AN INVESTIGATION OF THE EFFECT OF INQUIRY-BASED INSTRUCTION ENRICHED WITH ORIGAMI ACTIVITIES ON THE 7TH GRADE STUDENTS' REFLECTION SYMMETRY ACHIEVEMENT, ATTITUDES TOWARDS GEOMETRY AND SELF-EFFICACY IN GEOMETRY

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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

AN INVESTIGATION OF THE EFFECT OF INQUIRY-BASED INSTRUCTION ENRICHED WITH ORIGAMI ACTIVITIES ON THE 7TH GRADE STUDENTS' REFLECTION SYMMETRY ACHIEVEMENT, ATTITUDES TOWARDS GEOMETRY AND SELF-EFFICACY IN GEOMETRY

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The purpose of the study is to investigate the effect of inquiry-based instruction enriched with origami activities on the 7th grade students' reflection symmetry achievement, attitudes towards geometry and self-efficacy in geometry.

The study was conducted during the academic year 2015-2016 and lasted 15 class hours in three weeks. The sample was consisted of 48 seventh grade students in a public middle school in Altındağ district of Ankara. Two classes, instructed by the researcher, were randomly assigned to experimental and control groups. The experimental group students were taught the subject reflection symmetry through inquiry-based instruction method, while the control group students were taught the subject reflection symmetry through regular instruction. In order to gather data, participants were administered Reflection Symmetry Achievement Test (RSAT), Geometry Attitude Scale (GAS) and Geometry Self-Efficacy Scale (GSES) as pretest and posttest.

The Analysis of Covariance (ANCOVA) was performed in order to answer the research questions. Results indicated that the inquiry-based based instruction enriched with origami activities had a significant effect on students’ reflection symmetry achievement, attitudes towards geometry and self-efficacy in geometry positively compared to the regular instruction.

Keywords: Inquiry-based Instruction, Origami, Reflection Symmetry, Geometry Attitude, Geometry Self-Efficacy

ÖZ

ORİGAMİ ETKİNLİKLERİYLE ZENGİNLEŞTİRİLMİŞ SORGULAMA TEMELLİ ÖĞRETİMİN ORTAOKUL YEDİNCİ SINIF ÖĞRENCİLERİNİN YANSIMA SİMETRİSİ KONUSUNDAKİ BAŞARILARI, GEOMETRİ DERSİNE YÖNELİK TUTUMLARI VE GEOMETRİYE YÖNELİK ÖZ YETERLİK ALGILARI ÜZERİNE ETKİSİNİN İNCELENMESİ

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Bu çalışmanın amacı, origami etkinlikleriyle zenginleştirilmiş sorgulama temelli öğretimin ortaokul yedinci sınıf öğrencilerinin yansıma simetrisi konusundaki başarılarına, geometri dersine yönelik tutumlarına ve geometriye yönelik öz-yeterlik algılarına etkilerini incelemektir.

Bu çalışma 2015-2016 eğitim-öğretim yılında uygulanmış ve 15 ders saati (3 hafta) sürmüştür. Örneklem, Ankara'nın Altındağ ilçesindeki bir devlet okulunun 48 yedinci sınıf öğrencisinden oluşmaktadır. Araştırmacının dersine girdiği ve okulda halihazırda var olan iki sınıf, deney ve kontrol grubu olmak üzere rastgele atanmıştır. Deney grubunda bulunan öğrenciler yansıma simetrisi konusunu sorgulama temelli eğitim yöntemiyle işlerken, kontrol grubundaki öğrenciler geleneksel yöntemle ders işlemişlerdir. Veri toplama aracı olarak, Yansıma Simetrisi Başarı Testi, Geometri Tutum Ölçeği ve Geometri Öz-Yeterlik Ölçeği katılımcılara öntest ve sontest olarak uygulanmıştır.

Araştırma sorularını yanıtlamak üzere kovaryans analizi kullanılmıştır. Analizlerin sonuçları, geleneksel öğretim ile karşılaştırıldığında, origami etkinlikleriyle zenginleştirilmiş sorgulama temelli öğretim yönteminin öğrencilerin yansıma simetrisi konusundaki başarılarını, geometri tutumlarını ve geometriye yönelik öz-yeterlik algılarını olumlu yönde etkilediğini göstermiştir.

Anahtar Kelimeler: Sorgulama Temelli Öğretim, Origami, Yansıma Simetrisi, Geometri Tutumu, Geometri Öz-Yeterliği

To My Parents
Şengül & Pirağa KANDİL

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LIST OF ABBREVATIONS

NCTM: National Council of Teachers of Mathematics

MoNE: Ministry of National Education

RSAT: Reflection Symmetry Achievement

GAS: Geometry Attitude Scale

GSES: Geometry Self-Efficacy Scale

TIMMS: Trends in International Mathematics and Science Study

NRC: National Research Council

n: Sample size

IBI: Inquiry-based Instruction

RI: Regular Instruction

ANCOVA: Analysis of Covariance

SD: Standard Deviation

p: Significance Level

r: Correlation Coefficient

$\eta 2$: the Eta Squared Value

Pre_RSAT: Reflection Symmetry Achievement administered before treatment

Pre_GAS: Geometry Attitude Scale administered before treatment

Pre_GSES: Geometry Self-Efficacy Scale administered before treatment

Post_RSAT: Reflection Symmetry Achievement administered after treatment

Post_GAS: Geometry Attitude Scale administered after treatment

Post_GSES: Geometry Self-Efficacy Scale administered after treatment

CHAPTER I

INTRODUCTION

Geometry is a branch of mathematics which investigates points, lines, planes, and planar shapes along with the relations among them and such measurements as length, area and volume of geometric shapes (Baykul, 2000). Geometry, which has the content goals of shapes and properties, transformation, location and visualization (Van de Walle, Karp & Williams, 2013), enables students to gain an in-depth understanding of the mathematical ideas, underlying tasks and activities since students make sense by using their natural intuitions of physical environment to analyze geometric concepts (Outhred & Mitchelmore, 2001). Moreover, mathematical ideas and skills underlying geometric reasoning help students to understand high level mathematical concepts (Herbst, 2002; Jacobsen & Lehrer, 2000) and support the development of students' conceptual understanding (Outhred & Mitchelmore, 2001).

As a sub learning area, geometry is also pointed out as being a significant topic to be taught in mathematics education by mathematics educators (Clements & Battista, 1992). Hollebrands (2003) emphasized three significant reasons why geometric transformations should be taught in schools: it enables students (1) to think about mathematical concepts, (2) to view mathematical concepts embedded in a context, and (3) to show high level thinking in activities by using different representations. Moreover, Peterson (1973) also emphasized that transformational geometry enables students to explore abstract concepts such as reflection, congruence, similarity, and to get more experienced in geometry, imagination and visualization. Thus, it is pointed out to contribute to students' spatial abilities.

Transformation refers to a change in position (rigid-motion) or the size of a shape (nonrigid-motion) (Van de Walle, Karp, & Williams, 2013). Van de Walle and his colleagues (2013) emphasize that transformational geometry includes three rigid-motions as *translations* or slides, *reflections* or flips, and *rotations* or turns and a nonrigid-motion as *dilation* or enlargement/reduction. Accordingly, the study of symmetry is also included under the study of transformations. Weyl (1952) defines symmetry as line symmetry (reflection) as it was used in the 1998 Middle School Mathematics Curriculum (MoNE, 1998). On the other hand, Leikin, Berman and Zaslavsky (1997) define symmetry as a transformation which does not change the properties of the figure as it was used with the same meaning in the 2005 Middle School Mathematics Curriculum (MoNE, 2005). In detail, Usiskin and his colleagues (2003) defined symmetry as "if T(F)=F, then F is symmetric". According to this explanation, translation, reflection and rotation could be categorized under the title of symmetry. In the current study, line symmetry, which means reflection through a line, will be referred to as reflection symmetry.

According to the literature, there are studies which show that students in both elementary and middle schools have misconceptions and difficulties in the concept of symmetry (Bell, 1993; Edwards & Zazkis, 1993; Hoyles & Healy, 1997; Köse, 2012; Küchemann, 1993; Soon, 1989; Xistouri, 2007; Yanik & Flores, 2009; Zaslavsky, 1994; Zembat, 2007). Brooks and Brooks (1999) emphasize the importance of using curriculum as a handbook for an effective learning environment. Based on the curriculum, focus was placed on exploration, communication and conceptualization through activities enriched with concrete material instead of traditional methods for teaching the concept of symmetry (MoNE, 2005). In this sense, inquiry based instruction is found to be an effective approach as it entails activities, fosters mathematical thinking and provides student with opportunities for reflection of understanding critically (Cobb, Wood, & Yackel, 1990; Glasersfeld, 1984, Jaworski, 1994).

Inquiry-based instruction is a student-centered instructional approach which enables students to spontaneously explore, raise questions, and make attempts to justify their answers (Artigue & Blomhøj, 2013). In order to understand the inquiry-based instruction approaches, it is essential to reveal the meaning of inquiry (Kwon, Bae, & Oh, 2015). Inquiry in mathematics fosters learning, speaking and act mathematically through engaging in mathematical discussions, suggesting explanations, and following the process of solving new and unfamiliar problems (Richards, 1991).

Approaches such as inquiry-based instruction foster students' performance on standardized tests in terms of achievement (Kirschner et al., 2006). Evidence related to the theory also shows that inquiry-based instruction contributes to students' academic achievement and their higher order thinking skills (Spronken-Smith, 2007). This is also supported by relevant literature in which there are numerous studies showing that inquiry-based instruction has a positive effect on achievement (e.g., Abdi, 2014; Altunsoy; 2008; Çalışkan, 2008; Çelik, 2012; Ferguson, 2010; Kula, 2009; Maxwell, Lambeth & Cox, 2015; Sarı & Bakır-Güven, 2013; Sever & Güven, 2014). In addition to achievement, attitude towards mathematics is one of the affective variables related to learning mathematics and learning environment (Reyes, 1984). Negative attitudes towards mathematics may prevent students from showing full performance on mathematics as well (Reyes, 1980). For this reason, it is important to study students' attitudes towards mathematics to improve their learning mathematics performance (Fennema & Sherman, 1976; Reyes, 1984). In this sense, inquiry-based instruction is an effective method to develop and foster attitudes that are vital for supporting students to face and accomplish uncertain futures (Artigue & Blomhoej, 2013). The studies conducted in this sense also indicate that this instructional method influence attitude towards the related course in a positive way (e.g., Akpullukçu, 2013; Altunsoy; 2008; Çalışkan, 2008; Çelik, 2012; Kula, 2009; Laipply, 2004; Supovitz, Mayer & Kahle, 2000; Wilkins, 2008). In addition to attitude, self-efficacy is another affective variable which is an important determinant of a student's attitude toward a given subject, and both efficacy (Brannick et al., 2005) and attitude (Cote & Levine, 2000) reflect how successful a student may be in a given subject. The studies conducted in this respect show that this instructional method also increases the self-efficacy level of learners (e.g., Kocagül, 2013; Özdilek & Bulunuz, 2009; Laipply, 2004; Roster, 2006; Thrift, 2007), especially in science education. Therefore, there are many studies conducted to investigate the impact of inquiry-based instruction on students' achievement, attitude and self-efficacy, which are determinants of each other. However, while most of these studies are conducted in science education, few studies exist in mathematics education.

Although inquiry-based instruction is found as an effective method in education and employed in the curriculum of many countries such as Australia or the U.S., many teachers are found reluctant to use inquiry-based approach in their classrooms (Cheung, 2007). Teachers explain various barriers to implementing this inquiry-based approach. For instance, they complain about the lack of effective inquiry materials or their being expensive to obtain. Another barrier reported by teachers is that students felt uncomfortable when they were asked to plan their experiments and, thus, they were found to complain. In this sense, when the students were asked what kind of activities they prefer to complete, it was seen that students had four essential goals while choosing activities: s*uccess* (the need for mastery), c*uriosity* (the need for understanding), o*riginality* (the need for self-expression), and *satisfying* r*elationships* (the need for involvement with others) (Strong, Silver, & Robinson, 1995). Origami responds to all these four features (Özçelik, 2014) mentioned by Strong et al. (1995); hence, it can be used as an effective inquiry-based instructional tool. Thus, in the content of the current study, it was believed that origami can be used as a tool which requires paper as a cheap, disposable everyday material (Klett & Drechsler, 2011) and scissors especially for the kirigami figure in the concept of reflection symmetry.

In conclusion, although there are various studies in the literature which investigate the impact of the inquiry-based instruction approach on students' achievement, attitude and self-efficacy through the related course, most of them were conducted on science education. In this sense, in the current study, the impact of this inquiry-based instruction on students' achievement, on the concept of reflection symmetry, and on attitude towards geometry and geometry self-efficacy is investigated through the use of origami activities to contribute to the relevant literature.

1.1 Purpose of the Study

The aim of this study is to determine the effect of inquiry-based instruction enriched with origami activities on the 7th grade students' achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry, which are determinants of each other.

1.2 Research Questions and Hypotheses

In accordance with the purpose of the current study, the following research questions are investigated and for each research question a hypothesis is formulated as stated below:

1. What is the effect of inquiry-based instruction enriched with origami activities on the 7th grade students' achievement in reflection symmetry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled?
   H_0: There is no significant effect of inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of achievements in reflection symmetry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled.

2. What is the effect of inquiry-based instruction enriched with origami activities on 7th grade students' attitudes towards geometry when the effect of students'

pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled?

H_0: There is no significant effect of inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of attitudes towards geometry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled.

3. What is the effect of inquiry-based instruction enriched with origami activities on 7th grade students' self-efficacy in geometry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled?

   H_0: There is no significant effect of inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of self-efficacy in geometry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled.

1.3 Definition of the important terms

In this section, definitions of the main terms in this study are given for the clarity of the research hypotheses.

Inquiry-based instruction is a constructivist instruction method where students are given a problem solving task to discover the concept by reasoning and making connection (NCTM, 2000).

Origami means paper folding which is formed with the composition of "ori" and "kami", which mean "folding" and "paper", respectively (Beech, 2009; Franco, 1999; Yoshioka, 1963).

Crease pattern means the collection of crease lines and vertices in the unfolded paper (Belcastro & Hull, 2002).

Inquiry-based instruction enriched with origami refers to an inquiry-based geometry instruction in which origami activities constructed on real life situations are used to teach concepts of reflection symmetry through paper folding based on students' active participation while teachers act as facilitators.

Geometry Achievement refers to the scores of the students obtained from the Reflection Symmetry Achievement Test (RSAT).

Attitude is defined by Aiken (2000) as "a learned predisposition to respond positively or negatively to a specific object, situation, institution, or person" (p.248).

Geometry Attitude refers to the scores of the students obtained from the Geometry Attitude Scale (GAS).

Self-efficacy is defined by Bandura (1995) as "the belief in one's capabilities to organize and execute the courses of action required managing prospective situations" (p. 2).

Geometry Self-efficacy refers to the scores of the students obtained from the Geometry Self-Efficacy Scale (GSES).

1.4 Significance of the Study

International examinations showed that mathematics success of Turkish students were not at the desired level as highlighted in Trends in International Mathematics and Science Study (TIMSS) (Mullis, Martin, Robitaille and Foy, 2009; Mullis, Martin, Robitaille and Foy, 2012). Especially geometry achievement levels of Turkish students are at the lowest level (Büyüköztürk, Çakan, Tan, & Atar, 2014). The reason of this failure can be attributed to the affective domain (Bilican, Demirtasli, &

Kilmen, 2011), which is a significant factor that can affect achievement (Bandura, 1997; Bloom, 1998). One of the affective domains which influences mathematics achievement is attitude, which plays a critical role in the teaching and learning practices of mathematics (Farooq & Shah, 2008). Another affective domain which affects mathematics achievement is self-efficacy beliefs of students, which influence their activity choices, goal orientations, effort and determination, learning and success from several aspects (Schunk, 2011; Usher, 2009). According to the literature, the teaching method also affects the attitudes towards mathematics (Farooq & Shah, 2008); self-efficacy level of learners (e.g., Kocagül, 2013; Özdilek & Bulunuz, 2009) and achievement (Njoroge, Changeiywo, & Ndirangu, 2014; Taylor & Bilbrey, 2012). In this sense, in publications specifically related to science education, inquiry-based instruction is pointed out to be an effective method to increase students' achievement, attitude and self-efficacy toward a course. However, few studies were dedicated to inquiry-based instruction in mathematics and conducted an empirical design. For that reason, there is a need for conducting an experimental study on inquiry-based instruction in mathematics and stating the impact of inquiry-based instruction on students' achievement, attitude and self-efficacy by means of quantitative data analysis techniques.

According to the relevant literature, although inquiry is adapted as a key instructional approach for effective teaching (NRC, 1997), many teachers are reluctant to implement inquiry-based instruction in their classrooms since they find it very difficult to manage (Cheung, 2007). However, it is also revealed that several inquiry-based instruction samples that are designed appropriately were found to change beliefs and attitudes of teachers (Supovitz, Mayer, & Kahle, 2000; Thrift, 2007). Related studies in the literature may be representative for the teachers to see the benefits of this method and how to apply it. However, studies that investigate its treatment effects in mathematics lessons are limited. Current research studies commonly focus on how inquiry-based instruction can be effectively used in mathematics lessons (e.g., Artigue & Blomhøj, 2013; Kim & Ju, 2012) and how effective it is, especially in science education through experimental designs (e.g., Akpullukçu, 2013; Çelik, 2012; Kula, 2009; Maxwell, Lambeth & Cox, 2015; Thrift, 2007). There is a gap in the literature as regards the treatment effects of inquiry-based mathematics instruction with appropriate activities in mathematics on students' achievement, attitude and self-efficacy. In this sense, it is expected that constructing an inquiry-based mathematics instruction setting and investigating its effectiveness on students may be beneficial to enrich the literature and may provide an example of an instructional model for teachers.

To be able to construct an appropriate inquiry-based instruction, the literature was reviewed and it was seen that in addition to their negative attitudes towards inquiry, teachers also reported that there were some barriers to implementing inquiry-based experiments in schools (Cheung, 2007). For instance, teacher beliefs, lack of effective inquiry materials, student complaints and material demands were mentoned to constitute some of these barriers. Consequently, it is believed that using origami activities for inquiry-based instruction can be effective to overcome these barriers. Teacher beliefs can be a barrier to the employment of an inquiry-based approach since some teachers believe that only high-ability students can complete inquiry activities successfully (Costenson & Lawson, 1986; Welch, Klopfer, Aikenhead & Robinson, 1981). However, during instruction with origami, teachers can adapt to the level of the design in accordance with the ability level of the students (Sze, 2005). Moreover, origami was shown as an effective instructional tool (Şimşek, 2012; Takıcak, 2012; Dağdelen, 2012) in that it merely requires accessible and cheap material: paper (Klett & Drechsler, 2011). Studies also revealed that students who experienced origami-based instruction had a positive attitude toward origami-based instruction where they wanted to continue such an instruction (Çakmak, 2009). Therefore, origami is seen as an effective instruction method that can overcome the barriers inherent in the inquiry-based approach. Thus, in the present study, inquiry-based instruction will be enriched with origami activities and the influence of instruction supported with origami on students' achievement in reflection symmetry, their attitude towards geometry and their self-efficacy in geometry will be examined.

As one of the topics in which students have difficulties and misconceptions (Hoyles & Healy, 1997; Küchemann, 1993), reflection symmetry is one of the most appropriate subjects which can be taught through origami activities (O'Rourke, 2011). However, despite the emphasis laid upon constructing mathematical ideas through paper folding in the curriculum (MoNE, 2013), sample activities for the application of origami to the concept of reflection symmetry are limited. When the existing activities in the literature were examined, it was seen that they were not applicable in inquiry-based instruction in terms of the role of teachers and students. That is, the lesson plans and activity templates revealed that students were guided by the instructor by means of a step-by-step process in constructing the related origami figure, which is more appropriate for regular instruction. In this sense, another purpose of the current study was to construct origami activities which are appropriate for the inquiry-based instruction approach. With this purpose, origami activities related to reflection symmetry were developed in a problem situation since the instructional tasks play a key role in presenting a context of inquiry to students so that they can learn mathematics by engaging in the process of problem solving (Kwon, Bae, & Oh, 2015).

To sum up, it is expected that this study will contribute to the literature as regards the effect of inquiry-based instruction in mathematics education and how to use origami according to the inquiry approach. Moreover, the findings of this study are believed to offer useful information for mathematics teachers in planning instructional activities within an inquiry-based instruction environment.

1.5. My Motivation to Conduct the Study

Since my childhood, I have been interested in handmade objects, drawings, embroidery, painting, paper works which are generally performed in the visual arts courses in elementary and middle schools. I have always been successful in work requiring handcraft. When I started university, I searched into the student clubs and found the most appropriate one for me to pursue my hobbies; it was the Turkish-

Japanese Communication Club. There were sub-courses offered by the members of the clubs like anime-manga drawing, Japanese, mahjong, origami etc. I attended origami courses to learn how to construct figures with a piece of paper. And after a one-year training, I became the instructor of the course. During the courses I realized that while teaching origami, I was using the names of geometric shapes, polygons, polyhedrons etc. After I had realized the geometric aspects of origami, I decided to use origami as an enjoyable activity to support what I would teach in my mathematics lessons in the future as a middle school mathematics teacher. However, I had never thought of using origami to teach new concepts; I just thought of using it as a supplementary tool to present the new knowledge. However, I learnt that it can be used as an instructional tool in mathematics education in the Methods of Teaching Mathematics. Therefore, it drew my attention even more.

When I started to pursue my master's degree, the subject of my thesis was clear: origami. However, there was a problem. When I read about the activities related to origami, I saw that the methods of using origami as a tool contradicted with constructivism. Most of the researchers used origami figures in education by using direct instruction in that students followed their teachers step-by-step while constructing a figure. The lessons were far away from being student-centered. I thought about it for weeks and always folded figures to find a gap. I realized that as special forms of origami, especially crease patterns and kirigami included the concept of symmetry hidden in them. In this respect, I examined origami figures through their crease patterns and kirigami works in the form of paper-chain to be able to choose the most appropriate figures for refection symmetry to work on. Then I decided to write problems on these figures so that I wouldn't have to tell the students to fold the paper, but they would feel the necessity to fold it themselves. Thus, I constructed my problems on the most appropriate origami figures. Therefore, I decided to investigate the effectiveness of the activities that I developed.

CHAPTER II

LITERATURE

The purpose of the current study is to investigate the effect of inquiry-based instruction enriched with origami problems on 7^{th} grade students' geometry achievement, attitudes and self-efficacy. In accordance with this purpose, this chapter is devoted to review the relevant literature in order to provide a justification for conducting this study and a theoretical perspective allowing for the interpretation of the research results. In the first part, constructivism is explained as the theoretical background of the study. In the second part, inquiry-based instruction is explained in detail and related studies which investigate the impact of inquiry-based instruction on achievement, attitude and self-efficacy are examined. In the third part, general information related to origami and its mathematical side is clarified by offering related studies in both international and national contexts. Finally, a brief summary of related literature which represents the aim of investigating the impact of inquiry-based instruction on students' achievement, attitude towards geometry and self-efficacy in geometry is presented.

2.1 Constructivism

Mathematics instruction today bears out the concept and goal of mathematics literacy, but the means to fulfill this goal varies (Doctorow, 2002). With that respect, there are numerous theories which give directions to how mathematics should be taught (Guffin, 2008). One of the most important learning theories which have great influence in education is cognitive psychology (Post, 1988). Cognitive psychology supports the key theoretical explanation for the encouragement of students' to be active in the learning process. In this sense, cognitive psychology aligns with the constructivist approach with the belief that when people are provided the advantage of interacting with numerous features of their environment, the level of their learning is maximized. Constructivism is accepted as a contemporary offshoot of cognitive psychology (Post, 1988).

Constructivism is “the theory according to which each child builds his knowledge from the inside, through his own mental activity, by interacting with the environment” (Kamii & Lewis, 1990, p. 34). The origin of this theory of learning stems from Jean Piaget’s (1972) theory on how people learn derived from the result of his study on children’ stages of cognitive development. Moreover, Piaget contributed mainly to the direction, meaning and understanding of the constructivist theory which is most likely cognitive constructivism. According to Piaget’s cognitive development theory, cognitive constructivism regards knowledge schemes as being constructed by learners and filtered through previous experiences. Moreover, interaction with the environment was emphasized to so that learners could assimilate complementary components of external world into their existing cognitive schemata (Piaget, 1972). On the other hand, social constructivism relies on the social context of learning. According to Vygotsky (1978), cultural history, language and social context have a significant impact on the development of children. Vygotsky also claimed that children can overcome the obstacles of learning on their own with the help of more experienced individuals (Vygotsky, 1978).

The practice of constructivism in a classroom setting actually began many years ago. Conversations between Socrates and his fellows in the ancient Greece include evidence of constructivism (Lotfi, Dehkordi, & Vaez-Ghasemi, 2012). Throughout these dialogs, Socrates asked guided questions in order to enable his students to realize their weaknesses in their thinking process. This Socratic questioning method was used as a significant strategy by constructivist teachers to evaluate the learning outcomes of the students and to plan future activities. As in this example, constructivist teachers today encourage students to asses and direct their own learning by questioning themselves and their method and by learning how to learn. Students are expected to discuss, reflect and negotiate meanings (Cobb, Wood, & Yackel, 1990). In a constructivist setting, students are provided with some strategies such as problem solving and inquiry-based activities by working collaboratively (Mrayyan, 2014).

Research studies have pointed out that students in a constructivist instruction setting have a greater understanding of mathematics and they are more successful in mathematics than those in a traditional instruction setting (Brewer & Daane, 2002). To be able to build such a learning environment under the philosophy of constructivism, it is essential to choose appropriate instructional method. Inquiry-based instruction is one of the applications of this theory advocating that learning should be active and constructed by the learner (Kuhlthau, 2001). Inquiry-based instruction fits with a constructivist perspective in that it poses activity, fosters mathematical thinking and provides advantages for understanding mathematics conceptually (Cobb, Wood, & Yackel, 1990; Jaworski, 2006).

2.2 Inquiry-Based Instruction

Inquiry-based instruction is a learner-centered teaching method grounded in constructivism. This instruction method is defined as a pedagogy that uses real life problems to increase capacities of students in an investigation setting so that teachers have the chance to gain insight into students' thinking processes (Supovitz, Mayer & Kahle, 2000). Deskins (2012) also states that inquiry requires students to pose questions, seek for answers, and set a bridge to existing knowledge instead of collecting facts. It suggests that students should investigate information through materials and problem solving instead of memorization of content.

Inquiry-based instruction is not a new idea in that its theoretical roots have been constructed on beliefs of theorists such as Lev Vygotsky, John Dewey and Jean Piaget (Doolittle & Camp, 1999). These theorists contributed to the improvement of inquiry-based instruction although their philosophies of learning sometimes contradict with each other. For instance, considering the role of the teacher, Vygotsky supports the idea that a teacher is more like a mentor, while Dewey supports the idea that he/she is more a facilitator as commonly accepted by the inquiry-based instruction approach. On the other hand, philosophies of Dewey, Vygotsky and Piaget settle on that the goal of inquiry-based instruction is cognitive development in a social context. According to the inquiry-based instruction approach, knowledge is built by means of the cooperation of individuals and the society, where language has a central impact on the development of knowledge (Vygotsky), and through experience and reflection on these experiences (Piaget). Therefore, it can be concluded that the inquiry-based instruction method supports the understanding or construction of new knowledge upon current knowledge, concurrent with personal interest and experience in a social interaction within the real world (Dewey).

Grounded on this theoretical framework, curriculum developers attempted to improve their current curricula in terms of objectives and activities to address and encourage scientific inquiry (Abd-El-Khalick et al., 2004). Examining the countries which are successful in science and their educational programs, researchers pointed out the significance of inquiry-based instruction grounded on constructivism (Tatar, 2006). In this respect, there has also been a revolution in the middle school mathematics curriculum in Turkey to move from a didactic model (i.e, instructor-centered) to a constructivist model (i.e., learner-centered) (MoNE, 2005). In other words, pedagogies covered by the curriculum were changed from behaviorism to constructivism with this curricular reform. In the year 2005, a constructivist mathematics curriculum supporting the inquiry approach as a skill was designed to entail learning activities with various opportunities for developing students' critical thinking skills while working on tasks and constructing problem-solving solutions. This new curriculum focuses on exploration, communication and conceptualization through activities enriched with concrete materials instead of traditional methods, while the previous curriculum was based on a set of facts, formulas and procedures requiring memorization. Inquiry skills mentioned in the curriculum involve asking scientifically meaningful and appropriate questions, planning of procedures and materials to solve problems, guessing the results of problems, considering unexpected situations, testing results and justifying their explanations (MoNE, 2005). With the revision of this curriculum in terms of the content of learning areas considering teacher reflections, the current middle school mathematics curriculum was revised in the year 2013 in line with the goals of inquiry in education.

As it is emphasized in the curriculum, inquiry-based instruction promotes students to express their ideas, create solutions, share their ideas, extend them through argumentation and revise them. Thus, inquiry-based instruction is used here as a broad umbrella term to identify strategies related to learning that are driven by a process of inquiry. For an extensive exploration and understanding of the underlining strengths of the qualities of inquiry-based instruction, the National Research Council reported that inquiry-based instruction has five features that can be applied across all grade levels (NRC, 2000). The first feature is that the *learner engages in scientifically oriented questions* (p. 24). Scientifically oriented questions play a crucial role in an inquiry-based instruction setting. Scientists emphasize two major scientific question types, which are “why” and “how” questions (Malley, 1992). Students generally tend to ask “why” questions, such as “Why do some rocks contain crystals?”. However, many “why” questions cannot be explained scientifically. Instead of “why” questions, “how” questions are advised to narrow and sharpen the inquiry and to contribute to its scientific nature. These questions may be posed by the teacher, the learner, the instructional material, or other sources. Teachers have a significant role in guiding the explanations given as a reply to these questions, especially when they come from students. The quality and efficiency of inquiry-based instruction depend on meaningfulness and relevance of questions in that they must be interesting and open to investigation (NRC, 2000).

The second feature of inquiry-based instruction is that *learners give priority to evidence, which allows them to develop and evaluate explanations that address scientifically oriented questions* (p. 25). The difference between science and other disciplines is the use of empirical evidence to explain the phenomena in the natural world. It is essential to gather accurate data through observations, investigations and measurements, such as observations of animals, organisms, rocks or measurements of distance, magnitude, or time. Students obtain evidence from the real life setting or from the teachers, the instructional material or other sources (NRC, 2000).

The third feature is that *learners formulate explanations from evidence to address scientifically oriented questions* (p. 26). Although this feature is parallel to the previous one, it is constructed on the previous feature in that it draws attention to the importance of gathering explanation according to evidence rather than the importance and features of evidence. Students come up with explanations based on reasons and evidence by establishing cause and effect relationships. Explanations are also a means to gain insight into unclear information by establish relationships with observations and existing knowledge. Thus, explanations enable students to go beyond previous knowledge and construct new knowledge (NRC, 2000).

The fourth feature of inquiry-based instruction is that *learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding* (p. 27). Students may review explanations by engaging in dialogs, comparing their results or having the results confirmed by instructor or teaching materials. The key point of that feature is constructing a bridge between their findings and scientific knowledge applicable to their grade level. Thus, the explanations of students must definitely be parallel to current scientific knowledge (NRC, 2000).

The last feature of inquiry-based instruction is that *learners communicate and justify their proposed explanations* (p. 27). This feature is constructed on the communication between the scientist and his/her explanations in that it requires clear circulation between the question, evidence, procedures and review of alternative explanations and poses new questions for other scientists to work on. Giving students a chance to share their results and explanations provides others with the opportunity to pose questions, discuss and make connections to current scientific knowledge. That is, students can overcome contradictions based on classroom discussions (NRC, 2000).

Therefore, the processes of posing scientific questions, gathering evidence, formulating, evaluating and communicating explanations play a significant role in inquiry-based instruction settings.

Although features of inquiry-based instruction are explained within the content of science especially in terms of examples set on scientific phenomena, they are also valid to be applied in mathematics education. As in scientific inquiry, mathematical inquiry is also encouraged by questions arising from real life with the purpose of understanding the natural, social and cultural world (Artigue & Baptist, 2012). Instruction which starts with a certain problem or experiment goes beyond engaging students in hands-on experiments and activities to elicit explanations and evidence to the problems or experiments on which the instruction is constructed.

By offering students several skills such as questioning, exploring, observing, discovering and proving (Artigue & Baptist, 2012), inquiry-based instruction encourages students to be creative during problem solving and to take risks in mathematics (Perez, 2000). According to Haury (1993), inquiry-based instruction has positive influence on students' performance in and attitudes to science and mathematics. Saunders-Stewart et al., (2012) also emphasize that inquiry-based instruction enhances students' achievement, knowledge application, thinking and problem-solving skills, and their attitudes towards learning. This instruction method does not only affect achievement and attitude, but also fosters learners' motivation towards learning independently and their self-confidence (Aulls & Shore, 2008). Malone (2008) also emphasizes the benefits of the inquiry-based model postulating that it enhances self-efficacy, confidence, and independence of the learners. Many studies were conducted related to inquiry-based instruction and its relation with the achievement, attitude and self-efficacy of students. These studies are presented under the relevant subtitles.

2.2.1 Effect of Inquiry-Based Instruction on Achievement

It has been stated in the literature that inquiry-based instruction has an effective feature to improve the achievement of learners along with the satisfaction level of teachers when inquiry environments are prepared appropriately (Thompson, 2009). Numerous papers, theses and books have been published to investigate the effectiveness of inquiry-based instruction on studnets' achievement both in Turkey (Akpullukçu, 2013; Altunsoy; 2008; Çalışkan, 2008; Çelik, 2012; Fansa, 2012; Göksu, 2011; Kula, 2009; Sağlamer-Yazgan, 2013; Sakar, 2010; Sarı & Bakır-Güven, 2013; Sever & Güven, 2014; Tatar, 2006; Türkmen, 2009) and in other countries (Abdi, 2014; Ferguson, 2010; Johnston, 2014; Maxwell, Lambeth & Cox, 2015; Njoroge, Changeiywo, & Ndirangu, 2014; Taylor & Bilbrey, 2012).

In Turkey, the studies related to the effect of inquiry-based instruction on achievement have been conducted in various disciplines such as science, chemistry, and biology. In a study carried out by Sakar (2010), the effect of inquiry-based chemistry education on 9th grade students' chemistry achievement levels were investigated. In her study, the researcher used a pre-test and post-test research design with control (n=26) and experimental (n=28) groups. After an eight-week instructional period, the post-test scores were measured through an Academic Achievement Test and were then examined. The results revealed that there was a significant difference between students' achievement scores in favor of the experimental group that had received inquiry-based instruction.

Altunsoy (2008) also conducted a study to examine the impact of inquiry-based education on the achievement scores of 9th grade students this time in a biology course. She also conducted a pre-test and post-test research design with control (n=17) and experimental (n=19) groups to implement regular instruction and inquiry-based instruction, respectively on the unit of "The Fundamental Unit of Life: Cell". According to the results of the post-tests measured through the Academic Achievement Test, students in the experimental group, who received the inquiry-based instruction for nine weeks in the biology course, were found to have significantly higher scores than the students in the control group.

Another study was conducted by Çalışkan (2008) on the efficiency of inquiry-based instruction on achievement and retention degree of the knowledge of 7th graders in the unit of "Conquest of Istanbul and its Aftermath" in a social studies course. In this study conducted by means of a pre-test and post-test research design with control (*n*=30) and experimental (*n*=30) groups, the treatment was inquiry-based instruction. This inquiry-based instruction in the classroom started with an interesting phenomenon or anecdote or a quotation and forced the cooperative student groups in the classroom to brainstorm to reach a decision regarding what equipment or tool they needed. The instruction was also moved out of the classroom, to libraries, to the home or the internet environment. Reporting the results gathered by their inquiry, students studied in an inquiry-based instruction environment subjected to a hidden curriculum for 5 weeks. According to the analysis of the data collected through the achievement test, the researcher concluded that using the inquiry-based instruction method in a social studies course had a positive impact on the students' academic achievement levels and their degrees of knowledge retention in comparison with traditional learning approaches.

In addition to these studies in various disciplines, it has been observed that most of the studies in the accessible literature were conducted to investigate the impact of inquiry-based instruction in science education. For instance, Akpullukçu (2013), Sağlamer-Yazgan (2013), Sever and Güven (2014), and Tatar (2006) conducted their studies with 7th grade students in different districts separately to apply their inquiry-based instruction setting requiring supplementary materials that provided students with extra practice in computational and procedural skills in the science lessons of the experimental groups, while they used the teacher-centered descriptive methods in the control group. The statistical data analysis results revealed that the mean scores of the experimental group showed significantly greater increase than those of the control group. That is, the the findings revealed that the use of the technics practiced in an inquiry environment in science and technology was beneficial in increasing the academic achievements of 7th grade students.

Studies carried out in science courses are not limited to 7th graders; there are also other research studies conducted with 5th and 6th grade students. Çelik (2012) and Kula (2009) conducted an experimental research with 6th graders to observe the effect of inquiry-based instruction designed according to the elementary science education curriculum renewed in 2005 and enriched with the inquiry approach. According to the pre-test and post-test scores gathered from both experimental and control groups members, it was reported that students' mean scores of pre-test and post-test in both the control and experiment groups significantly increased (Kula, 2009); however, the increase of mean scores belong to the experimental groups was greater than those belong to the control group (Çelik, 2012; Kula, 2009).

In this respect, studies related to the consequence of the inquiry-based instruction method on 5th grade students were studied in different districts by Türkman (2009) in the unit of "The Earth, Sun and Moon" and by Fansa (2012) in the unit of "Matter and Its Properties". In the instruction implemented to the experimental group, Fansa asked the students to use a diary to report their inquiry and observations through the experiments conducted collaboratively according to the explained inquiry steps on the related subjects. On the other hand, Türkman (2009) prepared an inquiry-based instruction enriched with educational technologies to improve observation abilities, use simulations or experiences of professional training, encourage students' cooperation, foster student-directed learning, inspire self-regulating study and foster reflection in the experimental group, while the control group was exposed to a teacher-directed traditional instruction. Using a pretest and posttest experimental design, both researchers found out that, at the end of the analyses of scores gathered from their achievement tests on related units, using an inquiry approach had a positive impact on the students' achievement scores.

In addition to these studies conducted on students, some researchers studied with pre-service teachers in Turkey to investigate the influence of inquiry-based instruction. For instance, Göksu (2011) studied with pre-service science teachers to investigate their misconceptions about force and motion and to overcome these misconceptions through inquiry-based laboratory instruction and to examine the relationships between achievements, misconceptions, and epistemological beliefs. The findings of this pre-test and post-test semi-experimental study revealed that inquiry-based instruction has a meaningful effect on preservice science teachers' achievement,their overcoming misconceptions about force and motion, and their epistemological beliefs.

In another study, Sarı and Bakır-Güven (2013) studied with prospective teachers in two different classes of modern physics courses in the Department of Science Education in Kırıkkale University. The purpose of the researchers was to reveal the impact of interactive whiteboard supported inquiry-based instruction method on students' level of academic achievement and to investigate their level of motivation in teaching modern physics. In this pre- and post-test control groups design, data were collected by means of academic achievement tests and a motivation scale. The treatment implemented to the experimental group was an inquiry-based instruction method enriched with activities such as simulations, videos and animations supported with the interactive white board, while the traditional instruction method was implemented in the control group. Therefore, the experimental group had the advantage of technology support in procedures of orienting and posing questions, identifying problems, generating hypothesis, testing and planning and the advantage of simulations in lessons supporting measuring, sketching graphs, monitoring the variables and interpreting data. The study reported that the application of an inquiry-based instruction significantly increased students' level of motivation and academic achievement. Furthermore, prospective teachers were also found to develop positive opinions regarding the features of an inquiry-based instruction such as providing an entertaining lecture environment, making abstract concepts more concrete, and facilitating the learning.

In conclusion, it can be seen that there are a considerable number of studies conducted in Turkey to investigate how inquiry-based instruction affect both students' and preservice teachers' achievement in various disciplines except mathematics, such as social studies, chemistry, and science courses. All of these studies proved that this instruction method increases learners' level of achievement. In addition to the studies in Turkey, related literature was also reviewed for studies conducted in other countries, and it was found that the effect of inquiry approach on the achievement of elementary, middle and secondary school students was also investigated in various countries.

In one of these studies, Abdi (2014) worked on the impact of the inquiry-based instruction on students' achievement levels in science course with 40 fifth grade students from two different classes selected through purposive sampling method. For eight-weeks, the experimental group was exposed to the inquiry-based instruction. This instruction was supported by 5E learning cycle including education through activities and lesson plans prepared to increase students' active participation in instruction, whereas the other group received traditional instruction. To be able to test the effect of the inquiry-based instruction compared to the traditional instruction, a 30-item achievement test in science was completed by the students in both groups before and after the treatment. The results gathered through ANCOVA showed that the students who received science education in accordance with inquiry approach supported with 5E learning cycle in the experimental group got higher scores than those in control group who were instructed through traditional methods.

In another study conducted with 5th grade students, Maxwell, Lambeth and Cox (2015) investigated the influence of inquiry-based instruction on achievement levels and engagement in the science course. They also used the pretest and posttest experimental design in their study. The students in the control group were guided by the instructor who used the step-by-step process of structured learning experiences and provided information and definitions of terms related to the standards of the unit and the materials needed for experimentation, which were conducted again via step-by-step instructions. On the other hand, students in the experimental group were provided informational reading and posed a question or problem to investigate the solution. They worked independently of the instructor's guidance, they engaged in critical thinking while solving the questions, they carried out discussions with group members, and they made decisions about which steps to follow to arrive at a solution. At the end of the six-week instruction, the posttest results were analyzed and it was concluded that students in the experimental group that was subject to the inquiry-based instruction scored higher than those in the traditional group in terms of academic achievement; however, the difference between scores of the students in both groups was not found statistically significant.

From a different perspective, Taylor and Bilbrey (2012) analyzed the effectiveness of traditional and inquiry-based instruction in 5th grade science and mathematics courses at a school in Alabama. This school changed the science and mathematics education programs for a period of 3 years so that during first three years, teacher-directed instruction was employed, and while during the following three years, inquiry-based instruction was employed. The data for both mathematics and science were collected through the subtests of SAT-10 applied to the students in each school term. The performance scores of the students who were administered teacher-directed instruction and inquiry-based instruction was analyzed in terms of subgroups of gender, skin color, and economic status. Based on the results in mathematics achievement, it was concluded that inquiry-based instruction in mathematics was effective in increasing students' mathematics achievement scores for certain student subgroups, particularly black students. Moreover, the results related to the science scores revealed that inquiry-based science instruction significantly affected the achievement of student subgroups, particularly black students, female students, and students living in poverty.

Another study related to the effect of inquiry-based instruction in elementary school was conducted by Johnston (2014). The researcher compared the instructional practices of the inquiry-based instruction method in elementary mathematics classrooms to those in regular mathematics instruction. Four-hundred and sixty-seven students from 24 classrooms participating in the study; 113 (24%) of the participants constituted the experimental group and received inquiry-based mathematics instruction using the Pearson's Investigations curriculum, while 354 (76%) of the participants made up the control group and received traditional mathematics instruction using the MacMillan McGraw-Hill's Math Connects curriculum. Data collected by means of a mathematics achievement test and a word-problem assessment were analyzed to compare students in the experimental group and those in the traditional group. Students' scores were assessed by a team of teachers using a rubric which made assessments based on the given correct answer and the methods of solution to the question using more than one problem solving strategy. At the end of the study, it was found through the mathematics achievement test that there was no statistically significant difference between the scores of students in the experimental group and those in the control group. However, the findings showed that the students instructed with the inquiry-based curriculum showed statistically significant increase in terms of gains in scores over the students instructed with the traditional mathematics curriculum on the math word-problem assessment.

In addition to the studies conducted in elementary schools, the related literature also includes some studies that selected their participants from middle and secondary schools. For instance, Ferguson (2010) evaluated the information obtained from two 8^{th} grade classrooms in a middle school where one of the classes was implemented inquiry-based mathematics instruction as the experimental group, while the other one was implemented traditional mathematics instruction as the control group. The data were collected before and after each of the two units of study through an achievement test related to the units. Analysis of the data showed that both the experimental and control groups had made progress after instructions for both units. However, in the second unit, the experimental group that received inquiry-based instruction showed a significantly higher level of improvement than the control group.

Other than those conducted in elementary and middle schools, another study examined the influence of inquiry-based instruction on the students in a secondary school. In their study, Njoroge, Changeiywo, and Ndirangu (2014) aimed to find the influence of inquiry-based instruction on students' achievement in physics in Nyeri County in Kenya. They used a quasi-experimental design and stratified random sampling to select four boys and four girls from secondary county schools in Nyeri County. Three hundred and seventy students were involved in the study in which those in the experimental groups an inquiry-based instruction was implemented while those in the control groups regular instruction was implemented using teacher demonstrations and lecture methods using the same physics content across groups. The data related to the physics achievement of the students was collected through the Students' Physics Achievement Test (SPAT). At the end of the four-week study, the analysis of the data showed that the inquiry-based instruction method resulted in significantly higher achievement student scores in physics for the experimental group.

In conclusion, there are many studies in literature conducted on the effect of inquiry based-instruction both in Turkey and other countries. All these studies revealed that inquiry-based instruction increases the achievement levels of students on related content in many areas such as chemistry, mathematics, physics, and biology. As can be seen through the literature, most of the studies were related to science and its branches such as biology and physics. However, studies related to mathematics education are limited; hence, it cannot be evaluated whether it is effective for mathematics success or whether it is used in Turkey or how to apply inquiry-based instruction in mathematics so that it can help students to be more successful. Thus, the literature was found to be weak in this respect. Consequently, further studies need to be conducted on the influence of inquiry-based instruction in mathematics.

