hand for writing, it was difficult to use it."

In general, most of the students stated that they have never seen the symmetry mirror before and they stated that it was useful and enjoyable.

4.2.2.3 Students' Opinions about Using Acetate Paper in Translation Activities

In the reflection papers, students stated that using acetate paper was a different experience for them. Nearly all of the students worked with it in the mathematics class for the first time in their life. Before using it, they did not know what they would do with it. However, after the activities, 28 out of 32 students indicated that using acetate paper helped them to understand the translation topic. While most of the students stated that they had never seen acetate paper before, some students mentioned that they have seen it before but using it in mathematics activities surprised them. Throughout the activities acetate papers provide students deeper understanding of translation topic:

> "I did not anticipate the acetate like this. First time I saw it in this lesson. I knew the translation before but it helped me to reinforce my learning."

> "When I heard "acetate paper," I expected a normal paper but it was transparent. I could see any movement under the paper while making translation. It was funny."

> "I have seen acetate paper before but using it in mathematics surprised me. Without using acetate paper I could make translation but using it helped me to cover the topic easily."

> "It helped me because this topic was difficult to me for years. It helped me to understand some."

> "By using acetate I could see every movement in the coordinate plane. It was useful."

> "It helped me to see the translation of shapes unit by unit in the paper."

Some students mentioned the difficulties of using acetate but after learning how it works they realized its usefulness:

> "Although it was challenging for me to draw shapes onto acetate it is a nice tool and helped me to understand the topic."

> "I was confused at the beginning because it was difficult to draw shapes onto acetate but after learning how it works it helped me to understand the topic. It was enjoyable."

Furthermore other students explained that using acetate made translation easy:

"Every student thinks that translation is an easy topic but it is not. Most of the students make translation wrong. Using acetate paper makes it easy."

"Using acetate was useful. It was first time for me to understand this topic easily. However, I don't have any idea whether I can make translation well without using acetate."

"I learnt how to use acetate and I can make translation faster."

However, 4 out of 32 students did not have the ideas their friends had. They stated that they had difficulties when they tried to understand and use the acetate paper.

"It was difficult for me to understand."

"Making translation was an easy topic. There was no need to use it because it was more confusing."

In general, most of the students benefited from using acetate paper and they stated their opinions with words such as "enjoyable" and "useful."

4.2.2.4 Students' Opinions about Using Acetate Paper in Rotation Activities

According to students' explanations, 27 out of 32 students thought that using acetate paper in rotation activities helped them to understand the topic. By the help of the acetate paper, students realized the rotation in coordinate plane by seeing it step by step and it enhanced their learning, visualization and perception. Their opinions about the topic and using acetate in this topic stated above:

"Rotation was not an easy topic for me but acetate paper made it easy."

"I made every rotation with acetate paper and I learnt it."

"At the beginning I did not understand how to use it. After learning it was enjoyable and thoughtful."

"Before the acetate, I turned the paper to see the rotation then drew it to the correct place in the coordinate plane. By the help of the acetate I could make the rotation at once and saw it in the correct place together. It was the combination of what we did before."

"Once flipped over the acetate I could see the rotation. It worked well."

"Sometimes there was difference between my solution and what acetate showed. Of course acetate was true. It made me to see my false."

"First I rotated without using acetate and I made wrong. After using acetate I made true."

Furthermore they stated that:

"I could make rotation without using it but it helped us."

"I made some rotations without using it but I did not make some rotations without using it."

"Acetate or anything else, it was instructive with doing manipulatives."

Moreover, some students thought that it was difficult but useful and enjoyable:

"At the beginning it was difficult but after learning it was easy."

"It was difficult but enjoyable".

"It was helpful but challenging".

However, five students did not think this way. It was difficult for these students to understand rotation:

"I did not like drawing on acetate. It was waste of time but thanks for you."

When we looked at the students' explanations about using acetate paper in the concept of translation and rotation, most of them stated that it was useful, enjoyable, and thoughtful. While some students had never seen acetate paper before, some students had seen it before but using it in mathematics activities surprised them.

4.3 Summary of the Findings

The aim of the study was to investigate the effect of using manipulatives on seventh grade students' achievement in orthogonal views of geometric figures and transformation geometry. The results showed that there was no statistically significant mean difference between the groups who received instruction with manipulatives and who received regular instruction in terms of pretest scores. Although the difference was not significant between groups, control group (M = 6.78) had higher mean score than experimental group (M = 6.32). In other words, control group had advantage over control group at the beginning of the study. After the treatment, t-test result showed that there was no statistically significant mean difference between groups in terms of posttest scores. Although the mean difference between groups was not significant, experimental group (M = 9.38) had higher mean score than control group (M = 9.14). While at the beginning of the study control group had advantage over experimental group, at the end of the study there was no significant difference in terms of the mean ATSA scores for the two groups. Furthermore, both experimental and control groups had positive improvements in their ATSA scores.

The other findings of the study revealed that almost most of the students in experimental group indicated their positive opinions about using manipulative in mathematics lessons. They thought that using manipulative in activities helped them doing the tasks easily and using manipulative enhanced their learning. Additionally, students stated that manipulatives should be used in other topics of mathematics as well.

CHAPTER V

DISCUSSION AND CONCLUSIONS

In this chapter discussion of results and recommendations for further studies were stated. In the first part, results of the findings were discussed and in the second part, implications and recommendations for further studies were discussed.

The main purpose of the present study was to investigate the effects of using manipulatives on seven grade students' achievement in orthogonal views of geometric figures and transformation geometry. In order to investigate the effectiveness of treatment,static-group pretest-posttest research design was used. Seventy three seventh grade students participated in this study. While 37 of them were in experimental group, 36 of them were in control group. Both experimental and control group were taught by the researcher throughout the study. Experimental group interacted with manipulatives such as unit cubes, symmetry mirror and acetate paper. Control group, on the other hand, did not use any manipulatives in activities. The data for this study were collected through Achievement Test in Spatial Ability (ATSA) which was a paper-pencil test for evaluating spatial ability in the concepts of geometric figures and transformation geometry. The test was prepared by the researcher by reviewing the related literature and considering the related objectives in the elementary mathematics curriculum (MONE, 2009). Students' views about using manipulatives in the experimental group were also gathered through written reflections.

5.1 Effects of Using Manipulatives on Spatial Ability

The comparison of experimental and control group students' mean scores in ATSA showed that there was no statistically significant mean difference between groups in terms of posttest scores. Therefore, it can be concluded that using manipulatives in the concept of geometric figures and transformation geometry did not result in better outcomes compared to regular instruction. This finding was consistent with those of similar studies by Boakes (2009), Boyraz (2008), Drickey (2000), Eraso (2007), and Pleet (1990). In these studies, students' grade level changed between 5 and 10 and the studies had quasi experimental pretest-posttest research design with control group. Eraso (2007) indicated that optimal age should be between 7 and 12 for students to develop their spatial ability. According to Piaget (1973), concrete operational stage, which begins at age 7 and continues up to 12, is critical for using manipulative. Therefore, manipulative usage might not result in considerably better outcomes when employed in rather later ages. Students participated in this study were 11 to 12 ages. It might be concluded that these ages could be rather late to support the development of students' spatial ability. The mentioned studies also had limited duration for the treatment changing from two weeks to six weeks. The limited exposure to manipulatives could be the reason of for the non-significant results of these studies and the present study. Drickey (2000) stated that duration of treatment from 4 to 5 weeks might be the reason of finding non-significant result in his study. Sowell (1989) indicated that students' spatial ability could be significantly improved when there was longer treatment with manipulatives. In other words, duration of treatment could be an important factor for enhancing students' spatial ability. Indeed, studies conducted by Bayrak (2008) and Çakmak (2009) resulted with significant results favoring students who used manipulatives when the duration of the treatment was ten weeks or more.

Although the mean difference between groups was not significant, the experimental group (M=9.38) had higher mean score than the control group (M=9.14) in posttest of ATSA. Furthermore, both experimental and control groups had positive improvements in their ATSA scores. The mean score of experimental group had an increase of 3.06 from pretest to posttest. Similarly the mean score of control group had an increase of 2.36 from pretest to posttest. Increased result on Achievement Test (ATSA) for both groups may be explained by students' existing adequate pre-requisite knowledge from the sixth grade. Both group members used manipulatives in the mathematics lessons one year before the present study and they were familiar with manipulatives. Therefore, it can be concluded that the effect of manipulative on experimental group students' mean scores might have been more if they were not instructed by the manipulative in the previous grades. There was no significant difference in the pretest scores of experimental and control group in the beginning of the study, which might also be explained by the similarity of the instruction they received in the sixth grade. Additionally, the reason why there was no group difference might be that both groups had the same teacher (the researcher) throughout the study. For this reason, both groups might have benefitted from the instruction the researcher provided in similar ways.

5.2 Students' Views about Instruction with Manipulatives

Although there was no significant mean difference between groups, students who were in the experimental group had positive attitude toward mathematic lesson and manipulatives as expressed in their written reflections for using manipulative in the mathematics class, similar to previous results (Sowell, 1989). Almost all of the students enjoyed learning with manipulatives throughout the activities. They stated that using manipulatives in the activities increased their like and motivation for the mathematics course. It helped them to understand the topics easier and they claimed that they learnt the correct way of completing the tasks with the help of manipulatives. Manipulatives in mathematics lessons reinforced their learning and it was more enjoyable and educative than regular instruction for students.

Students actively participated in the activities and they were in the center of the process during the implementation in the experimental group. They learnt the topic in different ways and with different manipulatives throughout the treatment. In another words, experimental group learnt the topic in an alternative way to the regular instruction which was used in control group. Bruner (1961) stated that when students learned topics through discovering, they gained enthusiasm, critical thinking skills, encouragements, and confidence. These characteristics were observed in the experimental group students' reflections at the end of the treatment. Therefore, it can be concluded that using manipulative influenced students' emotions and attitudes in the mathematics class. However, this finding is limited because control group students' emotions and attitudes were not gathered and there was no statistically significant measure of students' emotions and attitudes.

5.3 Observation of Using Manipulatives

Observation notes and students' written reflection findings showed that some students had difficulties with acetate paper in translation and rotation activities throughout the study. Students indicated that they had never seen acetate paper before and using it in mathematics lesson surprised them, and this was the reason why they encountered with this difficulty. They tried to handle this difficulty by themselves, with the help of their friends, and by asking the researcher during the lessons. However, using a new manipulative which was new to students for a short period of time did not result in better learning outcomes. There is a need to use manipulative consistently for a considerable period of time so that students can understand the mathematical principles (Fennema, 1969). They were familiar with unit cubes and isometric drawing from the sixth grade one year before the study. The researcher, who was the teacher of students, used unit cubes and isometric drawing in geometric shapes topic. Therefore, they did not encounter any difficulties with this manipulative. Most of the time, some students did not use unit cubes in the activities. They used them for validating their responses after completing their tasks. Using symmetry mirror in the activities was enjoyable part of the activities and nearly all of the students used this manipulative throughout the study.

5.4 Recommendations for Further Studies

The present study was carried out with seventh grade students. For further implications, future studies can be conducted with different grade levels. Moreover, in this study there were one treatment and one control group. In future studies, the number of both treatment and control groups can be increased. For further implication, treatment groups can use digital manipulatives beside concrete manipulatives. While manipulatives were used in the activities throughout the study, students were not allowed to use them in pretest and posttest. It is recommended that manipulative should be used during all part of the assessment process. Additionally, large sample size for further studies is recommended to increase the generalizability of the study. Therefore, the study may be repeated with several classrooms in several schools. The amount of time allocated for present study was 3 weeks which could be the reason for lack of statistically significant improvement in students' spatial ability.

The longer treatment time beyond 3 weeks is recommended for further studies. Unit cubes, symmetry mirror, and acetate paper were used to enhance students' spatial ability in the present study. For further studies, different manipulatives can be used for the topic. Moreover, throughout the study students in both groups individually participated in the activities. It is recommended that cooperative groups can be formed and students can work together. Rottier and Ogan (1991) suggested that cooperative learning made students move from concrete to abstract thinking and made difficult tasks easier (cited in Bayram, 2004). In future studies, students' attitudes toward geometry can be investigated and both surveys and one to one interviews can be conducted with students.

5.5 Recommendations for Practice

In this section, recommendation for teachers, curriculum developers, and Ministry of National Education are stated for developing students' spatial ability.

First, activities used in present study can be an example for the teachers to create their own activities. Mathematics teachers can use the activities and ATSA in their lessons as a resource or they can adopt these resources into their own class environment. Manipulatives are the concrete objects that aid students in making connections between mathematical ideas. Therefore, mathematics teachers should not hesitate to use them in the classroom. The use of manipulatives also enhances students' attitude and intrinsic motivation toward mathematics lesson. They gain positive attitude toward mathematics while understanding the concept and topics. Moreover, teachers can use different manipulatives, computer programs, and hands-on materials to enhance their students' spatial ability. Development of spatial ability can be achieved over a long period of time. Thus, teachers should be determined and select appropriate activities and manipulatives for students' cognitive level.

Curriculum developers should rearrange the textbooks according to new changes in curriculum and appropriate spatial ability activities should be integrated into textbooks. Importance of spatial ability in students' academic and work life also should be mentioned in the textbooks.

Ministry of National Education can distribute manipulatives like unit cubes or symmetry mirror to the students. Hereby, students can access them whenever they want. Development of spatial ability should be supported by manipulation of the environment and by direct experience with manipulatives. Therefore, students' immediate access to the manipulatives is important. Teachers can also help students build their manipulatives before the related units, preferably in the beginning of the school year, to be used in and out of the mathematics classes.

5.6 Implications for my Future Practice

Throughout my teaching profession, I tried to take students in the center of the learning process. It is important for me to gain their interest and appeal their senses. I used manipulatives several times in my classes before conducting my research study. Because most of the teachers have negative experience with manipulatives, they do not use them in their lessons rather, they employ regular instruction. However, once students interact with manipulatives, they do not play with them as if they play a "game". Many students realize their abilities while interacting with them. Manipulatives are not only important for spatial ability but important for other topics of mathematics. With the help of this study, my students realized their potential in spatial ability. Afterwards, I will give more chance my students to develop their abilities and skills via introducing different methods and materials.

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APENDICES

APPENDIX A

Spatial Ability Test

Uzamsal Yetenek Testi

Sevgili öğrenciler:

Bu testin amacı sizlerin uzamsal yeteneklerinizi ölçmektir. Testin sonuçları sadece bilimsel bilgi edinmek amacıyla kullanılacaktır. Herhangi bir şekilde not ile değerlendirme amacıyla kullanılmayacaktır.

Bu amaçla:

1. Aşağıda size ait bilgileri eksiksiz olarak doldurunuz.

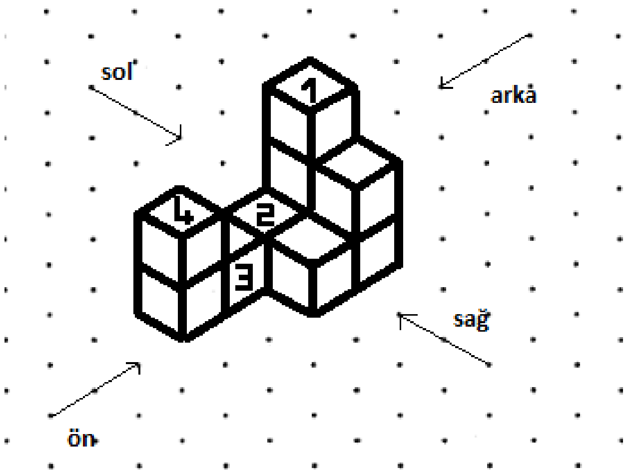
2. Testi tamamlamak için 40 dakika süreniz vardır.

Teşekkürler.

Kerim ENKİ

ADI SOYADI :

1



Yanda verilen cisimde numaralandırılmış eş küplerden hangisi çıkarılırsa cismin soldan görünümü **değişmez**?

Cevap:

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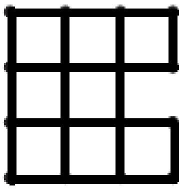
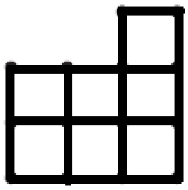
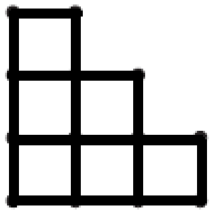
2)



üstten



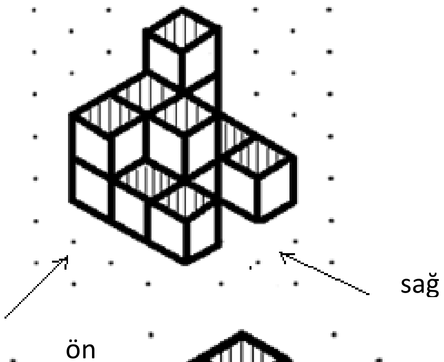
sağdan



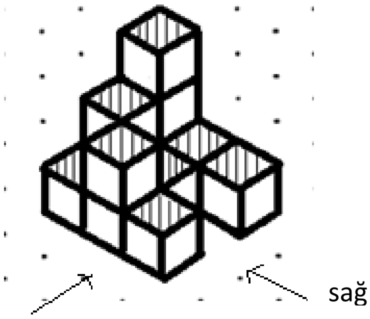
önden

Yukarıdaki şekilde üç farklı yönden görünümü verilen cisim aşağıdakilerden hangisi **olamaz**?

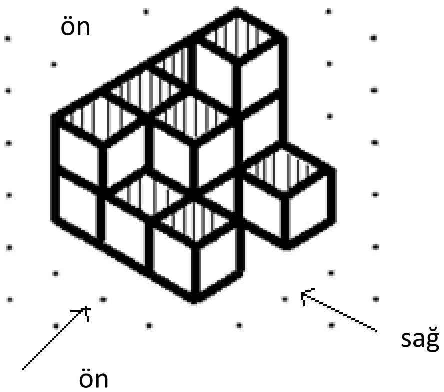
A)



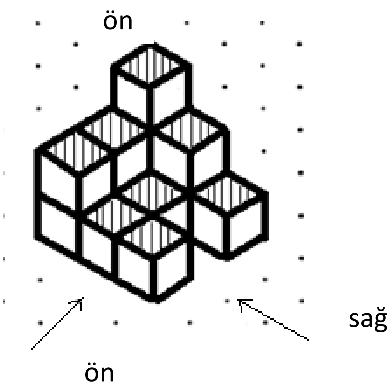
B)



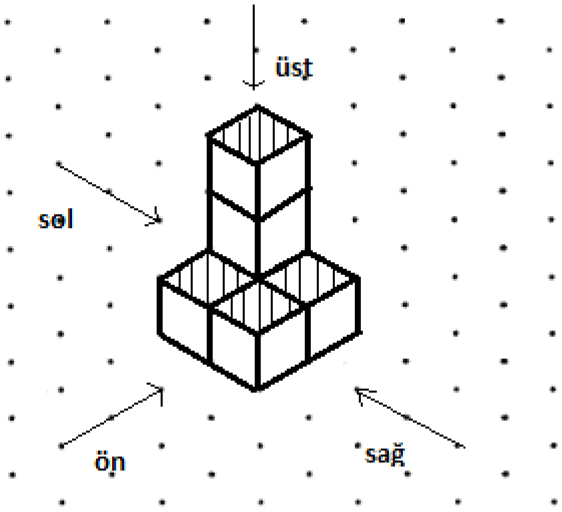
C)



D)



3)



Yanda eş küplerle oluşturulmuş yapının soldan, önden, sağdan ve üstten görünümlerini aşağıda belirtilen alana çiziniz.

soldan görünümü önden görünümü sağdan görünümü üstten görünümü

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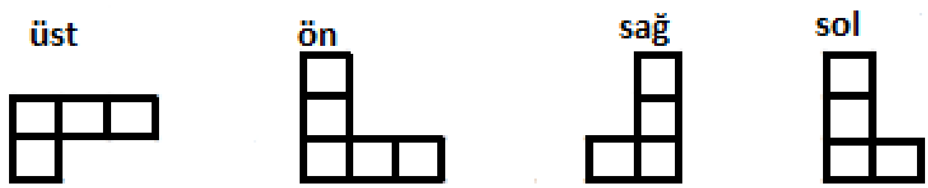
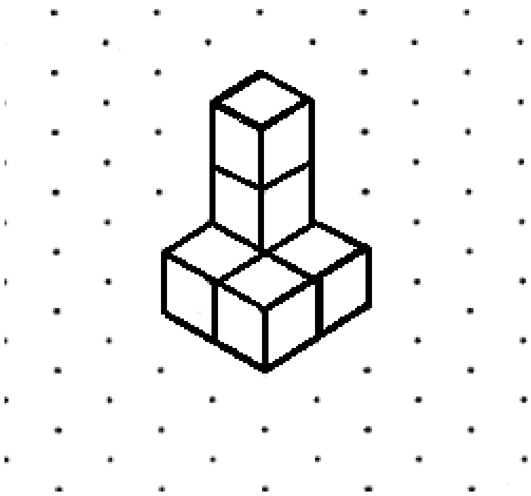
4)



Yukarıda eş küplerle oluşturulmuş bir yapının üstten, önden, sağdan ve soldan görünümleri verilmiştir. Buna göre verilen bu yapıyı aşağıya çiziniz.

5)

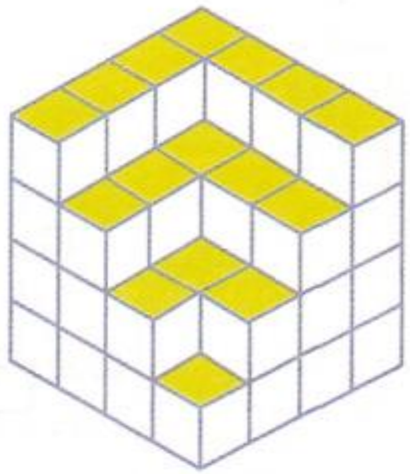


Yanda verilen cisme **<u>en az</u>** kaç eş küp daha eklenirse bir küp elde edilir?

Cevap:

---

6)



Yanda verilen şekil kaç tane eş küpten oluşmuştur?

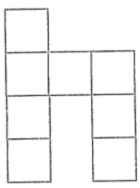
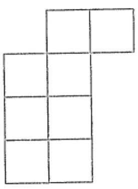
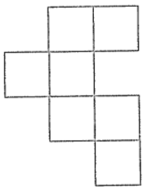
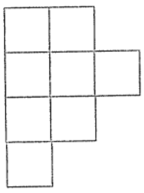
Cevap:

---

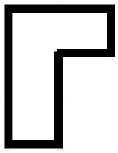
7)

4	3	1

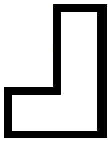
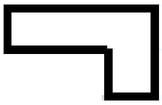
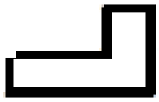
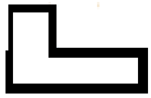
Yandaki şekilde bir cismin üstten görünümü ve kaç birim küpten oluştuğu verilmiştir. Buna göre bu yapının önden görünümü aşağıdakilerden hangisi olabilir?

A)  B)  C)  D) 

8)



Aşağıdakilerden hangisi yandaki şeklin döndürülmesi ile elde **edilemez**?