In this section, the literature related to the effect of inquiry-based instruction on achievement was reviewed in detail. However, studies are not limited to the benefits of this instructional method in terms of achievement. There are also other studies conducted on the effect of this method on the affective domain such as attitude and self-efficacy. In the following sections, studies related to attitude and self-efficacy are reviewed.

2.2.2 Effect of Inquiry-Based Instruction on Attitude

When studies related to inquiry-based instruction are reviewed, it can be observed that researchers have been interested in the impact of the inquiry approach on the affective domain of students, such as their attitude. In this sense, there are many studies related to the influence of inquiry-based instruction on the attitude of students in both national (Akpullukçu, 2013; Altunsoy; 2008; Çalışkan, 2008; Çelik, 2012; Fansa, 2012; Kula, 2009; Sakar, 2010; Tatar, 2006; Türkmen, 2009) and international literature (Gibson & Chase, 2002; Laipply, 2004; Lord & Orkwiszewski, 2006; Roster, 2006; Supovitz, Mayer & Kahle, 2000; Wilkins, 2008).

In Turkey, there are many studies directed to examine the impact of inquiry-based instruction on the attitude of the students towards the related course. In this sense, researchers planned their study with students in different courses. While they were interested in the effect of inquiry-based instruction on achievement in the related course as mentioned in the previous section, some Turkish researchers also applied an additional test to measure the attitude of the students towards the related course. These tests were "Attitude Scale toward Biology" by Altunsoy (2008), "Attitude Scale Toward Social Studies" by Çalışkan (2008), "Attitude Scale toward Chemistry" by Sakar (2010), and "Attitude Scale towards Science and Technology" by Akpullukçu (2013), Çelik (2012), Fansa (2012), Kula (2009), Tatar, (2006), and Türkmen (2009). All these researchers investigated the impact of inquiry approach on students' attitudes toward related courses, and their findings revealed that inquiry-based instruction has a positive influence on students' attitudes toward the course.

In addition to the studies in the Turkish literature, there are also several studies in the international literature. One of them is the study conducted by Gibson and Chase (2002) to examine the long-term influence (from 1992 to 1994) of a 2-week inquiry-based science camp entitled Summer Science Exploration Program (SSEP). The purpose of this camp was to increase the level of interest of middle school students towards science and scientific careers. Stratified random sampling procedures were used to choose 152 students from a pool of applications to attend the camp and to select 22 of these participants for follow up interviews. Thirty-five students who applied for SSEP but were not accepted (the control group) and seventy-nine students accepted for SSEP were administered the Science Opinion Survey and the Career Decision-Making Revised Surveys as pretest and posttest. The scores gathered through the surveys were analyzed to examine for any significant change over time. The interviews and surveys showed that the SSEP students had more positive attitudes towards science and higher interest in science careers than those in the control group.

Beside middle school students, college students have also been the subject of other studies to measure the effect of this inquiry-based instruction method. In this sense, Laipply (2004) initiated her study in the light of the outcome stated by research studies that attitudes toward science are associated with future acceptance in science courses, decision of major in college, and even career. The researcher found that it was significant to survey the influences of these affective domains and other aspects which influence the undergraduate science experience. Thus, she conducted her study in the introductory college science class with college students who were trained to be science teachers and scientists in the future. The goal of the study was to observe the effect of an inquiry-based biology laboratory on students' attitudes toward science. The participants were selected from an urban public university and data was gathered during a fifteen-week laboratory section by means of participant observations, interviews, and the Test of Science-Related Attitudes administered three times. The analysis of the data showed that the inquiry experience increased students' level of positive attitudes toward science. Moreover, it was concluded that group collaboration and student communications with the teaching assistant facilitated the inquiry-based instruction process and the growth of positive attitudes.

From another perspective, Roster (2006) claimed that few studies had been directed at the rural community college level, where many students, including many would-be educators, chose to take their introductory science courses, while many conducted to show the impact of such pedagogies at universities and four-year colleges. For that reason, he examined whether inquiry-based instruction used in universities to increase student attitudes and science reasoning can also have a positive impact on students in a small, rural community college. Data related to attitudes and scientific reasoning of the students were collected through pre-tests and post-tests. Three different settings were administered as completely traditional classes, traditional lectures with inquiry labs and inquiry lectures with lab components. According to the analysis results, it was found that in traditional classes, students' attitudes decreased while their scientific reasoning did not change. In classes of traditional lecture with inquiry labs, students' attitudes increased, but scientific reasoning did not change. Finally, in the classes of inquiry lecture with lab components, although students' attitudes remained unchanged, their scientific reasoning increased. Based on these findings, the researcher concluded that inquiry-based instruction can effect community college students positively. Moreover, using three different measures provided evidence to allow for a more complete picture of the effects of inquiry-based instruction.

In addition to the studies conducted by Laipply (2004) and Roster (2006) with college students, Lord and Orkwiszewski (2006) also planned their study on college students having biology classes. Participants were enrolled in either experimental and control groups but their background in terms of SAT scores in science and mathematics, college major, year of graduation, and the number of science and math courses they had previously completed was not significantly different. Students in the control group were administered written directions and a laboratory handbook to follow. Although they worked in groups in the labs, they completed a lab report each week individually. On the other hand, students in the experimental group were administered an inquiry-based instruction which enabled them to be active in manipulating their own experiments in small, cooperative learning teams. The participants of this group had advantages of cook-book procedures instead of page-long directions, testing their explanations with concrete real materials and evaluating their explanations through classroom discussions. All the participants were administered a Science Attitude Survey and an Integrated Processing Skills test. According to the analysis results, it was found that the students in the experimental group developed greater attitude towards science, while the students in the control group revealed no difference. Moreover, the students in the experimental group in which attendance, eagerness, and curiosity in the labs were more evident were better prepared to deal with science problems than those in the control group.

The studies in the international literature are not limited to the students; there are also other studies investigating the teachers' attitude toward inquiry-based instruction approach (Supovitz, Mayer, & Kahle, 2000; Wilkins, 2008). To begin with, Supovitz, Mayer and Kahle (2000) examined the influence of professional development programs on mathematics and science teachers. These programs offer skills and knowledge necessary for teachers to alter their teaching strategies, and improve their leadership to change their schools and district. Through the longitudinal data collected with surveys, the influence of a professional development program on teachers' attitude towards inquiry-based instruction, their ability to use strategies related to inquiry, and their experiences of using inquiry in classroom were modeled. The results significantly showed that teachers' attitudes, preparation, and practices significantly increased. Moreover, these gains were persistent over several years after their involvement. The researchers also emphasize the importance of the standards-based systemic reform to have a dominant and continued influence on teachers.

In another study, Wilkins (2008) studied with 481 in-service elementary teachers. The researcher examined their mathematical content knowledge, attitudes toward mathematics, beliefs in the efficiency of inquiry-based instruction, use of inquiry-based instruction. Moreover, the relationships between these variables were also modeled. Participants attended a professional development project related to employment of NCTM standards-based mathematics program. The results of the survey applied to the teachers revealed that upper elementary teachers (Grades 3–5) had better content knowledge and more positive attitudes toward mathematics than primary teachers (Grades K-2). On the other hand, primary teachers were observed to use inquiry-based instruction more frequently than upper elementary teachers. Furthermore, it was revealed that teachers' content knowledge was negatively related to beliefs in the efficiency of inquiry-based instruction and their use of inquiry-based instruction in classrooms. However, a positive relationship was found between teachers' attitudes toward mathematics and both believe in efficiency of inquiry-based instruction and frequency of using it for teaching in classroom.

In conclusion, many studies associated with the effects of inquiry based-instruction on attitude have been found to be conducted in both national and international contexts. Moreover, all these studies revealed that inquiry-based instruction increases the attitudes of students towards the related courses, such as chemistry, physics, and biology. In addition, there are studies conducted to examine the attitudes of science and mathematics teachers towards inquiry-based instruction which concluded that teachers' attitudes towards this approach can be increased with professional development programs. As it is seen through the literature, most of the studies were related to science and its branches, such as biology, physics, and science. However, the studies related to the mathematics education are limited; thus, it cannot be evaluated whether it is effective on attitude toward mathematics and geometry. In this sense, there were gaps in the literature. Hence, studies need to be carried out to explore the influence of inquiry-based instruction on attitude towards mathematics.

In this section, the literature related to the effects of inquiry-based instruction on attitude was reviewed in detail. However, the studies are not limited to the benefits of this instructional method in terms of attitude as an affective domain. There are also other studies conducted on the effect of this method on another affective domain, namely self-efficacy. In the following sections, studies related to self-efficacy are reviewed.

2.2.3 Effect of Inquiry-Based Instruction on Self-Efficacy

Self-efficacy is defined as *perceived ability or a belief in one's personal capabilities or performance in a particular future task* (Bandura, 1986, p.391). These perceived properties are developed as being based on past actions or experiences on the same or similar task. Self-efficacy is not a static disposition, so it can transform into new experiences or events (Bandura, 1986). Bandura (1997) believed that students construct their self-efficacy beliefs through four main sources. *Performance accomplishments* which refers to being successful or unsuccessful in performing a task is the most effective source to increase self-efficacy. After they complete performing a task, students evaluate their performance. Their interpretations determine increase or decrease on their self-efficacy. Students' self-efficacy beliefs are also influenced by *vicarious experience*, or performance of others. When students observe that their peers manage a task well, they also believe that they can succeed. On the contrary, when they see that their peers failed in completing the task, they tend to think that they will fail as well. *Social persuasions* are another source that refers to feedbacks from others related to students' performance. Students' self-efficacy may change through encouragement or discouragement of others such as friends, teachers and parents. Final source of self-efficacy is related to *emotional and physiological states*. Students' emotional responses such as anxiety, mood, and tiredness may affect their beliefs in their capabilities in completing a given task. These four theoretical sources of efficacy increase or decrease a person's expectation of mastery and influence the way people feel about a specific task and their performance on the task (Bandura, 1997). Bandura (1997) also conducted several studies related to teacher behavior and explained that teachers with high sense of self-efficacy have more desire to teach, make efforts to inspire and encourage students through guidance. On the other hand, teachers with low self-efficacy are less inspired to spend time and effort for teaching and encouraging students.

In this respect, a significant amount of research has also been conducted and it was found that well-designed courses can have powerful effect to increase degree of self-efficacy (Watters & Ginns, 1995). Numerous studies are reported on the influence of inquiry-based instruction on self-efficacy in both national (Kocagül, 2013; Özdilek & Bulunuz, 2009; Usta-Gezer, 2014) and international literature (Laipply, 2004; Roster, 2006; Thrift, 2007; Tuan, Chin, Tsai & Cheng, 2005).

In the national literature, various studies were conducted on the self-efficacy belong to pre-service and in-service teachers. For instance, Usta-Gezer (2014) aimed to explore the impact of Reflective Inquiry-Based General Biology Laboratory practices on the laboratory self-efficacy perceptions, the biology laboratory concerns, the critical thinking tendencies and the science process skills of preservice science teachers at a state university. In the General Biology II Laboratory Course, the units of "Photosynthesis, "Respiration" and "Germination" were taught by the researcher for a period of eight weeks in both experimental (*n*=30) and control (*n*=36) groups. The treatment administered to the experimental group included activities designed by the reflective inquiry-based instruction approach enriched with 5E model. The results revealed that laboratory self-efficacy perceptions, critical thinking tendencies, scientific process skills and reflection skills significantly increased by means of the approach of the reflective inquiry-based instruction.
Similarly, Özdilek and Bulunuz (2009) also examined the effect of a guided inquiry instruction for teaching science on the self-efficacy beliefs of elementary pre-service teachers. A pretest and posttest single group research design was conducted to study with pre-service elementary teachers. A hundred and one pre-service teachers that were registered to a science laboratory course completed the Elementary Science Teaching Efficacy Belief Instrument (STEBI) before and after a fourteen-week science laboratory course. The laboratory course was prepared according to the guided inquiry-based instruction method enriched with activities relying on the use of science process skills such as collecting necessary knowledge from the library or internet, deciding on the required materials, addressing scientific processes, posing questions, discussing, and making connections with real life. The results of the study revealed that the participants' efficacy expectations and outcome expectations on the posttest scores were greater than their pretest scores. Moreover, it was concluded that the guided inquiry-based instruction method increases pre-service teachers' self-efficacy beliefs in science teaching.

In another setting, Kocagül (2013) used the inquiry-based instruction to influence in-service teachers' beliefs, their level of self-efficacy and their skills related to inquiry-based instruction, which are the dependent variables of the study. The researcher also examined the effect of gender and teaching experience on the dependent variables. A single group pretest posttest design was administered for the study conducted with 30 elementary science and technology teachers. The teachers were applied inquiry-based professional development practices. The results of the study showed that after working on inquiry-based professional development practices, teachers' beliefs, their level of self-efficacy and their skills related to inquiry-based instruction significantly increased. Moreover, it was found that teachers' self-efficacy towards inquiry-based instruction varied in terms of gender in favor of male teachers.

Besides the national studies, there are also international studies conducted to investigate the relationship between inquiry-based instruction and self-efficacy. For instance, Tuan, Chin, Tsai and Cheng (2005) investigated the change in the motivation outcomes of 8th grade students with different learning styles after implementing a ten-week inquiry-based instruction. Two hundred and fifty-four students in the experimental group were taught inquiry-based instruction, while 232 students were taught traditional science teaching methods. Both groups completed the students' motivation toward science learning questionnaire (SMTSL) before and after the instruction. Participants in the experimental group additionally completed a learning preference questionnaire before the instruction. Forty students with different learning styles in the experimental group were interviewed after the instruction. The results of the study showed that the motivation of the students after inquiry-based instruction increased significantly than that of the students instructed through traditional teaching. More specifically, students' learning styles determined through SMTSL showed statistically significant change. Their self-efficacy, active learning strategies, science learning value, performance goal and achievement goal increased with the influence of inquiry. Moreover, the findings did not show any significant difference between these increased learning styles after inquiry instruction.

Moreover, Laipply (2004) and Roster (2006) also investigated the self-efficacy of the college students through the Biology Self-Efficacy Survey in their studies mentioned in the previous section. These researchers applied a self-efficacy survey in addition to their attitude test. The results of both studies revealed that inquiry-based instruction had positive outcome on college students' biology self-efficacy (Laipply, 2004; Roster, 2006) and their collaborations in a group, and student communication with the teaching associate were found to assist the inquiry instruction and progress in self-efficacy (Laipply, 2004).

In another study, Thrift (2007) focused on elementary teachers' self-efficacy in teaching science. For sixteen weeks, the researcher gave lessons to the fourth grade teachers to guide them in how to teach science through inquiry-based instruction to the students. After these teachers taught about inquiry-based instruction, then they implemented this method to their students while the researcher observed the class. The teachers also completed the STEBI (Science Teaching Efficacy Belief Instrument) as a pretest and posttest to measure the effects of the procedure. The findings of the study showed that inquiry-based professional development through the use of a mentor increased certified elementary teachers' level of science teaching self-efficacy.

In conclusion, there are several studies in both national and international literature which reveal that inquiry-based instruction is an effective method to improve self-efficacy of students and teachers. However, since these studies have generally been conducted on science courses, the current studies are limited in terms of studies to show the effect of inquiry-based instruction on mathematics education. Furthermore, the studies are conducted generally with pre-service and in-service teachers. Therefore, the studies with students may give detailed information to capture a bigger picture related to the benefits of inquiry instruction.

To sum up, although the literature is rich in terms of the studies that reveal a positive impact of the inquiry-based instruction approach on achievement, attitude and self-efficacy of both students and teachers especially in science education, they are limited in terms of mathematics education. Inquiry in mathematics education enables students to develop related subject knowledge by engaging them in activities in problem situations and also develop general attitudes and behavior towards inquiry across disciplines (Artigue & Blomhøj, 2013). That is, as it is concluded that inquiry is an effective approach on achievement, attitude and self-efficacy in various courses, it is also believed that it would be valuable to use inquiry-based instruction method for teaching reflection symmetry concept in 7th grade mathematics classrooms. For that reason, the purpose of the current study is to construct an inquiry-based instructional design to investigate the effect of that design on students' achievement in reflection symmetry, attitude towards geometry course and self-efficacy in geometry. In this sense, literature and curriculum were examined and it was seen that many inquiry-based curricula are constructed on numerous resources such as models or manipulatives and realistic problems to explore a given concept (Lappin, 1995). For inquiry-based learning design, manipulative materials can be used and lessons can be shaped with activities on concrete materials. Manipulatives can be used for students to experience meaningful learning, to think and make self-explanations, and to improve their knowledge and thoughts (Battista & Clements, 1992). For the improvement of geometric thinking of students, cutting, tearing, folding, pasting, dividing, connecting and modeling techniques should be given priority (Baykul, 2002). Origami is one of the hands-on materials including these techniques. In the following section, origami and its benefits will be explained in detail.

2.3 Origami

Origami means the art of *paper folding*, a concept derived from the combination of two Japanese words: "ori" which means "to fold", and "kami", which means "paper" (Beech, 2009). The roots of origami can be traced back to China where it was called as Zhe Zhi around 100 BCE (Hull, 2008). Later, in the 6th century, it was brought to Japan, where it became popular and was considered as a Japanese art (Krier, 2007). There are two types of origami, which are traditional and modular origami (Tuğrul & Kavici, 2002). In traditional origami, a single sheet of paper is used to construct flowers, birds, fish etc. without cutting and using glue. Moreover, the initial sheet of paper should be in the shape of a convex polygon, such as a square and rectangle, which are mostly used. On the other hand, in modular origami, more than one sheet of paper which are folded in the same way is used so that they are locked together to form a larger model (Krier, 2007). Modular origami is also called as “Unit Origami” since it is constructed with the combination of unit pieces (Georgeson, 2011).

Origami is not only developed by the Japanese culture, but also improved by other cultures referring to it using different names such “papierfalten” in German, “paper folding” in English, “papiroflexia” in Spanish (Arıcı, 2012). As a result of this multicultural effect on origami, different types of origami such as kirigami emerged. Parallel to the commonly known art of origami, kirigami is known as another paper art, which is constructed by both folding and cutting a sheet of paper. In ancient times, kirigami was used to cut the symbols of great Samurai families. These paper made stencils were carried on their clothes as a sign (Melichson, 2011). For symmetric designs in kirigami, the paper is often folded before cutting and then unfolded. Sometimes folding is involved, as in “pop-up cards”. As in origami, kirigami also has the style of modular kirigami, which has symmetric assemblages of cut paper (Hart, 2007).

The popularity of origami and its other types such as kirigami, modular origami and architectural orgami has increased since the 1960s with the discovery of the mathematical aspects of these models (Krier, 2007). It was claimed that many instructional objectives can be attained with the use of origami as an activity-centered method parallel to modern learning methods. It also promotes various of learning methods such as collaborative learning, project-based learning and creative learning (Tuğrul & Kavici, 2002). In the following section, the mathematical dimension of origami used as an instructional tool is explained in detail.

2.3.1 Origami in Mathematics Education

Origami provides many educational benefits, such as behavioral skills, cooperative learning, understanding mathematics, cognitive development, multicultural awareness, and community building (Levenson, 1995). Origami enables students to learn through activities (Tuğrul & Kavici, 2002) in that students watch closely and listen carefully, which are the requirements of being successful. Moreover, cooperative learning environment through origami activities increase students' attention and interaction with peers to help each other's understanding. Working in such an interactive environment enhances students' cognitive development. Other than these properties, origami improves mathematical skills (Levenson, 1995).

Recently, origami has been accepted as an instructional and scientific tool in mathematics education by many researchers and authors (Boakes, 2008; Cornelius and Tubis, 2006; Çakmak, 2009; Golan and Jackson, 2010; Higginson and Colgan, 2001; Kavici, 2005; Pope, 2002; Robichaux and Rodrigue, 2003; Sağsöz, 2008; Tinsley, 1972; Tuğrul and Kavici, 2002) since origami has a huge mathematical potential (Higginson & Colgan, 2001). In the related literature there are several studies which were conducted on the use of origami related to different topics. For instance, origami can be helpful for the instruction of fractions with the help of crease patterns on unfolded models constructed through proportional reasoning (Akan-Sağsöz, 2008; DeYoung, 2009). Origami is also used for modeling of algebraic equations such as (a+b) and $(a+b)^2$ on a sheet of paper (Koylahisar-Dündar, 2012; Yoshioka, 1963). That is, origami supports students to learn in a concrete (Georgeson, 2011) and active, enjoyable learning environment (Olson, 1989). Although it has various features related to mathematics education, origami was mostly given place in its application to geometry topics in the literature. Origami enables students to learn the properties of triangles (Takıcak, 2012) and quadrilaterals (Dağdelen, 2012). In addition to polygons, it is also possible to construct polyhedrons, which allows students to gain knowledge on the related figure in this process (Bayraktar-Kurt, 2012; Cagle, 2009; Şimşek, 2012).

Geometry topics are not taught only by folding paper. Unfolding is also a useful method for geometry activities (Georgeson, 2011). The creases which are obtained by unfolding a paper of an origami figure presents many geometric properties.

Unfolding can help students to understand postulates such as two points constructing a line (Krier, 2007; Özçelik, 2014). Crease patterns also help to teach many topics, such as polygons, properties of polygons, angles, parallelism, symmetry, proportional reasoning, similarity, and equality of sides and angles (Canadas, Molina, Gallardo, Martinez, Santaolla, & Penas, 2010; Cornelius & Tubis, 2009; Dağdelen, 2012; Frigerio, 2009; Özçelik, 2014; Yoshioka, 1963). In this sense, origami improves students' spatial ability constructions generated by origami (Boakes, 2009; Golan & Jackson, 2010) and their problem solving skills (Boakes, 2006; Brady, 2008; Chen, 2006; Sze, 2005). Origami is also found to provide an environment which encourages higher order thinking (Sze, 2005), so students can guide their own learning.

Benefits of origami in geometry instruction is highly clear in that it also influenced the national geometry curriculum of some countries. For instance, in Israel, the program of Origametria, a word formed with the combination of two words - origami and geometry-, was employed. This program has been used by seventy schools since 2002 (Golan & Jackson, 2010). Moreover, in Turkey, as a result of the curriculum reform, origami was included in the education program. Samples of origami activities were placed in the mathematics education program for 1st to 5th grade students to increase their creativity, psychomotor and spatial abilities (MoNE, 2009a). The impact of origami on students' problem solving skills, 2D and 3D thinking, understanding abstract facts and geometrical figures in middle school is also mentioned (MoNE, 2009b). Origami did not only influence elementary and middle school mathematics curriculum, it was also emphasized in the high school geometry curriculum. In this curriculum, origami is emphasized as an instructional tool and some sample origami activities are included (MoNE, 2011).

In conclusion, there is a common idea among the researchers that origami is an effective teaching aid in mathematics education in that it helps improvement of students' abilities in intuition, problem solving, imagination and spatial reasoning. In this respect, researchers investigated the effect of mathematics instruction enriched with origami activities. In the following section, the studies related to origami will be explained in detail.

2.3.2 Origami in International Research Studies

Since folding a square is compatible with geometrical problems, many studies on origami have been conducted in the field of mathematics (Furuta, Mitani, & Fukui, 2008). Sze (2005) described the common characteristics between origami and the constructivist learning theory. It was emphasized that origami has all the characteristics of hands-on learning, higher order thinking, multimodal instruction, social learning and self-management strategies described as major characteristics of constructivism. Consequently, it can be determined that origami based activities can be used in constructivist learning environments. Moreover, paper folding entails effective mathematical usability (Higginson & Colgan, 2001) and origami helps students communicate abstract mathematical concepts concretely (Georgeson, 2011).

In this sense, there are several studies conducted on the effect of origami-based mathematics instruction. In one of them, Brady (2008) prepared a setting on origami activities varying from easy to more difficult activities in order to investigate the effect of paper folding activities in mathematics education. This study was conducted over a period of 8 weeks with 26 students in grade 5. Students were given three different activities of paper folding, which proceeded from the easiest to the most difficult. Students were asked to write a reflection paper about the related activity. These reflection papers were used to analyze the products of the activities and to categorize students' reactions. In point of cognitive skills, some of the reflections of the students were as follows: 'I learned the shapes', 'I learned 3-d shapes', 'I learned to form figures' and 'I learned that all mathematics have a pattern'; in terms of affective skills, students reflected as 'we had fun', 'we were happy' etc. and finally in terms of behavioral skills, students reflected as 'it was hard to fold perfectly at the beginning; however, we could overcome these difficulties through activities'.

Therefore, it was concluded that origami in mathematics education has a positive effect on cognitive, affective and behavioral skills.

In another study, Yuzawa and Bart (2002) investigated the impact of origami activities on children's size comparison strategies. Researchers selected twenty-four 5-to-6 year-old children from an elementary school in the United States. Children in the experimental group worked on origami activities in addition to size comparison tasks, while the others in the control group worked on only size comparison tasks for five days. The size comparison tasks including seven pairs of triangles, such as congruent pairs, symmetrical pairs, and pairs with unequal bases but equal heights. According to the findings, it was concluded that origami exercises increased the success of students in size comparison tasks throughout the five days. Moreover, it was found that origami has a positive effect on children's size comparison strategies in terms of one-on-another placement strategy.

On the other hand, Boakes (2009) investigated the effectiveness of origami activities on spatial visualization skill and achievement of 7th grade elementary students. In the study, 56 students from 7th grade were chosen as participants according to the convenience sampling method. A quasi-experimental design was used. There were 25 students in the treatment group in which students were applied instruction based on origami activities in addition to the traditional method, while there were 31 students in the control group in which students were applied instruction with only the traditional method for one month. The researcher used an achievement test including 27 questions for geometry and spatial ability. According to the achievement test scores, it was seen that the experimental and control groups had no significant mean difference in their achievement. The researcher attributed the reason underlying this result to time limitation.

To sum up, with its increasing importance, several studies were also conducted in other countries. It is believed that origami-based instruction is effective; the unexpected results are grounded on limitations such as time limitation. Although there are various studies related to origami, these studies are insufficient in respect to giving information about how an origami-based instruction is conducted or what kinds of activities should be used or which origami figures should be used for related topics. In addition to the studies in international literature, there are also national studies. They will be explained in detail in the following section.

2.3.3 Origami in National Research Studies

With its increasing importance in mathematics education for nearly all grade levels, many studies were conducted in Turkey. Most of these studies investigated, by means of experimental studies, the effect of origami-based instruction in mathematics education in Turkey.

In one of these experimental studies, Akan-Sağsöz (2008) studied the influence of origami-based instruction on the concept of fractions in grade 6. Convenience sampling was used in the study and the participants were 80 students from a school in Erzurum; an equal number of students were assigned to the control and treatment groups. The traditional instruction method based on the textbook was implemented in the control group, while lessons based on origami activities in addition to traditional instruction were implemented in the treatment group. A pretest and posttest research design was administered as an experimental setting. Whereas the scores of the two groups in the pretest were not significantly different, their scores in the posttests were significantly different. Moreover, in accordance with the scores of posttests, students provided with origami activities had significantly greater scores than those in control group. Therefore, it was concluded that paper folding practices affects students' achievement in the fractions unit significantly.

Dağdelen (2012) also investigated how origami based instruction influence students' academic achievement related to the concept of symmetry. The researcher used both quantitative and qualitative techniques for the investigation conducted with forty 7th grade students. The quantitative part of the study was conducted according to a quasi-experimental pretest-posttest design. According to the analysis results, paper folding activities in lectures have a significant impact on students' achievement score in terms of the symmetry concept in grade 7. Therefore, it is concluded that origami based instruction is more effective than the current instruction in the education program.

In her master thesis, Koylahisar-Dündar (2012) investigated the effect of origami activities on 8th grade students' constructing a relation between algebra and geometry and making sense of the mathematical identity concept and modeling these mathematical identities. A case study was conducted and the data were analyzed by means of descriptive analyses. According to the results, it was concluded that students' ability to relate algebra and geometry was increased. Moreover, making sense of the concept in their mind was supported with origami. An interesting result was also found in this study. To the question of "which concept would you like to use origami for?", the answers of the students were "prisms, pyramids and cones etc., since there are many formulas for these concepts, and origami would be useful to remember the formulas".

Özçelik (2014) also conducted a study to test the effect of origami-based instruction on students' achievement on the topic of postulates related to points and lines in geometry learning area. The researcher prepared a pretest and posttest quasi-experimental design with experimental and control groups. During instruction, origami activities were used in the experimental group, while activities in the teacher guide book were implemented in the control group. In data analysis, significant differences were observed in favor of the experimental group in terms of achievement.

In another study, Bayraktar-Kurt (2012) examined the influence of origami-based instruction on 8th grade students' ability and adequacy in two and three dimensional thinking. It was a two-stage research study. In the first stage, "The Geometric Shapes and Objects Test," which consisted of 6 open-ended questions was completed by 165 students. The responses of the participants were analyzed by means of descriptive statistics methods. In the second stage, a single group pre-test and post-test design was employed with 32 students who were implemented origami-based instruction.

This experimental group completed the Geometry Achievement Test before and after instruction. The results of the data collected in the first stage showed that students' three dimensional thinking ability was low. Achievement test scores gathered during the second stage revealed that origami-based instruction had a significant positive effect on 8^{th} grade students' geometry achievement.

Dağdelen (2012) also conducted an action research to reveal how origami practices influence 5^{th} grade students' proficiency in special quadrilaterals and to determine the impact of this change to Van Hiele levels of geometric thought. 5 students in different thinking levels were selected from 20 students who had completed the Van Hiele Geometric Test. These selected participants completed 16 open-ended questions and were subjected to clinical interview on every type of quadrilateral. After the interviews, they completed the Van Hiele Geometric Test and 16 open-ended questions. The data gathered from the clinical interviews were analyzed descriptively. The research findings revealed that origami-based instruction significantly increased the students' Van Hiele levels of geometric thought, their skills in drawing special quadrilaterals, determining essential and supplementary elements, classifying these elements' features and also associating special quadrilaterals with each other.

In addition to these studies related to the effect of origami-based instruction, there are also other studies which tested the effect of this method on the attitude of students in addition to achievement. For instance, Takıcak (2012) and Şimşek (2012) studied the effectiveness of origami-based instruction in the same way but related to different topics. Both of them concluded that origami activities have a significant effect on students' achievement and attitudes toward geometry. In another study, Çakmak (2009) conducted a study on the attitudes of 15 fourth graders, 9 from fifth grade and 14 from sixth grade from a private school in Ankara. Origami based instruction was used during ten weeks in all groups to teach geometrical shapes and their properties in her experimental design. The researcher collected qualitative data of reflection papers and conducted face to face meetings in order to understand students' attitudes. At the end of the study, 37 of the total 38 students had gained positive attitudes towards using origami as a teaching tool. Moreover, reflection papers showed that most of the students described origami as an enjoyable activity.

As can be seen, the researchers chose the students as participants of their studies. However, the national literature is limited in term of studies with teachers. In this sense, Arslan (2012) developed scales in order to measure beliefs and perceived self-efficacy beliefs towards using origami in mathematics education and then applied these scales to prospective mathematics teachers. Factor analysis related to the scales of Origami in Mathematics Education Belief Scale (OMEBS) and Origami in Mathematics Education Self-Efficacy Scale (OMESS) revealed that they were valid and reliable instruments to measure prospective teachers' beliefs and perceived self-efficacy beliefs in terms of teaching mathematics through using origami. The participants of the study were chosen from universities in three different regions of Turkey in which participants have elective origami course experience and completed these scales. The findings showed that teacher candidates powerfully believe in that origami is useful and suitable to be employed in mathematics education. On the other hand, their perceived self-efficacy belief level was a little higher than moderate level. Lastly, the researcher also investigated gender differences in these scales and it was found that female participants have a significantly greater belief and perceived self-efficacy beliefs in using origami in mathematics education than male prospective teachers.

In conclusion, the studies conducted in Turkey to investigate the impact of origami-based instruction enriched with origami activities revealed that this instruction method increases students' success and attitude toward the lessons. However, when the activities and their approach to instruction are examined, it is seen that their way of implementing these origami activities are not well appropriate according to the constructivist curriculum. During the activities, teachers showed how to fold sheets of paper and the students followed the instructions. Subsequently, they were asked to discover the mathematical idea behind this folding activity or they were directly explained. In this sense, the activities in the studies conducted in Turkey must be revised.

2.4 Summary of the Literature

The review of the accessible literature showed that the curriculum emphasizes the use of an inquiry approach, and there is evidence that inquiry-based instruction is an effective method to increase achievement (e.g., Abdi, 2014; Altunsoy; 2008; Çalışkan, 2008; Çelik, 2012; Ferguson, 2010; Kula, 2009; Maxwell, Lambeth & Cox, 2015; Sarı & Bakır-Güven, 2013; Sever & Güven, 2014), attitude (e.g., Akpullukçu, 2013; Altunsoy; 2008; Çalışkan, 2008; Çelik, 2012; Kula, 2009; Laipply, 2004; Supovitz, Mayer & Kahle, 2000; Wilkins, 2008) and self-efficacy (e.g., Kocagül, 2013; Laipply, 2004; Özdilek & Bulunuz, 2009; Roster, 2006; Thrift, 2007) especially in science education. However, studies related to mathematics education are limited to investigate its impact in mathematics. Consequently, in the present study it was aimed to examine how inquiry-based mathematics instruction affects these variables.

The related studies have been conducted in both international and national contexts to examine how inquiry-based instruction influences students' achievement, attitude and self-efficacy in various courses such as science, chemistry, biology and mathematics. All these studies concluded that this instructional method increases students' achievement, attitude and self-efficacy. When these studies are examined in terms of their context, it is seen that studies related to mathematics education are limited. That is, it is hard to evaluate whether this method is effective on achievement, attitude and self-efficacy in mathematics and how to use inquiry-based instruction in mathematics effectively. Thus, the literature is seen as weak in this sense. Moreover, especially the studies related to the effect of inquiry on self-efficacy are conducted generally with pre-service and in-service teachers. For that reason, the studies conducted with students may be given place to be able to have better idea related to impact of inquiry-based instruction. Consequently, further studies need to be conducted on the influence of inquiry-based instruction on students' achievement, attitude and self-efficacy in mathematics.

Moreover, literature review also revealed that curriculum and accessible resources are also limited in terms of inquiry activities related to mathematics topics. In the light of the information that many inquiry-based curricula are constructed on numerous resources such as models or manipulatives and realistic problems to explore a given concept (Lappin, 1995), the mathematics sources were examined and it was decided that origami would be an appropriate tool for inquiry-based instruction.

In conclusion, inquiry-based instruction is proven as a significant method for education in terms of both cognitive and affective skills. However, the studies are limited to show its impact in mathematics education. For that reason, the purpose of the current study is to examine the impact of inquiry-based instruction enriched with origami on students' achievement in reflection symmetry, geometry attitudes toward geometry and self-efficacy in geometry which is regarded as an effective and important instructional tool in both international and national mathematics education programs to fill the gap in the literature.

CHAPTER III

METHOD

The aim of this study was to investigate the effect of inquiry-based instruction enriched with origami activities on 7th grade students' achievement in reflection symmetry, attitudes toward geometry and self-efficacy in geometry. The goal of this chapter is to give detailed information about the research design, population and sample, data collection instruments, reliability and validity of the study, data collection procedure, analyses of data, assumptions and limitations, and lastly the internal and external validity of the study.

3.1 Design of the Study

This study aimed to investigate the effect of inquiry based instruction enriched with origami activities on 7th grade students' achievement, attitudes and self-efficacy regarding geometry. To this end, the quantitative research method was employed to examine the research questions. The quantitative method that was conducted was the experimental research method. In experimental research, researchers seek for the effects of at least one independent variable on at least one dependent variable (Fraenkel & Wallen, 2006). According to Fraenkel and Wallen (2006), the most important and distinct characteristic of experimental research is that "researchers manipulate the independent variable" (p.267) and this characteristic enables them to choose the nature of the treatment by means of the experiences that the subjects would undergo and also the extent of these experiences. It is further claimed that experimental research can serve beyond description and prediction and it is the most appropriate design to investigate cause and effect relationships. Therefore, in the current investigation of the effectiveness of inquiry-based instruction on students' achievement, attitudes and self-efficacy regarding geometry, a static group pretest-posttest control group design, which is a type of experimental research design, was utilized as outlined in Table 3.1. Intact groups were used; students from two already existing classes were randomly assigned to either the inquiry-based (experimental) or the regular (control) instruction group. The dependent variables were students' post-test scores gathered by means of the Reflection Symmetry Achievement Test (RSAT), the Geometry Attitude Scale (GAS), and the Geometry Self-Efficacy Scale (GSES).

Table 3.1. Research Design of the Study

Groups	Pretests	Treatment	Posttests
Experimental Group	RSAT GAS GSES	Inquiry-based Instruction (IBI)	RSAT GAS GSES
Control Group	RSAT GAS GSES	Regular Instruction (RI)	RSAT GAS GSES

3.2 Population and Sample

The target group for the study was determined as 7th grade students in public schools in Altındağ district of Ankara. The accessible population was constituted of 7th grade students in public middle schools in the Ulubey neighborhood in Altındağ. Participants of the study were selected by means of the convenience sampling method, which is a method by which the researcher studies with groups who are available for the study (Fraenkel & Wallen, 2006). The sample of this study was selected from the population of 7^{th} grade students in a public school in the Ulubey neighborhood in Altındağ. In this middle school, students were at moderate and low achievement levels according to the information supported by classroom teacher. There were two classrooms of seventh graders, including 23 (16 females and 7 males) in one and 25 students (14 females and 11 males) in the other; one of them received inquiry-based instruction and the other one – the control group - received regular instruction.

3.3 Variables

Variables of the current study were categorized as Independent Variables, Dependent Variables, and Covariates.

3.3.1 Independent Variables

Independent variable of this study was the treatment implemented. Inquiry-based instruction was used in the experimental group, while regular instruction was used in control group.

3.3.2 Dependent Variables

Dependent variables of this study were the studensts' posttest scores on the Reflection Symmetry Achievement Test, Geometry Attitude Scale and Geometry Self-Efficacy Scale which measure students' achievement in reflection symmetry, geometry attitude and self-efficacy in geometry respectively.

3.3.3 Covariate

Possible covariates of the current study were students' pretest scores on the Reflection Symmetry Achievement Test, Geometry Attitude Scale and Geometry Self-Efficacy Scale. These variables were analyzed and determined in the Determination of Covariates section statistically.

3.4 Instruments

The data collection instruments used in the present study are the Reflection Symmetry Achievement Test (RSAT), the Geometry Self-Efficacy Scale (GSES) and the Geometry Attitude Scale (GAS). These instruments are discussed in the following subsections in detail.

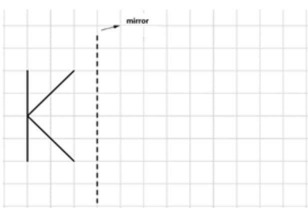
3.4.1 Reflection Symmetry Achievement Test (RSAT)

The instrument was developed by the researcher specifically to examine 7th grade students' achievement levels related to reflection symmetry concept. The instrument was consisted of ten open ended reflection symmetry problems. Two of the items were adapted from TIMMS (2011) and revised and the other items were written by the researcher. While adapting already existing problems and writing new problems, Middle School Mathematics Education Curriculum in Turkey was taken into account. There were three objectives specific to refection symmetry in 7th grade mathematics curriculum. In addition, the literature related to the topic was reviewed to be able to develop appropriate items for the instruments. Therefore, in the light of the objectives, a table of specification was prepared (See Appendix A) and the items of RSAT were developed. Each item in RSAT is explained in detail below.

The first item presented in the Figure 3.1 was developed by the researcher to measure the knowledge of students related to reflecting line segments on a plane. In the part a, students are expected to draw the reflection of letter K which is consisted of line segments. While content knowledge of students is measured in this part, in the part b, procedural knowledge of the students is measure. In this sense, students are asked to explain their strategy to reflect the given letter.

Q 1:

a) Draw the mirror reflection of the given letter of K.



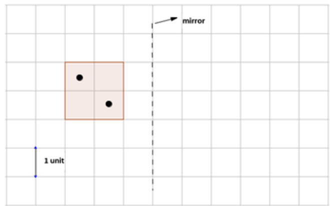
b) Explain how did you draw the reflection of the letter.

Figure 3.1. The first item of RSAT

The second item which was developed by the researcher is represented in the Figure 3.2. This item measures both conceptual and procedural knowledge of students related to reflecting points and shapes on a plane. Students are asked to reflect a shape with points on it and explain their strategy to reflect. Moreover, they are also expected to explain the relationship between the shape and its reflection to let them represent conceptual knowledge related to reflection symmetry.

Q 2:

a) Draw mirror reflection of given shape below.



b) Explain how did you draw the reflection of the shape.

c) What kind of relationship is there between the shape and its reflection?

Figure 3.2. The second item of RSAT

The third item which was developed by the researcher measures conceptual knowledge of students related to reflecting a figure placed on symmetry line. Therefore, since the national mathematics education curriculum emphasizes working on shapes which are placed on the line of symmetry, in this item the line of symmetry is given right on the shapes as it is represented in Figure 3.3.

Q 3:

Which word is obtained when the given shapes are reflected over the line of d? ....

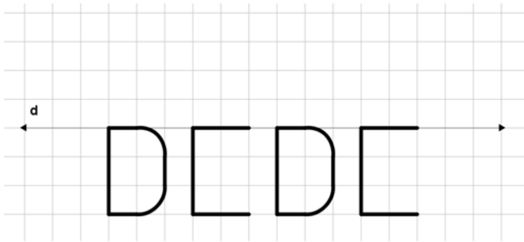
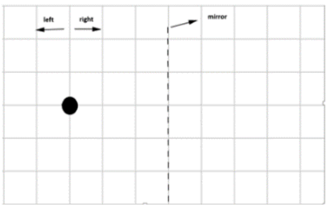


Figure 3.3. The third item of RSAT

The fourth item was also developed by the researcher to measure the conceptual knowledge of the students related to reflection of a point as in the second item. Moreover, in this item represented in the Figure 3.4, it is also measured whether students know the relationship between the point and its reflection. Students are asked to evaluate the change on the place of reflection according to the movements of the point. With the parts of b, c, and d, it was expected to have insight into students' conceptual knowledge of reflection symmetry.

Q4:

a) Draw mirror reflection of given point.



b) What is the relationship between the distance of the point to the mirror and the distance of the reflection to the mirror?

c) If the point is translated 1 unit to the right, how many units and through which side does its reflection point move?

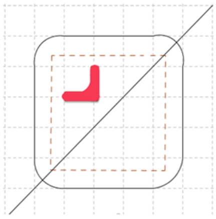
d) If the point is translated 2 units down, how many units and through which side does its reflection point move?

Figure 3.4. The fourth item of RSAT

In the fifth item which was developed by the researcher, students are expected to show their conceptual knowledge related to reflect a shape over a diagonal line. The question is constructed within a real life context to make the question more familiar to the students. When a shape can be folded into halves which match on each other, the crease of the fold represents line symmetry. Since the students are used to folding a paper, clothes etc., folding is included in the context of the question represented in the Figure 3.5.

Q5:

In the feeding time at school, Ali spilled jam to his handkerchief. When Ali folded the handkerchief over the line as shown in the figure below, jam also stained to other side.



a) Find the place that jam stained on the other side.

b) What is the relationship between the distances of two stains to the folding line?

Figure 3.5. The fifth item of RSAT

The sixth item, presented in Figure 3.6, is one of the common exercises related to reflection symmetry that is frequently seen in textbooks. It helps measure the knowledge of student regarding objects that have line of symmetry as it is emphasized in the curriculum to do exercises with the shapes which have line of symmetry on them.

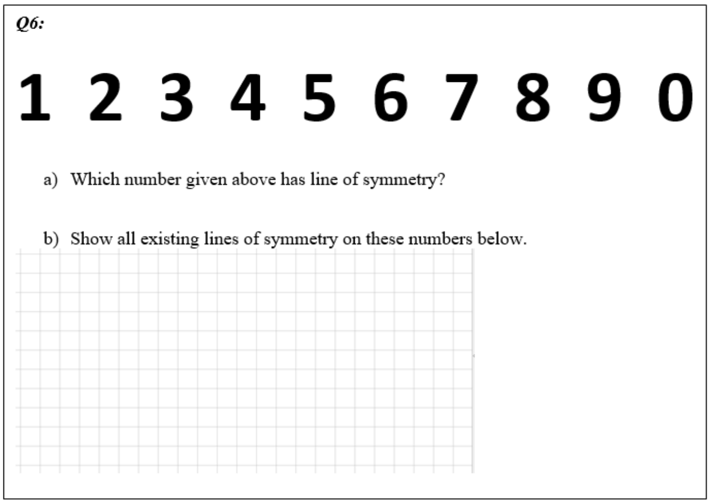


Figure 3.6. The sixth item of RSAT

The seventh item seen in the Figure 3.8 was adapted from a question in TIMMS 2011 for 4th graders which is represented in the Figure 3.7. Students are asked to complete given shape to a pentagon so that the pentagon should have a line of symmetry. Up to that point the item was adapted from TIMMS. Students are not restricted so that they are free to draw convex or concave pentagon. Moreover, in part b, students are asked to draw line of symmetry belong to shape they drawn. The purpose of this part is to have insight to the students' thinking, what kind of line of symmetry they imagine and complete the shape.

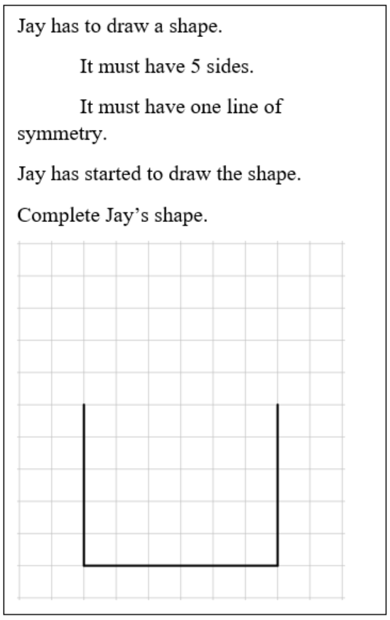


Figure 3.7. The original version of the seventh item of RSAT

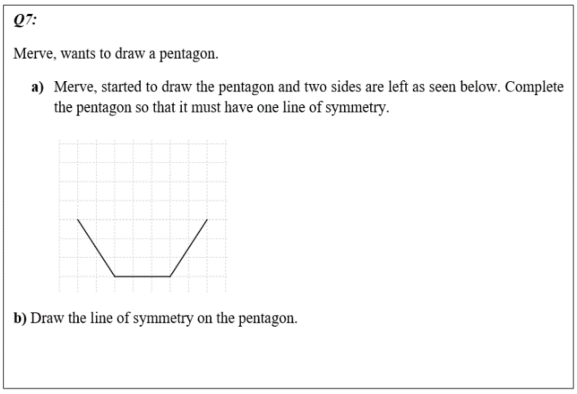
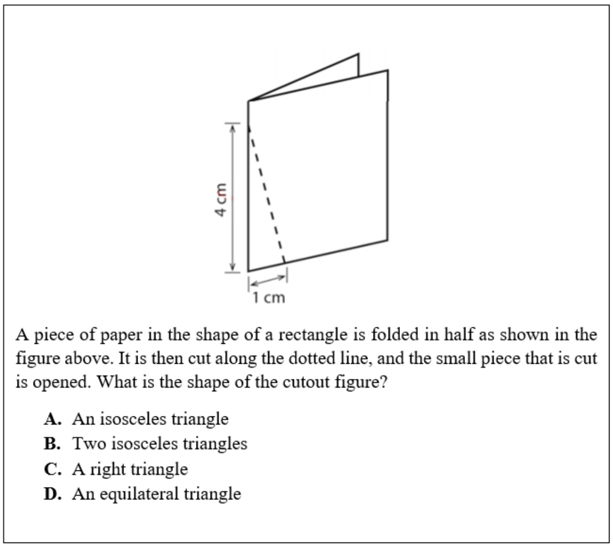


Figure 3.8. The seventh item of RSAT

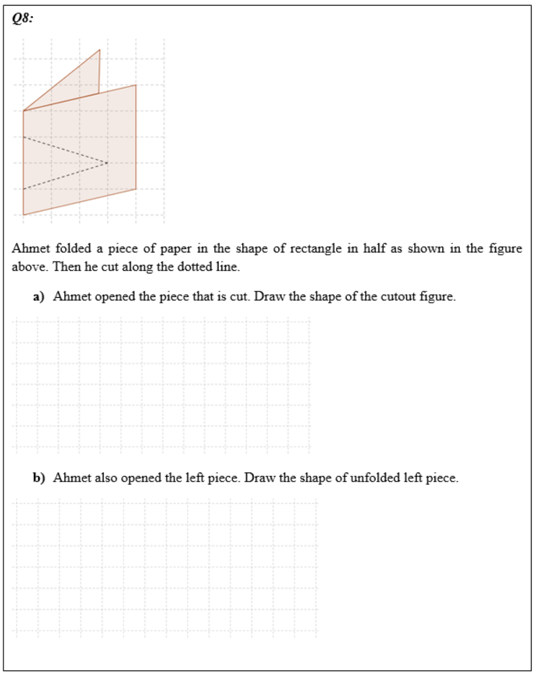
The eighth item was adapted from a question in TIMMS 2011 for 8th graders which is presented in Figure 3.9. The question is turned to an open ended question as seen in Figure 3.10. The shape of the cut out piece is changed so that lengths of the cutout figure is not given. The reason of this change is that students' knowledge on reflection symmetry concept is asked to be measured, not the knowledge of geometric shapes or spatial ability related to geometric shapes. Students were asked to focus just on the main purpose of reflecting a figure. Students are expected to imagine that the both sides of this cut out piece are equal and they are reflection of each other over the crease on which the paper was folded. In part b, students are also asked to open the left piece and apply the same procedure to this piece.



A piece of paper in the shape of a rectangle is folded in half as shown in the figure above. It is then cut along the dotted line, and the small piece that is cut is opened. What is the shape of the cutout figure?

A. An isosceles triangle
B. Two isosceles triangles
C. A right triangle
D. An equilateral triangle

Figure 3.9. The original version of the eighth item of RSAT



Q8:

Ahmet folded a piece of paper in the shape of rectangle in half as shown in the figure above. Then he cut along the dotted line.

a) Ahmet opened the piece that is cut. Draw the shape of the cutout figure.

b) Ahmet also opened the left piece. Draw the shape of unfolded left piece.

Figure 3.10. The eighth item of RSAT

The ninth item was adapted from a question in 2009 Proficiency Examination for Middle School Seventh Grade Students which is represented in Figure 3.11. The question is turned to an open ended question as seen in Figure 3.12 to measure students' knowledge of reflecting a point over given line. Moreover, the question was enriched so that students are not only asked to find the places of numbers under reflection in part b, they are also asked to decide the place of the symmetry mirror to reflect a number anywhere it is desired to reflect.

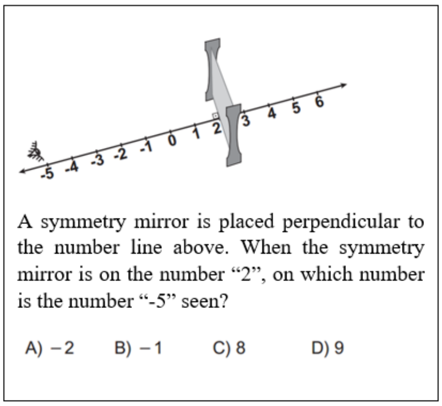


Figure 3.11. The original version of the ninth item of RSAT

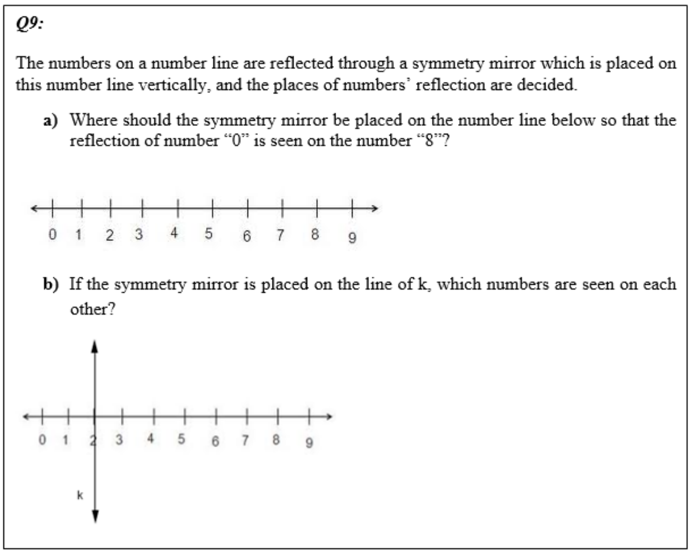


Figure 3.12. The ninth item of RSAT

The last item which was developed by the researcher is related to the patters constructed through repetitive reflections of a unit as it is seen in the Figure 3.13. The rhombus is reflected three times over the given lines. Students are expected to decide the piece which should be shaded.

Q10:

The pattern given below is created by reflecting rhombus A three times through the lines on the right of the shape. Please, specify the regions which should be shaded to complete the patter under the reflection.

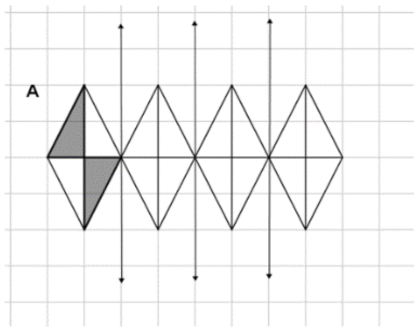


Figure 3.13. The original version of the tenth item of RSAT

Test items were constructed in the light of the studies in the literature and the table of specification. Moreover, TIMSS questions were inspiration for the researcher so that 7th and 8th items of the test were generated according to two questions published in TIMSS 2011; one constructed for 4th graders and the other for 8th graders. Validity of the items in test was checked with two experts according to objectives in the table of specification. In order to evaluate answers would be given to the test; rubric was developed with the help of expert opinions. While developing the rubric, a framework related to reflection symmetry was assigned to be able to categorize the responses. With this regard, scoring in the rubric was determined in accordance with four-level developmental approach explained by Küchemann (1993). These four levels were defined structurally as follow:

1. **Global Level:** In this level, students consider the objects as a whole and they reflect these objects without reference points like angles, vertices, sides.

2. **Semi-analytic Level:** In semi-analytic level, students reflect a part of the object first and then draw the rest of the objects by matching with original shape and size.

3. **Analytic Level:** In this level, students think fully analytically. Students reduce the objects to critical points like angles, vertices, sides, and reflect these points. Then, the images of these critical points are connected and the result is accepted as a reflection of the original object.

4. **Analytic-synthetic Level:** In analytic-synthetic level, students use both global and analytic approaches coordinately, and draw image precisely and correctly.

Students' possible responses were categorized according to these four developmental levels so that while students at global level gets lowest point, ones at analytic-synthetic level gets the highest point. A sample item and rubric belong to it is given below in Figure 3.14 and Table 3.2.

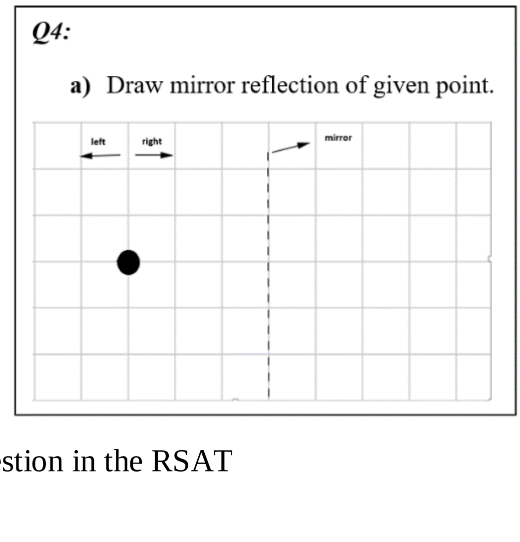
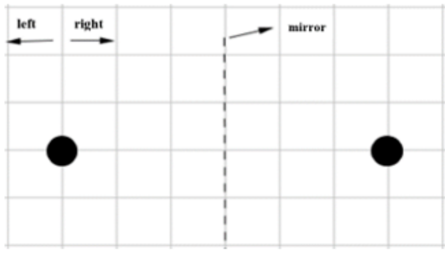
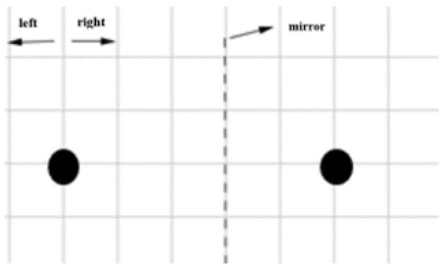
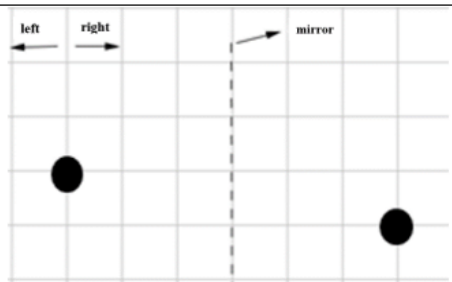


Figure 3.14. First question in the RSAT

Table 3.2. Rubric for the first part of 4th question

Points	Description
3	 • Correct reflection as same distance from the mirror with the original point and on the same horizon.
2	 • Drawing point on the same horizon with the original point, but with wrong distance from the mirror.
1	 • Drawing point with correct distance from the mirror, but not on the same horizon with the original point.
0	• Drawing point not only with wrong distance from the mirror, but also not on the same horizon with the original point. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

As it is seen on the Table 3.2, the possible responses were categorized according to their characteristics and they were scored hierarchically. The students who reflect the point correctly; same distance from the mirror with the original point and on the same horizon get the highest points. On the other hand, the students who draw the reflection not on the same horizon with the original point and with wrong distance from the mirror get any points. The critical issue is here to decide the points of the students who decide the horizon of the point correctly and the ones who decide the distance from the mirror correctly. According to the literature, the reason of the students' making mistake related to the position of reflection is that students do not consider the slope of the lines. This shows that they are still in the global level (Aksoy &

Bayazit, 2014). In this sense, it is decided that student who cannot place the point on the required horizon is in the global level. Moreover, student who decided the place of the point on the correct distance from the line are evaluated as in the higher level. Therefore, they were coded in the rubric according to this consideration. Therefore, all the items were scored according to four-level developmental approach, so that maximum score which can be get in this test is 70.

3.4.1.1 Pilot Study

The achievement test was piloted with approximately 160 students. Participants of the pilot study were chosen from Altındağ and Mamak districts in Ankara. The responses of these students were examined to modify test items and rubric according to these possible responses. According to students' responses, some of the items were detected that they required some modifications.

For instance in the seventh item, the incomplete pentagon caused also students to get confused. Many students got difficulty to decide on the midpoint of the base of pentagon. While the tests were being completed, students reflected as "there is no midpoint for the base of the pentagon". They thought that the line of symmetry should pass through the lines on the squared background of the sheet. For this reason, the base of the model was changed as four units as it is seen in the Figure 3.15.

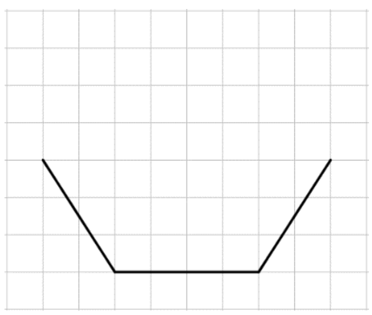


Figure 3.15. Revised model for the seventh item.

Moreover, in the eighth item, the model given to represent the paper folded was confusing since it was drawn wrong spatially. The model was constructed on a squared base and named as rectangle. However, the folded version of the paper was parallelogram while the opened version of this paper was concave hexagon. This wrong visualization of the folded figure was discovered while applying the tests to the students. Students stated that they could not understand the question. It was confusing. For that reason, the model was changed as in the Figure 3.16 to make it clear for the participants and in the correct form as rectangle.

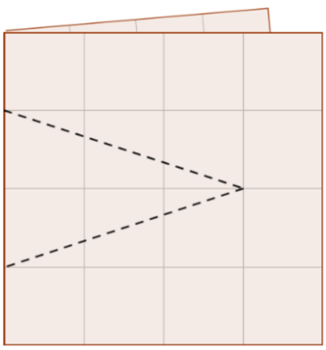


Figure 3.16. Revised model for the eighth item.

In addition to this problem arose from the researcher, it was observed that students confused the parts a and b so that they draw the response of part a under the part b. That is students confused the small piece and large piece. For that reason, in the text of the question, pieces were defined as small and large.

Therefore, the final versions of the test (see Appendix B) were constituted. Moreover, the rubric was also revised according to the final version of the test and got its final version (see Appendix C).

Furthermore, for reliability of the test scores, inter-rater reliability study was conducted with 35 students of the pilot study. The answers were scored by researcher and one of her colleagues according to the rubric. Inter-rater reliability for the scores given by these two teachers was calculated by using SPSS program. The items scored same by both researchers were coded as “1”, while the items scored different were coded a “0”. Cronbach’s alpha coefficient was found as 0.99. This value was not only above .7, but also highly close to 1 so that the results gathered according to the rubric were reliable with the sample. Although the scores were found reliable, the results causing 0.01 points gap to highest reliability were examined. The items for which the coders gave different scores were detected and discussed by the coders. The reasons causing inconsistency between scores were examined and both questions and rubric were reorganized. Particularly, it was seen the most significant problem was related to the 8^{th} item, which the students confused the responses for part a and part b as it was stated above. While one of the coders took this situation account and evaluated the responses according to the drawings by ignoring where they were drawn, the other coder did not tolerate the responses drawn in the wrong part. Other than that situation, there was not any other inconsistency between the coders. It was thought that this problem might be overcome by modifying the item as it was explained above.

3.4.2 Geometry Attitude Scale (GAS)

To be able to measure students’ attitudes towards geometry, the Geometry Attitude Scale (GAS) developed by Bulut, İşeri, Ekici and Helvacı (2002) was administered to the participants as pre- and post-tests. GAS consisted of 10 positive and seven negative items in the form of a five-point likert scale, ranging from strongly agree (5) to strongly disagree (1). Obtaining a high score in total (max. 85) means that the students have a highly positive attitude towards geometry. The scale measures three dimensions: like/dislike geometry, usefulness and anxiety of geometry. Its reliability coefficient (Cronbach alpha) is measured to be 0.92 by the developers of the scale. A sample item and Cronbach alpha values belong to each dimension is given in Table 3.3.

Table 3.3. Sample Items for the Dimensions of GAS

Dimension	Sample Item	*Cronbach Alphas*
Like/dislike geometry	I like topics in geometry.	.93
Usefulness	Geometry is useless in real life.	.61
Anxiety	I have geometry anxiety.	.57

For the final version of GAS, see Appendix D.

Pallant (2001) states that Cronbach alpha coefficient belong to a scale should be above .7 ideally. In the current study, Cronbach alpha values related to the sub-dimensions were also found to be reliable: .909 for like/dislike geometry, .709 for usefulness, and 717 for anxiety. GAS as a whole was also found to be highly reliable for the current study with a Cronbach alpha value of .875.

3.4.3. Geometry Self-Efficacy Scale (GSES)

In order to measure students' self-efficacy in geometry, the Geometry Self-Efficacy Scale (GSES) developed by Cantürk-Günhan and Başer (2007) was administered to the participants as pre- and post-tests. GSES consisted of 18 positive and seven negative items in the form of five-point likert scale, ranging from strongly agree (5) to strongly disagree (1). Obtaining a high score in total (max. 125) means that the students have a high level of self-efficacy in geometry. The scale measures three dimensions: positive self-efficacy beliefs, beliefs on the use of geometry knowledge, and negative self-efficacy beliefs. A sample item is presented for each dimension in Table 3.4.

Table 3.4. Sample Items for the Dimensions of GSES

Dimension	Sample Item	*Cronbach Alphas*
Positive self-efficacy beliefs	I can understand the concepts in geometry easily.	.872
Negative self-efficacy beliefs	I think that I am not good at geometry as my friends are.	.694
Beliefs on the use of geometry knowledge	I can use knowledge of geometry in other courses.	.734

Moreover, the reliability of the scale was tested by Cantürk-Günhan and Başer (2007) and the Cronbach alpha coefficient was found to be .90 which means it is highly reliable. For the final version of GSES, see Appendix E. In the current study, Cronbach alpha values related to the sub-dimensions were also found to reliable: .818 for positive self-efficacy beliefs, .702 for negative self-efficacy beliefs, and .713 for beliefs on the use of geometry knowledge. With a Cronbach alpha value of .868, the GSES as a whole was found to be highly reliable for the current study.

3.5 Development of Activities

In the present study, activities for experimental group were developed in accordance with the principles of inquiry-based instruction. All of the activities and questions were prepared by the researcher and constructed on real life situations. Some activities and questions were constructed on anonymous origami figures, such as an origami fish, a fox, and paper doll chains. The reason why these figures were chosen was that they all contained reflection symmetry. The researcher started by choosing the most appropriate paper-folding activities and origami figures containing reflection symmetry. After deciding on the figures, problems were written related to these figures for students to apply inquiry process. The activities were developed to give students the opportunity to relate folding and reflection symmetry.

The first activity: Buttered Toast

The name of the first activity is “Buttered Toast” and it is related to the following objective: “students will be able to draw reflection symmetry of pints, line segments and shapes on the plane”. According to the activity, a problem situation is given as follows: “There are two slices of bread. Butter is spread on one of them and the other slice is placed on the buttered slice. When the slice on top is taken back, how does it look?” Students are given a toast model as in Figure 3.17 to work on it.

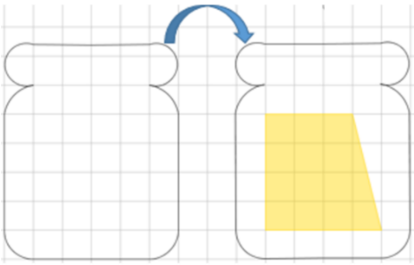


Figure 3.17. Toast model

The reason for giving the model was to give students the chance to fold one slice on the other. Students are not told to fold the model directly. They are expected to discover the necessity of folding in order to find the place which was stained in butter as in Figure 3.18.

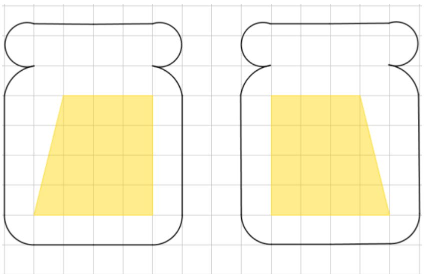


Figure 3.18. Opened version of the toast

After they fold the model to solve the problem, they are asked why they use this method and why this method give us the correct answer. Students are asked questions such as “Why did you fold the model?”, “How can you be sure that it is true?”, “How did you fold it?", "How can you be sure of the crease to fold?", and "What is the role of the crease on which you folded the model?" to make them explain their solutions and show evidence for their explanations by following the steps of inquiry. To make them discover the reflection symmetry behind paper folding, students are asked "how" questions as a key process in inquiry to make them communicate and support their explanations mathematically. During the discussion students started to realize the relation between folding and reflection symmetry.

In the second part of the activity, four drops of honey are added to another buttered bread prepared for Osman. In this part, again a piece of paper is placed on another which is buttered and has honey drops. Students are asked to draw how the piece on the top looks like when it is taken back. Students were given a bread model as in Figure 3.19 to work on it.

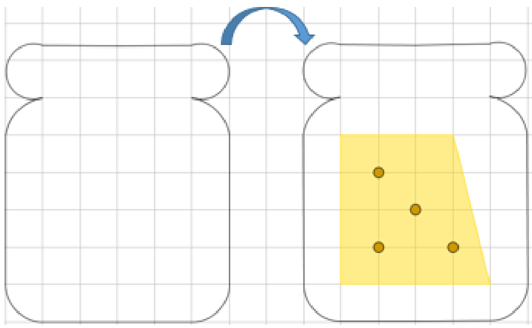


Figure 3.19. Toast model with honey drops

Students are expected to reflect points (honey drops) in addition to trapezoid (butter). They are again required to work individually as the first step of inquiry approach. Students who work on themselves solve the problem and develop their own explanations. When they complete the given task and ask for the confirmation from the researcher, they should be told to ask their peers. Therefore, they discuss with their peers and explain their reasoning. They try to convince their peers if they find different results. They make explanations and show evidence to prove their findings. They even start to use properties of reflection symmetry. For instance, they show the nature of reflection symmetry for the reason of folding the model into two equal pieces? They make evaluation of their explanation according to the explanations of others as inquiry requires.

The Second Activity

The second activity is making an origami fish which was prepared to make students familiar with the folding process and make them realize the reason of reflection behind this activity. Students were guided by the instructor to construct the fish step by step as in Figure 3.20.

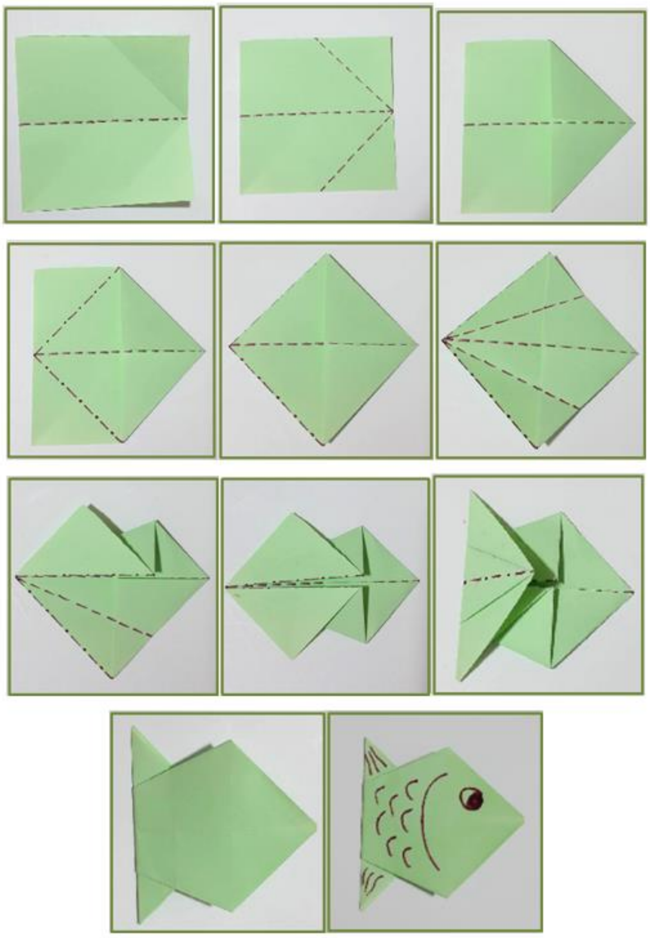


Figure 3.20. Step by step origami fish

After each fold, students are asked to examine and discuss the figure they construct. For instance, after the 8th step, a discussion can be held with a question posed by the researcher, namely "*What do you see here on the folded paper?*", as seen in Figure 3.21.

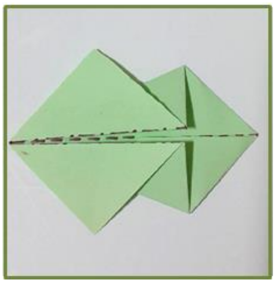


Figure 3.21. Eighth step of the origami fish

Students are expected to say that they see triangles. At that time the researcher asks whether or not there is a relationship between these triangles. At that time, students are expected to say that there is relationship since they are congruent. Some of them say that they are not congruent since their directions are different. They start a discussion in the classroom. The volunteers are asked to explain their reasoning. They try to convince each other and refute the opposing arguments. The students who think that they are congruent and the others who think that they are different owing to their different directions are given chance to discuss and explain their reasoning. At that point students are expected to explain their answers and evaluate their reasoning through the explanations of others. At the end of the discussion, they are expected to realize that these two triangles are symmetric to each other as a result of evaluation of their explanation in cooperation. The researcher asks them how they arrived at that decision to be able to follow whether they complete inquiry process successfully. They are expected to explain that by folding the model into two and prove that the triangles match each other. When they are asked how they decide on the line to fold, they are expected to say that they choose the line between the two shapes to be able to match them when the paper is folded according to that line. Moreover, the students are expected to define that line as line of symmetry and discover that each step has a line of symmetry as seen in Figure 20. Thus, the students were expected to be familiar with the paper-folding and its relations with symmetry through such discussions during the inquiry process.

The Third Activity

The name of the third activity is "Painted Handkerchief" and it is related to the following: "students will be able to discover the equality between the distance of a point on the shape to a symmetry line and the distance of the image of this point to the symmetry line under reflection". The scenario of the activity was written based on folding a painted handkerchief as in Figure 3.22 and finding the painted parts of the handkerchief after unfolding it. Students are again given a handkerchief model to be able to work on concretely. During this activity, students reflect a point not only vertically and horizontally, but also diagonally since the use of reflection through diagonal lines is emphasized in the curriculum.

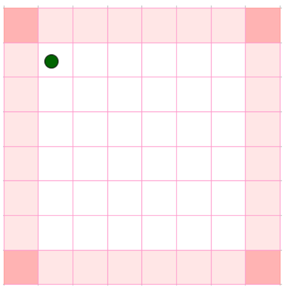


Figure 3.22. Painted handkerchief

However, for the steps ahead, students are not given any diagram or figure to see how to fold the handkerchief, so they are just given verbal directions. They are asked to find the painted parts after folding it vertically and horizontally without unfolding the first step and to find the painted parts after folding it vertically, horizontally and diagonally. Since they are familiar with the folding procedures from the previous questions, they are asked to combine what they know. The last question is asked them to discuss their folding. They are expected to realize that they may find different solutions because of their way of folding. In this sense, they are asked to compare their findings with those of others. If there are different solutions in the classroom, they are asked to decide on which one is correct. The researcher asks them to convince each other. This procedure is expected to give them the advantage to make explanations and to show evidence to their explanations. They are also expected to use mathematical language such as symmetry, reflection symmetry, and line of reflection. They should not only defense their solutions, but also discuss the solutions of others. They should also evaluate their own solutions under the light of others' explanations. At the end of the discussion, they are expected to realize that there are also other solutions which vary according to the place of the line of reflection, so the direction of the diagonal line changing the results.

The Fourth and the Fifth Activity

The names of the fourth and fifth activities are "Let's find the fox" and "Let's find the rabbit" and they are related to the following objective: "students will be able to discover the equality between the distance of a point on the shape to the symmetry line and the distance of the image of this point to the symmetry line under reflection symmetry. The shapes on the symmetry line are also used" (MoNE, 2013). In these activities, students are given crease patterns to construct a fox. Crease patterns means the collection of crease lines and vertices in the unfolded paper (Belcastro & Hull, 2002). These crease patterns consisted of two types of creases: mountain creases and valley creases (Hull, 1994). These creases are shown in Figure 3.23. The mountain creases are drawn with a dot-dash-dot line, and valley creases are drawn with a dashed line.

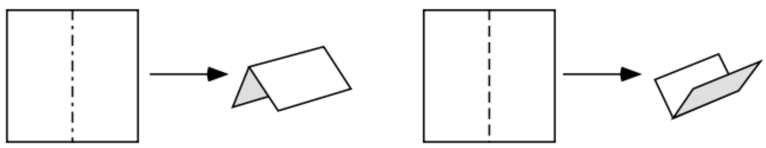


Figure 3.23. A mountain crease (left) and a valley crease (right).

According to this information, students are given a square paper with creases drawn on it. The meaning of the colors is explained to them, that green meant mountain crease and red meant valley crease as shown in Figure 3.24.

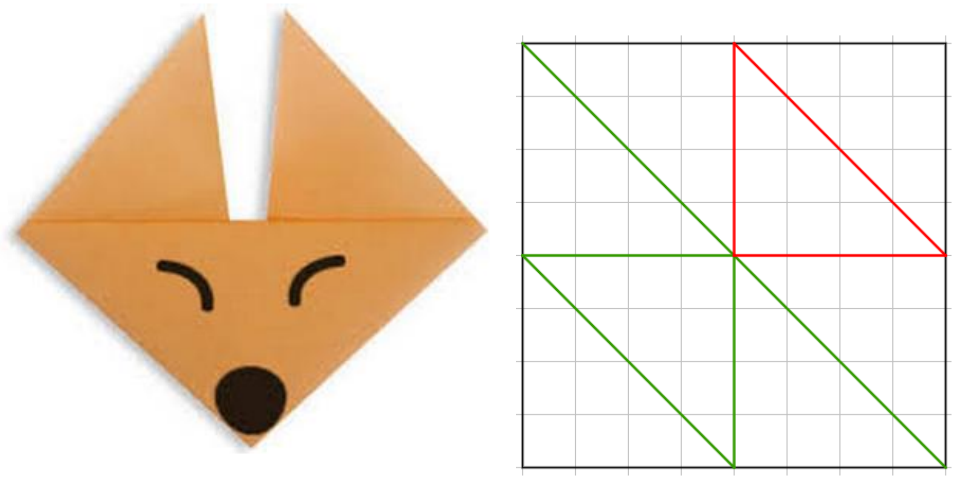


Figure 3.24. Origami fox and the creases belonging to it.

Students are asked to fold the paper according to these ceases to construct the given fox. They are expected to see that valley creases and mountain creases are reflection symmetry of each other according to one crease which divides the paper into two diagonally. This single crease represents the first fold. Since the paper is folded into two according to this crease, each of the following folds result in two creases, which are symmetric to each other. At the beginning, students may not figure out how to fold it. They may try to fold through the creases. However, it is more complicated at that time. Some of them may start to attribute meaning to the colors of the creases and make such comments as "Why were we given creases in different colors?", "There must be a reason for these colors", "I will fold from the creases". When they start to fold based on the meaning of the colors, they realize that the direction of the two halves of the paper is inverse. They are expected to put these two halves together, and realize the importance of the diagonal crease. When they start by folding the paper into half from the diagonal line, after that step, it will be enough to follow only the mountain creases or the valley creases. They should be asked why they follow only one type of crease. They are expected to explain that when they fold according to one type of crease, the other creases are also folded since they are symmetric to each other according to the big diagonal line.

Students first start with the fox activity since it has fewer steps than those in the rabbit activity. The students who complete the fox activity start the rabbit activity, which is more complex.

The Sixth Activity

The sixth activity is constructed on the following objective: "students will be able to draw the image of a shape after reflecting consecutively" (MoNE, 2013). This activity actually consisted on one single scenario with five different models. Students are asked to use the scissors as little as possible to extract the shapes out of the paper. They are given five different models from simpler to more complex ones. Students are expected to find the line of reflection symmetry and fold the figure according to these lines. Each shape is constructed by the reflection of a unit piece consecutively: paper chain. Instead of cutting the paper from the borders of the shape, students are expected to fold the paper according to the lines of symmetry and cut from the border of unit pieces so that the others will be automatically cut from their borders. To illustrate, the first paper chain is presented in Figure 3.25.

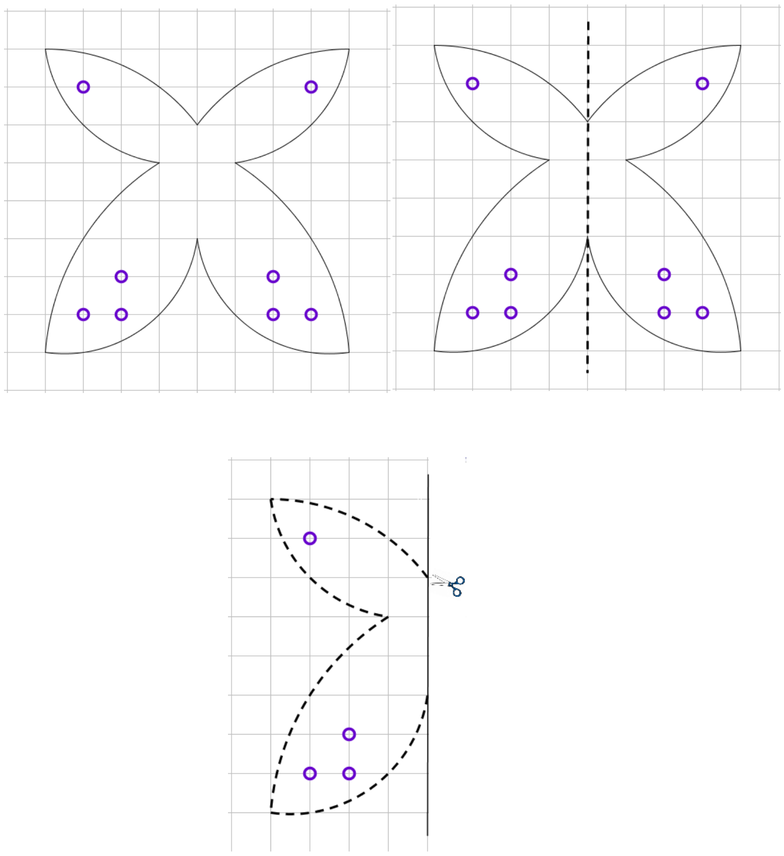


Figure 3.25. Paper chain butterfly and the symmetry lines on it

The students are asked to use scissors as little as possible. However, it is hard for them to understand what is meant by using as little as possible. They try to cut the butterfly out through all the borders. They are asked whether they can find any way to cut requiring less effort with scissors. They are expected to start to make comments such as “I must cut less than this, how I can minimize the use of the scissors?” and become aware of the line of symmetry as expected. They will fold the model into two and cut it through one wing of the butterfly as in Figure 3.25. They are asked “how can you be sure that this is the way to use the scissors minimally?”. They should show evidence that there are no more lines of symmetry to fold.

After this butterfly model, students are given more complex models to cut out. For instance, they are given a flower as the third model as in Figure 3.26.

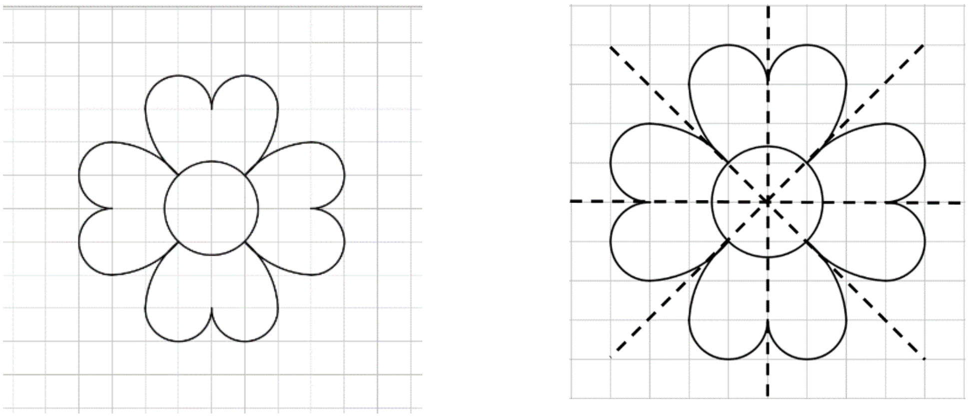


Figure 3.26. Paper chain flower and the symmetry lines on it.

Students are expected to fold the figure into eight equal parts according to the symmetry lines i.e fold the figure into halves three times. Since they will be familiar with the problem from the previous models, they are expected to start to fold the paper into two and cut the figure out. When they finish, they are asked to discuss with their peers whether they are right. There may be students who fold the paper just once before cutting. They will be explained and shown evidence by their peers. They will also evaluate their explanations in light of the explanations of their peers.

In conclusion, the activities are developed and applied in the classroom according to the features of inquiry-based instruction. That is, lessons are planned in order to give students the chance to take advantage of inquiry by means of posing questions, gathering evidence, formulating, evaluating and communicating explanations in origami activities.

The activities developed by the researcher were examined by two mathematics education researchers on mathematics education from the faculty of education. The activities were developed in accordance with the feedback provided by the experts. For instance, they suggested using real life contexts in order to ensure students' involvement in the activity more effectively and to make the activity clearer to the students. Moreover, in the beginning, the creases in the fourth and fifth activity were not colored. It was not clear and, thus, difficult for the students. They suggested giving some clues to make it simpler for the students. The creases were colored to specify whether they were mountain or valley creases. Furthermore, the last activity consisted of just two models; butterfly and children model. While one of them was very simple, the other one was very complex. They suggested adding some more models to construct a bridge from the simplest to the most complex one.

After the activities reached their final version, a pilot study was conducted. The activities were applied to two classes of 8th grade students in a public school by the researcher. Since the pilot study was conducted in the fall semester of the 2015-16 academic year and translation symmetry was the subject of 7th graders in the spring semester, the pilot study was conducted with two classes of 8th graders who had already known the subject. The activities were tested in order to find out whether the students could understand the activities and how much time was needed to complete them. By means of the pilot study, it was realized that some drawings in the activities caused misunderstandings. For instance, in the first activity, the drawings were not found clear to the students. The preparation steps of a toast were represented as in Figure 3.27. According to the figure, the piece on the right represents the whole toast which contains both slices. However, students thought that it was the slice on which they were expected to draw the opened version.

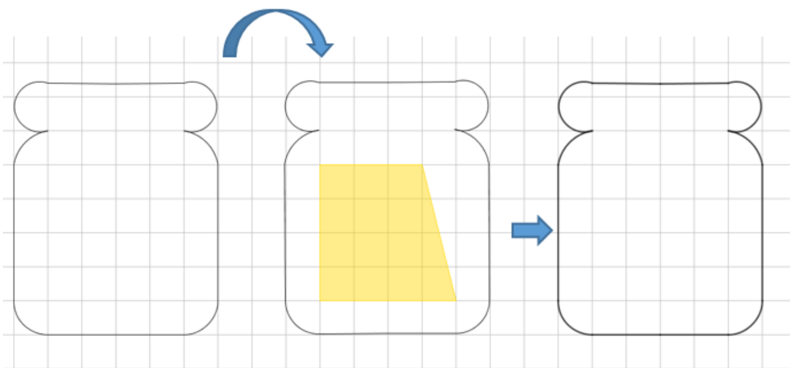


Figure 3.27. Toast model

Thus, the students were confused. Therefore, the model was changed to the version in Figure 3.28. Students were asked to draw their answers on the blank squared area under the question.

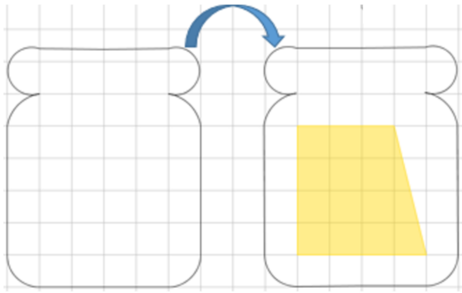


Figure 3.28. The last version of the toast model

Moreover, in the third activity, students were asked to find the place of the stain after folding the handkerchief vertically, horizontally and diagonally, respectively. However, students did not understand how to fold it. They asked what folding vertically meant or what folding diagonally meant. They asked the researcher for clarifications. For this reason, it was decided that the students should be guided by means of the drawings on the activity sheet to make the questions clearer for them as seen in Figure 3.29.

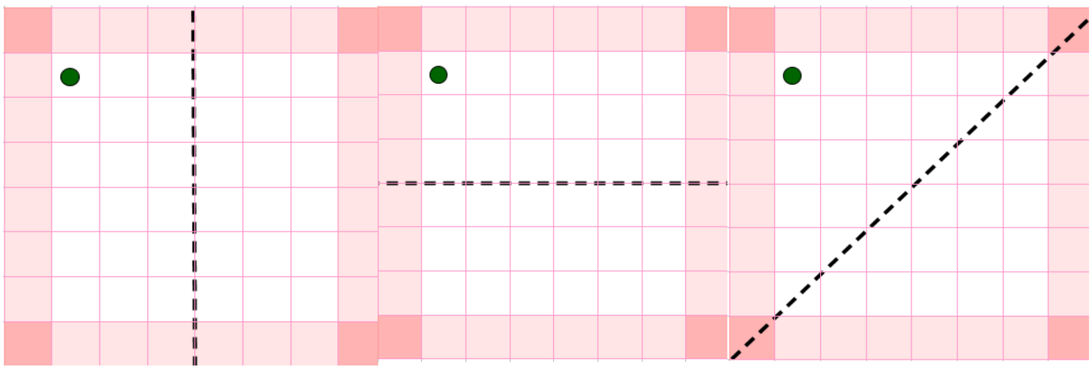


Figure 3.29. Folding the handkerchief vertically, horizontally and diagonally

Moreover, the texts of the activities were a little confusing for the students. During the treatment, the students asked the researcher to explain the activity and what they should do. For instance, in the fox activity, the students could not understand the explanations related to the direction of creases. They asked what the colors and the creases meant. Consequently, it was decided that the students should be shown a sample folding for both mountain and valley creases on another piece of paper. After this warm up, they understood the meanings of the creases. Subsequently, it was decided that the creases during the previous activities, for instance while constructing the origami fish, should be emphasized. Thus, students could adapt to the activity related to constructing a fox and rabbit easily.

To conclude, the activities were implemented with 8th grade students and each activity took approximately 35 minutes. The problems were detected and noted down during this pilot study. The texts of the activities were simplified and the drawings were reconstructed in order not to cause misunderstandings for the students. For the final versions of the activities, see Appendix F.

3.6 Data Collection Procedures

The data were collected from two seventh grade classes from a public school in the Ulubey neighborhood in Altındağ district of Ankara during the spring semester of the 2015-16 academic year during approximately 3 weeks. First of all, official permissions were taken from the school, from the METU Ethics Center and the Ministry of Education. The study was under control not to cause any physical or psychological harm to the participants.

Students were administered the Reflection Symmetry Achievement Test (RSAT), the Geometry Self-Efficacy Scale (GSES) and the Geometry Attitude Scale (GAS) before the treatment as pretests in order to measure students' existing knowledge, attitude and self-efficacy. Two already existing classes participated in the study; one was assigned to the control group, while the other was assigned to the experimental group.

Lesson plans for the control group were prepared in accordance with the students' regular mathematics textbook, yet the lesson plans for the experimental group were prepared using distinct sources other than regular mathematics textbooks in such a way that the lessons were carried out using origami activities in the topic of properties of reflection symmetry: the lesson plans for both groups were prepared by the researcher. The opinions of the teacher of the classes were also taken into consideration. The prepared lesson plans applied in both groups were previewed by the teacher of the classes to evaluate their appropriateness to the subject matter and their efficiency in reaching the specified objectives.

Instructions were planned to be conducted in three weeks, totally fifteen class hours for each group during the 2015-16 spring semester. However, before the instruction of reflection symmetry, there were prerequisite objectives on translation symmetry in the unit of transformation geometry. These objectives related to translation geometry were also taught by the researcher during 7 class hours (5 hours of mathematics course and 2 hours of mathematics applications course) in the light of the lesson plans prepared by the teacher of the classrooms. After a one-week period, which was also a warm up session for both the researcher and the students to get used to each other, the main study started. The reflection symmetry instruction was conducted as explained in the following section. Both the control and experimental groups were instructed by the researcher in their regular mathematics class hours. At the end of the instruction, students were administered the Reflection Symmetry Achievement Test (RSAT), the Geometry Self-Efficacy Scale (GSES) and the Geometry Attitude Scale (GAS) as posttests.