A)  **B)**  **C)**  **D)** 

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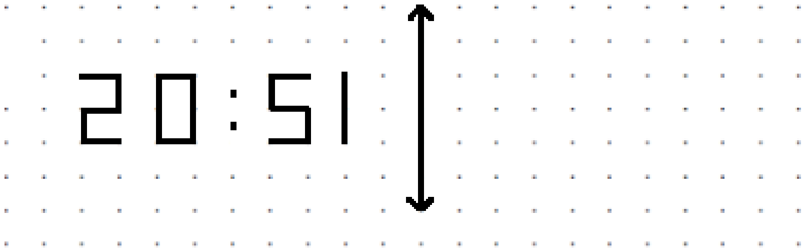
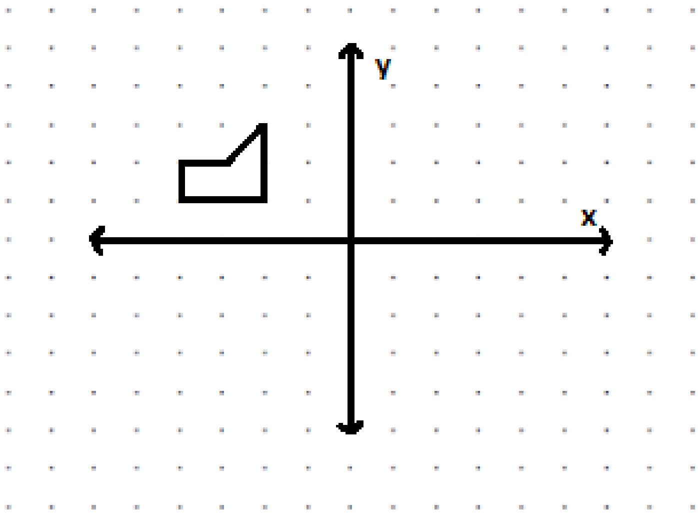
9)



Yukarıda gösterilen dijital saat göstergesinin verilen doğruya göre yansımasını çiziniz.

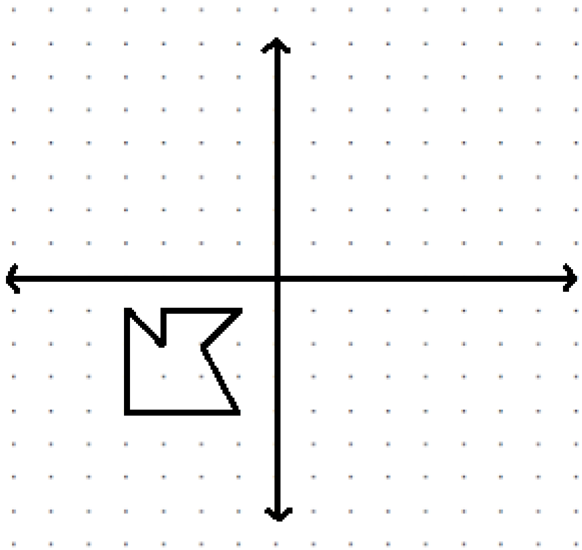
---

10)



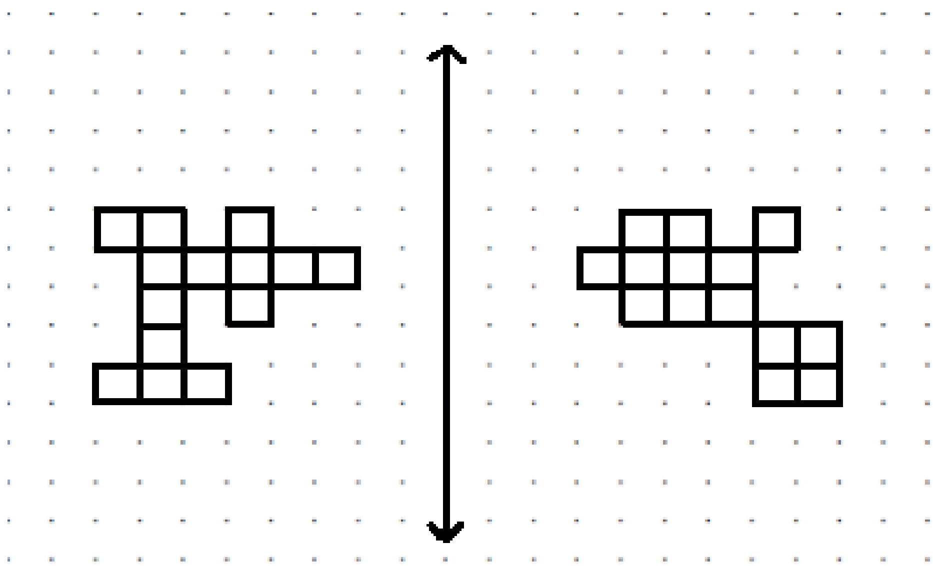
Yanda verilen şeklin orijin etrafında saat yönünde 90^0 döndürülmesi ile oluşan şekli aynı koordinat düzleminde çiziniz.

11)



Yanda verilen şeklin 3 birim yukarı, 5 birim sağa ötelenmesi ile oluşan şekli çiziniz.

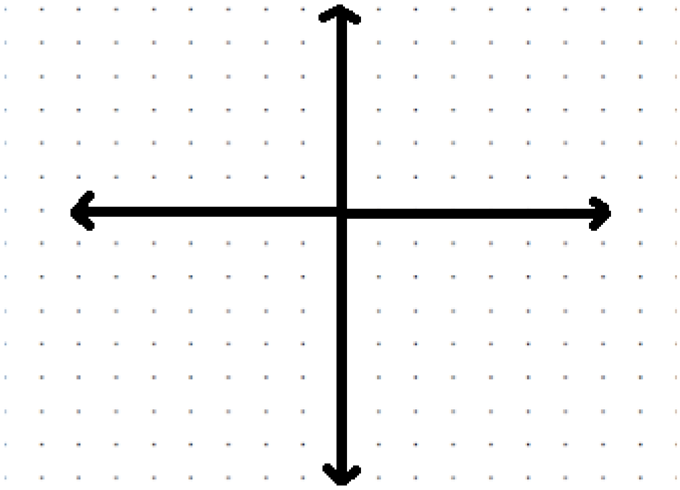
12)



Yukarıda eş karelerle oluşturulmuş şekillerin verilen doğruya göre simetrik olabilmesi için <u>en az</u> kaç kare eklenmelidir?

Cevap:

13)



Köşe koordinatları A(2, -1), B(3, 1) ve C(6, -2) olan üçgen orijin etrafında saat yönünün **tersine** 90^0 dödürüldüğünde oluşan şekli çiziniz.

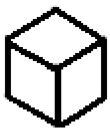
APPENDIX B

Activities of Experimental Group

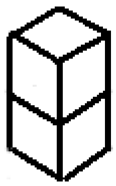
AKTİVİTE 1

1) Aşağıda eş küplerle oluşturulmuş yapıların çizimlerini görmektesiniz. Bu yapıları size verilen birim küp modellerini kullanarak oluşturduktan sonra izometrik kağıda çizimlerini yapınız.

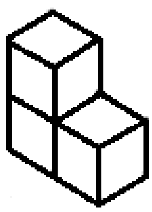
a)



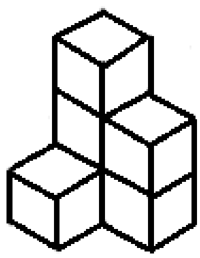
b)



c)

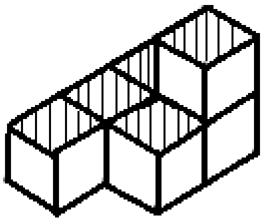


d)



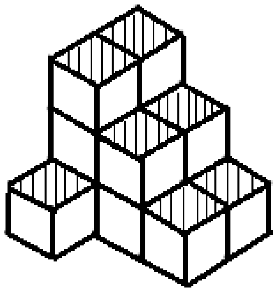
2) Aşağıda eş küplerle oluşturulmuş yapıları, size verilen birim küp modellerini kullanarak oluşturduktan sonra yapının kaç birim küpten oluştuğunu bulunuz.

a)



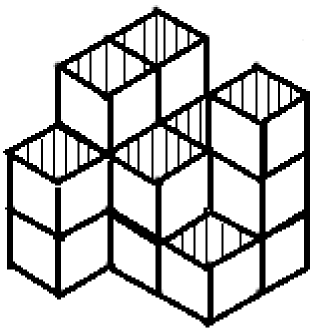
.... birim küpten oluşmuştur

b)



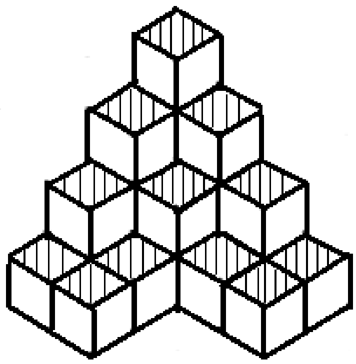
.... birim küpten oluşmuştur

c)



.... birim küpten oluşmuştur

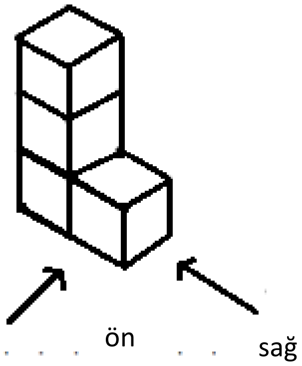
d)



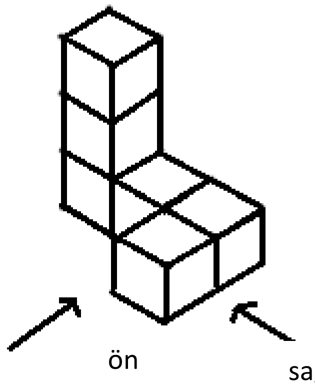
.... birim küpten oluşmuştur

AKTİVİTE 2

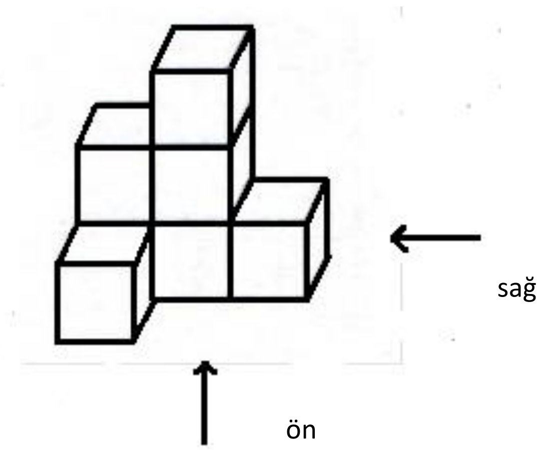
1) Aşağıda birim küplerle oluşturulmuş yapıları sizlere verilen eş küp modellerini kullanarak oluşturduktan sonra yapıların önden, sağdan, soldan ve üstten görünümlerini belirtilen alanlara çiziniz.



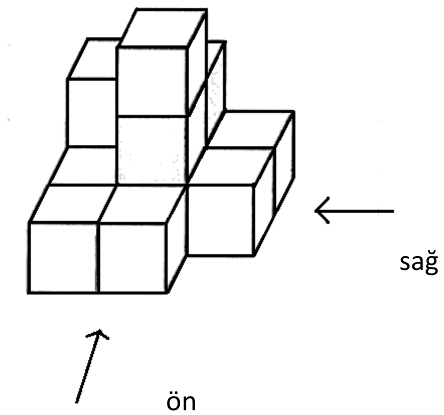
soldan görünümü **önden görünümü** **sağdan görünümü** **üstten görünümü**



soldan görünümü **önden görünümü** **sağdan görünümü** **üstten görünümü**

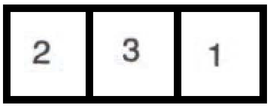


soldan görünümü önden görünümü sağdan görünümü üstten görünümü

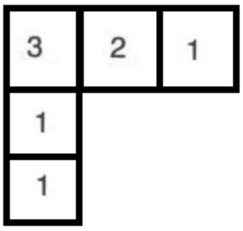


soldan görünümü önden görünümü sağdan görünümü üstten görünümü

AKTİVİTE 3

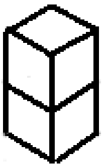


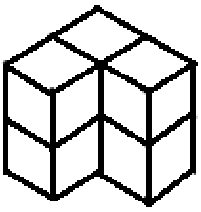
Yandaki şekilde bir cismin üstten görünümü ve cismi oluşturmak için kullanılan eş küp sayıları verilmiştir. Bu yapıyı size verilen eş küp modelleriyle oluşturduktan sonra bu cismin <u>önden</u> görünümünü çiziniz.