3.7 Implementation of Treatment

In this section, treatments given to both experimental group which is inquiry-based instructed and control group which is regularly instructed are explained in two parts.

3.7.1 Treatment given to Experimental Group

Inquiry-based instruction was implemented in one class in a public middle school for five mathematics lessons in a week. In the first two lessons, students were given an activity sheet entitled “Buttered Toast”, in which they had to perform hands-on inquiry activities about reflection symmetry. They completed the activity and realized the relationship between folding and reflection symmetry. During the activities, the role of the researcher was that of a facilitator as a teacher whenever students felt the need. However, students were not guided in solving the problems since inquiry requires students to discover new knowledge. They were just provided with the explanation of the scenario in the problem and were then asked to work on the problem by themselves. Students were expected to use their prior knowledge and construct new knowledge through inquiry. Students who had finished the activity were told to compare and discuss their solutions with the researcher and their peers. They were expected to support their reasoning though their previous knowledge in reflection symmetry. They made explanations related to their solutions by using mathematical language. For instance, in the activity of buttered toast, they were expected to name the creases formed as line of reflection so that it should be located in the middle of two slices. Subsequently they showed evidence for these explanations as it was expected in inquiry-based instruction by folding. They also valuated their own solution according to the explanations of others. During this procedure, the researcher made the students think and discuss by posing some questions which is the first requirement of inquiry such as “How can you be sure that it is correct?”, “How did you decide to fold from that crease?”,” Is there any other way to fold?”. At the end of the activity, one of the students explained the solution and then the whole class discussed the solution. The purpose of discussion sessions was to make students to make explanations through evidence and evaluate their explanations through other’s responses which are constitute the process of inquiry-based instruction.

While the students were doing activities with concrete models offered to them, terms like symmetry, reflection, inverse, and folding were not used until they were spoken out by the students. After the students experienced these concepts and needed a common term to define, for instance, the congruent shapes on the paper, these terms were used by the students. The students did not learn that folding a paper created symmetric figures. Since they had already known the term 'symmetry', they used this term during the activities. That is, they discovered the relationship between origami and symmetry.

In the activity sheets, there were some drawings and figures to make the activities clearer for the students. For instance, in the activity of painted handkerchief, how to fold vertically, horizontally and diagonally is represented in the activity sheet to make students understand basic procedures. However, for the following steps which include more than one fold, they were not given any directions since they were expected to construct their own figure and discuss on this figure mathematically. Moreover, concrete models drawn on the papers were given to the students for each activity. The aim of these models was to give students a chance to fold and discover the mathematical dimension of origami, which is symmetry. They were given these models to work on them so that they could realize the necessity of folding. The students, who discussed their reasons to fold, also realized the relationship between folding and reflection symmetry.

3.7.2 Treatment given to the Control Group

After the population and sample of the study were defined, the researcher observed the regular lessons of the selected classes to understand the teacher's teaching style. The teacher was using direct teaching method. He presented the content, the fundamental principles, the necessary formulas and asked the students to note them down. After the students had written in their notebooks what was on the board, he solved sample quantitative examples on the board. He gave general rules to solve these examples, and wrote some more questions as he solved them. He did not use any manipulative or real life examples. Therefore, the researcher intended to use this lecture method.

During the treatment, the researcher taught reflection symmetry concepts according to regular instruction. The researcher made the required definitions and explanations. Exercises were solved on the board and students noted them down. The researcher did not use any manipulative material or mention paper folding during instruction.

3.8 Analysis of Data

In this study, quantitative analysis techniques were used to examine the data collected from the RSAT, GAS and GSES. Both descriptive and inferential statistics were evaluated. According to the analysis results in the SPSS program, descriptive statistics, namely the means, standard deviations, skewness and kurtosis values of RSAT, GAS and GSES scores were examined for both groups. To investigate the differences between the mean scores of the experimental and control groups on RSAT, GAS and GSES, Analysis of Covariance (ANCOVA) was used while controlling the pretest scores. The hypotheses were tested according to a level of significance of .05.

3. 9 Assumptions and Limitations

In this section, information is given related to the assumptions and limitations of this study.

In the current study, experimental group was assumed to be instructed through inquiry-based instruction. In the light of the requirements of inquiry, approach, activities were developed for students to have them discover the properties of reflection symmetry conceptually. It was assumed that the activities used in the current study were appropriate for the objectives in the curriculum and the grade level of the students. It was also assumed that the activities and models were closely related to the concepts of the reflection symmetry and were effective in teaching students by means of origami figures in real life problem situations.

Moreover, the instruments of the study were assumed to measure related variables. Another assumption was that all participants responded to the questions in the tests seriously without omission. Furthermore, it was assumed that the items in the tests were understandable to the students.

On the other hand, participants of the study were selected by the convenience sampling method in which the researcher studies with individual groups available for the study (Fraenkel & Wallen, 2006). Since the sample included participants only from one public school and only two classes of 7^{th} graders in this school, the sampling method of the study limited the generalizability of the results.

Lastly, since the study contained only one geometry topic, the results of the study could not be generalized to other geometry or mathematics topics. However, clues, advice, techniques and resources that would help instructors to create origami based activities for other mathematics topics will be stressed in this study. Moreover, the results are also limited with respect to the instruments used and the sample chosen. The results may not reveal the same findings for another sample or according to data collected through other instruments.

3.9 Validity of the Study

Issues of internal and external validity are crucial for all kinds of studies. Thus, the two validity types are discussed in this section.

3.9.1 Internal Validity

If a dependent variable in a study changes and this change is only related to the independent variable, it can be said that this study is internally valid (Fraenkel & Wallen, 2006). There can be several threats to internal validity depending on the type of the study. All these threats should be kept in mind in all stages of the study and some precautions could be taken in order to eliminate these threats.

Mortality, the loss of subjects, is one of the internal threats in experimental studies (Fraenkel & Wallen, 2006). During this study, there were some students who changed their schools. Although they had completed the pretests, they could not attend all the class hours and left the school. Since the number of these students was low, these students were omitted from the study.

Location is another threat to internal validity in experimental studies and it occurs when the participants are applied treatments or instruments in different places (Fraenkel & Wallen, 2006). Since the data was gathered from two classrooms and the treatment was implemented in students' regular rooms and classroom hours, the location threat was eliminated.

It is possible that any event that might occur throughout the study can affect the responses of the participants, which constitutes the history threat (Fraenkel & Wallen, 2006). To be able to eliminate this internal threat, all kinds of events (e.g. national and religious holidays, exams, etc.) that were likely to occur at any phase of the study were taken into consideration. The time interval to apply the instruction was planned according to the 23 April International Children's Festival so that instructions could be completed before the 23rd of April. Also the school administration and personnel were informed about the time and location of the treatment.

Maturation might be another threat for internal validity so that it occurs when the dependent variable changes due to events which are naturally occurred out of researcher's control (Fraenkel & Wallen, 2006). However, in the current study, there was approximately a month between pretest and posttes. And, any maturation might have occurred in this time interval.

Implementation threat occurs when the person who implements the experimental group has personal bias (Fraenkel & Wallen, 2006). In the current study, both experimental and control groups were instructed by the researcher who tried to be unbiased in each group during the lessons. Implementation threat was assumed to be reduced in this way. In the same way, data collecteor bias was also taken into consideration. Pretests and posttests were both implemented by the researcher who did not help students and was unbiased while students were completing the tests.

Instrumentation treat occurs when the instrument or scoring procedure is changed in some way (Fraenkel & Wallen, 2006). For both experimental and control groups, same instruments were applied in the same conditions. Students' attitudes towards geometry and self-efficacy in geometry were measures through five Likert type scales. They were assumed to be scored unbiased. Scale and Geometry self-efficacy scale scored. For the achievement scores in reflection symmetry, a test consisted of ten essay type items used. Students' responses were scored by researcher and her colleague through the rubric of the test.

According to Fraenkel and Wallen (2006), using a pretest can result in the pretest-treatment interactions threat. Implementation and content of a pretest might make the experimental group members be alerted to what will be taught and the objectives of the study. Since the post-test was exactly the same as the pre-test, the pretest-treatment interaction threat might have been a possible threat for this study. To be able to eliminate this threat, there was approximately a one-month interval between the pre-test and post-test.

3.9.2 External Validity

Fraenkel and Wallen (2006) defined external validity as "the extent to which the results of a study can be generalized from a sample to a population". External validity involves two dimensions, namely population generalizability and ecological generalizability.

Population generalizability means "the degree to which a sample represents the population of interest" (Fraenkel & Wallen, 2006). Convenient sampling was the sampling method used in the present study, yet convenient samples are not likely to represent populations (Fraenkel & Wallen, 2006). Therefore, the current study was limited in its generalizability of the results to the population. In addition, since the students were from only a public school in Ankara, which is the capital of the country, the population generalizability, was affected negatively in such a way that the results could not be generalized to private school students.

Ecological generalizability means “the degree to which the results of a study can be extended to other settings or conditions” (Fraenkel & Wallen, 2006). Again, since this study was carried out with students only from a public school which was close to the city centrum, the results could not be generalized to other students. Since the school was chosen conveniently, the findings cannot be generalized to a larger population. However, the results can be generalized to a population of samples having similar characteristics with the sample of this study.

CHAPTER IV

RESULTS

This chapter includes four sections related to the results of the study. In the first three sections, descriptive and inferential statistics, which includes missing data analysis, determination of covariates, assumptions related to ANCOVA and results of ANCOVA, are presented related to the first, second and third research questions, respectively. Finally, the summary of the results is presented in the last section.

4.1 Results of the First Research Question

The first question is "What is the effect of inquiry-based instruction enriched with origami activities on the 7th grade students' achievement in reflection symmetry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled?" With the purpose of examining the effect of an inquiry-based instruction on the students' achievement in reflection symmetry, this section aims to present the results in two main parts: descriptive and inferential statistics.

4.1.1 Descriptive Statistics

In this part, descriptive statistics of the pretest and posttest scores of the students obtained by the Reflection Symmetry Achievement Test (RSAT) are presented to describe and characterize the data. RSAT was administered to the students before and after the treatment respectively as pretest (Pre_RSAT) and posttest (Post_RSAT). Descriptive statistics related to the pretest, the posttest, and the gained scores of the experimental group are represented in Table 4.1.

Table 4.1. Descriptive statistics for both the pretest and posttest scores of the experimental group

	Pre_RSAT	Post_RSAT	Gain Score (Posttest-Pretest)
N	23	23	23
Minimum	1.00	14.00	5.00
Maximum	54.00	62.00	39.50
Mean	22.65	42.54	19.89
Std. Deviation	17.31	14.86	9.08

Table 4.1 indicates that while the students in the experimental group had a mean score of 22.65 (SD = 17.31) on the Pre_RSAT, their mean scores in the Post_RSAT was 42.54 (SD = 14.86) out of 70. Thus, the mean of the gain score was 19.89 (SD= 9.08), which shows that there is an increase in the Reflection Symmetry Achievement Test scores of the 7th grade students' in the experimental group after the treatment. Moreover, it can be seen that both minimum and maximum values of the pretest scores ($\mathrm{Min}_{\mathrm{Pre\_RSAT}}$ = 1.00, $\mathrm{Max}_{\mathrm{Pre\_RSAT}}$ = 54.00) of the students in the experimental group increased after the intervention ($\mathrm{Min}_{\mathrm{Post\_RSAT}}$ = 14.00, $\mathrm{Max}_{\mathrm{Post\_RSAT}}$ = 62.00).

The descriptive statistics related to the pretest, posttest, and gained scores of the control group are presented in Table 4.2.

Table 4.2. Descriptive statistics for both the pretest and posttest scores of the control group

	Pre_RSAT	Post_RSAT	Gain Score (Posttest-Pretest)
N	25	25	25
Minimum	0.00	0.00	-11.00
Maximum	58.00	62.00	26.00
Mean	26.46	33.30	6.84
Std. Deviation	17.10	18.65	10.36

Table 4.2 indicates that while the students in the control group had a mean score of 26.46 (SD = 17.10) on the Pre_RSAT, their mean scores in the Post_RSAT was 33.30 (SD= 18.65) out of 70. Thus, the mean of the gain score was 6.84 (SD= 10.36), which shows that there is an increase in the Reflection Symmetry Achievement Test scores of the 7th grade students' in the control group after the treatment. However, the amount of increase is not as much as the gain score of the experimental group (19.89). Moreover, it can be seen that while the minimum value of the pretest scores remain stable ($\mathrm{Min}_{\mathrm{Pre\_RSAT}}$ = 0.00, $\mathrm{Min}_{\mathrm{Post\_RSAT}}$ = 0.00), the maximum score of the students in the control group increases after the intervention ($\mathrm{Max}_{\mathrm{Pre\_RSAT}}$=58.00, $\mathrm{Max}_{\mathrm{Post\_RSAT}}$ = 62.00).

In conclusion, the descriptive statistics related to the pretest and posttest scores of both groups have been presented in this part. It is clearly seen that the mean difference between the posttest and pretest scores of the experimental group is higher than that of the control group. The differences will be examined statistically in the analysis below.

4.1.2 Inferential Statistics

In addition to the descriptive statistics, which helped to describe the data gathered by means of the Reflection Symmetry Achievement Test, inferential statistics were used in order to test whether there was a statistically significant difference between the experimental and control groups. Before the Analysis of Covariance (ANCOVA), missing data analysis was conducted. Subsequently, covariates were determined, and the assumptions of ANCOVA were checked. Finally, ANCOVA was conducted to investigate the differences between the RSAT scores of the experimental and control groups.

4.1.2.1 Missing Data Analysis

The pretests were administered to 54 students in total; 28 students in the control group and 26 in the experimental group. However, three students in the control group and three students in the experimental group did not attend the instruction regularly, and did not complete the posttests. Hence, these six students were removed from the analyses, leaving 25 and 23 students in the control and experimental groups, respectively for the following analyses.

4.1.2.2 Determination of Covariates

Prior to checking assumptions and conducting ANCOVA, the covariates for the dependent variable (Post_RSAT) should be determined. According to Tabachnick and Fidell (2007), two conditions should be satisfied for selecting a set of covariates. The first one is a theory which explains and supports the relation between the covariate and the dependent variable. According to the relevant literature, there is a positive correlation between efficacy and achievement (Brannick et al., 2005), and between attitude and achievement (Cote & Levine, 2000; Işıksal & Aşkar, 2005). Thus, students' attitude scores towards geometry and self-efficacy scores in geometry are pre-determined as potential covariates for their achievement scores on reflection symmetry for the current study. In addition to the theory, the second condition is the determination of the covariates statistically. That is, independent variables that have a low correlation with one another and a high correlation with the dependent variables should be selected. Therefore, potential covariates were determined as Pre_RSAT, Pre_GSES and Pre_GAS, which have potential to correlate with the dependent variable, Post-RSAT. The results of the correlation analyses are presented in Table 4.3.

Table 4.3. Correlations between the dependent variable and the potential covariates

Variables	Pre_GSES	Pre_GAS	Pre_RSAT
Pre_GAS	.577**		
Pre_RSAT	.417**	.489**	
Post_RSAT	.309*	.348*	.770**

**Correlation is significant at the 0.01 level (2-tailed)

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

Table 4.3 indicates that all independent variables (Pre_RSAT, Pre_GSES and Pre_GAS) have a significant correlation with the dependent variable (Post_RSAT). However, Pallant (2001) states that if a dependent variable has more than one covariate, these covariates should not be too strongly correlated with one another (r=.8 and above). According to Table 4.3, the maximum correlation between the independent variables is .577 (between Pre_GSES and Pre_GAS), which is not strong. That is, the results reveal that the independent variables are not strongly correlated with one another and are significantly correlated with the dependent variable (Post_RSAT). Therefore, these independent variables will be used as covariates while conducting ANCOVA to examine the effect of inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of achievements in reflection symmetry.

4.1.2.3 Assumptions of ANCOVA for the First Research Question

Before conducting statistical analyses (ANCOVA) it is important to check that the assumptions are not violated. The key assumptions of ANCOVA are independence of observation, normality and outliers, reliability of covariates, multicollinearity, linearity, homogeneity of regression, and homogeneity of variance (Tabachnick & Fidell, 2007, p. 201). Details related to these assumptions are explained below.

Independence of observation

This assumption requires that the observations related to the data must be independent of one another. That is, the observations or measurements in the study must be independent so that they must not be influenced by another observation or measurement (Pallant, 2001). Violation of this assumption, according to Stevens (1996), is a very serious issue. For this reason, in the current study, the data was collected in the same conditions for both the control and experimental groups. The measurements were applied as pretest and posttest before and after the treatment. Moreover, each participant completed the RSAT independently without interacting with each other. Therefore, the assumption of independence of observation was assumed to be satisfied.

Normality and Outliers

In addition to their dependency, the values are required to be distributed normally according to the normality assumption. This assumption can be assessed to some extent by obtaining skewness and kurtosis values (Pallant, 2001). Skewness and kurtosis values of the dependent variable are represented in the Table 4.4. The table shows that the values belonging to both the experimental and control groups vary between -2 and +2, which is an acceptable range (Pallant, 2001).

Table 4.4. Descriptive statistics for the pretests and posttests with respect to the groups

	Skewness	*Kurtosis*
Pre-RSAT		
Control	0.09	-0.88
Experimental	0.35	-1.31
TOTAL	0.20	-1.13
Post-RSAT		
Control	-0.54	-0.84
Experimental	-0.42	-1.29
TOTAL	-0.61	-0.54

Besides the skewness and kurtosis values, histograms in which the shape of the distribution related to the values for each group can be seen are provided in Figure 4.1 and Figure 4.2. Normal distribution in the histograms is represented as a symmetrical, bell shaped curve (Gravetter & Wallnau, 2000).

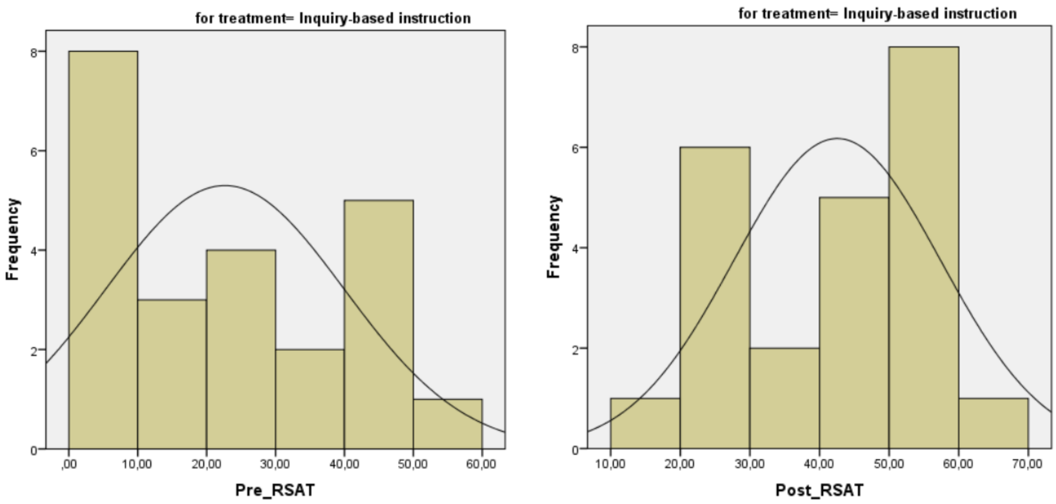


Figure 4.1. Histograms of experimental groups' pretest and posttest scores on RSAT

In Table 4.4, the kurtosis and skewness values related to the pretest and posttest scores in RSAT for the experimental group were presented as -1.31 and .35, respectively, which in the in the required range, between -2 and +2. Moreover, it can be seen in Figure 4.1 that the Pre_RSAT and Post_RSAT scores of the experimental group represent a bell shape with the greatest frequency of scores in the middle. Therefore, the assumption of normality was satisfied.

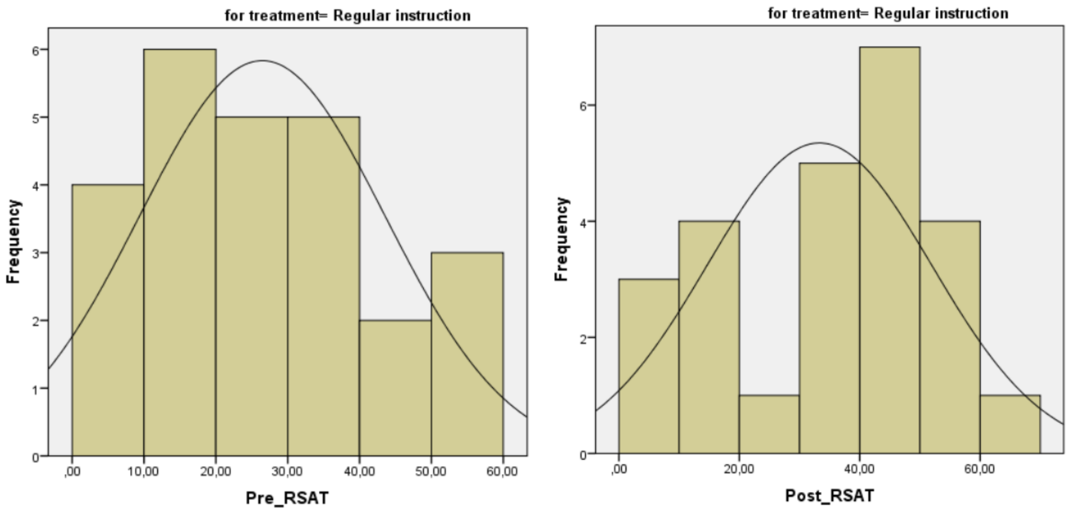


Figure 4.2. Histograms of control groups' pretest and posttest scores on RSAT

On the other hand, the kurtosis and skewness values related to the control group's pretest and posttest scores in RSAT are presented as -.88 and .09 in Table 4.4, respectively, which fall within the required range, between -2 and +2. Moreover, it can be seen in Figure 4.2 that the Pre_RSAT and Post_RSAT scores of the control group are symmetrical with the greatest frequency of scores in the middle. That is, the values are distributed normally.

In addition to the skewness and kurtosis values and the histograms, normality of distribution of the scores is also assessed by means of the Kolmogorov-Simirnov statistics. The Kolmogorov-Simirnov statistics related to the pretest and posttest scores of both the experimental and control group are presented in Table 4.5.

Table 4.5. Kolmogorov-Simirnov statistics for both groups

	Statistic	*df*	*Sig.*
Pre_RSAT			
Control Group	.110	25	.200
Experimental Group	.149	23	.200
Post_RSAT			
Control Group	.120	25	.200
Experimental Group	.149	23	.200

According to Kolmogorov-Simirnov statistics, a non-significant result (p>.05) indicates normality. As shown in Table 4.5, according to Kolmogorov-Smirnov statistics the normality assumptions were satisfied for the pretest and posttest scores of both groups (p>.05). Therefore, according to the skewness and kurtosis values, histograms and Kolmogorov-Simirnov statistics, the data related to RSAT was found to be normally distributed for both groups.

Besides the normality of the data, outliers should also be checked. Outliers refers to the cases with scores that are quite unlike the remainder of the sample, or the values much higher or much lower than the others (Pallant, 2001). Boxplots allow the researcher to identify outliers. The box plots related to the dependent variable (Post_RSAT) for both groups are displayed in Figure 4.3.

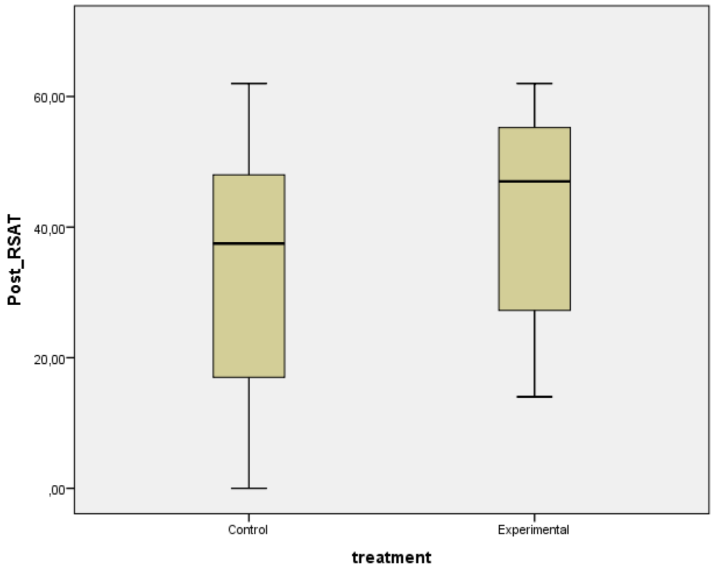


Figure 4.3. Box plots for the dependent variable of the control and experimental groups.

The values placed out of the rectangular shape represent the outliers in the data set. According to Figure 4.3, the box plots indicated that there was no outlier in this data set related to RSAT.

Reliability of covariates

In relation to the Analysis of Covariates, it is assumed that covariates are measured without error. Variables such as age and gender can be measured reasonably reliably (Pallant, 2001). However, values that rely on scales and open-ended questions as in the current study may not meet this assumption. At that point, checking the internal consistency of the scales used by calculating Cronbach alpha is beneficial in deciding on the reliability of the covariates, which should be above .7 or .8 to be considered reliable.

In the current study, three covariates were determined for ANCOVA. The reliability of these independent variables as covariates were calculated as .91 for the Reflection Symmetry Achievement Test, .88 for the Geometry Attitude Scale and .87 for the

Geometry Self-Efficacy Scale. These values are all above .80, which implies that the test was reliable. Therefore, it was assumed that the covariates were measured reliably.

Correlations among the covariates (Multicollinearity)

In addition to the assumption related to the reliability of covariates, ANCOVA also requires the multicolinearity assumption to be satisfied. Pallant (2001) states that if a dependent variable has more than one covariate, these covariates should not be too strongly correlated with one another (r=.8 and above). To check this assumption, the correlations between possible covariates were examined. These values can be seen in Table 4.3. According to Table 4.3, the maximum correlation between independent variables (Pre_GSES and Pre_GAS) is .577. Thus, all the correlation coefficients were found to be less than .80 for both the control and experimental groups. Therefore, the assumption of multicollinearity was assumed to be satisfied.

Linearity

Although the covariates are assumed not to be correlated with one another, they are expected to be in a linear relationship. Pallant (2001) states that ANCOVA assumes that the relationship between the dependent variable and each of the covariates is linear (straight-line). Since there is more than one covariate in the current study, the relationship between these covariates should be linear. If this assumption is violated, it is likely to reduce the power of the results. To check the linearity between the dependent variable (Post_RSAT) and each of the covariates (Pre_RSAT, Pre_GAS, Pre_GSES) and between the covariates, the matrix scatterplot is given as Figure 4.4.

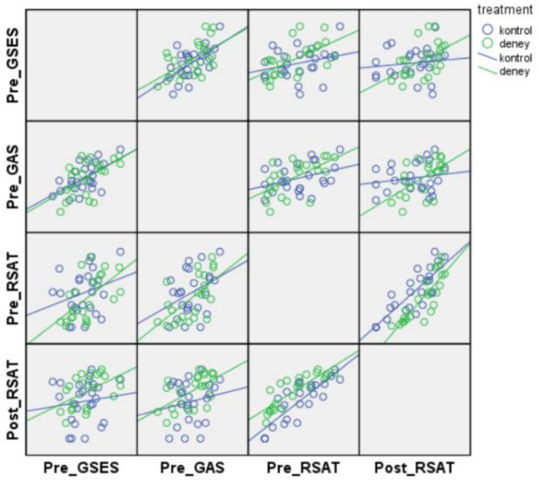


Figure 4.4. Relationship between each covariate and dependent variable for both groups

The matrix scatterplot in Figures 4.4 shows that the relationships between each covariate and the dependent variable for both the control and experimental groups were linear. Therefore, linearity assumption was assumed to be satisfied.

Homogeneity of regression slopes

In addition to the relationships of the covariates with one another and with the dependent variable, the relationship between the covariate and the treatment is also important, which is addressed by the assumption of the homogeneity of regression slopes. At this point, the target is to satisfy that there is no interaction between the covariate and the treatment or experimental manipulation for both groups.

The existence of the relationship between the treatment and the covariates can be observed graphically in Figure 4.4. That is, if the lines belonging to the groups are similar in terms of their slopes, it means that there is no interaction between the covariate and the treatment. Although it seems that the lines are similar in their orientation, it is difficult to decide on the similarity between their slopes. For this reason, this assumption will also be tested statistically.

An analysis was conducted to see whether there was a statistically significant interaction between the covariates and the treatment for both groups. The interaction levels were obtained from SPSS for each covariate as it can be seen in Table 4.6.

Table 4.6. Homogeneity of regression slopes assumption

	Source	*F*	*Sig.*
Post_RSAT	*Treatment * Pre_RSAT*	1.890	.177
	*Treatment * Pre_GSES*	.020	.890
	*Treatment * Pre_GAS*	1.039	.314

If the interaction is significant at an alpha level of .05, then it means that the assumption is violated (Pallant, 2001). According to Table 4.6, the interaction values between each covariate and the treatment are greater than .05, which means that there is no statistically significant interaction between the covariates and the treatment. Thus, the assumption of homogeneity of regression slopes is assumed not to be violated.

Homogeneity of Variance

This final assumption requires that samples are obtained from populations of equal variances. That is, each group should have a similar variability of scores (Pallant, 2001). To be able to test this assumption, SPSS performs the Levene's Test of Equality for the determination of the equality of variance assumption. The results related to the dependent variable are presented in Table 4.7.

Table 4.7. Levene's Test of Equality of Error Variances

	F	*df1*	*df2*	*Sig.*
Post_RSAT	2.190	1	46	.146

As made explicitly by Table 4.7, the error variances of the dependent variable across the groups were equal (F (1, 46) = 2.190, p= .146). These values mean that it failed to reject the null hypothesis of equality of error variances (p > .05). In other words, the variances across the groups for the dependent variable were equal. Thus, the assumption of homogeneity of variance had not been violated.

In conclusion, as all the assumptions are checked and assumed to be satisfied, the Analysis Covariance can be conducted to examine the effect of an inquiry-based instruction enriched with origami activities on the population means of 7^{th} grade students' post-test scores of achievements in reflection symmetry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled.

4.1.2.4 Results of ANCOVA for the First Research Problem

Analysis of covariance was performed to test the effect of an inquiry-based instruction (IBI) on students' academic achievement in reflection symmetry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled. The independent variable was the type of treatment: inquiry-based instruction (IBI) for the experimental group versus regular instruction (RI) for the control group. The dependent variable was academic achievement in reflection symmetry measured after the treatment. Students' academic achievement in reflection symmetry (Pre_RSAT), geometry attitude (Pre_GAS) and geometry self-efficacy (Pre_GSES) measured before the treatment were used as covariates in this analysis.

The statement of hypothesis was 'There is no significant effect of inquiry-based instruction enriched with origami activities on the population means of 7^{th} grade students' post-test scores of achievements in reflection symmetry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled'. The overall summary of inferential statistics for achievement in reflection symmetry gathered through ANCOVA is presented in the Table 4.8.

Table 4.8. Results of ANCOVA for the First Research Problem

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Partial Eta Squared*	*Noncent. Parameter*	*Observed Power[b]*
Corrected Model	10352.31	4	2588.08	28.73	.000	.728	114.93	1.00
Intercept	831.02	1	831.02	9.23	.004	.177	9.23	.84
Pre_GSES	40.81	1	40.81	.45	.504	.010	.45	.10
Pre_GAS	12.89	1	12.89	.14	.707	.003	.14	.07
Pre_RSAT	7503.49	1	7503.49	83.30	.000	.660	83.30	1.00
Treatment	1892.68	1	1892.68	21.01	.000	.328	21.01	.99
Error	3873.16	43	90.07					
Total	82553.00	48						
Corrected Total	14225.48	47						

Table 4.8 indicates that the first null hypothesis was rejected (F (1, 43) = 21.01, p=0.00). That is, the analysis results of the Post_RSAT scores of the students indicated that there was a statistically significant effect of inquiry-based instruction on 7th grade students' achievement scores in the concept of reflection symmetry. Moreover, the eta square value, .328, indicates a large relationship between treatment and dependent variable, implying that the size of the difference among groups was not small. In other words, 32.8 percent of variance in the Post_RSAT scores was explained by the treatment. In addition, power, which refers to the probability of detecting a significant effect when the effect truly does exist in nature, was found to

be .99. Hence, the difference found between the groups stemmed from the treatment effect and this difference had a practical value (Field, 2009).

4.2 Results of the Second Research Question

The second question is "What is the effect of inquiry-based instruction enriched with origami activities on 7th grade students' attitudes towards geometry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled?" With the purpose of investigating the effect of an inquiry-based instruction on students' attitudes related to geometry, this section is devoted to present the results in two main parts: descriptive and inferential statistics.

4.2.1 Descriptive Statistics

In this part, descriptive statistics related to students' pretest and posttest scores obtained by means of the Geometry Attitude Test (GAS) are presented to describe the data. GAS was administered to the students before and after the treatment as pretest (Pre_GAS) and posttest (Post_GAS), respectively. Descriptive statistics related to the pretest, posttest, and the gained scores of the experimental group are presented in Table 4.9.

Table 4.9. Descriptive statistics for both the pretest and posttest scores of the experimental group

	Pre_GAS	Post_GAS	Gain Score (Posttest-Pretest)
N	23	23	23
Minimum	33.00	33.00	.00
Maximum	76.00	84.00	8.00
Mean	59.40	67.87	8.47
Std. Deviation	13.38	13.06	.32

Table 4.9 reveals that while the students in the experimental group had a mean score of 59.40 (SD = 13.38) on the Pre_GAS, their mean score in the Post_GAS was 67.87 (SD = 13.06) out of 85. Hence, the mean of the gain scores was 8.47 (SD= .32), which means that there has been an increase in the Geometry Attitude Scale scores of the 7th grade students' in experimental group after the treatment. In addition, descriptive statistics indicated that while the minimum value related to students' pretest scores ($\mathrm{Min}_{\mathrm{Pre\_GAS}}$= 33.00) was stable after the treatment ($\mathrm{Min}_{\mathrm{Post\_GAS}}$= 33.00), the maximum values of the pretest scores ($\mathrm{Max}_{\mathrm{Pre\_GAS}}$ = 76.00) of the students increased after the intervention ($\mathrm{Max}_{\mathrm{Post\_GAS}}$= 84.00).

The descriptive statistics related to the pretest, posttest, and gained scores of the control group are presented in Table 4.10.

Table 4.10. Descriptive statistics for both the pretest and posttest scores of the control group

	Pre_GAS	Post_GAS	Gain Score (Posttest-Pretest)
N	25	25	25
Minimum	42.00	27.00	-15.00
Maximum	81.00	82.00	1.00
Mean	59.04	59.60	.56
Std. Deviation	10.83	13.40	2.57

Table 4.10 indicates that while the students in the control group had a mean score of 59.04 (SD = 10.83) on the Pre_GAS, their mean scores in the Post_GAS was 59.60 (SD= 13.40) out of 85. Thus, the mean of the gain score was 0.56 (SD= 2.57), which shows that there has been an increase in the Geometry Attitude Scale scores of the 7th grade students' in the control group after the treatment. However, the amount of increase is not as much as it is for experimental group (8.47). Furthermore, it is indicated that while the minimum value of the pretest scores ($\mathrm{Min}_{\mathrm{Pre\_GAS}}$= 42.00) decreased after the treatment ($\mathrm{Min}_{\mathrm{Post\_GAS}}$ = 27.00), the maximum score of the

students in the control group increased after the intervention ($\text{Max}_{\text{Pre\_GAS}}$= 81.00, $\text{Max}_{\text{Post\_GAS}}$= 82.00).

In conclusion, the descriptive statistics related to the pretest and posttest score of both groups related to GAS are presented in this part. The statistics revealed that the mean difference between the posttest and pretest scores in the experimental group is higher than that in the control group. This difference will be examined statistically in the analysis below.

4.2.2 Inferential Statistics

Besides descriptive statistics, which were utilized to describe the data gathered by the Geometry Attitude Scale, inferential statistics were used in order to examine whether there was a statistically significant difference between the experimental and control groups. Before conducting Analysis of Covariance (ANCOVA), missing data analysis was conducted. Afterwards, the covariates were determined, and the assumptions of ANCOVA were checked. Finally, ANCOVA was conducted to examine the differences between the GAS scores of the experimental and control groups.

4.2.2.1 Missing Data Analysis

As it was previously explained in Section 4.1.2.1, six students were removed from the analyses since they did not complete the posttests and did not attend the treatments. Hence, 25 and 23 students remained in the control group and the experimental group, respectively for the following analyses.

4.2.2.2 Determination of Covariates

As previously explained in Section 4.1.2.2, to be able to conduct ANCOVA, theory should be defined satisfying possible covariates. In this sense, relevant literature reveals that there is a positive correlation between attitude and self-efficacy (Roster, 2006), and between attitude and achievement (Cote & Levine, 2000; Işıksal & Aşkar, 2005). Hence, students' achievement and self efficacy scores are suggested as potential covariates in the current study. In addition to the theory, potential covariates (Pre_RSAT, Pre_GSES and Pre_GAS) which have the potential to correlate with dependent variable (Post-GAS) were also analyzed statistically. The results of the correlation analyses are presented below in Table 4.11.

Table 4.11. Correlations between dependent variables and potential covariates

Variables	Pre_GSES	Pre_GAS	Pre_RSAT
Pre_GAS	.577**		
Pre_RSAT	.417**	.489**	
Post_GAS	.567**	.623**	.256

**Correlation is significant at the 0.01 level (2-tailed)

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

As can be observed in Table 4.11, Pre_GSES and Pre_GAS had a significant correlation with the dependent variable (Post_GAS). However, as stated above in Section 4.1.2.2, the correlation between the independent variables (Pre_GSES and Pre_GAS) shoud be checked to determine whether they are strongly correlated or not. Therefore, the correlation value of .577 does not represent a strong correlation, so the results revealed that the Pre_GSES and Pre_GAS had a significant correlation with the dependent variable (Post_GAS). Hence, these independent variables were used as covariates in the Analysis of Covariates to investigate the effect of the inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of attitude towards geometry.

4.2.2.3 Assumptions of ANCOVA for the Second Research Question

As stated in the previous section, before conducting statistical analyses (ANCOVA) it is important to check that the assumptions are not violated. Details related to these assumptions are explained below.

Independence of observation

In the current study, the data were collected in both the control and experimental groups under the same conditions. The measurements were applied before and after the treatment as pretest and posttest. Moreover, each participant completed the GAS independently in that they did not engage in any interaction with each other. Thus, the assumption of independence of observation was assumed to be satisfied.

Normality and Outliers

To begin with normality, the skewness and kurtosis values related to the data gathered through GAS are recommended to be checked. The skewness and kurtosis values of the dependent variable are presented in Table 4.12. The table shows that the values belonging to both the experimental and control groups in GAS vary between -2 and +2, which is an acceptable range (Pallant, 2001).

Table 4.12. Descriptive statistics for the pretests and posttests with respect to the groups

		Skewness	*Kurtosis*
Pre-GAS			
	Control	.36	-.77
	Experimental	-.52	-1.04
	TOTAL	-.19	-.92
Post-GAS			
	Control	-.80	1.05
	Experimental	-1.07	.67
	TOTAL	-.80	.44

In addition to the table presenting the skewness and kurtosis values, the histograms related to both groups are provided in Figure 4.5 and Figure 4.6. The shape of the distributions on the histograms are examined.

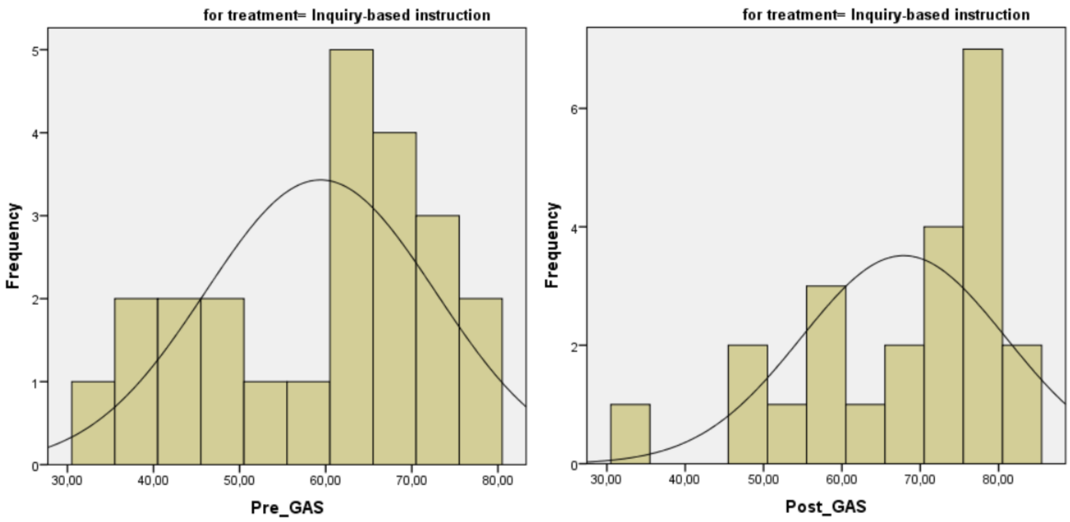


Figure 4.5. Histograms of experimental groups' pretest and posttest scores on GAS

As the skewness and kurtosis values varying between -1.07 and .67 support the fact that they were normally distributed, the histograms in Figure 4.5 also indicate that the

Pre_GAS and Post_GAS scores of the experimental group form a bell shape with the greatest frequency of scores in the middle, thus satisfying the normality assumption.

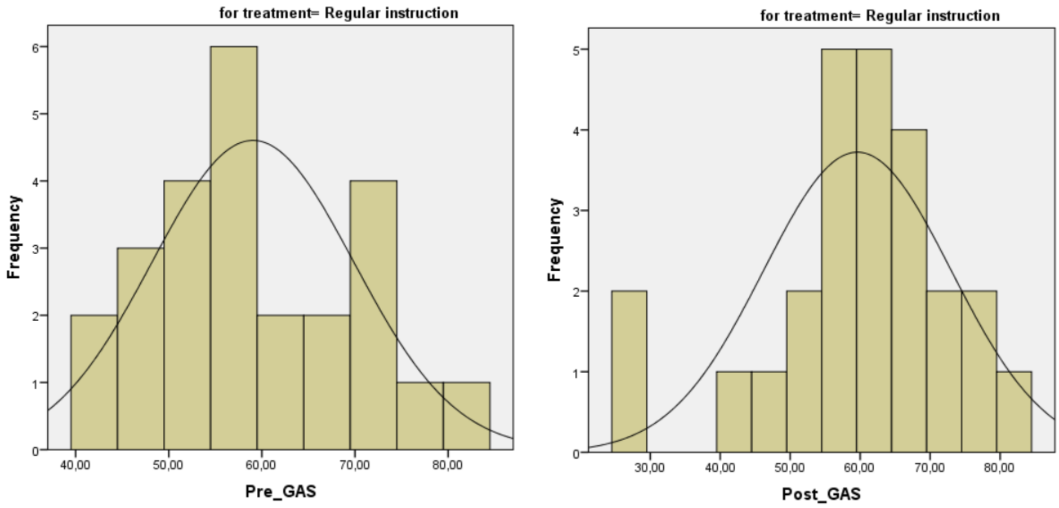


Figure 4.6. Histograms of control groups' pretest and posttest scores on GAS

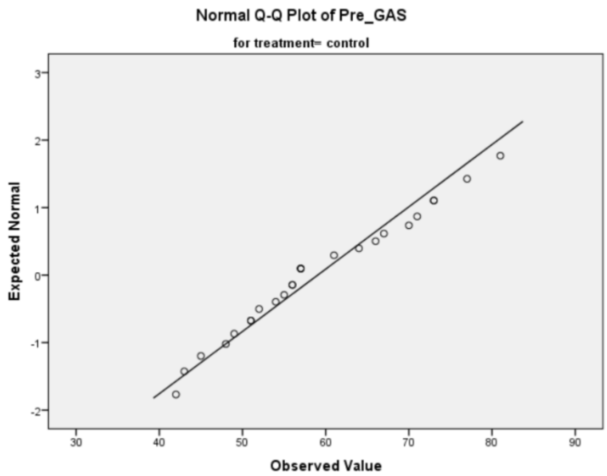
As for the control group, the skewness and kurtosis values were found to vary between -.80 and 1.05, which indicates a normal distribution. The histograms in Figure 4.6 also revealed that the Pre_GAS and Post_GAS scores of the control group form a bell shape, thus satisfying the assumption of normality.

In addition to skewness and kurtosis values and histograms, there is another determinant for normality -the Kolmogorov-Simirnov statistics-, which can be seen in Table 4.13.

Table 4.13. Kolmogorov-Simirnov statistics for both groups

	Statistic	*df*	*Sig.*
Pre_GAS			
Control Group	.175	25	.048
Experimental Group	.157	23	.149
Post_GAS			
Control Group	.178	25	.040
Experimental Group	.174	23	.071

According to Kolmogorov-Simirnov statistics, a non-significant result (p>.05) indicates normality. Table 4.13 reveals that, although the values related to the experimental group are non-significant, values related to both the pretest and posttest scores of the control group are significant. That is, although the skewness and kurtosis values and histograms indicated that the pretest and posttest scores belonging to the control group are distributed normally, komogorov-smirnov statistics do not support that. At this point, normal probability plots (labelled Normal Q-Q Plots) (Pallant, 2001) need to be checked. The plots of Pre_GAS and Post_GAS belonging to the control group are presented in Figure 4.7.



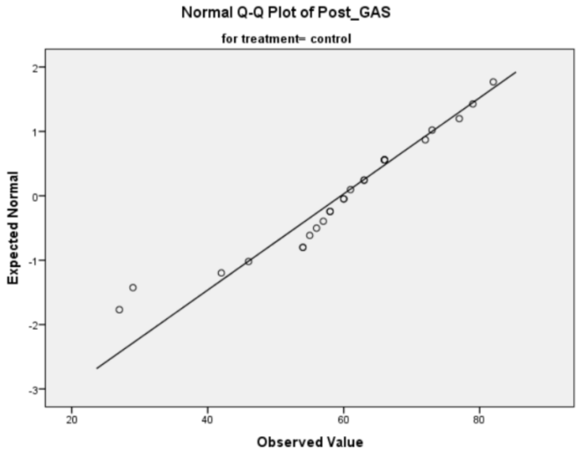


Figure 4.7. Normal Q-Q Plots belonging to the control group

In these plots, the observed value for each score is plotted against the expected value from the normal distribution. That is, a reasonably straight line suggests a normal distribution.

Besides the normality assumption, the outliers should be also checked. The box plots related to the dependent variable (Post_GAS) for both of the groups are displayed in Figure 4.8.

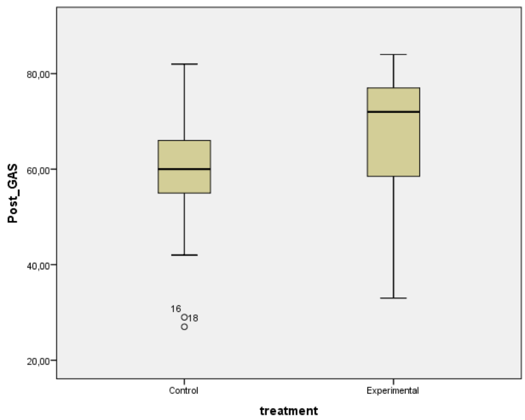


Figure 4.8. Box plots for the dependent variable of the control and experimental groups

The box plots indicated some outliers for the dependent variables in the control group related to GAS. These outliers were checked and they were within the range of possible scores for GAS. In order to see how much of a problem these outlying cases were likely to be, the 5 % Trimmed Mean was checked (Pallant, 2001). The 5% Trimmed Mean is obtained by removing the top and bottom 5 per cent of the cases and recalculating a new mean value. If the original mean and this new trimmed mean are compared and found to be very different, the data may need to be investigated further. The trimmed mean and mean values related to GAS are presented in Table 4.14 for both groups.

Table 4.14. 5% Trimmed Mean values for both groups

		5% Trimmed Mean	*Mean*
GAS	*Control*	60.18	59.60
	Experimental	68.82	67.87

As can be observed in Table 4.14, the trimmed means and the means of the control and experimental groups are very similar. Since the outlier values are not very different from the remaining distribution, these cases were retained in the data set.

Reliability of covariates

As explained above, it is assumed that covariates are measured without error. In this sense, checking the internal consistency of the scales by calculating Cronbach alpha is beneficial in determining the reliability of the covariates, which should be above .7 or .8 to be considered reliable. In the resent analysis, two covariates were determined for ANCOVA. The reliability of these independent variables as covariates were calculated as .88 for the Geometry Attitude Scale and .87 for the Geometry Self-Efficacy Scale. These values are above .80, which implies that the test was reliable. Therefore, it was assumed that the covariates were measured reliably.

Correlations among the covariates (Multicollinearity)

Besides the assumption of the reliability of the covariates, the multicollinearity assumption should be satisfied since there is more than one covariate in the present analysis. The correlation between the independent variables (Pre_GSES and Pre_GAS) was found to be .577. Thus, all the correlation coefficients were found to be less than .80 for both the control and experimental groups. Therefore, the assumption of multicollinearity was assumed to be satisfied.

Linearity

As previously explained, since there is more than one covariate in the current analysis, the relationship between these covariates should be linear. In this sense, to check the linearity between the dependent variable (Post_GAS) and each of the covariates (Pre_GAS and Pre_GSES) and also among the covariates, the matrix scatterplot is examined as displayed in Figure 4.9.

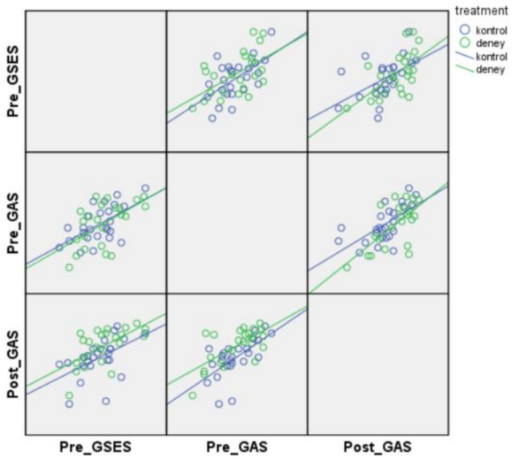


Figure 4.9. The relationship between each covariate and dependent variable for both groups

The matrix scatterplot in Figures 4.9 shows that the relationships between each covariate and the dependent variable for both the control and experimental groups were linear. Therefore, the linearity assumption was assumed to be satisfied.

Homogeneity of regression slopes

For the assumption of the homogeneity of regression slopes, it should be satisfied that there is no interaction between the covariate and the treatment or experimental manipulation for both groups.

The existence of the relationship between the treatment and the covariates can be observed graphically in Figure 4.9. Although it seems that the lines are similar in their orientation, which indicates that there is no interaction, it is hard to decide whether there is a similarity between the slopes. For this reason, this assumption was also tested statistically.

An analysis was conducted to see whether there was a statistically significant interaction between the covariates and the treatment for both groups, and the interaction levels for each covariate are presented in Table 4.15.

Table 4.15. Homogeneity of regression slopes assumption

	Source	*F*	*Sig.*
Post_GAS	Treatment * Pre_RSAT	.016	.900
	Treatment * Pre_GSES	.123	.728
	Treatment * Pre_GAS	.310	.581

According to Table 4.15, the interaction values between each covariate and the treatment are greater than .05, which means that there is no statistically significant interaction between the covariates and the treatment. Thus, the assumption of homogeneity of regression slopes is assumed not to be violated.

Homogeneity of Variance

This final assumption, homogeneity of variance, needs to be checked through Levene's Test of Equality, which indicates whether or not each group has a similar variability of scores. The results related to the dependent variable are presented in Table 4.16.

Table 4.16. Levene's Test of Equality of Error Variances

	F	*df1*	*df2*	*Sig.*
Post_GAS	.001	1	46	.975

As presented in Table 4.16, the error variances of the dependent variable across the groups were equal (F (1, 46) = .001, p= .975). Hence, it failed to reject the null hypothesis of the equality of error variances (p>.05). In other words, the variances across the groups for the dependent variable were equal. Therefore, the assumption of homogeneity of variance is assumed not to be violated.

In conclusion, as all the assumptions were checked and assumed to be satisfied, the Analysis Covariance could be conducted to investigate the effect of the inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of attitude towards geometry when the effect of students' pre-test scores of attitudes towards geometry and self-efficacy in geometry were controlled.

4.2.2.4 Results of ANCOVA for the Second Research Problem

Analysis of covariance was performed to investigate the effect of an inquiry-based instruction (IBI) on students' attitudes towards geometry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled. The independent variable was the type of treatment: inquiry-based instruction (IBI) for the experimental group versus regular instruction (RI) for the control group. The dependent variable was students' attitudes towards geometry measured after the treatment. Students' geometry attitude (Pre_GAS) and geometry self-efficacy (Pre_GSES) measured before the treatments were used as covariates in this analysis.

The statement of hypothesis was 'There is no significant effect of inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of attitudes towards geometry when the effect of students' pre-test scores of attitudes towards geometry and self-efficacy in geometry are controlled'. The overall summary of the inferential statistics for attitudes towards geometry gathered through ANCOVA is presented in Table 4.17.

Table 4.17. Results of ANCOVA for the Second Research Problem

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Partial Eta Squared*	*Noncent. Parameter*	*Observed Power^b*
Corrected Model	4639.77	3	1546.59	16.06	.000	.523	48.19	1.00
Intercept	197.82	1	197.82	2.06	.159	.045	2.06	.29
Pre_GSES	429.35	1	429.35	4.46	.040	.092	4.46	.54
Pre_GAS	1258.76	1	1258.76	13.08	.001	.229	13.08	.94
treatment	623.14	1	623.14	6.47	.015	.128	6.47	.70
Error	4236.05	44	96.27					
Total	202805.00	48						
Corrected Total	8875.81	47						

As can be seen in Table 4.17, the second null hypothesis was rejected (F (1, 44) = 6.47, p=.015). That is, the result of the analysis of the students' Post_GAS scores indicated that there was a statistically significant effect of the inquiry-based instruction on 7th grade students' attitudes towards geometry. Furthermore, the eta squared value ($\eta2 = .128$) indicates a moderate relationship between the treatment and dependent variable, indicating that the size of the difference among the groups was not small. In other words, 12.8 percent of the variance in the Post_GAS scores was explained by the treatment. In addition, the power was found to be .70, which is not withinin the desired level range (.80 and above), the reason of which may stem from an inappropriate sample size. Therefore, the difference found between the groups arose from the treatment effect and this difference had a practical value ($\eta2 = .128$).

4.3 Results of the Third Research Question

The third question is "What is the effect of an inquiry-based instruction enriched with origami activities on 7th grade students' self-efficacy in geometry when the effect of students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are controlled?" With the purpose of investigating the effect of an inquiry-based instruction on students' self-efficacy in geometry, this section is devoted to the presentation of the results in two main parts: descriptive and inferential statistics.

4.3.1 Descriptive Statistics

In this part, descriptive statistics related to students' pretest and posttest scores gathered by means of the Geometry Self-Efficacy Scale (GSES) are presented to describe the data. GSES was administered to the students as pretest (Pre_GSES) and posttest (Post_GSES) before and after the treatment, respectively. The descriptive statistics related to the pretest, posttest, and the gained scores of the experimental group are presented in Table 4.18.

Table 4.18. Descriptive statistics for both the pretest and posttest scores of the experimental group

	Pre_GSES	Post_GSES	Gain Score (Posttest-Pretest)
N	23	23	23
Minimum	56.00	67.00	11.00
Maximum	110.00	125.00	15.00
Mean	80.20	92.26	12.06
Std. Deviation	15.42	16.97	1.55

Table 4.18 indicates that while the students in the experimental group had a mean score of 80.20 (SD = 15.42) on the Pre_GSES, their mean scores in the Post_GSES was 92.26 (SD = 16.97) out of 125. Hence, the mean of the gain scores was 12.06 (SD= 1.55), which indicates an increase in the Geometry Self-Efficacy Scale scores of the 7th grade students' in the experimental group after the treatment. Moreover, the descriptive statistics revealed that both the minimum and maximum values related to the students' pretest scores ($\text{Min}_{\text{Pre\_GSES}}$ = 56.00; $\text{Max}_{\text{Pre\_GSES}}$ = 110.00) increased after the treatment ($\text{Min}_{\text{Post\_GSES}}$ = 67.00; $\text{Max}_{\text{Post\_GSES}}$ = 125.00).

The descriptive statistics related to pretest, posttest, and the gained scores of the control group are presented in Table 4.19.

Table 4.19. Descriptive statistics for both the pretest and posttest scores of the control group

	Pre_GSES	Post_GSES	Gain Score (Posttest-Pretest)
N	25	25	25
Minimum	49.00	47.00	-2.00
Maximum	110.00	113.00	3.00
Mean	77.03	78.76	1.73
Std. Deviation	13.83	15.67	1.84

Table 4.19 indicates that while the students in the control group had a mean score of 77.03 (SD = 13.83) on the Pre_GSES, their mean score in the Post_GSES was 78.76 (SD= 15.67). Therefore, the mean of the gain score was 1.73 (SD= 1.84), which shows that there is an increase in the Geometry Self-Efficacy Scale scores of the 7th grade students' in the control group after the treatment. However, the amount of increase is not as much as that in the experimental group (12.06). Furthermore, while the minimum value of the pretest scores ($\mathrm{Min}_{\mathrm{Pre\_GSES}}$ = 49.00) decreases after treatment ($\mathrm{Min}_{\mathrm{Post\_GSES}}$ = 47.00), the maximum score of the students in the control group increases after the intervention ($\mathrm{Max}_{\mathrm{Pre\_GSES}}$ = 110.00, $\mathrm{Max}_{\mathrm{Post\_GSES}}$ = 113.00).

In conclusion, in this part, the descriptive statistics related to students' GSES scores before and after treatment have been presented. The statistics showed that the mean difference between the posttest and pretest scores of the experimental group was higher than that of the control group. This difference is examined statistically in the analysis below.

4.3.2 Inferential Statistics

In addition to the descriptive statistics which enabled the researcher to describe the data gathered by means of the Geometry Self-Efficacy Scale, inferential statistics were used in order to examine whether there was a statistically significant difference between the experimental and control groups. Before conducting Analysis of Covariance (ANCOVA), missing data analysis was conducted. Subsequently, covariates were determined, and then the assumptions of ANCOVA were checked. Finally, ANCOVA was conducted to investigate the differences between the GSES scores of the experimental and control groups.

4.3.2.1 Missing Data Analysis

As previously explained, six students were removed from the analyses since they did not complete the posttests and did not attend the treatments. Therefore, 25 and 23 students remained in the control group and the experimental group, respectively, for the following analyses. However, there were also some students who had not completed some of the items in the scale. These missing items were replaced by multiple imputation with expected maximization (EM), an algorithm which is a computational method for efficient estimation of incomplete data (Dempster, Laird, & Rubin, 1977). These items were replaced with the mean score of the other items.

4.3.2.2 Determination of Covariates

Prior to conducting ANCOVA, the covariates of the analysis were determined. According to the relevant literature, there is a positive correlation between attitude and elf-efficacy (Roster, 2006). For this reason, the attitude and self-efficacy scores (Pre_GSES) of the students are potential covariates of the current study. Based on this theory, these independent variables should also be supported with statistical analyses. Therefore, the potential covariates were determined as Pre_GSES and Pre_GAS, which had the potential to correlate with the dependent variable, Post-GSES. The results of the correlation analyses are presented in Table 4.20.

Table 4.20. Correlations between dependent variables and potential covariates

Variables	Pre_GSES	Pre_GAS	Pre_RSAT
Pre_GAS	.577**		
Pre_RSAT	.417**	.489**	
Post_GSES	.657**	.403**	.182

**Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)

According to Table 4.20, Pre_GAS and Pre_GSES had significant correlation with the dependent variable (Post_GSES). When the correlation between the independent variables (Pre_GAS and Pre_GSES) is taken into consideration, it is seen that the value of .577 does not represent a strong correlation, so the results revealed that the Pre_GAS and Pre_GSES had a significant correlation with the dependent variable

(Post_GSES). Hence, these independent variables were used as covariates in the Analysis of Covariates to examine the effect of the inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of self-efficacy in geometry.

4.3.2.3 Assumptions of ANCOVA for the Third Research Question

As previously stated, before conducting statistical analyses (ANCOVA), it is important to check the assumptions to be sure that they are not violated. Details related to these assumptions are explained below.

Independence of observation

In the current study, the data were collected in both groups under the same conditions. The measurements were applied before and after the treatment as pretest and posttest. Moreover, each participant completed the GSES independently in that they were not engaged in any interaction with each other. Thus, the assumption of independence of observation was assumed to be satisfied.

Normality and Outliers

To begin with normality, the skewness and kurtosis values related to the data gathered through GSES are recommended to be checked. The Skewness and kurtosis values of the dependent variable are presented in Table 4.21. The table indicates that the values belonging to both groups in GSES vary between -2 and +2, which is the acceptable range.

Table 4.21. Descriptive statistics for the pretests and posttests with respect to the groups

	Skewness	*Kurtosis*
Pre-GSES		
Control	.05	.29
Experimental	.42	-.60
TOTAL	.28	-.19
Post-GSES		
Control	.31	.21
Experimental	.17	-.82
TOTAL	.27	-.38

In addition, histograms related to both groups are provided in Figure 4.10 and Figure 4.11 The shape of the distributions on the histograms were examined.

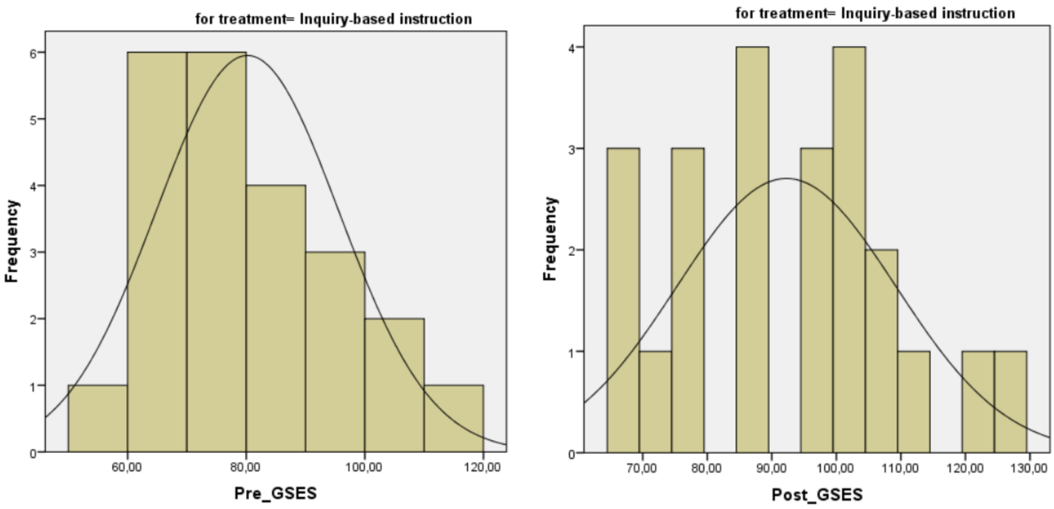


Figure 4.10. Histograms of experimental groups' pretest and posttest scores on GSES

In addition to the normal distribution of the skewness and kurtosis values, which vary between -.82 and .42, histograms in Figure 4.10 also indicated that the Pre_GSES and Post_GSES scores of the experimental group produced bell shape, which indicates a normal distribution of the data.

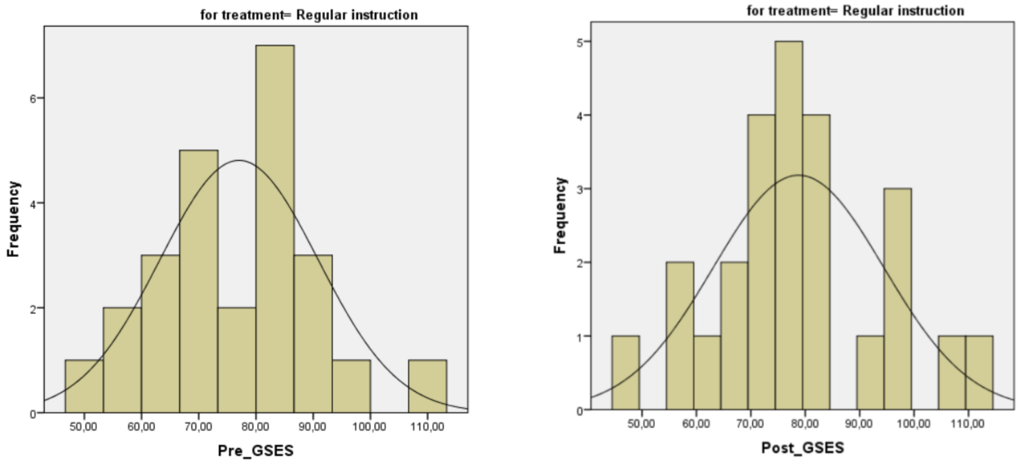


Figure 4.11. Histograms of control groups' pretest and posttest scores on GSES

The skewness and kurtosis values belonging to the control group vary between 0.05 and 0.31, which is an indication of normal distribution. Histograms, as displayed in Figure 4.11, also indicated that Pre_GSES and Post_GSES scores of the control group are normally distributed. Hence, the assumption of normality was satisfied.

The Kolmogorov-Simirnov statistics, which is another determinant for normality, are presented in Table 4.22.

Table 4.22. Kolmogorov-Simirnov statistics for both groups

	Statistic	*df*	*Sig.*
Pre_GSES			
Control Group	.093	25	.200
Experimental Group	.108	23	.200
Post_GSES			
Control Group	.129	25	.200
Experimental Group	.150	23	.197

According to Table 4.22, all the values related to the experimental group and control group are non-significant, which means that the scores are normally distributed.

Therefore, all the techniques used to measure normality of the data gathered from the students in both the experimental and control groups by GSES indicated that the scores are distributed normally.

In addition to the normality assumption, outliers should be also checked. The box plots related to the dependent variable (Post_GSES) for both groups are displayed in Figure 4.12.

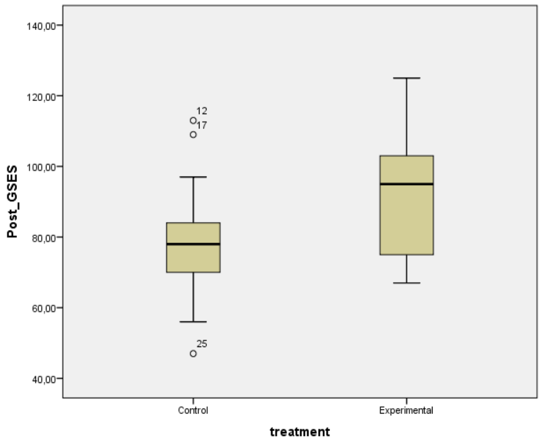


Figure 4.12. Box plots for the dependent variable of the control and experimental groups

Box plots indicated some outliers for the dependent variables in the control group related to GSES. These outliers were checked and they were found to fall within the range of possible scores for GSES. In order to see how much of a problem these outlying cases were likely to be, the 5% Trimmed Mean was checked (Pallant, 2001). The trimmed mean and the mean values related to GSES are presented in Table 4.23 for both groups.

Table 4.23. 5% Trimmed Mean values for both groups

		5% Trimmed Mean	*Mean*
GSES	*Control*	78.57	78.76
	Experimental	91.85	92.26

According to Table 4.23, the trimmed means and the means of both the control and experimental groups were very similar. Since the outlier values were not found to be very different from the remaining distribution, these cases were retained in the data set.

Reliability of covariates

As stated above, this assumption requires covariates to be measured without error. In this sense, checking the internal consistency of the scales by calculating the Cronbach alpha is beneficial in assessing the reliability of the covariates, which should be above .7 or .8 to be considered reliable. In the previous analysis, two covariates were determined for ANCOVA. The reliability of these independent variables as covariates were calculated as .88 for the Geometry Attitude Scale and .87 for the Geometry Self-Efficacy Scale, which implies that the test was reliable since they were found to be above .80. Therefore, it was assumed that the covariates were measured reliably.

Correlations among the covariates (Multicollinearity)

Since there is more than one covariate in the present analysis, the multicollinearity assumption should be satisfied. As can be seen in Table 4.20, the correlation between the independent variables (Pre_GSES and Pre_GSES) is .577, which is less than .80 for both the control and experimental groups. Therefore, the assumption of multicollinearity was assumed to be satisfied.

Linearity

Moreover, having more than one covariate in the current analysis requires one more assumption to be satisfied: linearity. According to this assumption, the relationship between the covariates should be linear. In this sense, to check the linearity between the dependent variable (Post_GSES) and each of the covariates (Pre_GAS and Pre_GAS) and also between the covariates, the matrix scatterplot was examined as displayed in Figure 4.13.

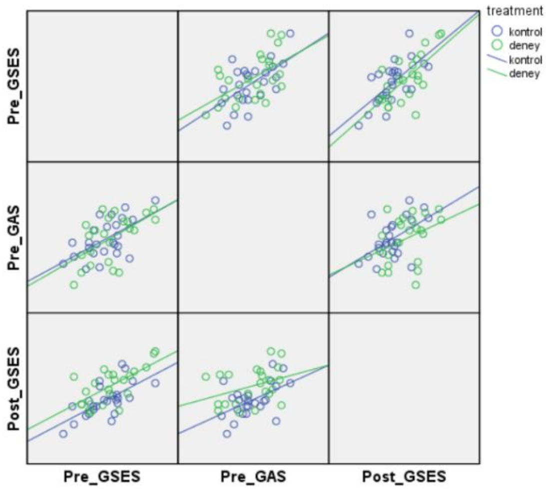


Figure 4.13. Relationship between each covariate and the dependent variable for both groups

The matrix scatterplot in Figures 4.13 indicates that the relationship between each covariate and the dependent variable for both the control and experimental groups were linear. Therefore, the linearity assumption was assumed to be satisfied.

Homogeneity of regression slopes

As explained in the previous section, this assumption of homogeneity of regression slopes necessitates that there be no interaction between the covariate and the treatment or the experimental manipulation for both groups.

Figure 4.13 can be examined to examine the relationship between the treatment and the covariates graphically. In the figure, the lines seem to be similar in their orientation, which indicates that there is no interaction. However, it is difficult to make decisions on the similarity between their slope. Hence, this assumption will also be tested statistically.

An analysis was conducted to see whether there was a statistically significant interaction between the covariates. The treatment for both groups and the interaction levels for each covariate are presented in Table 4.24 below.

Table 4.24. Homogeneity of regression slopes assumption

	Source	*F*	*Sig.*
Post_GSES	Treatment * Pre_RSAT	.361	.552
	Treatment * Pre_GAS	.406	.528
	Treatment * Pre_GSES	.507	.481

According to Table 4.24, the interaction values between each covariate and the treatment are greater than .05, which indicates that there is no statistically significant interaction between the covariates and the treatment. Thus, the assumption of homogeneity of regression slopes is assumed not to be violated.

Homogeneity of Variance

This assumption is checked through Levene's Test of Equality, which indicates whether or not each group has a similar variability of scores. The results related to the dependent variable are presented in the Table 4.25.

Table 4.25. Levene's Test of Equality of Error Variances

	F	*df1*	*df2*	*Sig.*
Post_GSES	.268	1	46	.657

As represented in Table 4.25, the error variances of the dependent variable across the groups were found to be equal (F (1, 46) = .268, p= .657). Hence, it failed to reject the null hypothesis of equality of error variances (p>.05). In other words, the variances across the groups for the dependent variable were equal. Therefore, the assumption of homogeneity of variance is assumed not to be violated.

In conclusion, as all the assumptions are checked and assumed to be satisfied, the Analysis Covariance could be conducted to examine the effect of the inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of self-efficacy geometry when the effect of students' pre-test scores of attitudes towards geometry and self-efficacy in geometry were controlled.

4.3.2.4 Results of ANCOVA for the Second Research Problem

Analysis of covariance was performed to investigate the effect of the inquiry-based instruction (IBI) on students' self-efficacy in geometry. The independent variable was the type of treatment: inquiry-based instruction (IBI) for the experimental group versus regular instruction (RI) for the control group. The dependent variable was students' self-efficacy in geometry measured after the treatment. Students' geometry attitude (Pre_GAS) and geometry self-efficacy (Pre_GSES) measured before the treatment were used as covariates in this analysis.

The statement of hypothesis was 'There is no significant effect of inquiry-based instruction enriched with origami activities on the population means of 7th grade students' post-test scores of self-efficacy in geometry when the effect of students' pre-test scores of attitudes towards geometry and self-efficacy in geometry are controlled. The overall summary of inferential statistics for geometry self-efficacy scores gathered through ANCOVA is presented in Table 4.26.

Table 4.26. Results of ANCOVA for the Third Research Problem

Source	*Type III Sum of Squares*	*df*	*Mean Square*	*F*	*Sig.*	*Partial Eta Squared*	*Noncent. Parameter*	*Observed Power[b]*
Corrected Model	7712,82	3	2570.94	16.89	.000	.523	50.67	1.00
Intercept	816.85	1	816.85	5.37	.025	.109	5.37	.62
Pre_GSES	3249.62	1	3249.62	21.35	.000	.327	21.35	1.00
Pre_GAS	35.02	1	35.02	.23	.634	.005	.23	.08
Treatment	1487.27	1	1487.27	9.77	.003	.182	9.77	.86
Error	6697.66	44	152.22					
Total	363083.00	48						
Corrected Total	14410.48	47						

As can be seen in Table 4.26, the third null hypothesis was rejected (F (1, 44) = 9.77, p=.003). That is, the result of the analysis of students' Post_GSES scores indicated that there was a statistically significant effect of inquiry-based instruction on 7th grade students' self-efficacy in geometry. Furthermore, the eta squared value ($\eta 2$ = .182) indicates a strong relationship between treatment and dependent variable, referring that the size of the difference among the groups was not small. In other words, 18.2 percent of the variance in the Post_GSES scores was explained by the treatment. In addition, the power was found to be .86. Hence, the difference found between the groups stemmed from the treatment effect and this difference had a practical value.

4.4 Summary of the Findings

The purpose of the current study was to investigate the effect of an inquiry-based instruction on students' achievement in the concept of reflection symmetry, attitude towards geometry and geometry self-efficacy. In this sense, ANCOVA was conducted to examine the effect of this instructional method on achievement in reflection symmetry, geometry attitude and self-efficacy in geometry. Assumptions of independence of observation, normality and outliers, reliability of covariates, multicollinearity, linearity, homogeneity of regression, and homogeneity of variance for ANCOVA were checked and all of the assumptions were met for each dependent variable (Post_RSAT, Post_GAS and Post_GSES). Moreover, it was found that the independent variables (Pre-RSAT, Pre-GSES and Pre-GAS) had a significant correlation with the dependent variables (Post-RSAT, Post-GSES and Post-GAS); in other words, Pre_RSAT was correlated with Post_RSAT, Pre_GAS was correlated with Post_GSES and Post_GAS, and Pre_GSES was correlated with Post_GSES and Post_GAS. Thus these independent variables were used as covariates in ANCOVA.

Results revealed that the means of the Post-RSAT, Post-GSES and Post-GAS scores of the students in the experimental group were greater than those in the control group. Moreover, the gain scores of the students in the experimental group in terms of RSAT, GSES and GAS were greater those in the control group. According to the results of ANCOVA, it was found that there was a statistically significant mean difference between the students taught by the inquiry-based instruction and those taught by regular instruction with respect to gained scores in achievement in reflection symmetry favoring inquiry-based instruction group. Moreover, ANCOVA results for the second and third question also revealed that there was a statistically significant mean difference between the students in the experimental and control groups in attitude toward geometry and self-efficacy in geometry in favor of the experimental group. Finally, the effect sizes calculated on the post-test scores of Post-RSAT, Post-GSES and Post-GAS were moderate and large for both groups, thus indicating practical significance.

CHAPTER V

DISCUSSION AND CONCLUSION

The purpose of this study was to examine the effect of an inquiry-based instruction enriched with origami activities on the 7^{th} grade students' achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry. With this purpose, an experimental research design was used to investigate the effect of the inquiry-based instruction method. In the first three sections of this chapter, findings related to the effect of an inquiry-based instruction on students' achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry are discussed and compared to previous research studies. In the fourth section, implications of the study are discussed. Finally, in the fifth section, recommendations for further studies are made.

5.1 Discussion on the Effect of an Inquiry-Based Instruction on Students' Achievement in Reflection Symmetry

In the current study, whether there was a significant effect of the inquiry-based instruction enriched with origami activities on the 7^{th} grade students' achievement in reflection symmetry was examined. ANCOVA was conducted to test the effect of the inquiry-based instruction on the students' achievement when the effect of the students' pre-test scores of achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry were controlled. The ANCOVA results indicated that there was a statistically significant effect of the inquiry-based instruction on students' achievement in the concept of reflection symmetry. That is, the students instructed with the inquiry-based instruction method got significantly higher achievement scores on the Reflection Symmetry Achievement Test than the students instructed with regular instruction.

Most studies related to inquiry-based instruction were conducted in science education and employed an experimental research design with a control group. The researchers used inquiry methods in science education to mostly support laboratory activities. For the analysis of the results, researchers used the independent sample t-test to examine the difference between experimental and control groups and paired sample t-tests to examine the difference between pretest and post test scores of each group. As in the current study, the researchers concluded that inquiry-based instruction has a positive impact on achievement levels of students in Turkey (Türkmen, 2009; Sağlamer-Yazgan, 2013; Tatar, 2006; Sakar, 2010; Fansa, 2012; Göksu, 2011; Akpullukçu, 2013; Sarı & Bakır-Güven, 2013; Çalışkan, 2008; Çelik, 2012; Kula, 2009; Altunsoy; 2008; Sever & Güven, 2014) and in other countries (Ferguson, 2010; Maxwell, Lambeth & Cox, 2015; Abdi, 2014; Taylor & Bilbrey, 2012; Johnston, 2014; Njoroge, Changeiywo, & Ndirangu, 2014). Although the sample, tools, techniques, and the topic of the current study are different from the studies related to inquiry-based instruction in the literature, the instructional method (inquiry-based instruction) and the key features of the instruction were similar. For this reason, this study revealed that inquiry-based instruction can be accepted as an effective instructional method since it increased the achievement level of the students.

Several factors may account for the positive impact of an inquiry-based instruction on students' achievement. One of these factors might be students' active participation during inquiry-based instruction. In this sense, inquiry-based instruction enables students to be active participants who make observations, work on problems and formulate questions, make assumptions, collect data and represent their findings, and make connections with their prior knowledge (Artigue & Blomhoej, 2013). Moreover, rather than engaging in memorization, being active during instruction may make students understand the reflection symmetry concept task (Brown & Campione, 1986). Hence, active participation during inquiry-based instruction might enable students to have higher achievement scores. Furthermore, during inquiry-based instruction, students are asked to explain their solutions to support their reasoning and they are made to hold discussions in the classroom. According to the inquiry-based instruction, peer interaction is unavoidable. Therefore, students' being active during instruction, social communication with others and discussing their mathematical reasoning might have had an impact on increasing students' achievement scores in the concept of reflection symmetry.

Another reason might be the effect of origami activities used during the inquiry-based instruction. Origami enables students to manipulate a piece of paper physically, so they can make connections of many mathematical concepts more concretely (Wares, 2016). According to Piaget (1965), students have difficulty understanding abstract mathematical concepts expressed in words or symbols solely through direct instruction since they are not mature enough cognitively. Concrete materials enable students to communicate mathematically and develop their own cognitive models (Ojose & Sexton, 2009). Moreover, long-term application of concrete materials at various grade levels increases students' mathematics achievement (Sutton & Krueger, 2002). In this sense, origami models can be regarded as concrete materials since origami provides students with ready-made manipulatives that can be improve visualization of abstract ideas in a concrete mode (Haga, Fonacier, & Isoda, 2008). For instance, while working on the activity of buttered toast, students folded the paper toast model into two to be able to decide on the place of butter. In this activity, students were asked what they considered while folding. Students were expected to realize the importance of the line on which the model folded. When they were asked why they folded the model through the line in the middle of two slices of bread, they explained that the crease represented line of symmetry and a figure and its reflection should be placed in equal distances from the line. For this reason, using origami models in the activities might have had a positive impact on increasing students' reflection symmetry achievement score in the current study. Moreover, inquiry-based mathematics instruction gives students the advantage of learning mathematical language and speak by engaging in mathematical discussion, by proposing reasons, and by working on new and unfamiliar problems. That is, inquiry enables students to learn mathematics through discursive activities (Richards, 1991). Artigue and

Blomhøj (2013) emphasize that ‘‘inquiry’’ and ‘‘problem solving’’ overlap philosophically. Furthermore, literature reveals that problem solving is an effective way of teaching mathematics (e.g., Hammorui, 2003; Özkaya, 2002; Ubuz, 1991). Thus, the activities in the current study were presented to the students in a problem context. In this sense, problems were constructed in which students were not asked to fold a given model, but were expected to feel the necessity to fold the paper to be able to answer the problem and use these models to support their solutions. Therefore, students were given the opportunity to work on problems under inquiry based instruction. These problem solving sessions might have been effective in increasing students' achievement in reflection symmetry.

Furthermore, a problem should have the capacity to engage all of the students in the class to make and examine mathematical hypothesis (Lampert, 1990). In this sense, Tandoğan and Akınoğlu (2006) stated that daily-life expressions of problems might lead students to participate actively. That is, if the students are asked to learn mathematics, dealing with real-life problems can be suitable for them since realistic approach enables them to understand abstract concepts (Artigue, and Blomhøj, 2013). Under the light of this information, the contexts of the problems were written on real life situations mostly experienced previously by students such as painted handkerchief, buttered toast. The aim was to make students establish a connection between their real life experiences and mathematical concepts while dealing with these problems. Therefore, the increase in their achievement scores related to reflection symmetry might have stemmed from their working on the activities in the light of their real life experiences.

As it was previously stated, students had prior knowledge which arose from the objectives in the elementary mathematics curricula for 2nd, 3rd and 4th grades. These objectives are generally related to explaining reflection symmetry, finding the line of symmetry and reflecting a figure over the given line (MoNE, 2009). When the explanations and sample activities related to these objectives in the curricula are examined, it can be seen that the goal is to teach students at the visualization level

(level 0) of the van Hiele geometric thinking levels. In this level, students identify, compare and sort shapes on the basis of global visual characteristics of the shapes in an informal language (Van de Walle, Karp, & Williams, 2013). Students operate on the figure given to them and begin to figure out the similarities and differences among shapes. According to these explanations, it is concluded that the activities related to reflection symmetry in the curricula of earlier grades ensure the characteristics described in level 0. On the other hand, in 7th grade, students are expected to explain reflection symmetry in terms of the moves of the figures, properties of these moves with justifications of the procedures according to the objectives in the curriculum (MoNE, 2013). The explanations and requirements of the objectives show that students are expected to move to analysis level (level 1) and informal deduction level (level 2). In level 1, students recognize and describe the properties of a shape (e.g., parallelogram) through observation, measurement and modeling in a formal language. When they move to the upper stage (level 2), they can follow and give informal arguments and notice new properties by deduction. Students are encouraged to ask "Why?" or "What if?" questions and make logical reasoning. The inquiry-based instruction administered in the current study was designed to teach objectives related to reflection symmetry in the 7^{th} grade under the guidance of the curriculum. Origami activities developed parallel to the objectives were applied from the easiest, which was designed for students to recognize and describe the properties of reflecting a figure (level 1), to the most complex ones, which were designed for students to discuss, make explanations, evaluate the explanations and notice new properties of reflection symmetry as the outcomes of inquiry-based instruction (level 2). For instance, in the first activity, students were expected to fold the paper into two to be able to decide the place of the butter and honey drops. Students who use folding to find the reflection of a figure are expected to realize the relation between folding and reflecting. In this sense, students were asked why and how they had folded the model. The students were asked to discuss the properties of the crease pattern that they had folded over. While asking such questions, the students were encouraged to describe the process of reflecting and support their reasoning (level 1). In another activity, students were asked to find the place of a painted point on a folded handkerchief. At the beginning of the activity, students were asked to find the place of the stain after a simple folding done as a warm up to grasp the terms related to folding. The steps that followed were more complex in that they were asked to find the place of the stain after double and triple folds. The critical characteristic of these steps is that students can find two different solutions which are both correct. Students were expected to discuss these different solutions and provide explanations on the characteristics of reflection symmetry (level 2). These activities applied within the inquiry process might have led to an increase in students' van Hiele geometric thinking levels. In the same way, Dağdelen (2012) stated that origami-based instruction had a positive impact on students' van Hiele levels of geometric thought. Therefore, in the current study, geometric thinking levels of the students might have increased after learning through origami activities within the inquiry process and as a result of this increase, their achievement scores in reflection symmetry might have increased.

5.2 Discussion on the Effect of Inquiry-Based Instruction on Students' Attitudes towards Geometry

In addition to the effect of the inquiry-based instruction on students' achievement in the concept of reflection symmetry, the effect of this method on the affective domain, such as attitude, was also examined. Attitude is a learned behavior, so it can be subject to change (Koballa, 1988). According to accessible literature, instructional strategies play an important role in students' building constant dispositions and affective responses i.e. attitude through mathematics. In this respect, it was believed that inquiry-based instruction can be effective for the improvement of students' attitudes toward the geometry course, just as it was found to be an effective instruction method for attitude towards other lessons such as biology and chemistry (Altunsoy, 2008; Sakar, 2010). Therefore, in this study whether there was a significant effect of inquiry-based instruction enriched with origami activities on the 7th grade students' attitudes towards geometry was examined. ANCOVA was conducted to investigate the effect of this method on the students' attitudes when the effect of students' pre-test scores of attitudes towards geometry and self-efficacy in geometry were controlled. The results of the analysis revealed that there was a statistically significant effect of inquiry-based instruction on students' attitudes towards geometry. That is, the students instructed with inquiry-based instruction enriched with origami activities got significantly higher attitude scores on the Geometry Attitude Test than the students instructed with regular instruction.

Inquiry-based instruction aims to improve and foster investigative minds and attitudes that enable students to face and accomplish ambiguous futures (Artigue &Blomhoej, 2013). In this sense, this instructional method is emphasized in the literature and educational programs to be used for teaching mathematics. However, although it is explained in terms of its positive impact on students, it is seen that this method is unlikely to be used during mathematics instruction (Doğan, 2006). In this sense, although students are not familiar with inquiry-based instruction, luckily they were eager and volunteered to be involved in inquiry-based instruction, to work on activities and to discuss their solutions. Since volunteering to participate in the study means having an open attitude and being willing to engage in this process (Drijvers et al., 2013), it can be said that the participants had an open attitude. For that reason, they might have been open to inquiry based instruction and to change in their attitudes towards geometry. That is, this characteristic might have enabled the instruction to have an impact on their attitude towards geometry.

Furthermore, creativeness and reasoning are assumed to function as principals in improving attitude toward mathematics (Putney & Cass, 1998). In addition, concrete materials also play a crucial role in the improvement of attitude toward geometry (Sowell, 1989). In this respect, origami, which has the related characteristics, was used in this study as an instructional tool for inquiry-based instruction. In their studies, Çakmak (2009), Şimşek (2012) and Takıcak (2012) observed that students who were instructed through origami-based instruction had a positive attitude towards origami. This might be the reason of their willingness to be active during their creation and reasoning of origami models. During the instruction, students used their creativeness to construct related figures and discuss their reasoning mathematically. For instance, in the activity of the fox, students were expected to fold through creases to create the fox. At the beginning, students started to fold from the creases without reasoning; however, they could not. When they were told that it entailed a mathematical explanation, they stopped folding and examined the model to be able to discover the solution. Students inquired their own solutions by willingly engaging in reasoning on the concrete model and assessing their performance by themselves according to the product that they constructed. Since they created their figure through reasoning, they were encouraged to support their solution during classroom discussion. Moreover, they observed that they could succeed in communicating, even discussing, mathematically. This might have improved students' attitudes towards geometry.

Moreover, as in this study, offering practice to students in ''doing mathematics'' is valued so that they can have a feeling for mathematical practices (Kim & Ju, 2012). During the inquiry-based instruction, all the students engaged in the process of asking, responding, solving problems, constructing origami figures, discussing and supporting their responses. Moreover, it was observed that students had a productive disposition. Productive disposition means committing to making sense and solving a task and knowing that it can be managed if it is worked on (Van de Walle, Karp & Williams, 2013). In other words, during the instructions, it was informally observed that students worked on origami activities which were presented in a non-routine problem context. Indeed, it was difficult for the students to solve the problems at first glance. Although they had difficulty most of the time, they refused to get help from the others who had completed the activity. When they were offered help and were explained the procedure to fold, they usually replied as "No, don't tell me, I will do it". Most of the students made significant progress on the activities in that they had a productive disposition- a "can do" attitude (Van de Walle, Karp & Williams, 2013). Therefore, having a productive disposition kept the students in class completely involved in the activities. This behavior of having a productive disposition might have increased their attitude towards geometry since they were willing to compete the given activities.

5.3 Discussion on the Effect of Inquiry-Based Instruction on Students' Self-efficacy in Geometry

In addition to attitude towards geometry, another concern of the current study in terms of the affective domain was students' self-efficacy in geometry. Self-efficacy is a person's belief that he or she can perform and achieve a given task (Bandura, 1997). Bandura also states that self-efficacy is not a static belief, i.e. it may change according to new practices or situations (Bandura, 1986). Cognitive researchers emphasize the importance of assessing students' self-efficacy in mathematics as a component of the increase in their mathematical performance (Bandura, 1997; Pajares, 1997). In this sense, it was believed that it would have been valuable to measure students 'self-efficacy in geometry and the effect of inquiry-based instruction on this affective belief. Therefore, the current study was conducted to investigate whether there was a significant effect of an inquiry-based instruction enriched with origami activities on the 7th grade students' self-efficacy in geometry. ANCOVA was conducted to test the effect of the instructional method on the students' self-efficacy when the effect of the students' pre-test scores of attitude towards geometry and self-efficacy in geometry were controlled. Analysis showed that there was a statistically significant effect of the inquiry-based instruction on students' self-efficacy in geometry. That is, the students instructed with inquiry-based instruction enriched with origami activities got significantly higher self-efficacy scores on the Geometry Self-Efficacy Test than the students instructed with regular instruction.

As in the current study, the impact of inquiry-based instruction on self-efficacy has been explained in a variety of disciplines and settings. There are studies related to the effect of inquiry-based instruction in the accessible literature on self-efficacy of students and teachers (Usta-Gezer, 2014; Kocagül, 2013; Özdilek & Bulunuz, 2009; Laipply, 2004; Roster, 2006; Thrift, 2007; Tuan, Chin, Tsai & Cheng, 2005). These studies revealed that professional development programs related to the application of this method change teachers' beliefs in this method and their self-efficacy in using it for instruction, and this instructional method has a positive influence on self-efficacy of students in related courses.