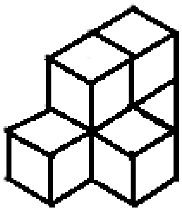


Yandaki şekilde bir cismin üstten görünümü ve cismi oluşturmak için kullanılan eş küp sayıları verilmiştir. Bu yapıyı size verilen eş küp modelleriyle oluşturduktan sonra bu cismin <u>sağdan</u> görünümünü çiziniz.

Aşağıda eş küplerle oluştulmuş yapıları sizlere verilen eş küp modellerini kullanarak oluşturduktan sonra bu yapılara <u>en az</u> kaç eş küp daha eklendiğinde bir küp elde edileceğini bulunuz.



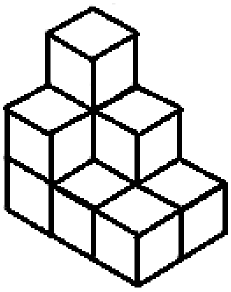


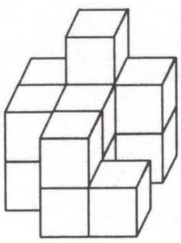


Cevap:

Cevap:

Cevap:





Cevap:

Cevap:

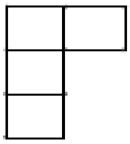
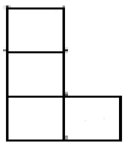
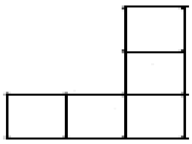
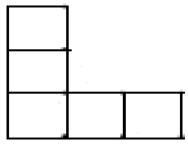
AKTİVİTE 5

Aşağıda eş küplerle oluşturulmuş yapıların üstten, önden, sağdan ve soldan görünümleri verilmiştir. Sizlere verilen eş küp modellerini kullanarak bu yapıları oluşturduktan sonra bu yapıları altlarında verilen izometrik kağıda çiziniz.

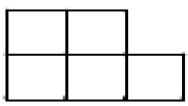
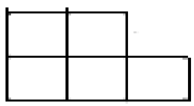
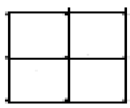
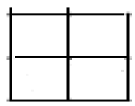
Üstten önden sağdan soldan

Üstten önden sağdan soldan

Üstten önden sağdan soldan

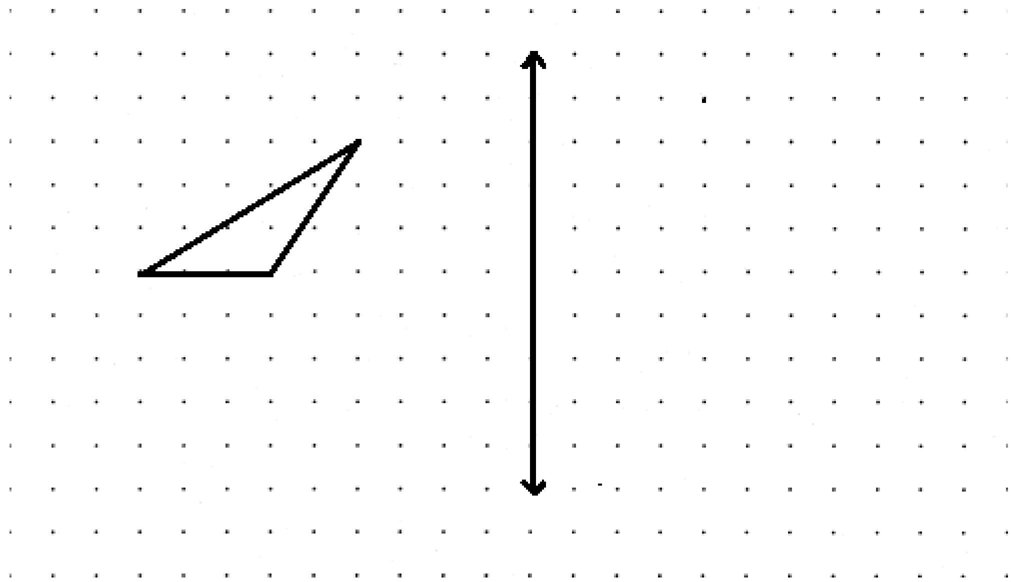
   

Üstten önden sağdan soldan

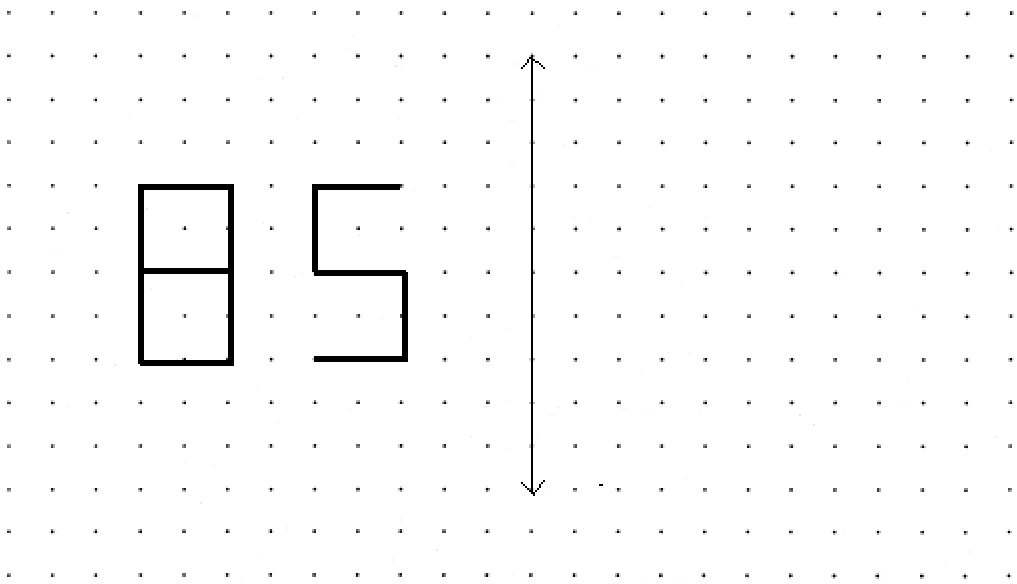
   

AKTİVİTE 5

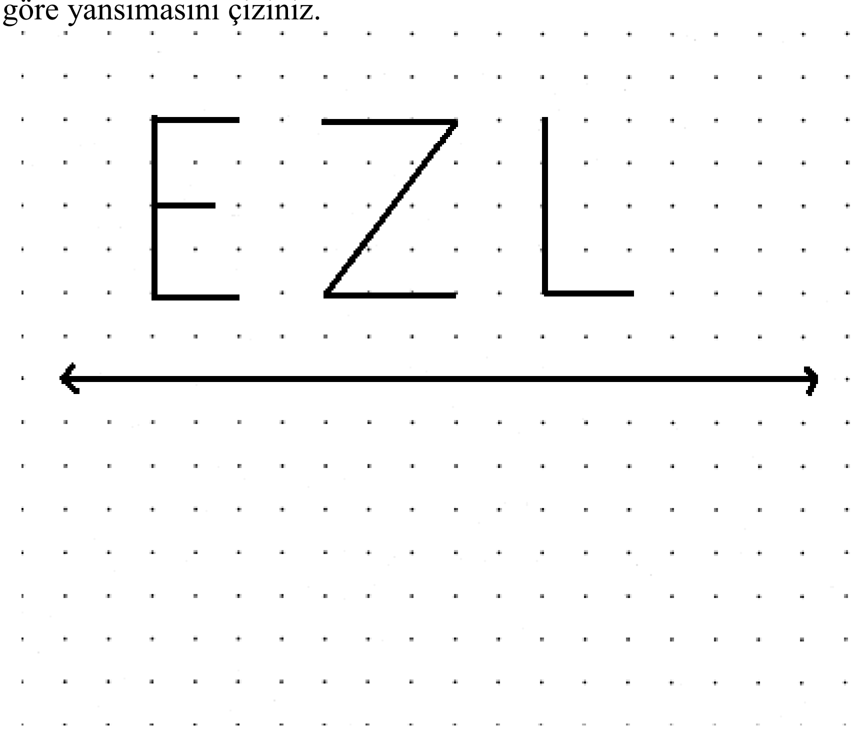
Aşağıda noktalı kağıt üzerine çizilmiş şeklin simetri aynası kullanarak verilen doğruya göre yansımasını çiziniz.



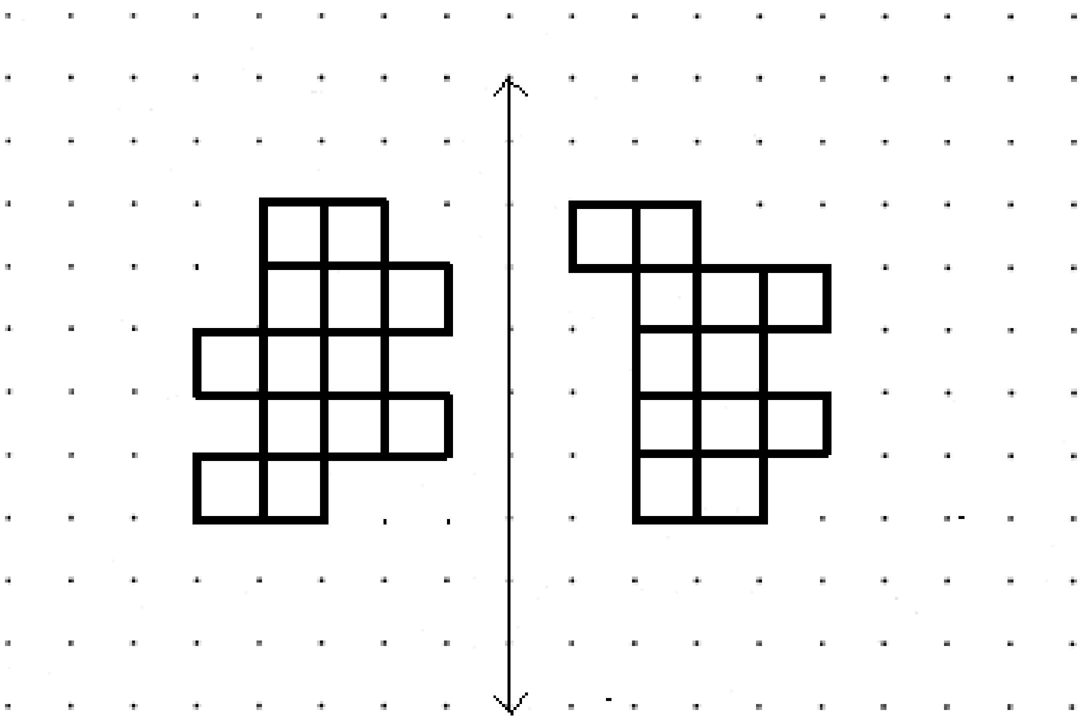
Aşağıda noktalı kağıt üzerine çizilmiş şeklin simetri aynası kullanarak verilen doğruya göre yansımasını çiziniz.