Another factor that can have an effect on self-efficacy might be the assistance provided in teaching. As Laipply (2004) explained, the reason underlying the increase in self-efficacy of the college students in a biology course might be the chance given to students to do science with appropriate guidance. Thus, in the current study, students were posed questions to direct them in completing the activities and engaging in mathematical reasoning. When they tried to complete some movements through trial and error, they were asked to explain their reasoning. Such questions enabled them to rethink about the solutions and to engage in mathematical reasoning. Therefore, the guidance of the researcher might have positive effect on students' self-efficacy in geometry.

Moreover, the difficulty level of the activities might be another reason of the increase in students' self-efficacy in geometry. Roster (2006) drew attention to the difficulty level of the activities during instruction, which may cause an increase in the self-efficacy of students. That is, students' self-efficacy tends to increase through the practice that they are familiar with or they have experienced before. In the same respect, although students had not experienced origami activities before, they were familiar with the contexts of the activities, such as stain on a handkerchief. Since they are familiar, student might have found them understandable and this might have changed their self-efficacy in geometry positively.

In addition to these findings, in the current study, it is believed that sources of self-efficacy might have played a crucial role in the improvement of students' self-efficacy in geometry. According to Bandura, self-efficacy can be improved by means of four sources: performance accomplishments, vicarious experiences, verbal persuasions, and emotional-physiological states occurring at any time during mathematical involvement (Bandura, 1977). Performance accomplishments are determined by students according to their success in previous tasks and activities. After completing the given task, students evaluate their performance (Bandura, 1997). In the current study, students worked on origami activities and tried to solve the given problems by folding paper. They obtained a product and talked about it to explain the mathematical idea underlying the folding. During the implementation, students had the opportunity to realize that they could construct the expected product and explain reflection symmetry based on the lines they folded over. Therefore, students had the advantage of assessing their own performances though the figure they had constructed and, thus, evaluated themselves. This performance accomplishment might have enhanced students' self-efficacy in geometry.

The second source of self-efficacy is vicarious experience, which is related to observing others' performance (Bandura, 1997). This influences efficacy when students observe others successfully performing a mathematical task and tend to achieve as they do. During the activities, the participants were observing their peers while they were trying to discover how to fold a given model. They were trying to assess their own performance according to others. When someone completed the activity, they made reactions, such as "Who finished?", "Is it the correct answer?", "Don't tell me, I will complete it too". Students were more encouraged and ambitious when the others completed the given activity. Thus, the increase in self-efficacy in geometry might have stemmed from these vicarious experiences of the students.

The third source of self-efficacy is verbal persuasion, which refers to the encouragement and discouragement of others, particularly of teachers who influence through the feedback they give to students' performance (Klassen, 2004; Usher & Pajares, 2006). Teachers are coded by students as the influential source of their motivational attitudes for a specific subject (Viau, 1999). In this study, the instruction to students was applied by the researcher. It was observed that students had a positive attitude towards the researcher in that they were asking whether or not she was going to attend the next lesson again. Moreover, during the instruction, students were encouraged to complete the activity by emphasizing that they could do it. When the students expressed that they could not find how to solve the problem and asked help from the instructor, she did not show how to do the folding and how to answer the problems. She tried to encourage them by uttering such statements as “You can do it”, “Did you read the problem correctly? Let’s read and understand together”, “Think about previous activities; you did this before.” Thus, the attitudes of the researcher towards the students might have increased students’ self-efficacy in geometry.

The final source of self-efficacy is emotional-physiological states, which can positively or negatively affect students’ perceptions of ability (Usher & Pajares, 2006). When students experience a positive emotional response, they tend to be energized and their perceptions of their abilities are enhanced and thus their self-efficacy beliefs increase (Bandura, 1997). In contrast, negative experiences cause students’ self-efficacy beliefs to get lower. During the study, there was no indication of students being in a stressful position. They were having fun while trying to figure out how to fold, discussing their reasoning and communicating mathematically during inquiry. Based on the students’ reactions during the instruction, such as “It is fun to do mathematics with these activities”, “I wish we had always had such mathematics lessons”,” I like the mathematics lesson”, and “I like constructing figures”, it is believed that students’ positive emotions in the lesson might have impacted their self-efficacy in geometry positively.

In addition to sources of self-efficacy, it is believed that having a productive disposition might have affected students’ geometry self-efficacy that is their perceptive ability in geometry. As previously explained, students had a productive disposition during instruction in that they showed self-confidence to complete the activities with an “I can do” attitude. Students with a positive self- efficacy tend to persist until they succeed (Bandura, 1977). Therefore, as stated above that it might have enhanced students’ attitudes toward geometry, having a productive disposition might have influenced students’ self-efficacy in geometry.

5.4. Implications for Mathematics Education

In the current study, the effect of an inquiry-based instruction enriched with origami activities on 7th grade students' achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry was examined. Grounded on the findings of this study, possible implications for teachers, curriculum developers, and teacher educators are stated in this part of the study.

According to the relevant literature, although inquiry is stated as an effective instructional approach for effective literature teaching of many disciplines, teachers are reluctant to implement inquiry-based instruction in their lessons (Cheung, 2007) and prefer using direct instruction strategies (Doğan, 2006). Some of the reasons of avoiding inquiry-based instruction are teacher beliefs, lack of effective inquiry materials, student complaints and material demands (Cheung, 2007). This study can be a sample for using inquiry in mathematics education with its features of involving all students in activities, working on cheap and accessible material and making students talk mathematically about what they produced. Thus, teachers should extend this study and use this method in other grade levels for the instruction of other topics in the light of the requirements of inquiry, which enables students to be active and to construct their own knowledge. It should be well-known that the middle school mathematics program requires teachers to use the inquiry approach in their courses (MoNE, 2013). Thus, current and similar studies can offer opportunities for teachers to become experienced in using the inquiry-based instruction in many topics in the mathematics curriculum.

As previously stated, sample inquiry-based instructions enable teachers in professional development programs to change their attitude and self-efficacy towards inquiry. In this sense, it is seen that teachers need to experience effective inquiry-based instruction to be inspired and use it in their classroom. The current study might be a sample for teachers to to see how an inquiry-based instruction should be applied. Moreover, they can observe that an application of a well-designed inquiry instruction can change students' attitudes and self-efficacy towards lessons. Therefore, teachers can design similar instructional settings to improve students' attitudes and self-efficacy in geometry.

Moreover, the findings of this study indicate that students who are instructed by means of origami activities within the inquiry approach showed improvement in terms of achievement, attitude and self-efficacy in the geometry course. As previously emphasized, although the importance of inquiry and paper folding activities were emphasized in the program, the curriculum does not include any examples or directions of how to use them. Thus, curriculum developers should offer examples on how to use the inquiry approach and how to develop origami activities in mathematics lessons effectively. For instance, sample activities in inquiry-based instruction and origami can be provided so that teachers and text book writers can use these methods and tools in mathematics courses/textbooks.

In addition to teachers and curriculum developers, literature review revealed that there are implications for teacher educators also. As previously emphasized, teachers are reluctant to use student-centered instructional methods because of several issues including lack of materials, lack of time, students' complaints, classroom measurement issues. According to literature, teachers tend to have more positive beliefs towards inquiry-based instruction and consequently have an increased level of self-efficacy in using it when they attend professional development projects (Thrift, 2007). Therefore, teacher educators should emphasize the importance of inquiry and how to use it in the classroom effectively by providing and practicing sample classroom settings through inquiry-based instruction in methodology courses.

Besides the implications for stakeholders, the present study also offers some recommendations for researchers for further studies. These recommendations will be presented in the following section.

5.5. Recommendations for Further Research Studies

The present study is focused on the effects of inquiry-based instruction enriched with origami activities on the 7th grade students' achievement in reflection symmetry, attitudes towards geometry and self-efficacy in geometry. Based on the findings of the study, some recommendations for further research studies can be suggested.

The study was conducted according to a pretest and posttest design with a control and experimental group. The convenience sampling method was used to select the sample of the study, which included 7th grade students in two classrooms from a public school. Similar studies could be conducted with students selected through random sampling. In this way, the findings of the study can be generalized to others. Moreover, it would be beneficial to conduct similar studies in both private and public schools. The results gathered from two different school types can be compared in other grade levels and the effect of gender and school type can be examined.

In the same way, this study can be conducted with students from different socio-cultural status. Participants of the current study were from a low socio-cultural background. The school was located in a district where there were refugees, gypsies and people who had immigrated from all around Turkey. This might be effective in students' being open to communication with others since they are used to it. Therefore, they did not have problems in communicating with the researcher although she was a stranger for them. They did not hesitate to participate in activities and explain their findings and participating in discussions. This might be effective in enhancing achievement, attitude and self-efficacy of the students. Hence, data can be gathered from students with different socio-cultural backgrounds to be analyzed and compared with each other.

From another perspective, it is believed that students' both attitudes towards geometry and self-efficacy in geometry might have been affected by their productive dispositions, which was observed by the researcher during instructions. These observations are explained by the researcher based on her personal observations, so there is no concrete evidence for justification. Further studies might be conducted by making visual or audio recordings so that the responses and behaviors of students can be examined in detail. In the same way, to be able to explain the effect of inquiry-based instruction on self-efficacy, similar studies could be supported by interview sessions. Questions written in accordance with the sources of self-efficacy could be posed to selected students. Such questions may help to explain the reason of the increase in self-efficacy in geometry.

REFERENCES

Abd-El-Khalick, F., Boujaoude, S., Duschl, R., Lederman, N. G., Mamlok-Naaman, R., Hofstein, A., & Tuan, H. L. (2004). Inquiry in science education: International perspectives. *Science Education*, *88*(3), 397-419.

Abdi, A. (2014). The effect of inquiry-based learning method on students' academic achievement in science course. *Universal Journal of Educational Research*, *2*(1), 37-41.

Aiken, L. R., Jr. (1970). Attitudes toward mathematics. *Review of Educational Research, 40,* 551-596.

Akan-Sağsöz, D. (2008). *İlköğretim 6. sınıftaki kesirler konusunun origami yardımıyla öğretimi.* Unpublished Master's thesis, Atatürk University, Erzurum.

Akpullukçu, S., (2013). Fen ve teknoloji dersinde araştırmaya dayalı öğrenme ortamının öğrencilerin akademik başarı hatırda tutma düzeyi ve tutumlarına etkisi. *Ege Eğitim Dergisi, 14*(1), 67-89.

Aksoy, Y., & Bayazit, İ. (2009). Simetri kavramının öğrenim ve öğretiminde karşılaşılan zorlukların analitik bir yaklaşımla incelenmesi. *İlköğretimde karşılaşılan matematiksel zorluklar ve çözüm önerileri*, *1,* 187-215

Altunsoy, S. (2008). *Ortaöğretim biyoloji öğretiminde araştırmaya dayalı öğrenme yaklaşımının öğrencilerin bilimsel süreç becerilerine, akademik başarılarına ve tutumlarına etkisi*. Unpublished Master's thesis, Selçuk University, Konya.

Arıcı, S. (2012). *The effect of origami-based instruction on spatial visualization, geometry achievement and geometric reasoning of tenth grade students*. Unpublished Master's thesis, Boğaziçi University, İstanbul.

Arslan, O. (2012). *Investigating beliefs and perceived self-efficacy beliefs of prospective elementary mathematics teachers towards using origami in* *mathematics education.* Unpublished Master's thesis, Middle East Technical University, Ankara.

Artigue, M., & Baptist, P. (2012). *Inquiry in mathematics education (Resources for implementing ınquiry in science and in mathematics at school).* Retrieved from http://www.fibonacci-project.eu/.

Artigue, M., & Blomhøj, M. (2013). Conceptualizing inquiry-based education in mathematics. *ZDM, 45*(6), 797-810.

Aulls, M. W., Shore, B. M., & Delcourt, M. A. (Eds.). (2008). *Inquiry in education: Overcoming barriers to successful implementation* (Vol. 2). Routledge.

Aulls,M. W., & Shore, B. M. (2008). *Inquiry in education: The conceptual foundations for research as a curricular imperative.* New York: Erlbaum.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review, 84*(2), 191.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Bandura, A. (1995). On rectifying conceptual ecumenism. In J. E. Maddux (Ed.), *Self-efficacy, adaptation, and adjustment: Theory, research, and application* (pp. 347-375). Springer US.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Battista, M. T. and D. H. Clements, 1992, "Geometry and Proof", *The Mathematics Teacher, 88*(1), 48-54.

Baykul, Y. (2000). *İlköğretimde matematik öğretimi: 1-5. sınıflar için*. İstanbul: PegemA Yayıncılık.

Bayraktar-Kurt, E. (2012). *İlköğretim geometri öğretiminde geometrik şekiller ve cisimlerin origami yardımı ile birbirine dönüştürülmesi* Unpublished Master's thesis, Ondokuz Mayıs University, Samsun.

Beech, R. (2009). *The practical illustrated encyclopedia of origami: The complete guide to the art of paper folding.* London: Lorenz Books.

Belcastro, S. M., & Hull, T. C. (2002). Modelling the folding of paper into three dimensions using affine transformations. *Linear Algebra and Its Applications, 348*(1), 273-282.

Bell, A. (1993). Some experiments in diagnostic teaching. *Educational Studies in Mathematics, 24*(1), 115-137.

Bilican, S., Demirtaşlı, R. N., & Kilmen, S. (2011). Matematik dersine ilişkin türk öğrencilerin tutum ve görüşleri: TIMSS 1999 ve TIMSS 2007 karşılaştırması. *Kuram ve Uygulamada Eğitim Bilimleri*, *11*(3), 1277-1283.

Bloom, B. S. (1998). *İnsan Nitelikleri ve Okulda Öğrenme.* İstanbul: MEB Yayınları.

Boakes, N. J. (2006). *The Effects of Origami Lessons on Students' Spatial Visualization Skills and Achievement Levels in a Seventh-grade Mathematics Classroom*, Ph.D. Thesis, Temple University.

Boakes, N. (2008). Origami-mathematics lessons: Paper folding as a teaching tool. *Mathidues, 1*(1), 1-9.

Boakes, N. J. (2009). Origami instruction in the middle school mathematics classroom: Its impact on spatial visualization and geometry knowledge of students. *Research in Middle Level Education Online, 32*(7), 1-12.

Brady, K. (2008). *Using Paper-Folding in the Primary Years to Promote Student Engagement in Mathematical Learning*. Proceedings of the 31st Annual Conference of the Mathematics Education Research Group of Australasia, 77-83.

Brannick, M. T., Miles, D. E., & Kisamore, J. L. (2005). Calibration between student mastery and self-efficacy. *Studies in Higher Education*, *30*(4), 473-483.

Brewer, J. & Daane, C. (2002). Translating constructivist theory into practice in primary grade mathematics. *Education*, *123*(2), 416-426.

Brooks, J. G., & Brooks, M. G. (1999). *In search of understanding: The case for constructivist classrooms*. Alexandria, VA: American Society for Curriculum Development.

Brown, A. L. & Campione, J. C. (1986). *Training for transfer: Guidelines for promoting flexible use of trained skills.* In M.G. Wade (Ed.), Motor Skill acquisition of the Mentally Handicapped (pp. 257-271). Amsterdam: North-Holland.

Bulut, S., Ekici, C., İşeri, A. İ., & Helvacı, E. (2002). Geometriye Yönelik Bir Tutum Ölçeği. *Eğitim ve Bilim*, *27*(125).

Büyüköztürk, Ş., Çakan, M., Tan, Ş., & Atar, H. Y. (2014). *TIMSS 2011 ulusal matematik ve fen raporu–8. sınıflar.* Ankara: İşkur Matbaacılık.

Cagle, M. (2009). Modular origami in the secondary geometry classroom. In R. J. Lang (Eds.), *Origami 4: Fourth international meeting of origami science, math, and education* (pp. 497-506). Natick, MA: A. K. Peters.

Canadas, M., Molina, M., Gallardo, S., Martinez-Santaolalla, M., & Penas, M. (2010). Let's teach geometry. *Mathematics Teaching*, *218*, 32-37.

Chen, K. (2006). Math in motion: Origami math for students who are deaf and hard of hearing. *Journal of Deaf Studies and Deaf Education*, *11*(2), 262-266.

Cheung, D. (2007). Facilitating chemistry teachers to implement inquiry-based laboratory work. *International Journal of Science and Mathematics Education*, *6*(1), 107-130.

Clements, D. H., & Battista, M. T. (1992). Geometry and spatial reasoning. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 420–464). New York, NY: Macmillan.

Cobb, P., Wood, T., & Yackel, E. (1990). *Classrooms as learning environments for teachers and researchers.* In R. B., Davis. C. A. Maher, & N. Noddings (Eds.). Constructivist views on the teaching and learning of mathematics. (Journal for Research in Mathematics Education Monograph No. 4, pp. 125-146). Reston, VA: National Council of Teachers of Mathematics.

Cornelius, V., & Tubis, A. (2009). On the effective use of origami in the mathematics classroom. In R. J. Lang (Eds.), *Origami 4: Fourth international meeting of origami science, math, and education* (pp. 507-515). Natick, MA: A. K. Peters.

Costenson, K., & Lawson, A. E. (1986). Why isn't inquiry used in more classrooms?. *The American Biology Teacher, 48*(3), 150-158.

Côté, J. E., & Levine, C. G. (2000). Attitude versus aptitude is intelligence or motivation more important for positive higher-educational outcomes? *Journal of Adolescent Research*, *15*(1), 58-80.

Çakmak, S. (2009). *An investigation of the effect of orıgami-based instruction on elementary students' spatial ability in mathematics*. Unpublished Master's thesis, Middle East Technical University, Ankara.

Çalışkan, H. (2008). *İlköğretim 7. sınıf sosyal bilgiler dersinde araştırmaya dayalı öğrenme yaklaşımının derse yönelik tutuma, akademik başarıya ve kalıcılık düzeyine etkisi.* Unpublished doctoral dissertation, Gazi University, Ankara.

Çelik, K., (2012). Canlılarda üreme büyüme ve gelişme ünitesinin araştırmaya dayalı öğrenme yöntemi ile işlenmesinin öğrencilerin akademik başarılarına bilimsel süreç becerilerine ve fen ve teknoloji dersine yönelik tutumlarına etkisi. *Ege Eğitim Dergisi*, *13*(2), 50-75.

Dağdelen, İ. (2012). *İlköğretim Geometri Öğretiminde Simetri Kavramının Origami ile Modellenmesi.* Unpublished Master's thesis, Ondokuzmayıs University, Samsun.

Dağdelen, M. G. (2012). *İlköğretim 5. sınıf geometriöğretiminde özel dörtgenlerin kavratılmasında origaminin etkisi.* Unpublished Master's thesis, Ondokuz Mayıs University, Samsun.

Deborah, O. M., Lambeth, D. T., Cox, J. (2015). *Effects of using inquiry-based learning on science achievement for fifth-grade students.* Retrieved from https://www.ied.edu.hk/apfslt/download/v16_issue1_files/cox.pdf.

Dempster, A. P., Laird, N. M., & Rubin, D. B. (1977). Maximum likelihood from incomplete data via the EM algorithm. *Journal of the royal statistical society. Series B (methodological)*, 1-38.

Deskins, L. (2012). Inquiry studies: Needed skills. *School Library Monthly, 28*(5), 20-23.

DeYoung, M. J. (2009). Math in the box. *Mathematics Teaching in the Middle School, 15*(3), 134-141.

Doctorow, R. (2002). *Mathematics education: A summary of research, theories, and practice*. Scarborough, ON: Thomson Nelson.

Doğan, O. (2006). *A study on pattern of 6th grade elementary mathematics lesson*. Unpublished Master's thesis, Middle East Technical University, Ankara.

Doolittle, P. E., & Camp, W. G. (1999). Constructivism: The career and technical education perspective. *Journal of Career and Technical Education, 16*(1). http://dx.doi.org/10.21061/jcte.v16i1.706.

Drijvers, P., Tacoma, S., Besamusca, A., Doorman, M., & Boon, P. (2013). Digital resources inviting changes in mid-adopting teachers' practices and orchestrations. *ZDM, 45*(7), 987-1001.

Edwards, L. D. & Zazkis, R. (1993). Transformation geometry: Naive ideas and formal embodiments. *Journal for Computers in Mathematics and Science Teaching, 12*(2), 121-145.

Fansa, M. (2012). *Araştırmaya dayalı öğrenme yönteminin ilköğretim 5. sınıf öğrencilerinin maddenin değişimi ve tanınması ünitesindeki akademik başarı, fen dersine karşı tutum ve bilimsel süreç becerilerine etkisinin incelenmesi.* Unpublished Master's thesis, Mustafa Kemal University, Hatay.

Farooq, M. S., & Shah, S. Z. U. (2008). Students' attitude towards mathematics. *Pakistan Economic and Social Review, 46*(1), 75-83.

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman mathematics attitudes scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for research in Mathematics Education, 7*(5), 324-326.

Ferguson, K. (2010). *Inquiry based mathematics instruction versus traditional mathematics instruction: The effect on student understanding and comprehension in an eighth grade pre-algebra classroom.* Retrieved from http://digitalcommons.cedarville.edu/cgi/viewcontent.cgi?article=1025&context=education_theses.

Field, A. (2009). *Discovering statistics using SPSS*. Sage publications.

Fraenkel, J. R., & Wallen, N. E. (2006). *How to design and evaluate research in education* (6th ed.). Boston: McGraw Hill.

Franco, B. (1999). *Unfolding mathematics with unit origami.* Emeryville: Key Curriculum Press.

Frigerio, E. (2009). *Origami, isometries, and multilayer tangram.* In R. J. Lang (Eds.), Origami 4: Fourth international meeting of origami science, math, and education (pp. 533-545). Natick, MA: A. K. Peters.

Furuta, Y., Mitani, J., & Fukui, Y. (2008). Modeling and animation of 3D origami using spring mass simulation. *Proceedings of NICOGRAPH International, 12,* 2008.

Georgeson, J. (2011). Fold in origami and unfold math. *Mathematics Teaching in Middle School, 16*(6), 354-361.

Gibson, H. L., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. *Science Education*, *86*(5), 693-705.

Glasersfeld, E.Y. (1984). An introduction to radical constructivism. In P. Watzlawick (Ed.) *The invented reality (*pp. 17-40). New York: Norton.

Golan, M., & Jackson, P. (2010). *Origametria: A program to teach geometry and to develop learning skills using the art of origami*. Retrieved online from http://www.emotive.co.il/origami/db/pdf/996_golan_article.pdf

Göksu, V. (2011). *Sorgulayıcı araştırmaya dayalı laboratuar ile doğrulayıcı laboratuar yöntemlerinin fen ve teknoloji öğretmen adaylarının başarı, kavram yanılgısı ve epistemolojik inançları üzerine etkisi.* Unpublished doctoral dissertation, Gazi University, Ankara.

Gravetter, F. J., & Wallnau, L. B. (2000). *Statistics for the behavioral sciences* (5th edition). Belmont, CA: Wadsworth.

Guffin, B. (2008). *Teacher beliefs toward inquiry-based mathematical instructional strategies in South Dakota Elementary Schools*. (Doctoral dissertation, University of South Dakota). Available from ProQuest Dissertations & Theses database. (UMI No. 3333957).

Günhan, B. C., & Başer, N. (2007). Geometriye yönelik öz-yeterlik ölçeğinin geliştirilmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *33*(33).

Haga, K., Fonacier, J., & Isoda, M. (2008). *Origamics: mathematical explorations through paper folding*. World Scientific.

Hammouri, H. A. (2003). An investigation of undergraduates' transformational problem solving strategies: Cognitive/metacognitive processes as predictors of holistic/analytic strategies. *Assessment & Evaluation in Higher Education*, *28*(6), 571-586.

Hart, G. (2007). Modular kirigami. *Proceedings of Bridges Donostia*, 1-8.

Haury, D. L. (1993). Teaching Science Through Inquiry. *ERIC CSMEE Digest* (March Ed 359 048).

Herbst, P. (2002) Engaging students in proving: A double bind on the teacher. *Journal for Research in Mathematics Education, 33*, 176-203.

Higginson, W., & Colgan, L. (2001). Algebraic thinking thorough origami. *Mathematics Teaching in the Middle School, 6*(6), 343-349.

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

Hoyles, C. & Healy, L. (1997). Unfolding meanings for reflective symmetry. *International Journal of Computers in Mathematical Learning, 2*(1). 27-59.

Hull, T. (1994). On the mathematics of flat origamis. *Congressus numerantium*, 215-224.

Işıksal, M., & Aşkar, P. (2005). The effect of spreadsheet and dynamic geometry software on the achievment and self efficacy of 7th grade students. *Educational Research*, *15* (2), 333-350.

Jacobson, C., & Lehrer, R. (2000). Teacher appropriation and student learning of geometry through design. *Journal for Research in Mathematics Education, 31*, 71-88.

Jaworski, B. (1994). *Investigating mathematics teaching. A constructivist enquiry*. London: The Falmer Press.

Jaworski, B. (2006). Theory and practice in mathematics teaching development: Critical inquiry as a mode of learning in teaching. *Journal of Mathematics Teacher Education*, *9*(2), 187-211.

Johnston, K. M. (2014). *Rethinking mathematics curriculum in a K-5 rural setting: Comparing inquiry-based to traditional approaches.* Unpublished doctoral dissertation, University of South Dakota.

Kamii, C., & Lewis, B. A. (1990). Research into practice. Constructivist learning and teaching. *Arithmetic Teacher*, *38*(1), 34-35.

Kavici, M. (2005). *Gelişimsel origami eğitim programı'nın okulöncesi dönem çocuklarının çok boyutlu gelişimlerine etkisinin incelenmesi*. Unpublished Master's thesis, Hacettepe University, Ankara.

Kim, D., & Ju, M. K. (2012). A changing trajectory of proof learning in the geometry inquiry classroom. *ZDM*, *44*(2), 149-160.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist*, *41*(2), 75-86.

Klassen, R. (2004). A cross-cultural investigation of the efficacy beliefs of South Asian immigrant and Anglo non-immigrant early adolescents. *Journal of Educational Psychology, 96*, 731–742.

Klett, Y., & Drechsler, K. (2011). Designing technical tessellations. *Origami*, *5*, 305-322.

Koballa, T. R. (1988). Attitude and related concepts in science education. *Science education*, *72*(2), 115-126.

Kocagül, M. (2013). *Sorgulamaya dayalı mesleki gelişim etkinliklerinin ilköğretim Fen ve Teknoloji öğretmenlerinin bilimsel süreç becerilerine, öz-yeterlik ve sorgulamaya dayalı öğretime ilişkin inançlarına etkisi*. Unpublished doctoral dissertation, Dokuz Eylül University, İzmir.

Koylahisar-Dündar, T. (2012). *İlköğretım 8. sınıf öğrencilerinde özdeşlikleri modelleme becerilerinin incelenmesi: origami ile modellenmesi.* Unpublished Master's thesis, Ondokuz Mayıs University, Samsun.

Köse, N. Y. (2012). İlköğretim öğrencilerinin doğruya göre simetri bilgileri. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *42*(42).

Krier, J. L. (2007). *Mathematics and Origami: The Ancient Arts Unite*. Retreived from http://math.uttyler.edu/nathan/classes/senior-seminar/JaemaKrier.pdf accessed at July 2010.

Kuhlthau, C. C.(2001). Inquiry learning and school reform. *SCAN, 23*(3), 21-33.

Kula, Ş. G. (2009). *Araştırmaya dayalı fen öğrenmenin öğrencilerin bilimsel süreç becerileri, başarıları, kavram öğrenmeleri ve tutumlarına etkisi*. Unpublished Master's thesis, Marmara University, İstanbul.

Küchemann, D. K. (1993). Reflection and rotation. In K. Hart (ed), *Children's understanding of mathematics: 11-16*. (pp. 137-157) London: John Murray.

Kwon, O. N., Bae, Y., & Oh, K. H. (2015). Design research on inquiry-based multivariable calculus: focusing on students' argumentation and instructional design. *ZDM*, *47*(6), 997-1011.

Laipply, R. S. (2004). *A case study of self-efficacy and attitudes toward science in an inquiry-based biology laboratory*. Unpublished doctoral dissertation, University of Akron. Available from ProQuest Dissertations & Theses database. (UMI No. 3139575).

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal, 27*(1), 29–63.

Lappin, G. (1995). How should mathematics be taught? Prospects for school mathematics, *Mathematics Teacher, 4*, 38-45.

Leikin, R., Berman, A., & Zaslavsky, O. (1997). Defining and understanding symmetry. In E. Pehkonen (Ed.), *Proceedings of PME 21* Vol. 3 (pp. 192-199).

Lord, T., & Orkwiszewski, T. (2006). Moving from didactic to inquiry-based instruction in a science laboratory. *The American Biology Teacher, 68*(6), 342-345.

Lotfi, F. H., Dehkordi, S. S., & Vaez-Ghasemi, M. (2012). Teaching method survey based on constructivist approach in permanent learning geometry. *Applied Mathematical Sciences*, *6*(6), 259-267.

Malley, M. (1992). *The Nature and History of Science. Chapter V in Teaching About the History and Nature of Science and Technology: Background Papers* (pp. 67-80). Colorado Springs: Biological Sciences Curriculum Study (BSCS).

Malone, D. M. (2008). Inquiry-based early childhood teacher preparation: The personal learning plan method. *Early Childhood Education Journal, 35*, 531-542.

Melichson, H. (2009). *The art of paper cutting.* Beverly, MA: Quarry Books.

Ministry of National Education [MoNE]. (1998). *İlköğretim okulu matematik dersi öğretim programı: 1.-8. Sınıflar (Elementary school mathematics curricula: Grades 1-8).* İstanbul: Milli Eğitim Basımevi.

Ministry of National Education [MoNE]. (2005). *Talim ve Terbiye Kurulu Baskanlıgı, İlköğretim Matematik Dersi (1-5. Sınıflar) Ögretim Programı.* (Board of Education, Elementary school mathematics curriculum (1-5th grades) Ankara: MEB.

Ministry of National Education [MoNE]. (2009b). İlköğretim *matematik dersi öğretim programı 6-8. sınıflar.* Retrieved from http://ttkb.meb.gov.tr/

Ministry of National Education [MoNE]. (2011). *İlköğretim matematik dersi öğretim programı 9-12. sınıflar*. Retrieved from http://ttkb.meb.gov.tr/

Ministry of National Education [MoNE]. (2013), *Ortaokul Matematik Dersi (5, 6, 7 ve 8. Sınıflar) Öğretim Programı (Middle School Mathematics Curricula Program for grades 5, 6, 7, and 8).* Ankara: MEB.

Mrayyan, S. (2014). The impact of constructivism learning in mathematics teaching on academic achievement and mathematical thinking among students in a college algebra course for first year students in vocational education. *Sci-Afric Journal of Scientific Issues, Research and Essays, 2*(10), 449-455.

Mullis, I. V., Martin, M. O., Robitaille, D. F., & Foy, P. (2009). TIMSS Advanced international report. *TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College*. Retrieved from http://timssandpirls.bc.edu/timss_advanced/downloads/TA08_Technical_Report.pdf.

Mullis, I. V., Martin, M. O., Ruddock, G. J., O'Sullivan, C. Y., & Preuschoff, C. (2012). *TIMSS 2011 assessment frameworks.* Chestnut Hill: International Association for the Evaluation of Educational Achievement.

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

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

National Research Council. (1997). *Science teaching reconsidered*. A Handbook. Washington, DC: National Academy Press.

National Research Council (2000). *Inquiry and the national science education standards: A guide for teaching and learning.* Washington, DC: National Academy Press.

NCTM. (2000). *Curriculum and evaluation standards for school mathematics.* Retrieved October 10 from http://www.nctm.org.

Njoroge, G. N., Changeiywo, J. M., & Ndirangu, M. (2014). Effects of inquiry-based teaching approach on secondary school students' achievement and motivation in Physics in Nyeri County, Kenya. *International Journal of Academic Research in Education and Review, 2*(1), 1-16.

O’Rourke, J. (2011). *How to fold it: The mathematics of linkages, origami, and polyhedra*. New York: Cambridge University Press.

Ojose, B., & Sexton, L. (2009). The effect of manipulative materials on mathematics achievement of first grade students. *The mathematics educator,12*(1), 3-14.

Olson, A. T. (1989). *Mathematics through paper folding*. National Council of Teachers of Mathematics. Reston: Virginia.

Outhred, L., & Mitchelmore, M. (2001). Young childrens’ intuitive understanding of rectangular array measurement. *Journal for Research in Mathematics Education, 31*,144-167.

Özçelik, B. (2014). *6. sınıf matematik dersi geometri öğrenme alanında origami etkinliklerine yer verilmesinin öğrenci başarısına etkisi.* Unpublished Master's thesis, Gazi University, Ankara.

Özdilek, Z., & Bulunuz, N. (2009). The effect of a guided inquiry method on pre-service teachers' science teaching self-efficacy beliefs. *Journal of Turkish Science Education, 6*(2), 24-42.

Özkaya, S. S. (2002). *Investigation of Tenth Grade Students’ Problem Solving Strategies in Geometry*. Unpublished Master's thesis, Middle East Technical University, Ankara.

Pajares, F. (1997). Current directions in self-efficacy research. *Advances in motivation and achievement, 10*(149), 1-49.

Pallant, J. (2001). *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Windows (Versions 10 and 11): SPSS Student Version 11.0 for Windows*. Open University Press.

Perez, C. (2000). Equity in the standards-based elementary mathematics classroom. *ENC Focus,7*(4), 29-31.

Peterson, J. C. (1973). Informal geometry in grades 7-14. In K. B. Henderson (Ed.), *Geometry in the mathematics curriculum: Thirty-sixth yearbook.* (pp. 52-91).Washington, (ERIC Document Reproduction Service No: EJ090197).

Piaget, J. (1965). The child's concept of number. New York: W. W. Norton.

Piaget, J. (1972). *Judgement and reasoning in the child.* Totowa, NJ: Littlefield, Adams.

Pope, S. (2002). The use of origami in the teaching of geometry. *Proceedings of the British Society for Research into Learning Mathematics*, *22*(3), 67-73.

Post, T. (1988). Some notes on the nature of mathematics learning. In T. Post (Ed.), *Teaching mathematics in grades K-8: Research based methods* (pp. 1-19). Boston: Allyn & Bacon.

Putney, L.D. & Cass, M. (1998). Preservice teacher attitudes toward mathematics: Improvement through a manipulative approach. *College Student Journal, 32*, 626- 632.

Reyes, L. H. (1980). Attitudes and mathematics. In M. M. Lindquist (Ed.), Selected issues in mathematics education(pp. 161-184). Berkeley, CA: McCutchan Publishing Corporation.

Reyes, L. H. (1984). Affective variables and mathematics education. *The Elementary School Journal*, *84*(5), 558-581.

Richards, J. (1991). Mathematical discussions. In E. von Glasersfeld (Ed.), *Radical constructivism in mathematics education* (pp. 13–51). Netherlands: Kluwer Academic Publishers.

Robichaux, R. R., & Rodrigue, P. R. (2003). Using origami to promote geometric communication. *Mathematics Teaching in the Middle School, 9*(4), 222-229.

Roster, N. O. (2006). *Effects of ınquiry-based teaching on attitudes, self-efficacy, and science reasoning abilities of students in introductory biology courses at a rural, open-enrollment community college* (Doctoral dissertation, Oklahoma State University). Available from ProQuest Dissertations & Theses database. (UMI No. 3222071).

Sağlamer-Yazgan, B. (2013). *Araştırmaya dayalı sınf dışı laboratuar etkinliklerinin öğrencilerin araştırma-sorgulama becerilerine ve çevreye karşı tutumlarına etkisi.* Unpublished doctoral dissertation, Marmara University, İstanbul.

Sakar, Ç. (2010). *Araştırmaya dayalı kimya öğretiminin öğrencilerin akademik başarı ve tutumları üzerine etkisi.* Unpublished Master's thesis, Selçuk University, Konya.

Sarı, U., & Güven, G. B. (2013). The effect of interactive whiteboard supported inquiry-based learning on achievement and motivation in physics and views of prospective teachers toward the instruction. *Neca Fac Educ Electron J Sci Math Educ*, *7*(2), 110-143.

Saunders-Stewart, K. S., Gyles, P. D., & Shore, B. M. (2012). Student outcomes in ınquiry ınstruction a literature-derived ınventory. *Journal of Advanced Academics*, *23*(1), 5-31.

Schunk, D. H. (2011). *Learning theories: An educational perspective*. Boston: Pearson Education, Inc.

Sever, D., & Guven, M. (2014). Effect of inquiry-based learning approach on student resistance in a science and technology course. *Educational Sciences: Theory and Practice*, *14*(4), 1601-1605.

Soon, Y. P. (1989). *An investigation of van Hiele-like levels of learning in transformation geometry of secondary school students in Singapore.* Unpublished doctoral dissertation, Florida State University, Tallahassee, Florida.

Spronken-Smith, R. (2007). Experiencing the process of knowledge creation: The nature and use of inquiry-based learning in higher education. *J. Geogr. Hıgher ed.*, *2*, 183.

Stevens, J. (1996). *Applied multivariate statistics for the social sciences* (3rd edition). Matiway, New Jersey: Lawrence Erlbaum.

Strong, R., Silver, H. F., & Robinson, A. (1995). *What do students want (and what really motivates them)?* Retrieved from http://www.ryan216.org/www/26Q216/site/hosting/PD%20Resources/What%20do%20students%20want.pdf

Supovitz, J. A., Mayer, D. P., & Kahle, J. B. (2000). Promoting inquiry-based instructional practice: The longitudinal impact of professional development in the context of systemic reform. *Educational Policy, 14*(3), 331-356.

Sutton, J., & Krueger, A. (Eds) (2002). *EDThoughts: What we know about mathematics teaching and learning.* Aurora, CO: Mid-Continent Research for Education and Learning.

Sze, S. (2005). Constructivism and the ancient art of origami. *Proceeding of the Academy of Creativity and Innovation*, 5-9.

Şimşek, M. (2012). *Geometrik cisimler konusunun origami destekli etkinlikler ile öğretiminin başarıya etkisi.* Unpublished Master's thesis, Ondokuzmayıs University, Samsun.

Tabachnick, B. G., & Fidell, L. S. (2007). Using multivariate statistics, 5th. *Needham Height, MA: Allyn & Bacon*.

Takıcak, M. (2012). *Origami etkinliklerine dayalı öğretimin ilköğretim 8.sınıf öğrencilerinin üçgenler ünitesindeki akademik başarılarına ve geometriye yönelik tutumlarına etkisi.* Unpublished Master's thesis, Kastamonu University, Kastamonu.

Tandoğan, Ö.R., & Akinoglu, O. (2007). The Effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science & Technology Education, 3*(1), 71-81.

Tatar, N. (2006). *İlköğretim fen eğitiminde araştırmaya dayalı öğrenme yaklaşımının bilimsel süreç becerilerine, akademik başarıya ve tutuma etkisi.* Unpublished doctoral dissertation, Gazi University, Ankara.

Taylor, J., & Bilbrey, J. (2012). Effectiveness of inquiry-based and teacher-directed instruction in an Alabama elementary school. *Journal of Instructional Pedagogies*, *8*, 1-7.

Thompson, C. (2009). Preparation, practice, and performance: An empirical examination of the impact of standards-based instruction on secondary students' math and science achievement. *Research in Education*, *81*(1), 53-62.

Thrift, M. (2007). *A case study of the effects of inquiry based professional development through the use of a mentor on an alternatively certified elementary teacher's science teaching self-efficacy.* Unpublished doctoral dissertation, University of Central Florida Orlando, Florida.

Tinsley, T. (1972). The use of origami in the mathematics education of visually impaired students. *Education of the Visually Handicapped*, *4*(1), 8–11.

Tuan, H. L., Chin, C. C., Tsai, C. C., & Cheng, S. F. (2005). Investigating the effectiveness of inquiry instruction on the motivation of different learning styles students. *International Journal of Science and Mathematics Education*, *3*(4), 541-566.

Tuğrul, B., & Kavici, M. (2002). Kağıt katlama sanatı ve öğrenme. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 1*(11), 1-17.

Türkmen, H. (2009). An effect of technology based inquiry approach on the learning of"Earth, Sun, & Moon" subject. *hkıed apflst*, *10*(1).

Ubuz, B. (1991). *The effect of Problem Solving Method with handout material on achievementin solving calculus word problems* Unpublished Master's thesis, Middle East Technical University, Ankara.

Usher, E. L. (2009). Sources of middle school student’s self-efficacy in mathematics a qualitative investigation. *American Educational Research Journal*, 46(1), 275-314.

Usher, E. L., & Pajares, F. (2006). Inviting Confidence in School: Invitations as a Critical Source of the Academic Self-Efficacy Beliefs of Entering Middle School Students. *Journal of Invitational Theory & Practice, 12*, 7-16.

Usiskin, Z., Peresini, A., Marchisotto, E.A .& Stanley, D. (2003). *Mathematics for high school teachers: An advanced perspective*. New Jersey: Pearson Education.

Usta-Gezer, S. (2014). *Yansıtıcı sorgulamaya dayalı genel biyoloji laboratuvarı etkinliklerinin fen bilgisi öğretmen adaylarının laboratuvar kullanımı özyeterlik algıları, eleştirel düşünme eğilimleri ve bilimsel süreç becerileri üzerine etkisi.* Unpublished doctoral dissertation, Marmara Üniversitesi, İstanbul.

van de Walle, J. A., Karp, K. S., & Bay-Williams J. M. (2013). *Elementary and middle school mathematics: Teaching developmentally* (8th Ed.). Boston, MA: Pearson Education, Inc.

Viau, R. (1999). *La motivation dans ‘apprentissage du francais* [Motivation in the learning of French]. Saint-Laurent, Canada: Éditions du renouveau pédagogique

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wares, A. (2016). Mathematical thinking and origami. *International Journal of Mathematical Education in Science and Technology*, *47*(1), 155-163.

Watters, J. J., & , & Ginns, I. S. (1995). Origins of and changes in preservice teachers science teaching self-efficacy. Paper presented at the annual conference of the National Association for Research in Science Teaching, San Franscisco, CA.

Welch, W. W., Klopfer, L. E., Aikenhead, G. S., & Robinson, J. T. (1981). The role of inquiry in science education: Analysis and recommendations. *Science Education*, *65*(1), 33-50.

Weyl, H. (1952). *Symmetry*. Princeton, New Jersey: Princeton University Press.

Wilkins, J. L. (2008). The relationship among elementary teachers' content knowledge, attitudes, beliefs, and practices. *Journal of Mathematics Teacher Education*, *11*(2), 139-164.

Xistouri, X. (2007). Students' ability in solving line symmetry tasks. In D. Pitta-Pantazi & G. Philippou (Eds.), Proceedings of *5th Conference of European Research in Mathematics Education* (pp. 526-535).

Yanik, H. B., & Flores, A. (2009). Understanding rigid geometric transformations: Jeff's learning path for translation. *The Journal of Mathematical Behavior*, *28*(1), 41-57.

Yoshioka, R. (1963). Fold paper to learn geometry. *The Science News-Letter, 83*(9), 138-139.

Yuzawa, M., & Bart, W. M. (2002). Young children's learning of size comparison strategies: Effect of origami exercises. *The Journal of Genetic Psychology, 163*(4), 459-478.

Zaslavsky, A.(1994). Tracing students' misconceptions back to their teacher: A case of symmetry. *Pythagoras, 33*, 10-17.

Zembat, İ. Ö. (2007). Yansıma dönüşümü, doğrudan öğretim ve yapılandırmacılığın temel bileşenleri. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi*, *27*(1), 195-213.

APPENDICES

Appendix A: TABLE OF SPECIFICATION FOR THE ITEMS IN REFLECTION SYMMETRY ACHIEVEMENT TEST

Test Item	Objective (MoNE, 2013)
Item 1	Students will be able to draw reflection symmetry of shapes on the plane.
Item 2	Students will be able to draw reflection symmetry of shapes on the plane.
Item 3	Students will be able to draw reflection symmetry of shapes on the plane.
Item 4	Students will be able to discover the equality of the distance of a point on the shape to symmetry line and distance of the image of this point to symmetry line under reflection.
Item 5	Students will be able to discover the equality of the distance of a point on the shape to symmetry line and distance of the image of this point to symmetry line under reflection symmetry (Shapes are reflected also according to inclined lines.).
Item 6	Students will be able to discover that shape and its image under reflection symmetry are congruent (Shapes on symmetry line are also used).
Item 7	Students will be able to discover that shape and its image under reflection symmetry are congruent (Shapes on symmetry line are also used).
Item 8	Students will be able to discover that shape and its image under reflection symmetry are congruent (Shapes on symmetry line are also used).
Item 9	Students will be able to discover the equality of the distance of a point on the shape to symmetry line and distance of the image of this point to symmetry line under reflection symmetry (Shapes on symmetry line are also used).
Item10	Students will be able to draw image of a shape after reflecting consecutively.

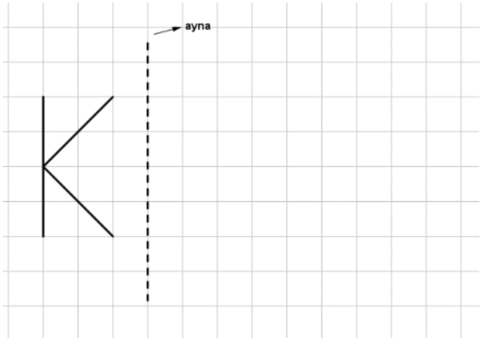
Table of specification for the items in Reflection Symmetry Achievement Test based on the objectives of national mathematics education curriculum.

*Translations are done by the researcher

Appendix B: 7. SINIF YANSIMA SİMETRİSİ BAŞARI TESTİ

Soru 1

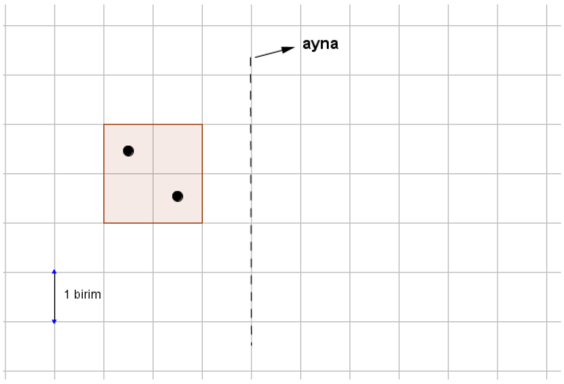
a) Aşağıda verilen K harfinin aynadaki görüntüsünü çiziniz.



b) Aynadaki görüntüyü nasıl çizdiğinizi açıklayınız.

Soru 2

a) Aşağıda verilen şeklin aynadaki görüntüsünü çiziniz.

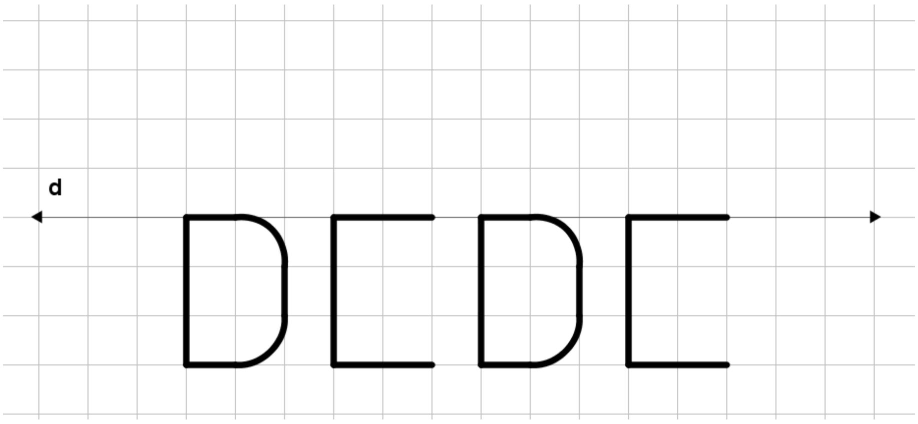


b) Aynadaki görüntüyü nasıl çizdiğinizi açıklayınız.

c) Şekil ile ayna görüntüsü arasında nasıl bir ilişki vardır?

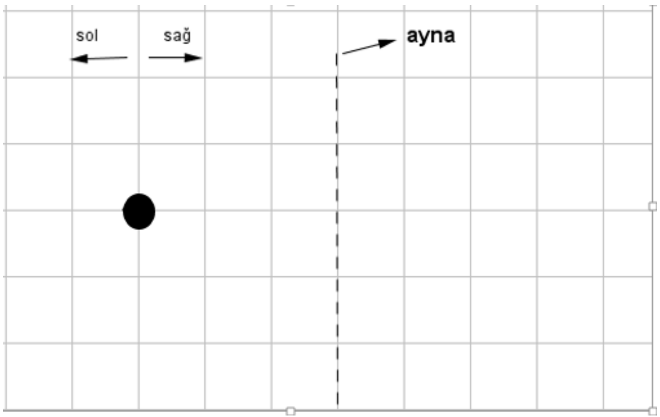
Soru 3

Aşağıda verilen şekil d doğrusuna göre yansıtıldığında hangi kelime oluşmaktadır? ....



Soru 4

a) Yanda verilen noktanın ayna görüntüsünü çiziniz.



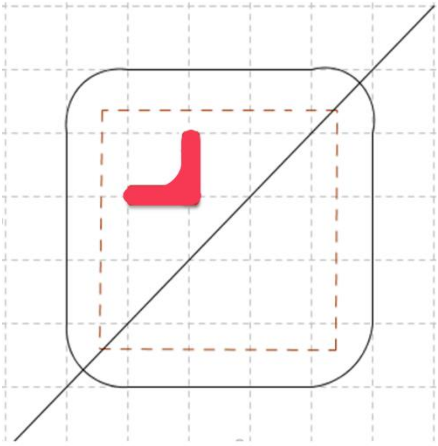
b) Noktanın aynaya olan uzaklığı ile görüntüsünün aynaya olan uzaklığı arasında nasıl bir ilişki vardır?

c) Nokta 1 birim sağa doğru hareket ettirildiğinde görüntüsü hangi yönde kaç birim hareket eder?

d) Nokta 2 birim aşağıya doğru hareket ettirildiğinde görüntüsü hangi yönde kaç birim hareket eder?

Soru 5

Ali, beslenme saatinde mendiline reçel dökmüştür. Ali beslenmesini toplarken mendili şekildeki doğru boyunca katlayınca reçel diğer kısma da bulaşmıştır.



a) Reçelin bulaştığı yeri işaretleyiniz.

b) Reçel lekelerinin katlama çizgisine olan uzaklıkları arasında nasıl bir ilişki vardır?

Soru 6

1 2 3 4 5 6 7 8 9 0

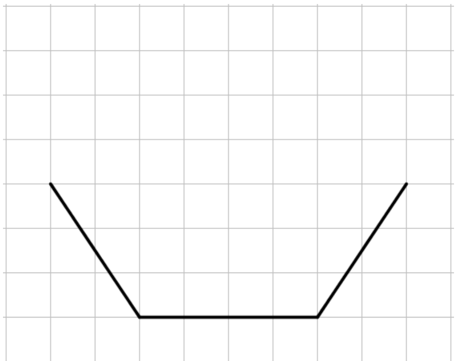
a) Yukarıda verilen rakamlardan hangilerinin simetri doğrusu vardır?

b) Bu rakamların varolan tüm simetri doğrularını aşağıda gösteriniz.

Soru 7

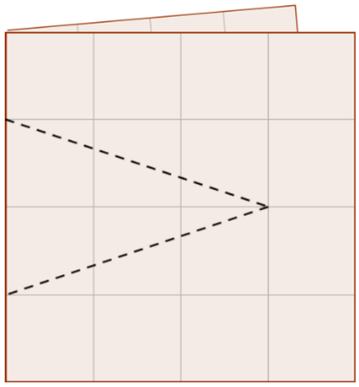
Merve, simetri ekseni olan bir beşgen çizmek istemektedir.

a) Merve, aşağıda görüldüğü gibi beşgenin üç kenarını çizmiştir. İki kenarı da sizin çizmeniz beklenmektedir. Kalan iki kenarı beşgende bir simetri ekseni çizilebilecek şekilde yerleştiriniz.



b) Oluşturduğunuz beşgenin simetri eksenini şekil üzerinde gösteriniz.

Soru 8



Ahmet şekilde verilen kâğıdı önce gösterilen şekilde ikiye katlamıştır. Daha sonra noktalı çizgiyle gösterilen yerden kesip içini çıkarmıştır.

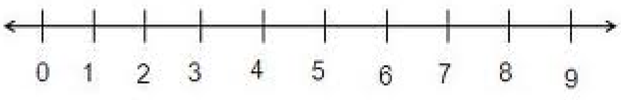
a) Çıkardığı parçayı açtığında elde ettiği şekli aşağıya çiziniz.

b) Arta kalan kağıt açıldığında elde ettiği şekli aşağıya çiziniz.

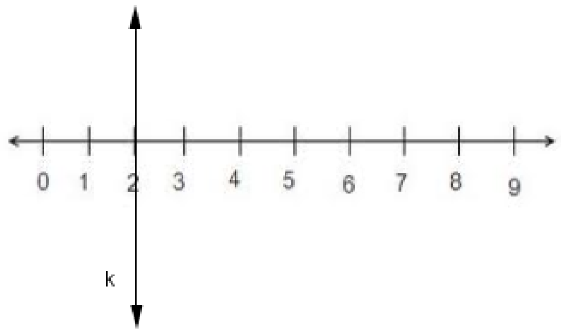
Soru 9

Sayı doğrusu üzerine ayna yerleştirilerek rakamların görüntülerinin nerde görüldüğü belirlenmeye çalışmaktadır.

a) Simetri aynası hangi sayının üzerine koyulursa 0 rakamı 8 rakamının üzerinde yer alır?

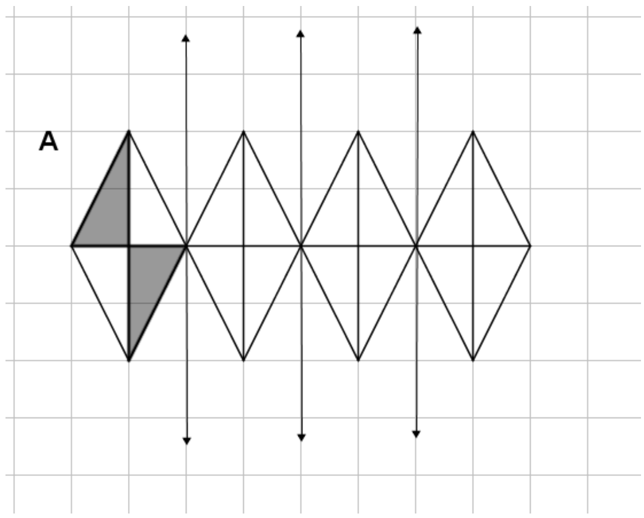


b) Simetri aynası k doğrusunun üzerine yerleştirilirse, hangi rakamlar birbirinin üzerinde yer alır?



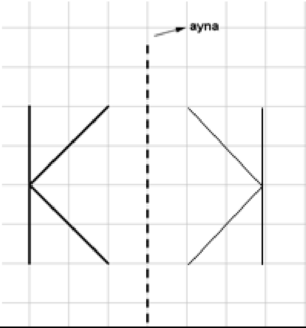
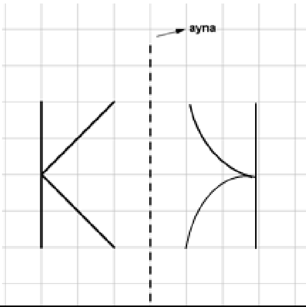
Soru 10

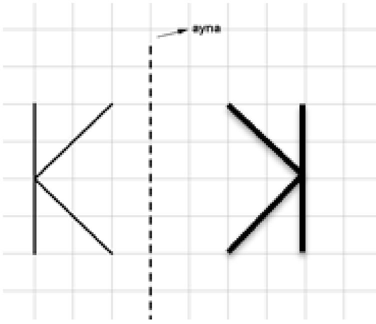
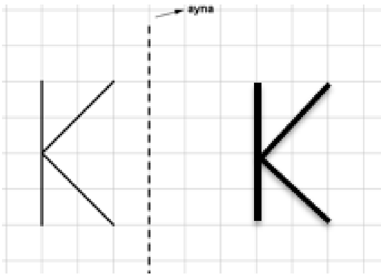
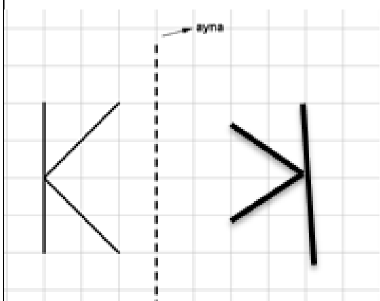
Aşağıda verilen A dörtgeni verilen doğrulara göre sağa doğru peş peşe 3 kere yansıtılarak bir süsleme oluşturulmak istenmektedir. Buna göre yansıma sonucu oluşan diğer üç dörtgenin taralı olması gereken kısımlarını tarayınız.



Appendix C: RUBRIC FOR ACHIEVEMENT TEST

QUESTION 1, a

Points	**Description**	
4		Drawing totally correct reflection.
3		Drawing end points of K correctly but, drawing other points on K wrong as drawn on the example on the left.

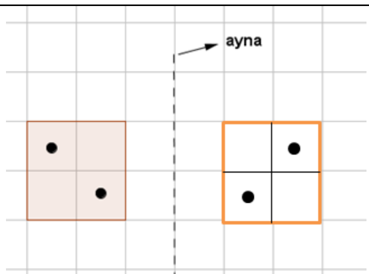
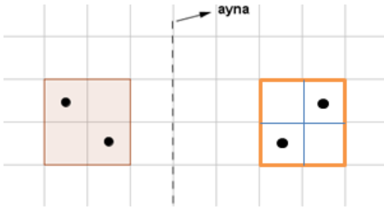
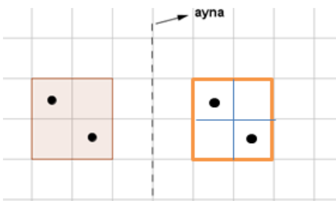
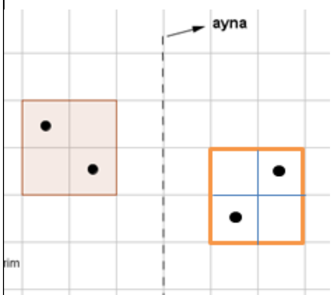
2	 Drawing exactly the inverse of K, but on the wrong place as drawn on the example on the left. Or  Drawing some part of K correctly according to reflection, completing other parts wrong.
1	 Drawing the inverse of K, but in the wrong size and on the wrong place as drawn on the example on the left.
0	• Not drawing the inverse of K, just drawing a regular K. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 1,b

Points	**Description**
4	• Specifying not only the shape as inverse of the K but also the place of the shape by counting units or reflecting critical points. • Explaining as folded version of K. • Using the words of “reflection” or “symmetry” which shows that students are capable of the concept.
3	• Just explaining the place of shape like counting units, specifying critical points etc.
2	• Drawing some part of K and completing the letter according to this part.

1	• Expressing the inversion. • Drawing according to imagination. • Justifying the inversion property of mirror as “ mirror shows the images inverse.”
0	• Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 2,a

Points	**Description**
3	 • Drawing totally correct reflection on the same horizon with original shape.
2	 • Wrong reflection of square but correct reflection of points.
1	 • Correct reflection of square but wrong reflection of points. Or  Inverse of the shape as correct reflection of both square and points, but not on the same horizon with original shape.
0	• Other drawings. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

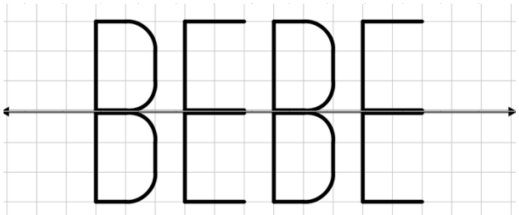
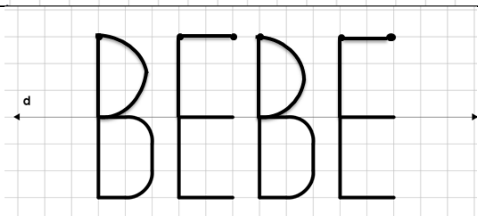
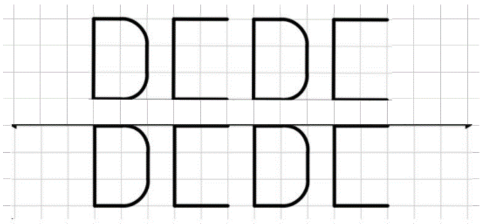
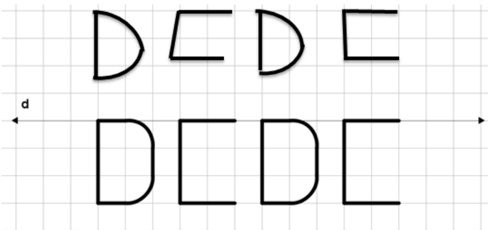
QUESTION 2,b

Points	Description
4	• Specifying not only the shape as inverse of original shape but also the place of the shape by counting units or reflecting critical points. • Explaining as folded version of original shape. • Using the words of "reflection" or "symmetry" or "mirror symmetry" or "mirror reflection" which shows that students are capable of the concept.
3	• Just explaining the place of shape like counting units, specifying critical points etc.
2	• Drawing some part of original shape and completing the rest of the shape.
1	• Expressing the inversion. • Drawing according to imagination. • Justifying the inversion property of mirror as " mirror shows the images inverse."
0	• Other incorrect (erased, crossed out, illegible, stray marks, off task).

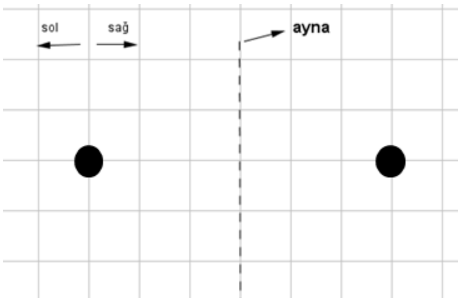
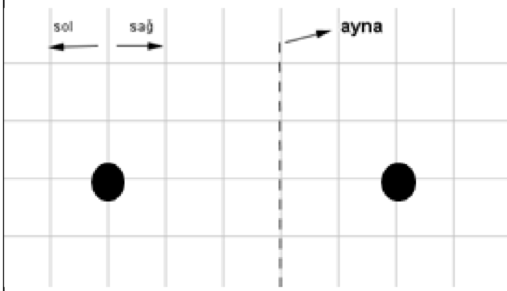
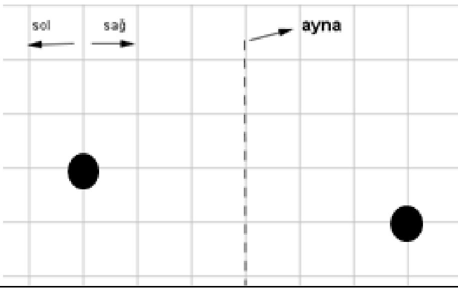
QUESTION 2,c

Points	Description
3	• Explaining the relationship with the words of "reflection" or " symmetry". • Explaining the relationship as both "they are inverse of each other" and their distance from the mirror. • Explaining the relationship as " they coincide when the paper is folded through the mirror line".
2	• Explaining the relationship in terms of their distance from the mirror. • Giving information about their distances.
1	• Explaining the relationship as both "they are inverse of each other" .
0	• Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 3

Points	Description
4	 • Correct reflection, and writing the word of BEBE
3	 • Drawing vertices of shapes correctly but, connecting these critical points wrong as ignoring other points on the original shape.
2	 • Drawing exactly the inverse of given shapes, but on the wrong place as drawn on the example on the left.
1	 • Drawing the inverse of given shapes, but in the wrong size and on the wrong place as drawn on the example on the left.
0	• Wrong reflection and wrong word. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 4,a

Points	Description
3	 • Correct reflection as same distance from the mirror with the original point and on the same horizon.
2	 • Drawing point on the same horizon with the original point, but with wrong distance from the mirror.
1	 • Drawing point with correct distance from the mirror, but not on the same horizon with the original point.
0	• Drawing point not only with wrong distance from the mirror, but also not on the same horizon with the original point. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 4,b

Points	Description
3	Any expression pointing the equality of the distances from the mirror.
0	• Not expressing the equality of the distances. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

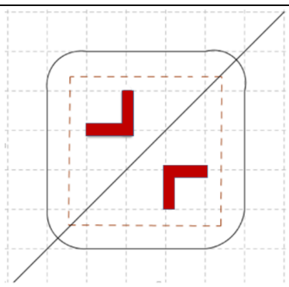
QUESTION 4,c

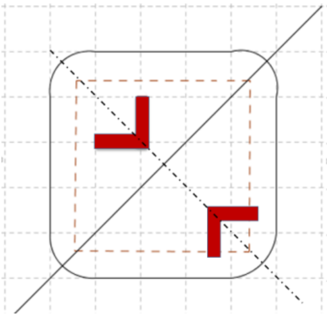
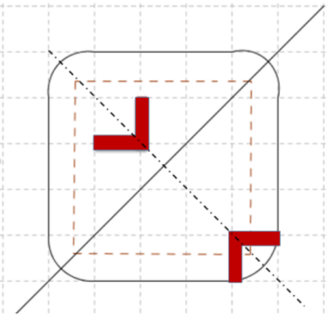
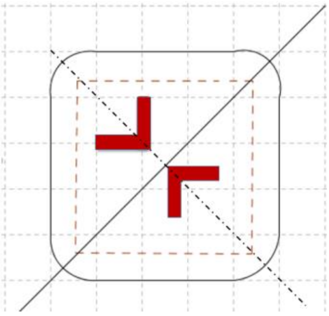
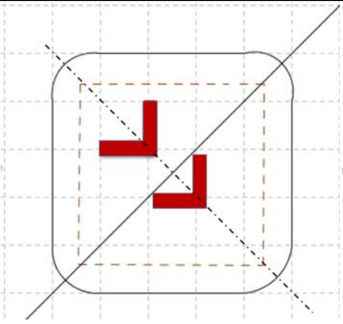
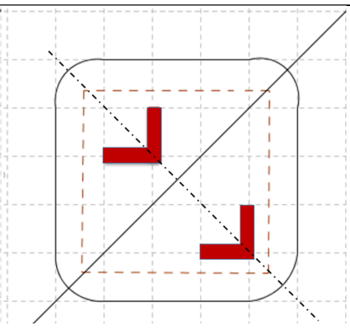
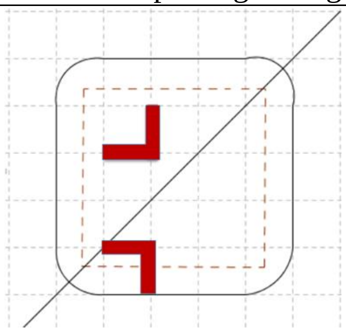
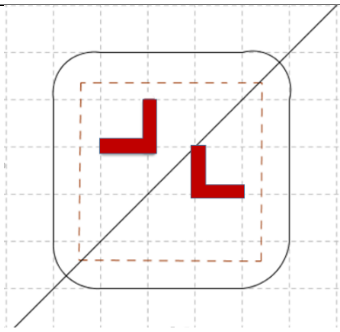
Points	Description
3	The point moves 1 unit through left hand side.(correct unit and correct side)
2	Correct unit (1 unit) but wrong side (not left hand side)
1	Correct side (left hand side), but wrong unit (not 1 unit)
0	• Wrong unit and wrong side • Other incorrect (erased, crossed out, illegible, stray marks, off task).

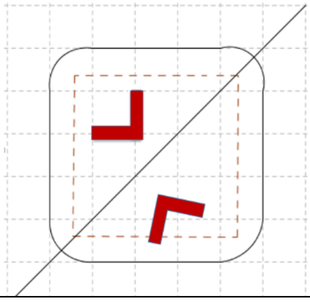
QUESTION 4,d

Points	Description
2	The point moves 2 units through down side.(correct unit and correct side)
1	• Correct unit (2 unit) but wrong side (not down side) Or • Correct side (down side), but wrong unit (not 2 unit)
0	• Wrong unit and wrong side • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 5,a

Points	Description
3	 Correct reflection.

2	   • Drawing the inverse of blot on the line perpendicular to the line of fold passing through main blot, but with wrong distance from line of fold.
1	  • Just translating the blot on the line perpendicular to the line of fold passing through main blot.
0,5	  • Drawing the inverse of blot by assuming line of fold as vertical or horizontal.

	Or  • Drawing the inverse of blot, but on the wrong place.
0	• Wrong reflection. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

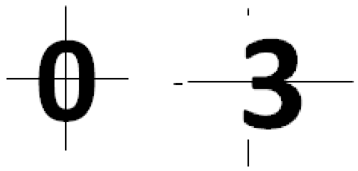
QUESTION 5,b

Points	**Description**
3	Any expression pointing the equality of the distances from the line of folding.
0	• Not expressing the equality of the distances. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

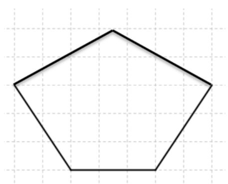
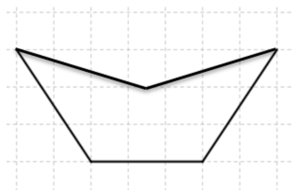
QUESTION 6,a

Points	**Description**
3	Giving all three numbers; 3,8,0
2	Giving two of three numbers; (3,0) or (3,8) or (8,0)
1	Giving only one of three numbers; 3 or 8 or 0
0	• Giving no one of three numbers • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 6,b

Points	Description
3	 Drawing all 5 symmetrical lines
Partial point	• **1 point**: symmetrical line of 3 • **0,5 point**: each of the symmetrical lines of both 8 and 0
0	• Showing symmetrical lines of wrong numbers. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

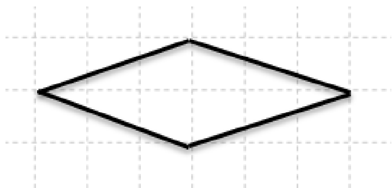
QUESTION 7,a

Points	Description
3	Correct shape drawn which has 5 sides and 1 line of symmetry. Height of intersection point of two segments drawn does not matter.  or 
0	• Drawing shape which has not 5 sides. • Drawing pentagon which has not a line of symmetry. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

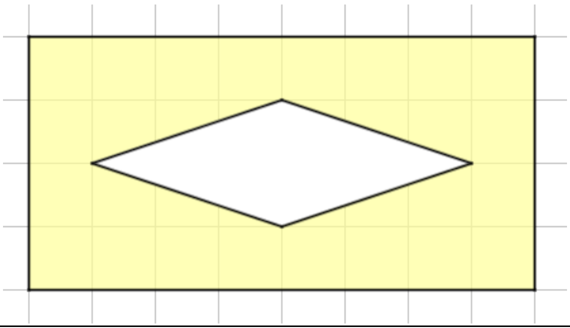
QUESTION 7,b

Points	Description
3	• Drawing line of symmetry of drawn pentagon. • Drawing any line passing through the midpoint of the base vertically.
2	• Drawing any line passing through one edge and a vertex across that adge.
1	• Drawing any line passing through two vertices.
0	• Any other drawing. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 8,a

Points	Description
4	 Drawing correct shape.
3	• Drawing a rectangle which has a line of symmetry passing through opposite vertices. • Calling the drawn shape as rhombus or baklava.
2	• Drawing a rectangle which has not a line of symmetry passing through opposite vertices.
1	• Drawing a triangle.
0	• Drawing any other shape. • Not opening the piece. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 8,b

Points	Description
4	 Drawing correct shape.
3	• Drawing a rectangle in which there is a hole in the shape of a rectangle which has a line of symmetry passing through opposite vertices i,e a rhombus.
2	• Drawing a rectangle in which there is a hole in the shape of a rectangle which has not a line of symmetry passing through opposite vertices.
1	• Drawing a rectangle in which there is a hole in the shape of a triangle.
0	• Drawing any other shape. • Not opening the paper. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 9,a

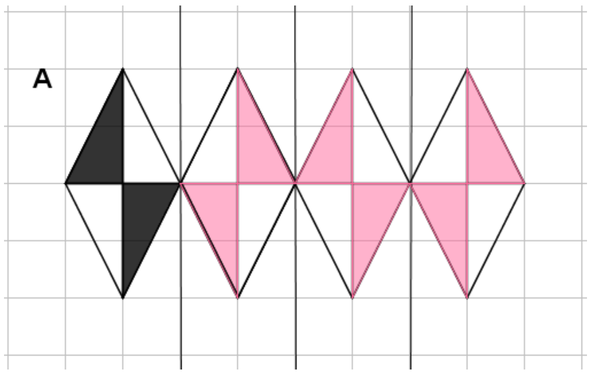
Points	Description
4	• Drawing mirror passing through point 4 and vertical to number line. • Drawing mirror passing through a point between 3 and 5, not exactly for, but expressing the correct idea in any way like 1 and 7 are seen on each other, or 2 and 6 are seen on each other etc.
3	• Drawing mirror passing through point 3 or 5 vertical to number line.
2	• Drawing mirror passing through any point between 0 and 8 vertical to number line. • Making some drawings to divide number line which shows that student tries to find a point between 0 and 8.
1	• Making any other reflections not related to question, because of misunderstandings.

0	• Unrelated answers to reflection. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 9,b

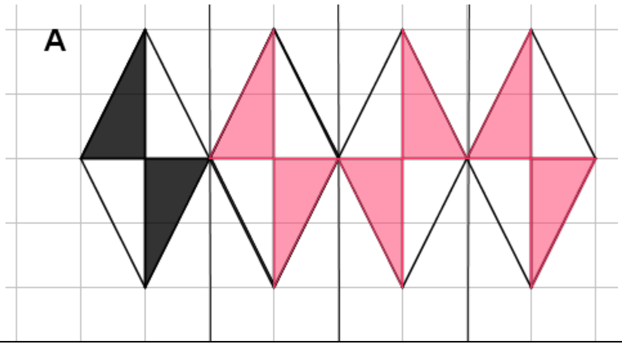
Points	**Description**
4	• While 1 and 3 are seen on each other, 0 and 4 are seen on each other.
3	• Writing that 0 and 1 are seen on 3 and 4, but not expressing which one is seen on which one.
2	• While 1 and 4 are seen on each other, 0 and 3 are seen on each other.
1	• Any other reflections which are reasonable in itself.
0	• Incorrect matchings. • Other incorrect (erased, crossed out, illegible, stray marks, off task).

QUESTION 10

Points	**Description**
3	• Painting following three quadrilaterals correctly. 

<table>
<tr><td>Partial</td><td>

- Each of three quadrilaterals is evaluated according to previous quadrilateral. If the quadrilateral is painted correctly as a reflection of previous one, it is **1 point**.



- For example the pattern painted on the left is 2 point.

</td></tr>
<tr><td>0</td><td>

- Other type of paintings.
- Other incorrect (erased, crossed out, illegible, stray marks, off task).

</td></tr>
</table>

Appendix D: GEOMETRİ TUTUM ÖLÇEĞİ

Genel Açıklama: Aşağıdaki geometriye ilişkin tutum cümleleri ile her cümlenin karşısında "Tamamen Katılıyorum", "Katılıyorum", "Kararsızım", "Katılmıyorum", ve "Hiç Katılmıyorum" olmak üzere beş seçenek verilmiştir. Her bir cümleyi dikkatle okuyarak boş bırakmadan bu cümlelere ne ölçüde katıldığınızı seçenekleri işaretleyerek belirtiniz.

	Tamamen Katılıyorum	**Katılıyorum**	**Kararsızım**	**Katılmıyorum**	**Hiç Katılmıyorum**
1. Geometri konularını tartışmaktan hoşlanırım.	O	O	O	O	O
2. Geometri benim için sıkıcıdır.	O	O	O	O	O
3. Geometri gerçek yaşamda kullanılmayan bir konudur.	O	O	O	O	O
4-Geometri ilgimi çeker.	O	O	O	O	O
5-Geometri benim için zevkli bir konudur.	O	O	O	O	O
6-Geometri konularını severek çalışırım.	O	O	O	O	O
7-Geometri konularından korkarım.	O	O	O	O	O
8-Geometri ile ilgili ileri düzeyde bilgi edinmek isterim.	O	O	O	O	O
9-Çalışma zamanımın çoğunu geometriye ayırmak isterim.	O	O	O	O	O
10-Geometri konuları zihin gelişimime yardımcı olmaz.	O	O	O	O	O
11-Geometri konularını severim.	O	O	O	O	O
12- Geometri konuları okulda öğretilmese daha iyi olur.	O	O	O	O	O
13-Geometri ile ilgili öğretilenleri günlük yaşama uygulayabilirim.	O	O	O	O	O
14-Geometri konusuna çalışmak içimden gelmez.	O	O	O	O	O
15-Geometri öğrenilmesi benim için zor bir konudur.	O	O	O	O	O
16-Geometri dersinde zaman benim için çabuk geçer.	O	O	O	O	O
17-Geometri konuları benim için eğlencelidir.	O	O	O	O	O

Appendix E: GEOMETRİYE YÖNELİK ÖZYETERLİK ÖLÇEĞİ

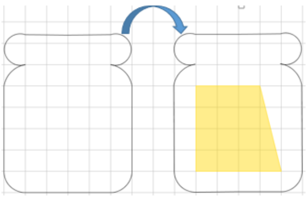
Bu ölçekte 5'li derecelendirme yapılmış olup 1 hiçbir zaman, 2 ara sıra, 3 kararsızım, 4 çoğu zaman ve 5 her zaman olarak düşünülmüştür. Lütfen verilen ifadeler için 1-5 arası size en uygun olan rakamı işaretleyiniz.

	Hiçbir Zaman	Ara sıra	Kararsızım	Çoğu Zaman	Her Zaman
1. Geometrideki kavramları rahatlıkla anlayabilirim.	O	O	O	O	O
2. Günlük yaşamda gördüğüm nesneleri geometrik şekillere benzetebilirim.	O	O	O	O	O
3. Geometride arkadaşlarım kadar iyi olmadığımı düşünüyorum.	O	O	O	O	O
4. Bir geometrik şekil gördüğümde onun özelliklerini hatırlayabilirim.	O	O	O	O	O
5. Bir geometri sorusu görünce ne yapılacağını bilemem.	O	O	O	O	O
6. Saatlerce çalışsam bile geometride başarılı olamayacağımı düşünüyorum.	O	O	O	O	O
7. Geometri ile el becerilerimi arttırabileceğimi düşünüyorum.	O	O	O	O	O
8. Geometri bilgimi diğer derslerde kullanabilirim.	O	O	O	O	O
9. Geometri konusunda yeterli bilgiye sahip değilim.	O	O	O	O	O
10.Geometri konusunda verilecek olan projelerde başarılı olacağımı düşünüyorum.	O	O	O	O	O
11.Geometri sorusu çözdükçe kendime olan güvenimin artacağını düşünüyorum.	O	O	O	O	O
12. Geometrik şekiller ile ilgili materyal geliştiremem.	O	O	O	O	O
13. Geometrik şekilleri kafamda canlandırabilirim.	O	O	O	O	O
14. Geometri ile ilgili problemler yazabilirim.	O	O	O	O	O
15. Geometri konusunda kendimi başarılı görüyorum.	O	O	O	O	O
16. Bir geometri problemini çözmek için gereken işlem basamaklarını çıkarabilirim.	O	O	O	O	O

17. Matematiksel problemleri çözerken geometrik şekillerden yararlanırım.	O	O	O	O	O
18. Geometrik şekiller arasındaki ilişkileri söyleyemem.	O	O	O	O	O
19. Geometrik şekillerin sahip oldukları çevre uzunluklarını tahmin edebilirim.	O	O	O	O	O
20. Yabancı bir yerde yolumu kaybedersem geometri bilgim ile yolumu bulabilirim.	O	O	O	O	O
21. Geometri ile ilgili sorun yaşayan arkadaşlarıma yardımcı olabilirim.	O	O	O	O	O
22. Bir geometrik şeklin özelliklerini duyduğumda şeklini çizebilirim.	O	O	O	O	O
23. Geometrik şekilleri kullanarak yeni bir geometrik şekil oluşturabilirim.	O	O	O	O	O
24. Bir geometri sorusunda işlemleri yaparken telaşa kapılacağımı düşünüyorum.	O	O	O	O	O
25. İleriki yıllarda geometri bilgisinin kullanıldığı bir meslek seçersem başarılı olacağıma inanıyorum.	O	O	O	O	O

Appendix F: ACTIVITIES

1. AKTİVİTE: TEREYAĞLI TOST ETKİNLİĞİ



Anneleri dışarda arkadaşlarıyla oynayan Ali ve Osman'ı çağırıp onlara tereyağlı tost vereceğini söyler. Yanda gösterildiği gibi önce bir dilim ekmeğe tereyağı süren anne üzerine bir başka dilimi kapatıp Ali'ye verir.

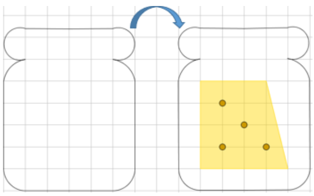
a) Ali ekmeğin içinde ne kadar yağ olduğunu merak edip tostun içini açar. Tereyağının diğer dilime de geçtiğini görür. Dilimlerin nasıl göründüğünü size verilen model üzerinde gösteriniz.

b) Diğer dilime bulaşan tereyağının yerini nasıl belirlediniz? Neye dikkat ettiniz?

c) Tereyağının yerini belirlerken dikkat ettiğiniz noktaların matematiksel bir adı var mı?

d) Diğer dilime bulaşan tereyağının şeklini nasıl belirlediniz?

e) İki dilimin birbirine göre durumunu matematiksel olarak açıklayınız.



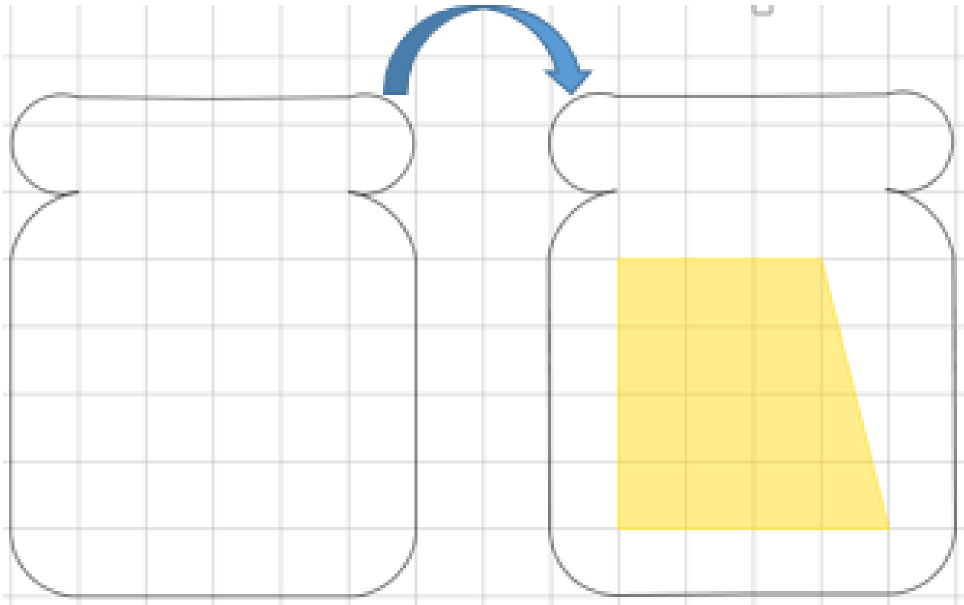
Osman'ın tostu için ise yanda gösterildiği gibi önce bir dilim ekmeğe tereyağı süren anne, tereyağlı dilime 4 damla da bal damlatıp diğer dilimi üzerine kapatır.

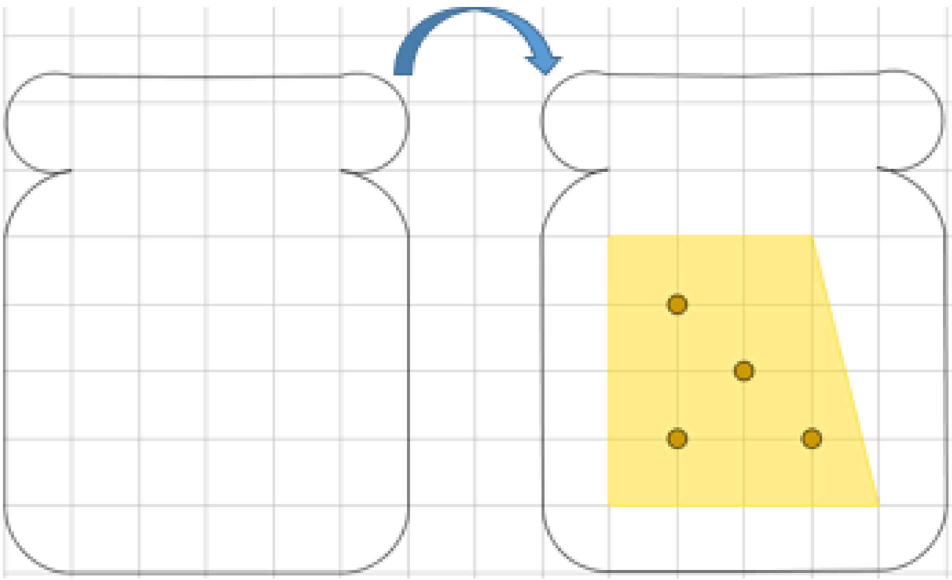
a) Osman, annesinin ne kadar tereyağı ve bal kattığını görmek için ekmekleri açar. Dilimler nasıl görünür? Size verilen model üzerinde gösteriniz.

b) Diğer dilime bulaşan balın yerini nasıl belirlediniz? Neye dikkat ettiniz?

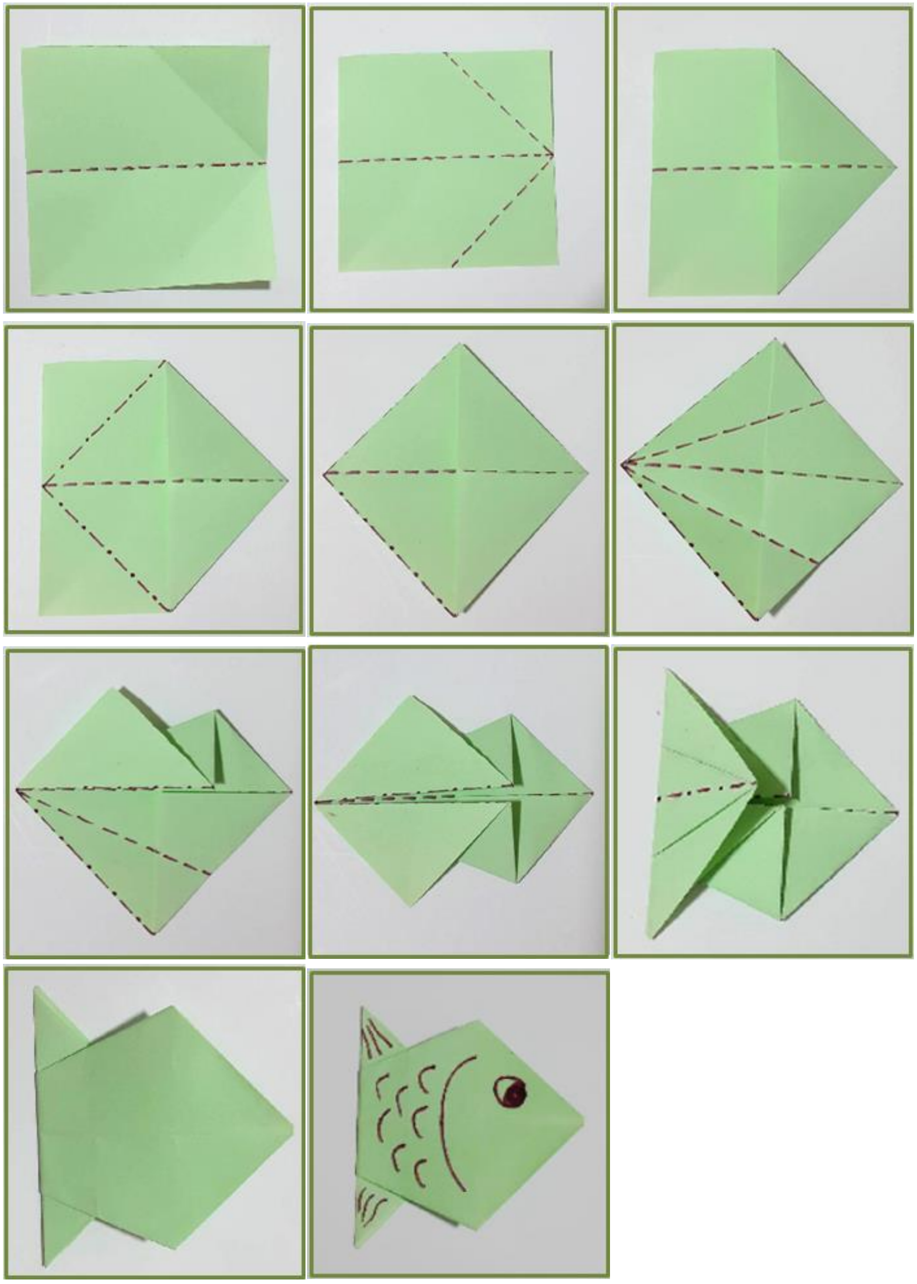
c) Balın yerini belirlerken dikkat ettiğiniz noktaların matematiksel bir adı var mı?

d) İki dilimin birbirine göre durumunu matematiksel olarak açıklayınız.

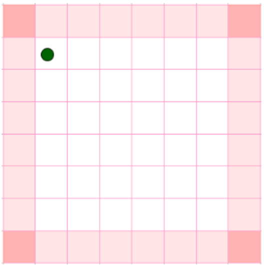




2. AKTİVİTE: ORIGAMI FISH

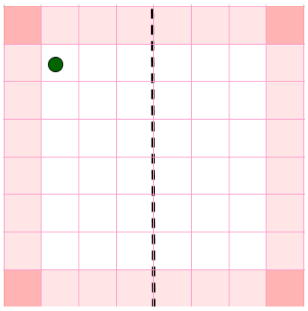


3. AKTİVİTE: BOYALI MENDİL ETKİNLİĞİ

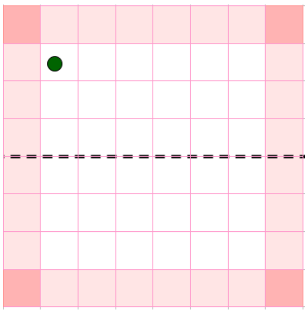


Merve resim dersinde sulu boya kullanırken mendiline şekilde görüldüğü gibi yeşil boya damlamıştır. Mendili henüz ıslakken katladığında boya diğer tarafa da bulaşır. Aşağıda farklı katlamalar sonucunda mendilde oluşacak lekelerle ilgili soruları cevaplayınız**.**

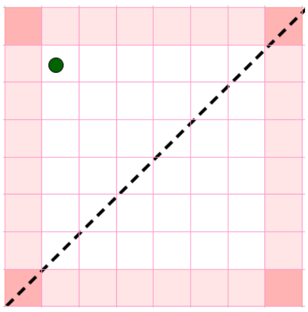
a) Mendili dikey olarak katlayıp açtığında meydana gelen görüntüyü çiziniz. Katlama çizgisini matematiksel olarak adlandırınız.