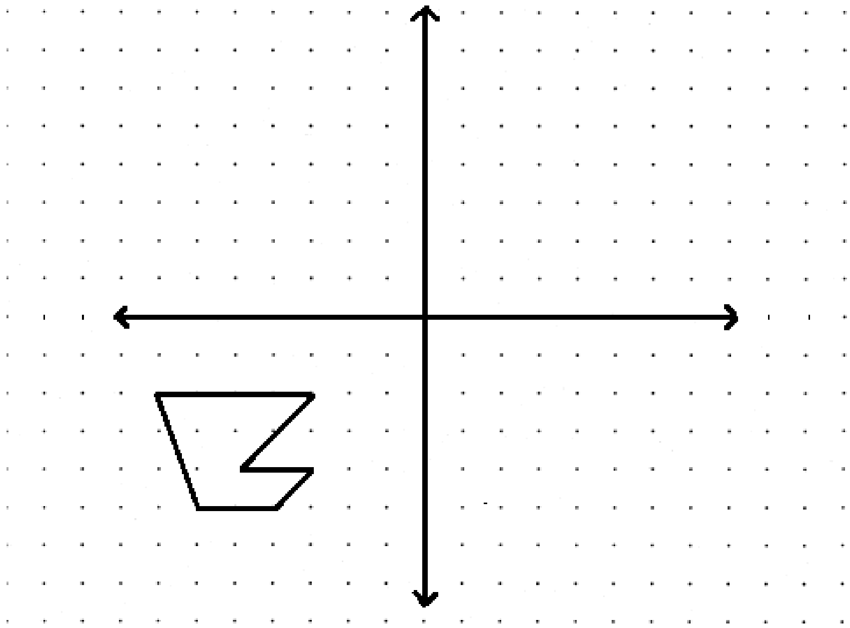
Aşağıda noktalı kağıt üzerine çizilmiş şeklin simetri aynası kullanarak verilen doğruya göre yansımasını çiziniz.



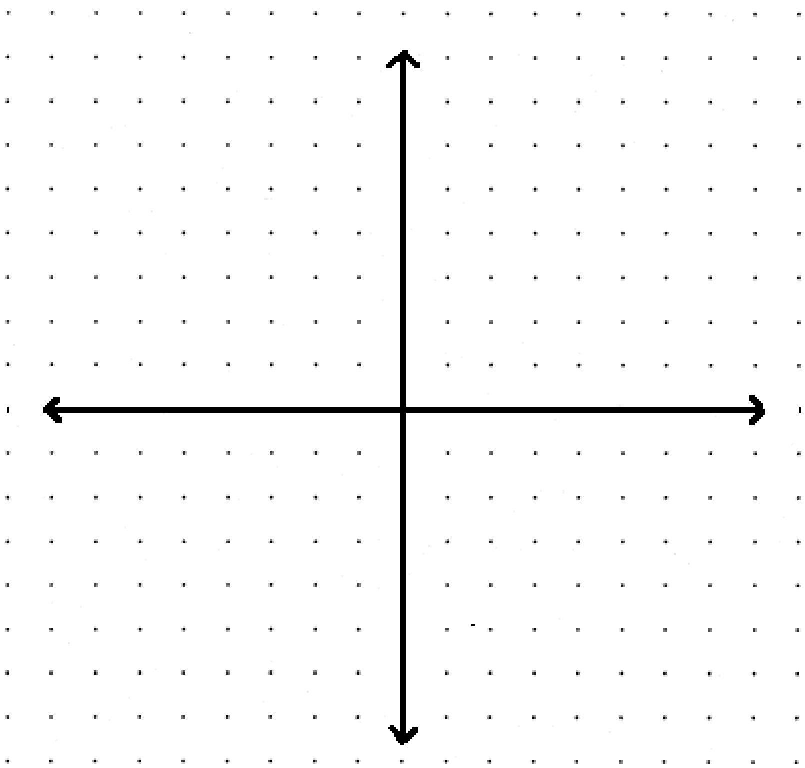
Aşağıda eş karelerle oluşturulmuş şekillerin verilen doğruya göre simetrik olabilmeleri için simetri aynasından faydalanarak en az kaç kare eklenmesi gerektiğini bulunuz.



Aşağıda verilen şeklin simetri aynası kullanarak x eksenine göre yansımasını çizdikten sonra yansıyan şeklin sonrada y eksenine göre yansımasını çiziniz.

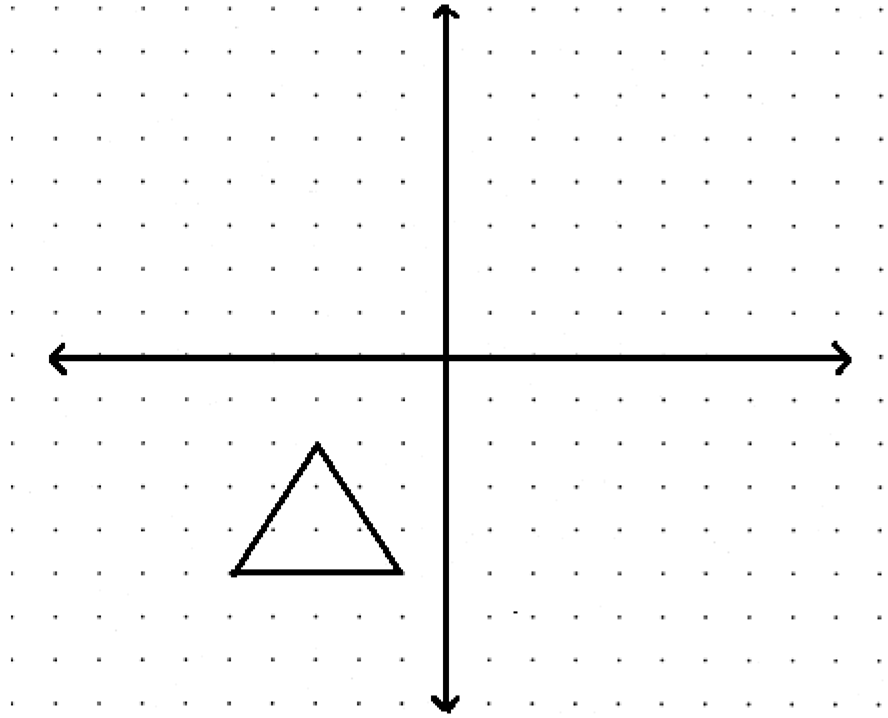


Köşe koordinatları A(0, - 3), B(- 4, 2) ve C(- 5, -2) olan üçgeni koordinat düzleminde gösterdikten sonra simetri aynasından faydalanarak bu üçgenin y eksenine göre yansımasını çiziniz.

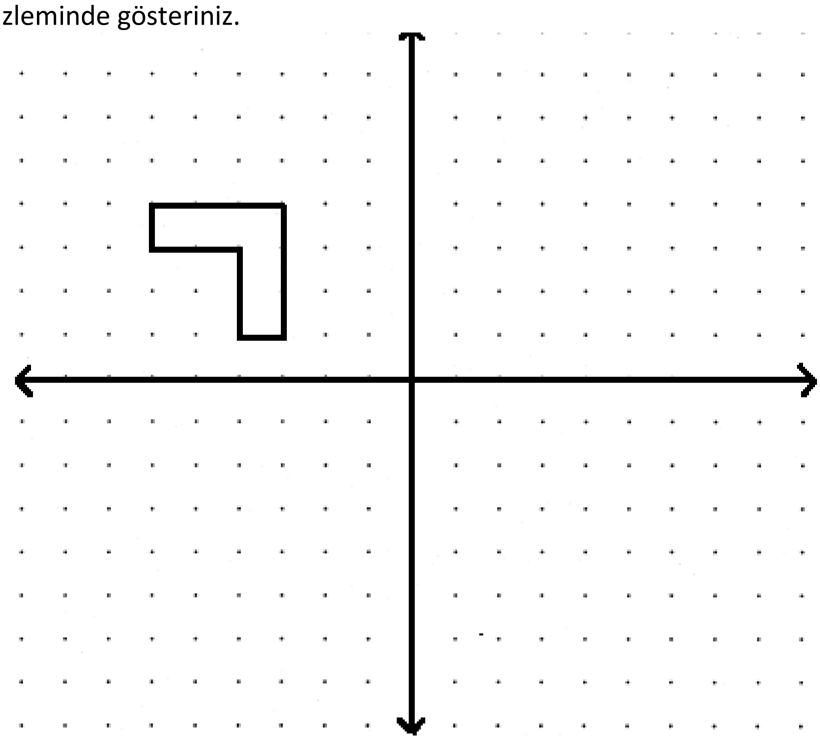


AKTİVİTE 6

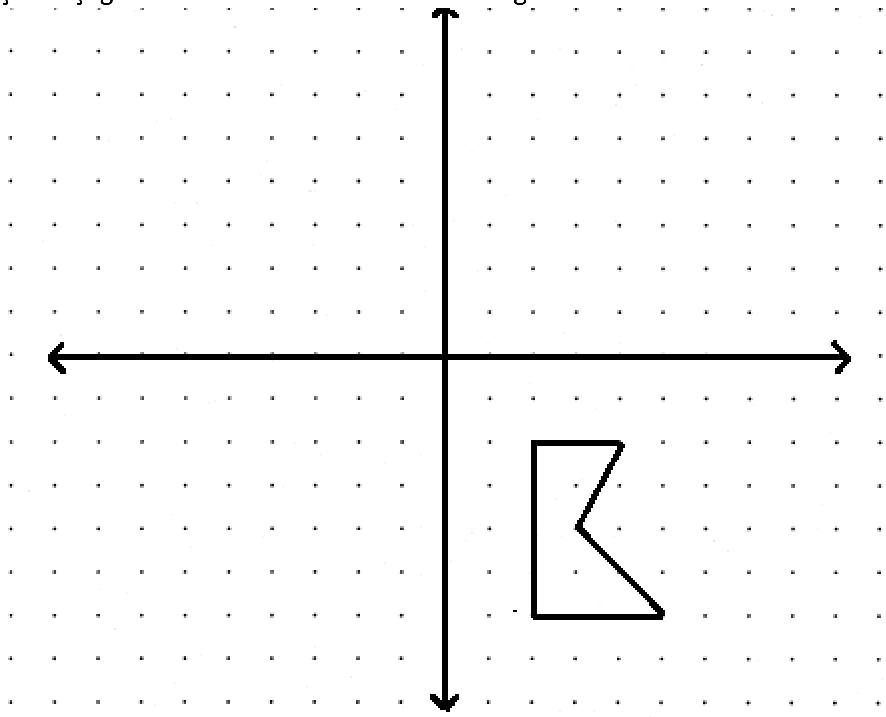
1. Aşağıda koordinat düzleminde verilen şekli asetata çiziniz. Asetata çizdiğiniz şekli x ekseni boyunca 6 br sağa öteledikten sonra oluşan şekli aşağıda verilen koordinat düzleminde gösteriniz.



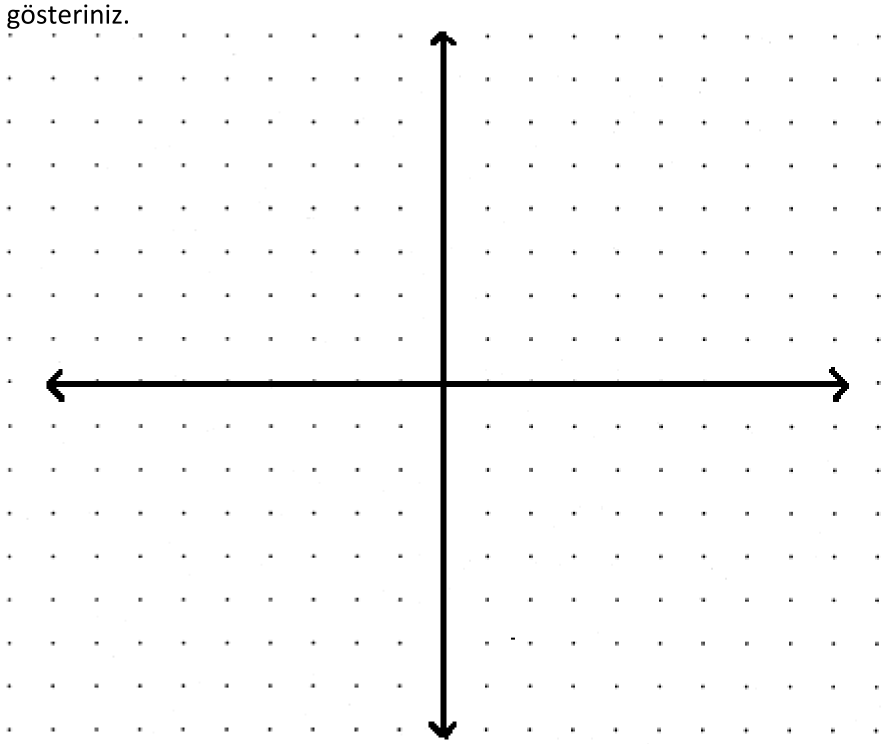
2. Aşağıda koordinat düzleminde verilen şekli asetata çiziniz. Asetata çizdiğiniz şekli y ekseni boyunca 4 br aşağı öteledikten sonra oluşan şekli aşağıda verilen koordinat düzleminde gösteriniz.



3. Aşağıda koordinat düzleminde verilen şekli asetata çiziniz. Asetata çizdiğiniz şekli x ekseni boyunca 4 br sola ve y ekseni boyunca 5 br yukarı öteledikten sonra oluşan şekli aşağıda verilen koordinat düzleminde gösteriniz.



4. Köşe koordinatları A(2 , 2), B(4 , 4), C(7, 0) ve D (7, 4)olan dörtgeni koordinat düzleminde gösterdikten sonra şekli asetata çiziniz. Asetata çizdiğiniz şekli y ekseni boyunca 7 br aşağı ve x ekseni boyunca 5 br sola öteleyiniz. Öteleme sonucunda oluşan şeklin y eksenine göre yansımasını aşağıda verilen koordinat düzleminde gösteriniz.



APPENDIX C

Ethical Approval

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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Sayı: 28620816/107 –283

26 Mart 2013

Gönderilen: Yrd.Doç.Dr.Çiğdem Haser
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Danışmanlığını yapmış olduğunuz İlköğretim Bölümü Yüksek Lisans öğrencisi Kerim Enki'nin "Somut Materyal Kullanımının Ortaokul 7. Sınıf Öğrencilerinin Geometrik Şekiller ve Dönüşüm Geometrisi Konularındaki Uzamsal Yeteneklerine Olan Etkisinin İncelenmesi" isimli araştırması ''İnsan Araştırmaları Komitesi'' tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

26/03/2013

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APPENDIX D

TURKISH SUMMARY

TÜRKÇE ÖZET

GİRİŞ

Türkiye'deki matematik programının genel amacı; öğrencilere belirli matematiksel bilgi, beceri ve tutum kazandırarak hayatlarının her aşamasında onlara gerekli olabilecek öğrenmeleri sağlamaktır. Matematik müfredatı işlemlerde akıcı olmayı, kavramsal öğrenmeyi ve öğrencilerin sorunları çözebilmelerini geliştirmeyi amaçlamaktadır (MEB, 2013). Ayrıca somut materyal deneyimleri ile öğrencilerde matematiksel duygu oluşturmak, soyutlama yapabilmek ve süreçte aktif rol almalarına imkan sağlamak vurgulanmıştır (MEB, 2005; 2013). Matematik programı ayrıca somut materyal, kağıt çeşitleri ve matematiksel görseller kullanarak öğencilerin psikomotor becerilerini geliştirmeye önem vermektedir (MEB, 2013).

Araştırmalar matematik başarısı ile uzamsal yeteneğin ilişkili olduğunu ortaya çıkarmıştır (Battista, 1994; Clements, 1998; Friedmen, 1992; Guay & McDaniel, 1977; Guzel & Sener, 2009; Hvizdo, 1992; Kayhan, 2005; Smith, 1964). Uzamsal yetenek özellikle geometri (Fennema & Tartre, 1985) ve matematik alanında (Clements, 1998) bir çok konunun öğrenilmesinde büyük öneme sahiptir. Matematik Öğretmenleri Ulusay Konseyi (NTCM) ayrıca uzamsal yeteneğin matematik eğitimindeki önemine dikkat çekerek öğrencilere çizimler yapabilecekleri, geometrik şekilleri karşılaştırabilecekleri ve görselleştirebilecekleri öğrenme aktivitelerinin geliştirilmesini tavsiye etmektedir (2000).

2000'lerin ortalarında ilköğretim matematik müfredatında yapılan değişikliklerle dönüşüm geometrisi, örüntü ve süslemeler gibi birçok önemli uzamsal yetenek konuları müfredattaki yerini almıştır (MEB, 2005). Matematiksel kavramların çoğu kez soyut olmalarından ve öğrenciler tarafından anlaşılmakta güçlüklerle karşılaşıldığından dolayı özellikle bu konuların öğretilmesinde somut materyal kullanılması gerekliliği vurgulanmıştır. Matematiksel kavramların ve uzamsal yeteneğin özel aktiviteler ve deneyimlerle geliştirilebilir olduğu savunulduğundan bu çalışmada somut materyal kullanımının öğrencilerin uzamsal yeteneklerini geliştirmedeki etkisi araştırılmıştır.

Çalışmanın Amacı ve Araştırma Soruları

Araştırmanın amacı somut materyal kullanmanın yedinci sınıf öğrencilerinin dönüşüm geometrisi ve geometrik figürlerin görünümleri konularındaki başarılarına etkisini araştırmaktır. Araştırma ayrıca öğrencilerin yazılı raporlarlarda belirttikleri matematik dersinde somut materyal kullanma hakkındaki görüşlerini incelemeyi de amaçlamaktadır.

Somut materyal kullanmanın yedinci sınıf öğrencilerinin dönüşüm geometrisi ve geometrik figürlerin görünümleri konularındaki başarılarına etkisini araştırmak için aşağıdaki araştırma soruları oluşturulmuştur.

Araştırma Sorusu 1 : Somut materyal kullanmanın yedinci sınıf öğrencilerinin dönüşüm geometrisi ve geometrik figürlerin görünümleri konularındaki başarılarına etkisini var mıdır?

Hipotez 1: Somut materyal kullanan ve kullanmayan grupların başarı testindeki sontest puanları arasında anlamlı bir farklılık yoktur.

Alternatif Hipotez 1: Somut materyal kullanan ve kullanmayan grupların başarı testindeki son test puanları arasında anlamlı farklılık vardır.

Araştırma Sorusu 2: Öğrencilerin matematik dersinde somut materyal kullanma hakkındaki görüşleri nelerdir?

Bu Araştırmayı Gerçekleştirme Amacım

Ankara'da ilköğretim okullarından birinde bir matematik öğretmeniyim. Öğretmenlik mesleğim boyunca sekizinci, yedinci ve altıncı sınflara eğitim verdim. Her öğrencinin bu dersten zevk aldığı veya anladığı birtakım konular vardır. Geometrik şekiller ve dönüşüm geometrisi öğrencilerin aktif olarak derse katıldıkları konulardan bazılarıdırr. Geometrik şekiller konusunu işlerken öğrencilere birim küpleri tanıttım ve onlarla vakit geçirmelerine olanak sağladım. Kullandığım bu materyal onlar üzerinde olumlu bir etki bırakınca birim küpler, simetri aynası, ve asetat kağıt gibi materyallerin onların uzamsal yeteneklerini geliştirmekte başarılı olup olamayacağını düşündüm. Bu çalışmanın sayesinde, bu sorumun cevabını bulmayı umuyorum. Ayrıca, bu çalışmanın benim öğretmenlik mesleğime katkıda bulunacağına inanıyorum.

YÖNTEM

Çalışmanın Deseni

Araştırmanın amacı somut materyal kullanmanın yedinci sınıf öğrencilerinin dönüşüm geometrisi ve geometrik figürlerin görünümleri konularındaki başarılarına etkisini araştırmaktır. Araştırma ayrıca öğrencilerin yazılı raporlarla da belirttikleri matematik dersinde somut materyal kullanma hakkındaki görüşlerini incelemeyi de amaçlamaktadır. Bu çalışmada araştırma sorularına cevap bulabilmek için nicel ve nitel yöntemler kullanılmıştır. Araştırmada deney ve kontrol gruplarının kullanıldığı okulda sınıflar 2012-2013 eğitim-öğretim yılının başında oluşturulduğundan dolayı denkleştirilmemiş grup öntest-sontest araştırma deseni ile gerçekleştirilmiştir. Çalışma Ankara'da bulunan bir devlet okulundaki 7.sınıf öğrencileri ile gerçekleştirilmiştir. Araştırmacı bu okulda çalıştığı için bu okul seçilmiştir. Somut materyal kullanımı bağımsız değişkeni oluştururken, öğrencilerin araştırmacı tarafaından hazırlanan başarı testinden aldıkları puanlar bağımlı değişkeni oluşturmaktadır. Tablo 3.1 araştırma desenini göstermektedir. "Deney Grubu" (DG), "Kontrol Grubu" (KG), "Başarı Testi" (T1), "Somut Materyal" (SM) ve "Geleneksel Öğretim" (NÖ) şeklinde gösterilmiştir.

Tablo 3.1 Araştırma Deseni

Grup	Öntest	Uygulama	Sontest
DG	T1	SM	T1
KG	T1	GÖ	T1

Dört tane yedinci sınıfın bulunduğu okulda araştırmacı bu sınıflardan iki tanesinin matematik dersine girmektedir. Deney ve kontrol grupları araştırmacının derslerine girdiği bu iki sınıf arasından rastgele belirlenmiştir. Başka bir deyişle araştırmacı deney ve kontrol gruplarının aynı zamanda matematik öğretmenidir.

Örneklem

Hedeflenen kitle Ankara'daki bütün yedinci sınıf öğrencileri iken, erişilebilir kitle Keçiören ilçesindeki bütün yedinci sınıf öğrencileridir. Bu çalışma 2012- 2013 eğitim-öğretim yılında Ankara'nın Keçiören ilçesinde bulunan bir devlet okulunda gerçekleştirilmiştir. Araştırmacı bu okulda matematik öğretmenliği yaptığı için bu okul seçilmiştir. Okuldaki 73 yedinci sınıf öğrencisi deney ve control grubunu oluşturmaktadır. Sınıflar matematik başarısı olarak heterojen bir dağılım gösterirken iki grubunda matematik başarıları arasında fark yoktur. Bu bilgiyi doğrulamak için öğrencilerin 6. sınıftaki matematik dersine ait notları bağımsız örneklem t-testi kullanılarak analiz edilmiştir. Tablo 3.2 bağımsız örneklem t-testi sonuçlarını göstermektedir.

Tablo 3.2 6.Sınıf Matematik Dersine Ait Notların T-Testi Sonuçları

	Deney	Grubu	Kontrol	Grubu	t değeri
	Ortalama	SS	Ortalama	SS	
Matematik Notları	2.38	1.40	2.50	1.36	-0.401

$p>0.05$

Sonuçlar öğrenciler arasında 6.sınıftaki matematik dersine ait notları bakımından anlamlı bir fark olmadığını göstermiştir. Tablo 3.3 deney ve kontrol grubundaki öğrencilerin cinsiyetlere göre dağılımlarını göstermektedir.