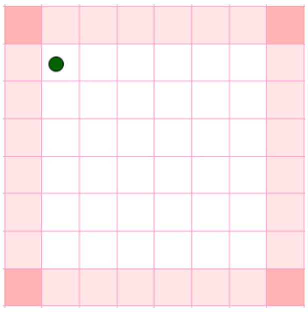
b) Mendili yatay olarak katlayıp açtığında meydana gelen görüntüyü çiziniz.



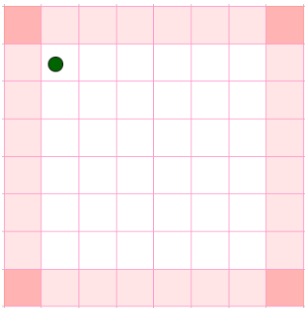
c) Mendili köşegeninden katlayıp açtığında meydana gelen görüntüyü çiziniz.



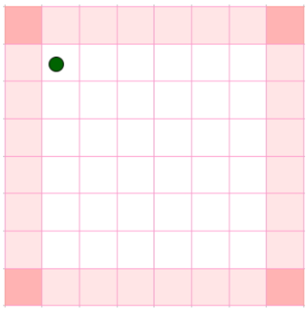
d) Mendili önce dikey sonra açmadan tekrar yatay kaylayıp açıyor. Meydana gelen görüntüyü ve katlama çizgilerini çiziniz.



e) Önce dikey sonra yatay katlanan mendili daha sonra köşegenden katlayıp açıyor. Meydana gelen görüntüyü ve katlama çizgilerini çiziniz.

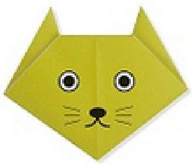


f) Bir önceki d ve e sorularında çizdiğiniz şekiller arasında bir benzerlik var mı? Varsa eğer nedenini sınıfta tartışınız.



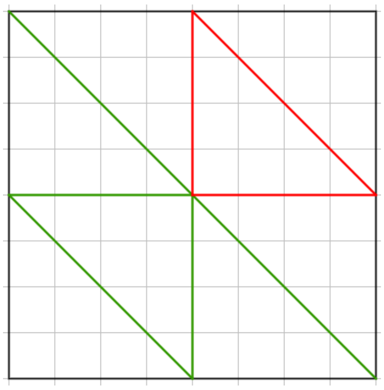
4. VE 5. AKTİVİTE: ÇİZGİLERDEN KATLAYALIM

Origami : O*rigami* kağıt katlama anlamına gelir. Genellikle kare kâğıt parçalarını kesmeden ve yapıştırıcı kullanmadan, sadece katlayarak, çeşitli canlı ve cansız figürler oluşturarak yapılır. Dikdörtgen kâğıtlardan, hatta kâğıt paralardan yapılan modeller de oldukça fazladır. Origamiyi aslında çoğumuz biliyoruz ve yapıyoruz. Çünkü küçüklükten beri yaptığımız kağıttan kayıklar ve uçaklar da birer origami figürüdür. Aşağıda bazı origami figürleri örnek verilmiştir.

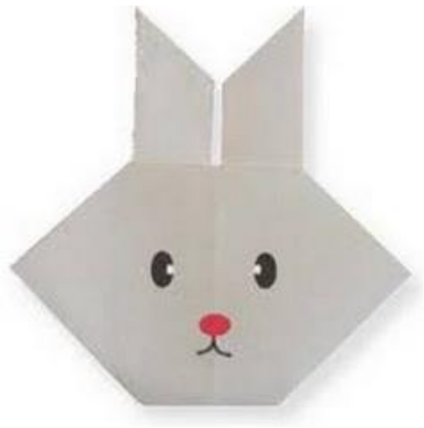



TİLKİYİ BULALIM

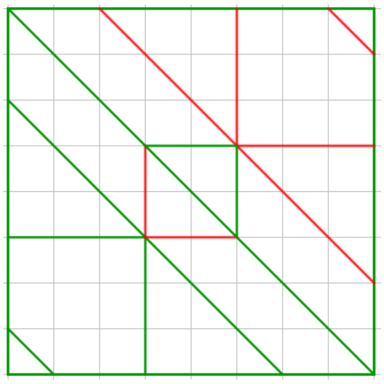
Yanda origami ile yapılmış bir tilki gösterilmektedir. Bu origami figürü açıldığında kağıtta oluşan katlama çizgileri aşağıda gösterildiği gibidir. Çizgilerin renkleri katlama izlerinin yönünü belirtmektedir. Yeşil izler dışarı bakarken; Kırmızı izler kağıdın içine doğru bakmaktadır. Bu izleri takip ederek en az sayıda katlama ile tilki figürünü oluşturunuz.



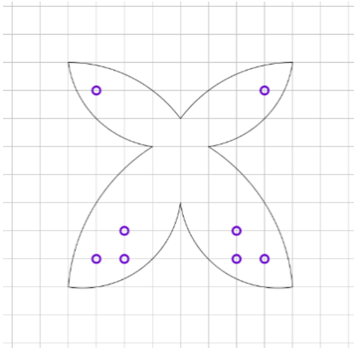
TAVŞANI BULALIM



Yanda origami ile yapılmış bir tavşan gösterilmektedir. Bu origami figürü açıldığında kağıtta oluşan katlama çizgileri aşağıda gösterildiği gibidir. Çizgilerin renkleri katlama izlerinin yönünü belirtmektedir. Yeşil izler dışarı bakarken; kırmızı izler kağıdın içine doğru bakmaktadır. Bu izleri takip ederek en az sayıda katlama ile tavşan figürünü oluşturunuz.



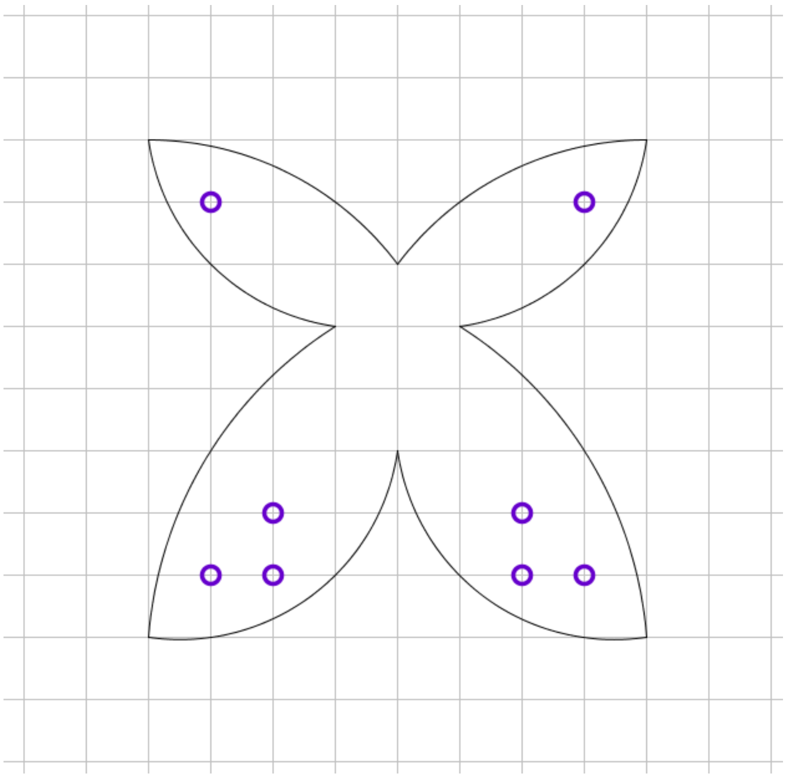
6. AKTİVİTE: AYŞE’NİN MAKASI

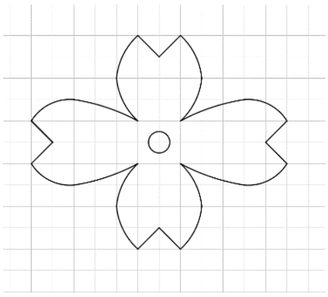


Ayşe yanda verilen kelebeği kâğıttan kesip çıkaracaktır. Makas parmaklarına göre küçük olduğu için keserken Ayşe’nin parmakları çok acır. Bu acıya daha fazla katlanmak istemeyen Ayşe, makası olabildiğince az kullanmak ister. Ayşe makası daha az kullanarak kelebeği kâğıttan nasıl kesip çıkarır?

a) Kelebeği kâğıttan kesip alırken nasıl bir strateji izlediniz?

b) Belirlediğiniz stratejiyi matematiksel olarak açıklayınız.

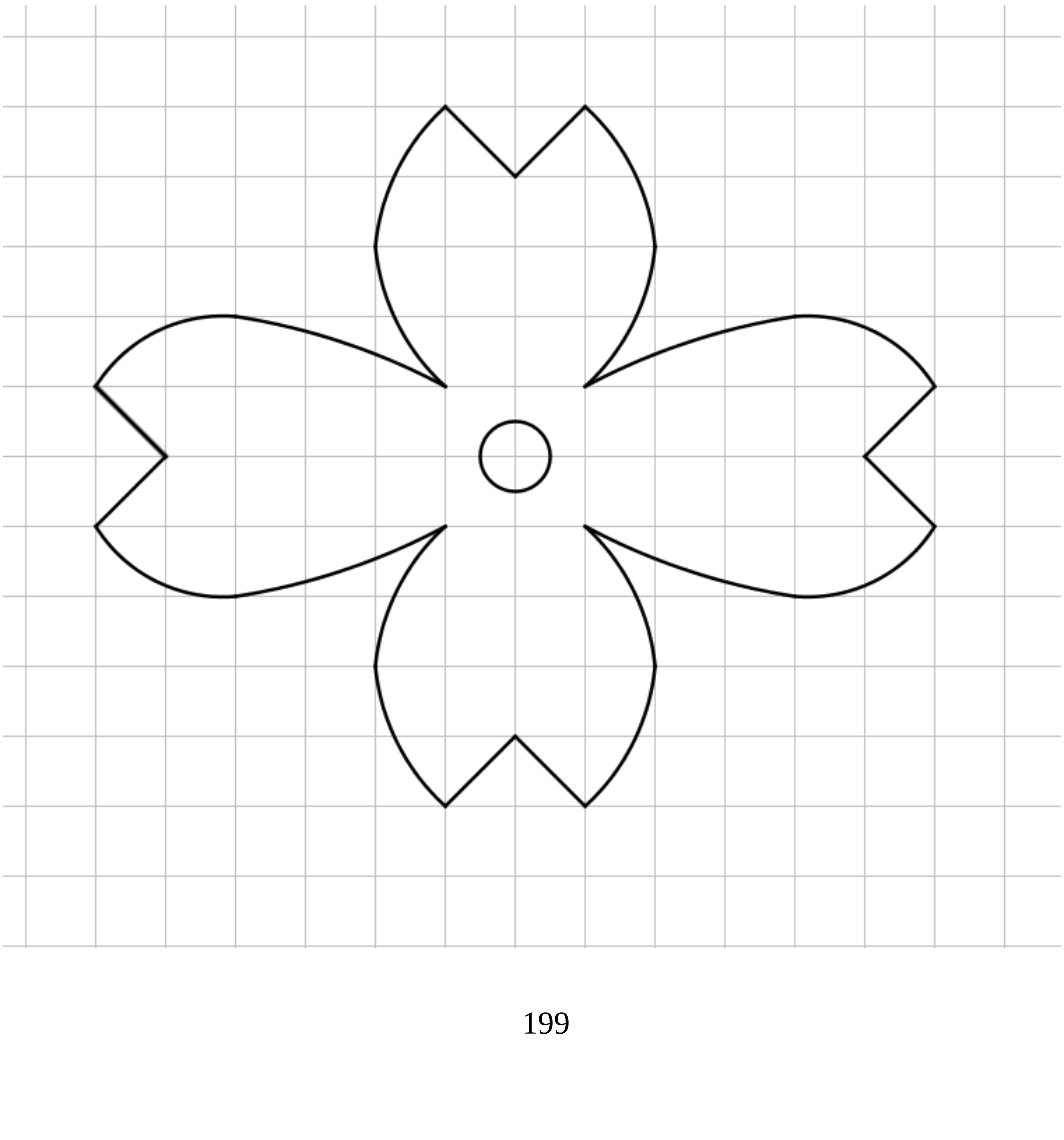


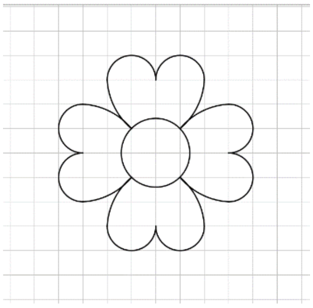


Ayşe aynı makasla yanda verilen çiçeği kağıttan kesip çıkarmak isteseydi nasıl keserdi?

a) Çiçeği kâğıttan kesip alırken nasıl bir strateji izlediniz?

b) Belirlediğiniz stratejiyi matematiksel olarak açıklayınız.

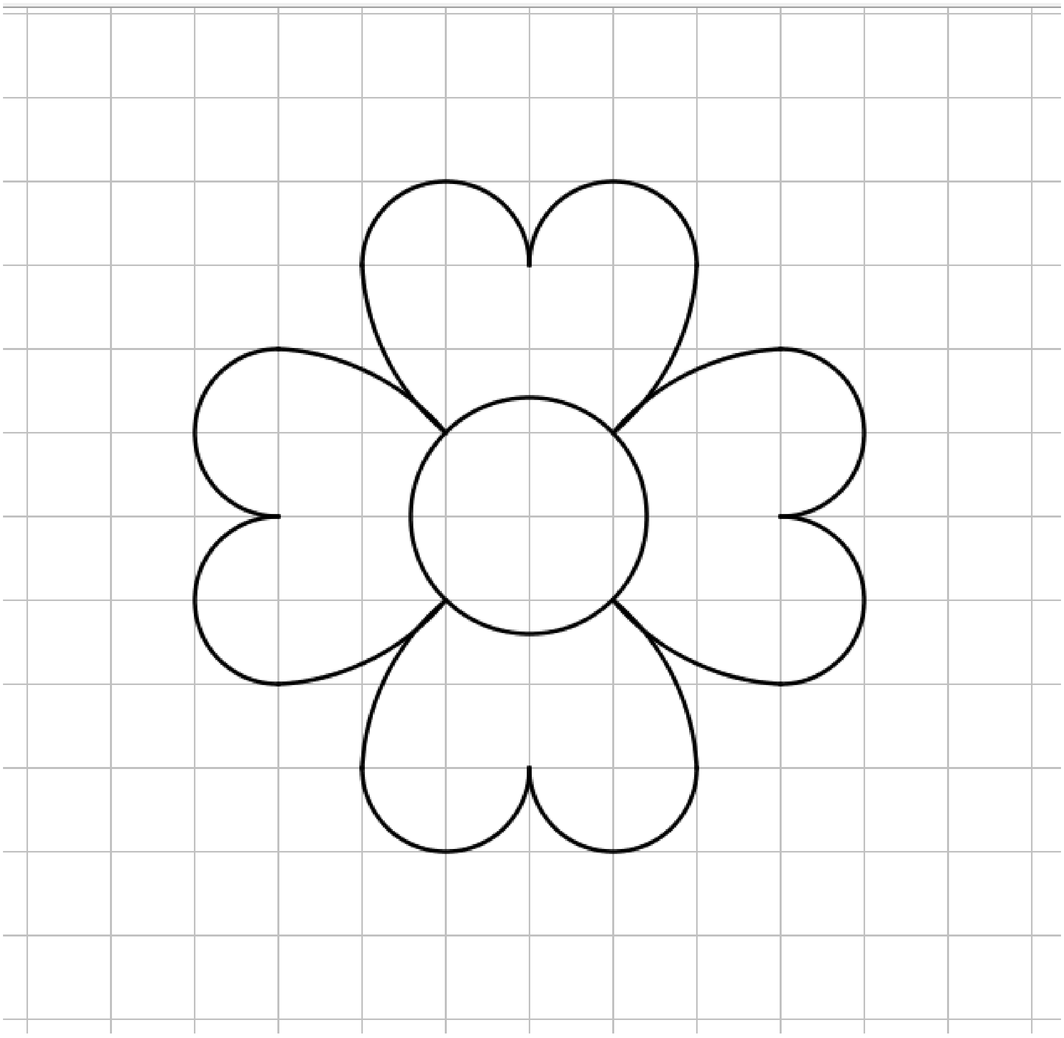


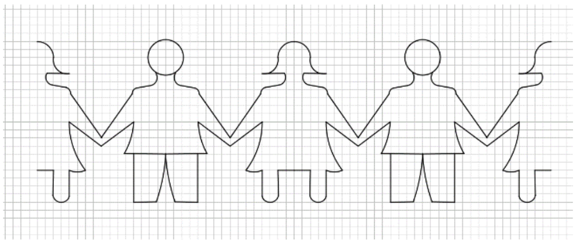


Ayşe aynı makasla yanda verilen çiçeği kâğıttan kesip çıkarmak isteseydi nasıl keserdi?

a) Çiçeği kâğıttan kesip alırken nasıl bir strateji izlediniz?

b) Belirlediğiniz stratejiyi matematiksel olarak açıklayınız.

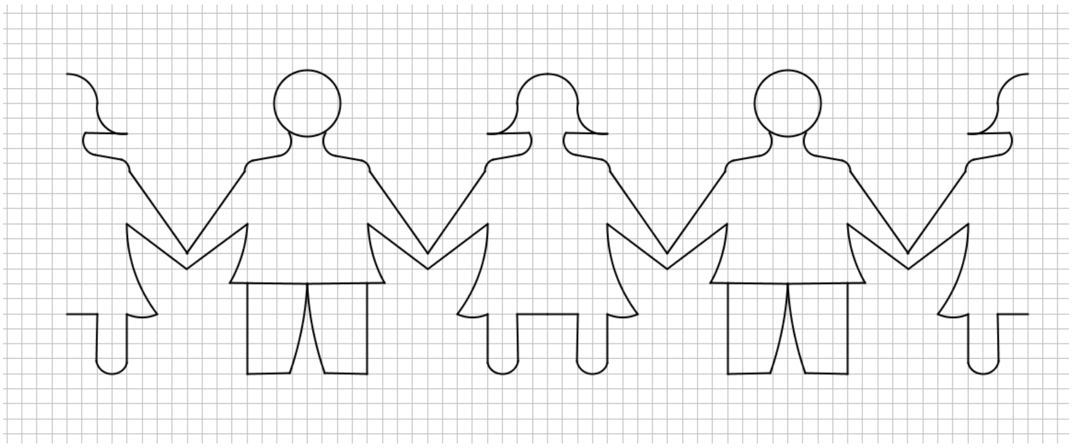


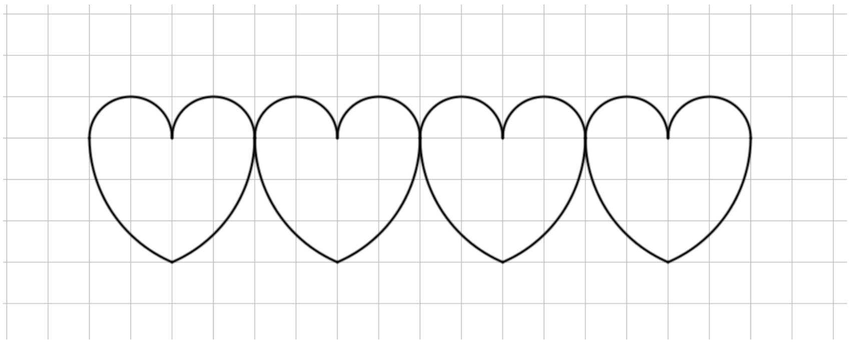


Ayşe aynı makasla yukarda verilen çocukları kâğıttan kesip çıkarmak isteseydi nasıl keserdi?

a) Çocukları kâğıttan kesip alırken nasıl bir strateji izlediniz?

b) Belirlediğiniz stratejiyi matematiksel olarak açıklayınız.

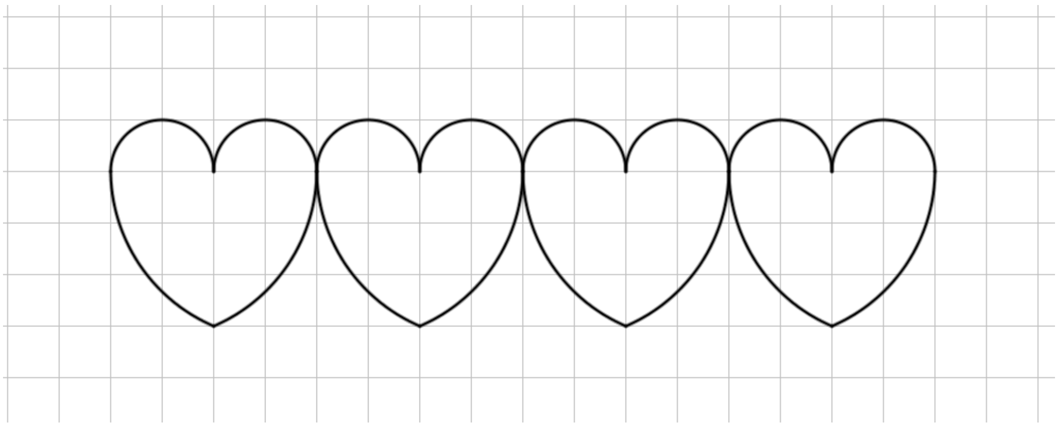




Ayşe aynı makasla yukarıda verilen kalpleri kâğıttan kesip çıkarmak isteseydi nasıl keserdi?

a) Kalpleri kâğıttan kesip alırken nasıl bir strateji izlediniz?

b) Belirlediğiniz stratejiyi matematiksel olarak açıklayınız.



Appendix G: ETHICAL PERMISSION

T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

ÖİDB

Sayı : 14588481-605.99-E.3324436 23.03.2016
Konu : Araştırma İzni

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi: a) MEB Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 2012/13 nolu Genelgesi.
b) 29/02/2016 tarihli ve 885 sayılı yazınız.

Üniversitesiniz İlköğretim Anabilim Dalı Yüksek Lisans Programı öğrencisi Semanur KANDİL'in **"Origami Problemleriyle Zenginleştirilmiş Sorgulamaya Dayalı Öğretim Yönteminin 7. Sınıf Öğrencilerinin Matematik Başarı ve Tutumlarına Etkisinin ve Bilişüstü Davranışlarının İncelenmesi"** konulu tez kapsamında uygulama talebi Müdürlüğümüzce uygun görülmüş ve uygulamanın yapılacağı İlçe Milli Eğitim Müdürlüğüne bilgi verilmiştir.

Görüşme formunun (5 sayfa) araştırmacı tarafından uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde bir örneğinin (cd ortamında) Müdürlüğümüz Strateji Geliştirme (1) Şubesine gönderilmesini arz ederim.

Müberra OĞUZ
Müdür a.
Şube Müdürü

Güvenli Elektronik İmzalı
Aslı İle Aynıdır.
23/3/2016

28-03-2016-5562

ışar SUBAŞI

Konya yolu Başkent Öğretmen Evi arkası Beşevler ANKARA
e-posta: istatistik06@meb.gov.tr

Ayrıntılı bilgi için
Tel: (0 312) 221 02 17/135

Bu evrak güvenli elektronik imza ile imzalanmıştır. http://evraksorgu.meb.gov.tr adresinden 4427-ed9c-389b-8a47-8639 kodu ile teyit edilebilir.

Appendix H: TURKISH SUMMARY

ORİGAMİ ETKİNLİKLERİYLE ZENGİNLEŞTİRİLMİŞ SORGULAMA TEMELLİ ÖĞRETİMİN ORTAOKUL YEDİNCİ SINIF ÖĞRENCİLERİNİN YANSIMA SİMETRİSİ KONUSUNDAKİ BAŞARILARI, GEOMETRİ DERSİNE YÖNELİK TUTUMLARI VE GEOMETRİYE YÖNELİK ÖZ YETERLİK ALGILARI ÜZERİNE ETKİSİNİN İNCELENMESİ

Giriş

Geometri; nokta, doğru, düzlem, düzlemsel şekiller ve bunlar arasındaki ilişkilerle birlikte uzunluk, alan, hacim gibi ölçüleri konu alan bir matematik dalıdır (Baykul, 2000). Şekiller ve özellikleri, dönüşümler, konum ve görselleştirme olmak üzere dört içerik hedefi içeren geometri (Van de Walle, Karp & Williams, 2013), öğrencilerin fiziksel çevrelerini sezgisel olarak anlamlandırmalarını ve geometri konularını bu çerçevede değerlendirerek verilen görev ve etkinliklerin altında yatan matematiği kavramsal olarak anlamalarını sağlar (Outhred & Mitchelmore, 2001).

Matematik eğitimcilerinin dikkat çektiği konulardan biri de, geometrinin hedef içeriklerinden biri olan dönüşümler konusudur (Clements & Battista, 1992). Hollebrands (2003) okullarda geometrik dönüşümlerin öğretilmesinin üç önemli nedeni olduğunu belirtmektedir. Dönüşümler, öğrencilerin matematik konularını anlamlandırmalarını, bir problem durumu içinde hissettirilen matematik konusunu fark etmelerini ve etkinlikler esnasında farklı gösterimler kullanarak üst düzey düşünmelerini sağlamaktadır. Dönüşüm bir şeklin pozisyonundaki (sabit hareketler) ve büyüklüğündeki (sabit olmayan hareketler) değişimlerdir (Van de Walle, Karp & Williams, 2013). Sabit hareketler, öteleme veya *kaydırma*, yansıma veya *çevirme* ve dönme veya *döndürme* olmak üzere üçe ayrılırken, sabit olmayan hareketler genişletme veya büzüştürme olarak sınıflandırılmıştır.

Bunlara ek olarak, simetri konusu da dönüşüm geometrisinin içine dahil edilmektedir. Bazıları simetriyi, doğruya göre simetri yani yansıma hareketi ile açıklarken (MEB, 1998; Weyl, 1952); bazıları da simetriyi şekillerin özelliklerini değiştirmeyen dönüşüm hareketi olarak tanımlar (Leikin, Berman & Zaslavsky, 1997; MEB, 2005). Daha açık bir ifadeyle, bu tanımlamalar ışığında simetri, öteleme simetrisi, yansıma simetrisi ve dönme simetrisi dönüşümlerini kapsayan sabit hareketleri ifade etmektedir.

İlgili yayın ve araştırmalar incelendiğinde, ilkokul ve ortaokul öğrencilerin simetri konusunu anlamakta zorlandıkları ve kavram yanılgıları yaşadıkları rapor edilmiştir (Bell, 1993; Edwards & Zazkis, 1993; Hoyles & Healy, 1997; Köse, 2012; Küchemann, 1993; Soon, 1989; Xistouri, 2007; Yanik & Flores, 2009; Zaslavsky, 1994; Zembat, 2007). Ulusal ortaokul matematik dersi eğitim programı dikkate alındığında, bu sorunların üstesinden gelebilmek için, geleneksel öğretim yaklaşımından öte öğrencilerin araştırabilecekleri, iletişim kurabilecekleri ve simetri konusunu kavramsallaştırabilecekleri somut materyallerle zenginleştirilmiş etkinliklerle öğretime odaklanıldığı görülmüştür (MEB, 2005). Bu bağlamda, etkinlik geliştirme, matematiksel düşünmeye teşvik etme ve eleştirel düşünmeye imkan sağlaması açısından sorgulama temelli öğretimin etkili olacağı düşünülmektedir (Cobb, Wood, & Yackel, 1990; Glasersfeld, 1984, Jaworski, 1994).

Sorgulama temelli öğretim yöntemi, öğrencilerin araştırmalarına, sorgulamalarına ve çözümlerini savunmalarına olanak sağlayan, öğrenci merkezli bir öğretim yaklaşımıdır (Artigue & Blomhøj, 2013). Matematik eğitiminde sorgulama yaklaşımı öğrencilerin alışık olmadıkları rutin olmayan problemler üzerinde çalışmalarını, bu problemler üzerinde matematiksel açıklamalar yapmalarını ve sınıfta yaratılan tartışma ortamında matematiksel dil kullanarak açıklamalarını savunmalarını gerektirir (Richards, 1991). Yapılan çalışmalar sorgulama temelli öğretim yaklaşımın öğrenci başarısını, (Kirschner vd. 2006), derse karşı tutumu (Reyes, 1984) ve öz yeterliliği (Laipply, 2004) olumlu yönde etkilediğini göstermektedir.

Araştırma Soruları

Bu çalışmada ele alınan üç araştırma sorusu aşağıda verilmiştir.

1. Yansıma simetrisi başarı puanları, geometri tutum puanları ve geometriye yönelik öz-yeterlik puanları kontrol edindiğinde, origami etkinlikleriyle zenginleştirilmiş sorgulama temelli öğretimin ortaokul yedinci sınıf öğrencilerinin yansıma simetrisi konusundaki başarılarına bir etkisi var mıdır?

2. Yansıma simetrisi başarı puanları, geometri tutum puanları ve geometriye yönelik öz-yeterlik puanları kontrol edindiğinde, origami etkinlikleriyle zenginleştirilmiş sorgulama temelli öğretimin ortaokul yedinci sınıf öğrencilerinin geometriye yönelik tutumlarına bir etkisi var mıdır?

3. Yansıma simetrisi başarı puanları, geometri tutum puanları ve geometriye yönelik öz-yeterlik puanları kontrol edindiğinde, origami etkinlikleriyle zenginleştirilmiş sorgulama temelli öğretimin ortaokul yedinci sınıf öğrencilerinin geometriye yönelik öz-yeterlik algılarına bir etkisi var mıdır?

Yöntem

Çalışma Deseni

Bu çalışma nicel araştırma yöntemleri kullanılarak gerçekleştirilmiş olup kontrol gruplu ön test-son test yarı deneysel araştırma deseni kullanılmıştır. Deneysel araştırma deseninde en az bir bağımsız değişkenin, bir ya da birden fazla bağımlı değişken üzerindeki etkisi incelenir ve doğru şekilde uygulandığında araştırma yöntemleri içinde en kesin sonuçların elde edildiği yöntemdir (Fraenkel & Wallen, 2006). Örneklemden elde edilen sonuçlar, evrene genellenebilir. Deneysel yöntemlerin özelliklerinden bir de katılımcıların deney ve kontrol gruplarına tarafsız olarak atanmasıdır. Yalnız bazı durumlarda katılımcıların gruplara rastgele dağıtılması mümkün olmamaktadır. Böyle durumlarda yarı deneysel araştırma deseni kullanılır (Fraenkel & Wallen, 2006). Bu çalışmada okul şartlarında öğrencilerin kontrol ve deney gruplarına rastgele ayrılmaları mümkün olmadığından, halihazırda bulunan iki sınıftan birisi deney grubu, diğeri kontrol grubu olmak üzere rastgele belirlenmiştir. Deney grubundaki öğrencilere origami etkinlikleriyle zenginleştirilmiş sorgulama temelli öğretim metodu uygulanırken, kontrol grubunda MEB 7. sınıf matematik ders kitabında bulunan etkinliklerle ders yapılmıştır. Sorgulama temelli öğretimin öğrencilerin yansıma simetrisi başarısı, geometri tutumu ve geometri öz-yeterliklerine etkisini değerlendirmek amacıyla öğrencilere deney öncesinde ve sonrasında ilgili testler uygulanmıştır.

Katılımcılar

Bu çalışmada örneklem, uygun örnekleme yöntemi kullanarak belirlenmiştir. Böylelikle, çalışmanın örneklemini, 2015-2016 öğretim yılında Ankara ilinin Altındağ ilçesindeki bir ortaokuldaki iki 7. sınıf oluşturmaktadır. Deney grubunda

23 (16 kız ve 7 erkek) ve kontrol grubunda 25 (14 kız ve 11 erkek) öğrenci bulunmaktadır.

Veri Toplama Araçları

Bu çalışmada nicel verileri toplamak amacıyla, Yansıma Simetrisi Başarı Testi, Geometri Tutum Ölçeği ve Geometriye Yönelik Öz-yeterlik Ölçeği kullanılmıştır.

Yansıma Simetrisi Başarı Testi

Bu ölçek araştırmacı tarafından öğrencilerin yansıma simetrisi konusundaki başarılarını ölçmek amacıyla hazırlanmıştır. Ölçeğin maddeleri hazırlanırken MEB Ortaokul Matematik Dersi Öğretim Programı 7. sınıf yansıma simetrisi konusundaki kazanımlar göz önünde bulundurulmuştur. TIMMS (2011) sorularından, 7.sınıf SBS (2009) sorularından, MEB 7.sınıf matematik ders kitabındaki örneklerden yararlanılarak hazırlanan ölçek, 160 öğrenciyle yapılan pilot çalışma sonucunda tekrar düzenlenmiştir. Bu öğrencileri kağıtlarından rastgele seçilen 35 kağıt, alanında uzman iki kişi tarafından değerlendirilerek, rubrikten elde edilen sonuçların güvenirliği test edilmiştir. Cronbach alpha güvenirlik kat sayısı .99 bulunmuştur.

Geometri Tutum Ölçeği

Öğrencilerin geometriye yönelik tutumlarını ölçmek amacıyla Bulut ve diğerlerinin (2002) geliştirmiş olduğu 10 olumlu ve 7 olumsuz olmak üzere toplam 17 maddeden oluşan tutum ölçeği kullanılmıştır. Beşli Likert tipindeki ölçekte, her bir madde sırasıyla “tamamen katılıyorum”, “katılıyorum”, “kararsızım”, “katılmıyorum” ve “hiç katılmıyorum” şeklinde görüş bildiren beş seçenek doğrultusunda değerlendirilmektedir. Bu seçenekler sırasıyla 5’ten 1’e doğru puanlanarak her bir katılımcı için tutum puanı hesaplanmaktadır. Toplam puan 17 ile 85 arasında değişmektedir. Araştırmacılar tarafından yapılan güvenirlik çalışması sonucunda

Cronbach Alpha kat sayısı .92 bulunmuştur. Ayrıca, ölçeğin hoşlanma, yarar ve kaygı olmak üzere üç boyuttan oluştuğu belirtilmiştir.

Geometriye Yönelik Öz-yeterlik Ölçeği

Öğrencilerin geometriye yönelik öz-yeterlilerini ölçmek amacıyla Cantürk-Günhan ve Başer'in (2007) geliştirmiş olduğu 25 maddeden oluşan beşli Likert tipindeki ölçek kullanılmıştır. Ölçekteki maddeler "hiçbir zaman katılmıyorum", "ara sıra katılıyorum", "kararsızım", "çoğu zaman katılıyorum" ve "her zaman katılıyorum" şeklinde derecelendirilmektedir. Her bir madde bu derecelendirme doğrultusunda sırasıyla 1'den 5'e doğru puanlanarak, her bir katılımcı için toplam öz-yeterlik puanı hesaplanmaktadır. Araştırmacılar yaptıkları güvenirlik çalışması sonucunda Cronbach Alpha kat sayısını .90 olarak bulmuştur. Ayrıca, ölçeğin "öğrencinin geometriye yönelik olumlu öz-yeterlik inançları", "öğrencinin geometri bilgisinin kullanılmasına yönelik inançları" ve "öğrencinin geometriye yönelik olumsuz öz-yeterlilik inançları" olmak üzere üç boyuttan oluştuğu belirtilmiştir.

Etkinliklerin Geliştirilmesi

Bu çalışmada deney grubu öğrencilerine uygulanmak üzere sorgulama temelli öğretim ışığında origami etkinlikleri oluşturulmuştur. Tüm etkinlikler araştırmacı tarafından gerçek yaşam durumlarına uyarlanarak hazırlanmıştır. Etkinliklerden bazıları (balık, tilki gibi) anonim origami figürleri üzerine kurulmuştur. Bu figürler seçilirken yansıma simetrisi konusuna uygunlukları göz önünde bulundurulmuştur. Daha açık bir ifadeyle, bu figürlerin oluşturulması esnasında kağıt üzerinde oluşan katlama izleri ve her bir katlama sonrasın kağıdın görüntüsü incelenmiş ve yansıma simetrisi konusunda örnek teşkil edebilecek olan figürler belirlenmiştir. Ayrıca figürlerin zorluk dereceleri de göz önünde bulundurulan diğer bir kriterdir. Çok sayıda ve karmaşık katlama gerektiren figürlerden kaçınılmıştır. Çünkü, etkinliklerin çoğunluğunda öğrencilerden katlamaları gerektiğini ve nasıl katlayacaklarını kendilerinin bulması beklenmektedir. Yansıma simetrisi konusuna en uygun figürler belirlendikten sonra, öğrencilerin sorgulama yaklaşımı doğrultusunda bu figürleri oluşturmasını gerektirecek problem durumları yazılmıştır. Etkinliklerin, öğrencilerin kağıt katlama ve yansıma simetrisi konularını ilişkilendirmelerine imkan sağlaması beklenmektedir.

1. Etkinlik: Tereyağlı Tost

Bu etkinlik "Düzlemde nokta, doğru parçası ve diğer şekillerin yansıma sonucu oluşan görüntüsünü oluşturur" kazanımı üzerine geliştirilmiştir. Etkinlikte öğrencilerden üzerine yağ sürülmüş olan bir dilim ekmeğin üzerine kapatılan başka bir dilime bulaşan yağın yerini bulmaları beklenmektedir. Öğrencilerin somut olarak çalışabilmeleri için, tostu temsil eden modeller hazırlanmıştır. Böylelikle öğrencilere katlama yapabilmeleri için imkan sağlanmış olacaktır. Etkinlik esnasında, öğrencilere doğrudan katlama yapmaları söylenmemelidir. Öğrencilerin katlamaya ihtiyaç duymaları ve bu doğrultuda etkinliği tamamlamaları beklenmektedir. Ayrıca, katlamanın gerekliliğini fark eden öğrencilerin çözüm stratejilerini matematiksel olarak gerekçelendirmeleri beklenmektedir. Genellikle, etkinlikte sorgulama temelli öğretimin gereği olarak, öğrencilerden sorgulamaları, çözümlerine açıklama sunmaları, arkadaşlarının açıklamaları doğrultusunda kendi çözümlerini değerlendirmeleri ve tartışma ortamında ellerindeki modelleri kullanarak bir genellemeye ulaşmaları beklenmektedir. Bu sırada öğretmen, gözlemci ve yol gösterici olarak öğrencilere gerektiği yerde kendi çözümlerini ve başkalarının çözümlerini sorgulamalarını gerektirecek sorular yöneltmelidir. Örneğin, "Neden katladın?", "Çözümünün doğu olduğuna nasıl emin oldun?", "Katlarken nelere dikkat ettin", "Katladığın yeri neye göre belirledin?" gibi sorular öğrencilerin yansıma simetrisinin özelliklerini fark etmelerine yardımcı olacaktır.

Etkinliğin ikinci yarısında öğrencilere üzerine bal damlatılmış olan yağlı ekmeğin üzerine kapatılan diğer dilimin nasıl göründüğü sorulmaktadır. Burada, öğrencilerden yamuk şeklindeki yağı yansıtmanın yanı sıra nokta şeklindeki bal damlalarını da yansıtmaları beklenmektedir. Öğrencilerden bu aşamada da sorgulama yaklaşımını kullanmaları beklenmektedir. Öyle ki, öğrenciler sorgulamalı, sorulanları matematiksel olarak açıklamalı, çözümlerine açıklama getirmeli ve matematiksel olarak desteklemeli, tartışma ortamında başkalarının açıklamaları doğrultusunda eleştirel düşünerek bir genellemeye varabilmelidirler.

2. Etkinlik: Origami Balık

Bu etkinlikte öğrencilerin kağıt katlama etkinliklerine aşinalık kazanmaları ve her bir katlamanın arkasında yatan yansıma konusunu fark etmeleri beklenmektedir. Her bir katlamadan sonra öğrencilerden oluşan şekilleri incelemeleri istenmelidir. Örneğin kağıt katlanırken oluşan üçgenler konusunda tartışmaları istenilebilir. Üçgenlerin eşliği ya da benzerliği konusunda tartışmaları, onların üçgenler arasındaki ilişkiyi fark etmelerini sağlayabilir. Öğrencilerden, üçgenlerin eş olup olmaması konusunda fikir ayrılığına sebep olan konum ve doğrultularını yorumlamaları beklenmektedir. Böylece, üçgenlerin birbirlerinin yansıması olduklarını fark edebilirler. Daha önceki yıllarda yansımayı öğrenmiş olan öğrencilerin, üçgenler arasındaki ilişkiyi yansıma simetrisi ile açıklamaları beklenmektedir. Bu ilişkiye nasıl karar verdikleri sorularak öğrencilerin tartışması ve şekiller üzerindeki katlama izlerini yorumlamaları ve matematiksel olarak adlandırmaları beklenmektedir.

3. Etkinlik: Boyalı Mendil

Bu etkinlik "Yansımada şekil ile görüntüsü üzerinde birbirlerine karşılık gelen noktaların simetri doğrusuna olan uzaklıklarının eşit olduğunu keşfeder" kazanımı doğrultusunda hazırlanmıştır. Etkinlikte, üzerine boya damlatılan bir mendilin çeşitli katlamalar sonucunda nasıl göründüğüne dair sorular sorulmaktadır. Öğrencilerin bu katlamalar sonucunda boyanın nereye bulaştığını keşfetmeleri beklenmektedir. Ayrıca mendil sadece yatay ve dikey katlanmamakta, köşegenden çapraz olarak da katlanmaktadır. Böylece öğrencilerden etkinliğin başında eğik simetri doğrusuna göre yansıtma yapmaları beklenmektedir. Bu ilk aşamaları takip eden diğer aşamalarda öğrencilerin birden fazla katlama sonucunda lekenin yerini bulmaları beklenmektedir. Her bir aşamanın sonunda öğrencilerin açıklamalarda bulunmaları, matematiksel olarak çözümlerini desteklemeleri ve kendi matematiksel bilgilerini kendilerinin elde etmeleri beklenmektedir. Bu etkinliğin en dikkat çeken aşamalarından biri de öğrencilerin farklı cevaplar bulabilecek olması ve tartışma ortamına elverişli olmasıdır. Bu farklılığın nedeninin çapraz katlamanın yönü olduğunu fark etmeleri beklenen öğrencilerin, bu durumu simetri doğrusunun konumu ile açıklamaları hedeflenmektedir. Sonuç olarak, öğrenciler sorgulama temelli öğrenmenin gereği olarak her aşamada açıklamalarını sunmalı, yanıtlarını matematiksel olarak desteklemeli ve diğer açıklamalar doğrultusunda değerlendirme yapmalıdırlar.

4. Etkinlik: Tilkiyi Bulalım ve Tavşanı Bulalım

Bu etkinlikler "Yansımada şekil ile görüntüsü üzerinde birbirlerine karşılık gelen noktaların simetri doğrusuna olan uzaklıklarının eşit olduğunu keşfeder, simetri doğrularının üzerinde olan şekillerle de çalışmalar yapılır" kazanımı doğrultusunda hazırlanmıştır. Bu iki etkinlikte, öğrencilerden üzerinde katlamaların yapılacak olduğu çizgiler gösterilmiş olan modelleri katlayarak tilkiyi oluşturmaları beklenmektedir. Tepe ve vadi katlamaları öğrencilere açıklanarak, bunların farklı renklerde verilmiş olduğu belirtilmelidir. Burada öğrencilerin keşfetmeleri gereken tepe ve vadi katlaması sonucu oluşacak olan izlerin birbirlerinin simetrisi olduğudur. Bunu keşfeden öğrencilerin nedenini açıklamaları gerekmektedir. Tüm bu katlama izlerinin sadece bir katlama izine göre birbirlerinin yansıması olduğunu görmelidirler. Kağıdı köşegeninden katlamak gerektiğin gösteren çizginin aslında simetri doğrusunu temsil ettiğini fark etmelidirler. Daha sonra "neden" ve "nasıl" sorularıyla öğrencilerin düşünmeye ve sorgulamaya yönlendirilmesi gerekir. Burada yapılması gereken genelleme, kağıt ikiye katlandıktan sonra yapılacak olan her bir katlamanın iki tane ize sebep olacağıdır. Kağıt açıldığında ise bir adet tepe izi oluşmuş olurken, buna simetrik olan bir de vadi izi oluşur. Bunu keşfeden öğrencilerin sadece tek tip katlama işlemini uygulaması yeterli olacaktır. Öğrencilerden bu sorgulama temelli öğrenme sürecinde uyguladıkları her bir işlemi açıklamaları ve çözümlerinin altında yatan gerekçeleri savunmaları beklenmektedir.

5. Etkinlik: Ayşe'nin Makası

Bu etkinlik, "Düzlemsel bir şeklin ardışık yansımalar sonucunda ortaya çıkan görüntüsünü oluşturur" kazanımı dikkate alınarak hazırlanmıştır. Bu etkinlik tek bir durum altında beş farklı modelden oluşmaktadır. Etkinlikte, küçük oluşundan dolayı keserken can yakan bir makası, olabildiğince az kullanarak verilen şekilleri kağıttan kesip çıkarmaları istenmektedir. Burada öğrencilerin verilen şekli çevre çizgileri doğrultusunda kesip çıkarmamaları gerekir. Böyle yaptıklarında ise, "daha az makas kullanımıyla aynı şekli kesebilir miydiniz?" sorusuyla çözümlerini sorgulamaları sağlanmıştır. Bu etkinliklerde öğrencilerden beklenen, verilen şeklin aslında