Tablo 3.3 Araştırmaya Ait Öğrenci Dağılımları

	Deney Grubu	Kontrol Grubu	Toplam
Kızlar	20	19	39
Erkekler	17	17	34
Toplam	37	36	73

Veri Toplama Yöntemi ve Araçları

Uzamsal Başarı Testi

Bu araştırmada veriler dönüşüm geometrisi ve geometrik cisimlerin farklı yönlerden görünümlerinin yer aldığı Uzamsal Yetenek Başarı Testi (UYBT) ile toplanmıştır. Başarı testi ilköğretim matematik müfredatı ve ilgili literatür taraması yapılarak araştırmacı tarafından hazırlanmıştır. İlköğretim matematik müfredatında geometrik figürler ve dönüşüm geometrisi ile ilgili olan kazanımlar Tablo 3.4 te belirtilmiştir. Bu kazanımlar deney ve kontrol grubunun aktivitelerinin ve öntest sontestlerin oluşturulmasına rehberlik etmiştir

Tablo 3.4 Yedinci Sınıf Matematik Dersi Müfredatı Kazanımları

Geometrik Figürler
4. Birim küplerle oluşturulmuş 3 boyutlu yapıları isometrik kağıda çizer.
5. Birim küplerle oluşturulmuş yapıların 2 boyutlu çizimlerini yapar (üst, sağ, sol ve ön).
6. 2 boyutlu çizimleri verilen yapıları birim küplerle oluşturarak 3 boyutlu çizimlerini yapar.
Dönüşüm Geometrisi
4. Yansımayı açıklar.
5. Ötelemeyi açıklar.
6. Şekilleri belirli bir açı ile belirli bir nokta etrafında döndürür.

Pilot uygulama öncesi geçerlik çalışması için matematik öğretmenleri ve matematik eğitimi araştırmacılarının görüşleri alınarak veri toplama aracı tekrar gözdengeçirilmiştir. Başarı testi, uygulamadan önce öntest, uygulamadan sonra ise sontest olarak kullanılmıştır. Teste 3 çoktan seçmeli ve 10 açık uçlu soru yer almaktadır.

Başarı testinin pilot uygulaması 40 dakikalık süre içerisinde aynı ilköğretim okulunda bulunan 55 8. Sınıf öğrencisine uygulanmıştır. Öğrencilerin doğru cevapları "1" olarak kodlanırken yanlış cevapları ve cevaplanmayan sorular "0" olarak kodlanmıştır. Bütün maddelerin zorluk dereceleri aynı olduğu düşünüldünden veri toplama aracının güvenirlik katsayısı Kuder-Richardson 21 formülü ile hesaplanarak güvenirlik katsayısı 0.71 olarak bulunmuştur. Uygulamada ise güvenirlik katsayısı öntest için 0.83 sontest için ise 0.86 olarak hesaplanmış ve oldukça yüksek bir değer bulunmuştur.

Yazılı (yansıtma) Raporu

Öğrenciler matematik dersindeki aktiviteler, aktivitelerde kullanılan somut materyaller ve uygulama hakkındaki görüş ve düşüncelerini belirtmek için uygulamadan sonra yazılı raporlara cevaplar vermişlerdir. Yazılı raporlarda öğrencilerden aktivelerde yaptıkları çizimler, kullandıkları birim küpler, simetri aynaları ve asetat kağıtları hakkındaki düşüncelerini belirtmeleri istenmiştir. Ayrıca somut materyal kullanmanın onlara yardımcı olup olmadığı sorulmuştur. Araştırmacı raporları okuduktan sonra sınıfta tartışma ortamı oluşturarak öğrencilere görüşlerini tekrar açıklama imkanı sağlamıştır. Bu sayede öğrencilerin gerçek düşünceleri uygulamada oldukça önemli ispat oluşturmuştur.

Uygulama

Bu araştırmadaki uygulamayı araştırmacının hazırladığı ve kendisinin uyguladığı aktiviteler oluşturmaktadır. Aktiviteler 2012-2013 eğitim öğretim yılında 73 7. Sınıf öğrencisine uygulanmıştır. Her iki grupa da aynı kişi tarafından öğretim yapılmıştır. Deney grubu aktivitelerde somut materyal kullanırken kontrol grubu herhangi bir somut materyal kullanmamıştır. Aktiviteler haftada 4 ders saati boyunca 3 hafta boyunca uygulanmıştır. Uygulamanın ilköğretim matematik programındaki karşılığı 12 ders saati olarak belirlendiğinden araştırmacı buna sadık kalmıştır. Her iki grup ta uygulama boyunca 6 aktivite yapmıştır. Aktivitelerden üçü geometrik figürler ile ilgili iken diğer üç aktivite ise dönüşüm geometrisi ile ilgilidir.

Deney Grubu Uygulaması

Her aktiviteye başlamadan önce dersin amacı ve kazanımları öğrencilere ayrıntılı bir şekilde açıklanmıştır. Aktivite kağıtları ve somut materyaller öğrencilere dağıtıldıktan sonra öğrencilerden aktivite kağıdında yer alan yönergeleri okumaları ve herhangi bir soruları varsa sormaları istenmiştir. Aktivitelere başlamadan önce her bir aktivitede kullanılması gereken somut materyaller ve nasıl kullanılmaları gerektiği konusunda öğrencilere bilgi verilmiştir. Gösterimden sonra öğrenciler bireysel olaral aktiviteleri yapmaya başlamışlardır. Ders boyunca uygulayıcı öğrencileri karşılaştıkları zorlukları gözlemlemiştir

Kontrol Grubu Uygulaması

Kontrol grubu öğrencileri uygulama boyunca herhangi bir somut materyal kullanmamışlardır. Sadece izometrik ve karesel kağıt kullanmışlardır. Aktivitelere başlamadan önce her bir aktivite ve dersin kazanımları öğrencilere detaylı bir şekilde anlatılmıştır. Aktivite kağıtları öğrencilere dağıtıldıktan sonra herkesin dikkatlice okumaları ve soruları varsa sormaları istenmiştir. Öğrenciler aktiviteleri yapmayı başladıktan sonra uygulayıcı ders boyunca öğrencileri ve karşılaştıkları zorlukları gözlemlemiştir

Veri Analizi

Bu çalışmada nicel ve nitel araştırma teknikleri kullanılmıştır. İlk araştırma sorusuna cevap bulabilmek için nicel veri analizi kullanılırken, ikinci araştırma sorusuna cevap bulabilmek için nitel veri analizi kullanılmıştır.

Nicel veri analizleri SPSS 18 programı kullanılarak yapılmıştır. Öğrencilerin cevaplarını değerlendirmek için puanlama cetveli kullanılmıştır. Puanlama cetvelinde öğrencilerin doğru cevapları “1” olarak kodlanırken yanlış cevapları ve cevaplanmayan sorular “0” olarak kodlanmıştır. Başarı testindeki sorulardan biri dört farklı kazanım içerdiğinden testten alınabilecek en yüksek puan 16 olarak hesaplanmıştır.

Araştıramada hem betimsel hem de çıkarımsal istatikler kullanılmıştır. Betimsel istatistiklerde öntest ve sontestlere ait ortalama puan, standard sapma ve frekans değerleri hesaplanmıştır. Çıkarımsal istatikte ise somut materyal kullanan ve kullanmayan grupların sontest puanları arasında anlamlı bir fark olup olmadığına bakmak için bağımsız örneklem t-testi kullanılmıştır.

İkinci araştırma sorusuna cevap bulabilmek için öğrencilerin yazılı raporları okunmuş ve verdikleri cevaplar kategorilere ayrılmıştır. Kategorilere ayrılmış cevaplar kodlanarak analiz edilmiştir.

Varsayım ve Sınırlılıklar

Katılımcıların maddeleri doğru bir şekilde okudukları ve anladıkları varsayılmıştır. Herbir öğrencinin ölçme aracına doğru ve samimi cevaplar verdikleri varsayılmıştır. Deney ve kontrol grubundaki aktivitelerin planlandığı gibi uygulandığı ve testin standart koşullar altında gerçekleştiği varsayılmıştır.

Araştırmanın sınırlılıkları ise şu şekilde belirtilmiştir: Öncelikle araştırmaya katılan katılımcılar rastgele seçilmemişlerdir. Bu örneklemin popülasyonu tam anlamıyla temsil ettiğini ve bulguların genellenebilirliğini sınırlamaktadır. Ayrıca bu araştırmada aktiviteler esnasında somut materyal kullanılırken değerlendirme aşamasında somut materyal kullanılmamıştır. Milli Eğitim Bakanlığı tarafından ilköğretim matematik müfredatında uygulamanın süresi 3 hafta ile sınırlandırılmıştır ve uygulayıcı buna sadık kalmıştır. Her iki grup ta bu çalışmadan bir sene önce yani 6.sınıfta matematik dersinde birim küp kullanmışlar ve isometrik kağıda çizimler yapmışlardır. Bu nedenle öğrenciler materyallerden bazılarına alışkın olduklarından dolayı testteki sorulara önceki senelerde öğrendiklerinden yansıtmış olabilirler. Ayrıca, uygulayıcı aynı zamanda araştırmacı olduğu için çalışmanın amacı hakkında bilgiye sahiptir.

SONUÇ

Betimsel Analiz

Çalışmada deney grubunda 37 öğrenci yer alırken kontrol grubunda 36 öğrenci yer almaktadır. Her öğrenciye uygulamadan önce öntest ve uygulamadan sonra sontest olmak üzere 13 sorunun bulunduğu Uzamsal Başarı Testi uygulanmıştır. Sorulardan biri 4 farklı kazanım içerdiği için bu testten alınabilecek en yüksek puan 16 olarak hesaplanmıştır. Tablo 4.1 her iki grup için Başarı Testinden almış oldukları puanları göstermektedir.

Tablo 4.1 Her İki Grubun Başarı Testinden Almış Oldukları Puanlar

	Deney Grubu		Kontrol Grubu	
	Öntest (16 puan üzerinden)	Sontest (16 puan üzerinden)	Öntest (16 puan üzerinden)	Sontest (16 puan üzerinden)
S	37	37	36	36
En Düşük	0	2	1	0
En Yüksek	14	16	14	16
Ortalama	6.32	9.38	6.78	9.14
Standard Sapma	3.70	4.00	3.53	4.26

Tablo 4.1 de görüldüğü üzere kontrol grubu öğrencilerinin öntestte almış oldukları puanların ortalaması (Ort= 6.78, SS=3.53) deney grubundaki öğrencilerin öntestte almış oldukları puanların ortalamalarından (Ort= 6.32, SS=3.70) yüksektir. Fakat, deney grubu öğrencilerinin sontestte almış oldukları puanların ortalaması (Ort= 9.38, SS=4.00) kontrol grubundaki öğrencilerin sontestte almış oldukları puanların ortalamalarından (Ort= 9.14, SS= 4.26) yüksektir. Ayrıca her iki grubun sontest puanlarının ortalamaları öntest puanlarının ortalamalarından yüksektir.

Çıkarımsal Analiz

Somut Materyal Kullanmanın Öğrencilerin Uzamsal Yeteneklerine Etkisi

İlk araştırma sorusu "somut materyal kullanmanın yedinci sınıf öğrencilerinin dönüşüm geometrisi ve geometrik figürlerin görünümleri konularındaki başarılarına etkisi" ni araştırmaktır. Araştırma sorusuna ait hipotezler şu şekildedir:

Hipotez 1: Somut materyal kullanan ve kullanmayan grupların başarı testindeki son test puanları arasında anlamlı farklılık yoktur.

Alternatif Hipotez 1: Somut materyal kullanan ve kullanmayan grupların başarı testindeki son test puanları arasında anlamlı farklılık vardır.

Araştırma sorusuna cevap bulabilmek için bağımsız örneklem t-testi kullanılmıştır.

Öntest Puanlarının Analizi

Deney grubu ve kontrol grubu öğrencilerinin öntest puanları arasında anlamlı bir fark olup olmadığını bulmak için bağımsız örneklem t-testi uygulanmıştır. Tablo 4.4 Ön test puanları t-testi sonuçlarını göstermektedir.

Tablo 4.4 Ön Test Puanları T-Testi Sonuçları

	Deney Grubu		Kontrol Grubu		t değeri
	Ort	SS	Ort	SS	
Öntest	6.32	3.70	6.78	3.53	-0.535

p>0.05

Tablo 4.4 te görüldüğü gibi somut materyal kullanan ve kullanmayan grupların başarı testindeki öntest puanları arasında anlamlı farklılık yoktur.

Sontest Puanlarının Analizi

Deney grubu ve kontrol grubu öğrencilerinin sontest puanları arasında anlamlı bir fark olup olmadığını bulmak için bağımsız örneklem t-testi uygulanmıştır. Tablo 4.5 sontest puanları t-testi sonuçlarını göstermektedir.

Tablo 4.5 Sontest Puanları T-Testi Sonuçları

	Deney	Grubu	Kontrol	Grubu	t değeri
	Ort	SS	Ort	SS	
sontest	9.38	4.00	9.14	4.26	0.248

$p>0.05$

Tablo 4.5 te görüldüğü gibi somut materyal kullanan ve kullanmayan grupların başarı testindeki sontest puanları arasında anlamlı farklılık yoktur.

Öğrencilerin Somut Materyal Kullanımı Hakkındaki Görüşleri

İkinci araştırma sorusu "öğrencilerin matematik dersinde somut materyal kullanma hakkındaki görüşleri nelerdir?" Öğrenciler matematik dersindeki aktiviteler, aktivitelerde kullanılan somut materyaller ve uygulama hakkındaki görüş ve düşüncelerini belirtmek için uygulamadan sonra yazılı raporlara cevaplar vermişlerdir. Yazılı raporlarda öğrencilerden aktivelerde yaptıkları çizimler, kullandıkları birim küpler, simetri aynaları ve asetat kağıtları hakkındaki düşüncelerini belirtmeleri istenmiştir. Ayrıca somut materyal kullanmanın onlara yardımcı olup olmadığı sorulmuştur. Öğrencilerin vermiş oldukları cevaplar analiz edildiğinde:

Hemen hemen tüm öğrenciler birim küpleri kullanmanın konuyu anlamalarında onlara yardımcı olduğunu belirtmişlerdir. 32 öğrenciden 29 u birim küpler ile etkileşim kurmanın onlara yardımcı olduğunu ifade etmiştir. Aynı zamanda matematik dersinde birim küpler ile çalışmaktan memnun olduklarını belirtmişlerdir.

Öğrencilerin açıklamalarına göre simetri aynası kullanmanın yansıma konusunu anlamada olumlu bir etkisi vardır. 32 öğrenciden 29 u simetri aynası kullanmanın konuyu anlamada onlara yardımcı olduğunu belirtmiştir. Öğrencilerin çoğu daha önce simetri ayna görmediklerini ve onlar için yararlı ve keyifli olduğunu belirtmişlerdir.

Öğrenciler asetat kağıdı kullanmanın onlar için farklı bir deneyim olduğunu belirtmişlerdir. Neredeyse tüm öğrenciler hayatlarında ilk defa matematik sınıfında asetat kağıdı ile çalıştığını belirtmişlerdir. Kullanmadan önce onlarla ne yapacaklarını bilmediklerini belirtirken, aktivitelerden sonra, 32 öğrenci arasından 28 i asetat kağıdı kullanmanın konuyu anlamada onlara yardımcı olduğunu belirtmişlerdir.

TARTIŞMA

Bu araştırmanın amacı somut materyal kullanmanın yedinci sınıf öğrencilerinin dönüşüm geometrisi ve geometrik figürlerin görünümleri konularındaki başarılarına etkisini araştırmaktır. Araştırma ayrıca öğrencilerin yazılı raporlarlarda belirttikleri matematik dersinde somut materyal kullanma hakkındaki görüşlerini incelemeyi de amaçlamaktadır.

Somut Materyal Kullanmanın Uzamsal Yeteneğe Etkisi

Deney ve kontrol grubundaki öğrencilerin başarı testindeki sontest puanları karşılaştırıldığında gruplar arasında anlamlı bir fark olmadığı ortaya çıkmıştır. Başka bir deyişle somut materyal kullanarak uygulanan eğitimde geleneksel yöntemle uygalan eğitime göre daha iyi sonuçlar elde edilememiştir.

Bu sonuç Boakes (2009), Boyraz (2008), Drickey (2000), Eraso (2007) ve Pleet (1990) gibi araştırmacıların elde ettiği sonuçlarla tutarlılık göstermektedir. Bu araştırmalarda yarı deneysel öntest sontest araştırma desenleri kullanılmış olup katılımcıların yaşları 5 ile 10 arasında değişmektedir. Eraso (2007) öğrencilerde uzamsal yeteneğin geliştirilmesi için uygun yaş aralığının 7 ile 12 arasında değiştiğini belirtmiştir. Piaget (1973) e göre , somut işlem dönemi, somut materyal kuulanımı için kritik dönem, 7 yaşından başlar 12 yaşına kadar devam eder. Bu nedenle geç yaşlarda kullanılan somut materyal kullanımı istenilen sonuçları vermeyebilir. Bu çalışmada yer alan katılımcıların yaşları 11 ve 12 olduğu için böyle bir sonuç bulunaması öğrencilerin somut işlem dönemi sonlarında yer almalarından kaynaklanabilir. Ayrıca yukarıda belirtilen çalışmaların ortrak bir özelliği de uygulamaya ayrılan süredir, 2 hafta ile 6 hafta arasında. Bu çalışmada da 3 haftalık bir uygulama anlamlı bir fark bulunamamış olmasına neden olmuş olabilir. Drickey (2000) ve Sowell (1989) ın da belirttiği gibi öğrencilerde uzamsal yeteğin geliştirilebilmesi için daha uzun sürede uygulama yapılmalıdır.

Grupların sontest puanları arasında anlamlı bir fark çıkmamasına rağmen deney grubu (Ort= 9.38) control grubuna (Ort=9.14) göre daha yüksek bir ortalama elde etmiştir. Aynı şekilde her iki grupta başarı testinde olumlu bir başarı elde etmişlerdir. Deney grubunun puan ortalaması önteste göre 3.06 artarken kontrol grubunun puan ortalaması 2.36 artmıştır. Her iki grubunda puanlarındaki benzer artış öğrencilerin 6.sınıfta somut materyallerle uygulama yapmış olmalarından kaynaklanabilir. Her iki grubunda öntestte aynı ortalamaları elde etmiş olmaları bu varsayımı desteklemektedir.

Öğrencilerin Somut Materyal Kullanma Hakkındaki Görüşleri

Gruplar arasında sontest puanlar bakımından anlamlı farklılık olmamasına rağmen, deney grubu öğrencileri yazılı raporlarında belirttikleri üzere matematik dersine ve bu derste somut materyal kullanılmasına karşı olumlu bir tutum sergilemişlerdir. Bu sonuç Sowell(1989) ın çalışmasında da bahsedildiği gibi benzerlikler göstermektedir. Hemen hemen tüm öğrenciler matematik dersinde birim küp, simetri aynası ve asetat kağıdı gibi somut materyallerkullanmaktan büyük zevk almışlardır. Somut materyal kullanmak öğrencilerin motivasyonunu arttırdığı gibi aynı zamanda kendilerine olan güvenin artmasını sağlamıştır. Somut materyal kullanmak öğrencilerin kendi öğrenmelerini güçlendirerek onlara farklı bakış açsısı kazandırmıştır.

Deney grubu öğrencileri bu süreçte aktif olarak aktivitelere katılmış ve öğrenme sürecinin merkezinde merkezinde yer almışlardır. Deney grubu öğrencileri aynı zamanda kontrol grubu öğrencilerinin kullandığı normal öğretime alternatif bir yolla konuyu öğrenmişlerdir. Bruner (1961) öğrencilerin keşfetme yoluyla konuları daha anlamlı şekilde öğrendiklerini belirterek, onlara eleştirel düşünme becerileri, teşvik ve güven duygusu kazandırdığını belirtmiştir. Bu özellikler uygulama sonunda deney grubu öğrencilerinin üzerindeki yansımaları gözlenmiştir. Bu nedenle, matematik sınıfında somut materyal kullanmanın öğrencilerin duygularını ve tutumlarını geliştirdiğini söyleyebiliriz.

Öneriler

Bu araştırmada 7.sınıf öğrencileri ile çalışılmıştır. İleride yapılacak çalışmalarda farklı seviyedeki sınıflarla çalışmalar yapılabilir. Ayrıca bu çalışmada bir deney ve bir control grubu yer alırken ileride yapılacak çalışmalarda grup sayıları arttırılabilir. Uygulama esnasında somut materyal kullanılmış fakat değerlendirme aşamasında kullanılmamıştır. Somut materyal kullanımı değerlendirme aşamasında da kullanılabilir. Bu çalışma sadece bir okulda gerçekleştirildiğinden bir sonraki çalışmalarda birden fazla okul çalışmaya katılabililir. Uygulama süresi 3 hafta gibi bir sürede gerçekleştiğinden 3 haftadan uzun bir uygulama takvimi önerilir. Öğrencilerin uzamnsal yeteneklerini geliştirmek için farklı materyaller kullanılarak farklı konularda çalışılabilir. Bu çalışmada öğrenciler bireysel olarak uygulamaya katılırken ileride yapılacak çalışmalarda öğrenciler grup çalışmalarına katılarak etkileşimde bulunabilirler. Rottier ve Ogan (1991) ında belirttiği gibi öğrencilerin birbirleriyle etkileşim içinde bulunabileceği öğrenme ortamları hazırlanarak etkili öğrenmeler gerçekleştirilmelidir. Son olarak öğrencilerin geometri dersine karşı tutum ölçeği kullanılabilir ve öğrencilerle ropörtajlar gerçekleştirilebilir.

Matematik öğretmenleri, mevcut çalışmada kullanılan aktiviteler ve başarı testi , öğretmenler için bir örnek olabilir ve kendi faaliyetleri oluşturmak için bunları kullanabilirler. Somut materyaller öğrencilerin matematiksel fikirler arasında bağlantı kurmasını kolaylaştırdığından ve öğrencilerin matematik dersine karşı tutum ve içsel motivasyonlarını arttırdığından dolayı aynı şekilde matematik öğretmenleri kendi derslerinde bu çalışmada kullanılan materyalleri kullanmaktan çekinmemelidirler. Ayrıca, öğretmenler öğrencilerinin uzamsal yeteneklerini geliştirmek için farklı materyaller, bilgisayar programları ve aktiviteler kullanabilir. Öğretmenlerin bu bağlamda öğrencilerin bilişsel düzeylerine uygun aktiviteler ve materyaller seçmeleri gerekir.

Gelecek İle İlgili Düşüncelerim

Kendi öğretmenlik mesleğinim boyunca, öğrencilerimi daima öğrenme sürecinin merkezinde almaya çalıştım. Onların ilgisini kazanmak ve onların duygularını anlamak benim için önemlidir. Bu araştırmanın öncesinde kendi sınıflarımda birkaç kez somut materyal kullandım.Öğretmenlerin çoğu materyal kullanma konusunda olumsuz deneyime sahip oldukuklarından, derslerde bunları kullanmaktan çekinmektedir. Fakat öğrenciler birkez bu materyallerle etkileşime geçtiklerinde kendi yeteneklerinin farkına varmaktadırlar. Bu çalışmanın sayesinde, öğrenciler kendi potansiyellerini fark ederek bu derse farklı gözle bakmaya başlamışlardır. Bundan sonraki öğretmenlik hayatımda, farklı yöntemler ve materyaller kullanarak onların yeteneklerini ve becerilerini geliştirmeye devam edeceğim.

APPENDIX E

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : ENKİ
Adı : Kerim
Bölümü : İlköğretim Fen ve Matematik Eğitimi

TEZİN ADI : Effects of Using Manipulatives on Seventh Grade Students' Achievement in Transformation Geometry And Orthogonal Views of Geometric Figures

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

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

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: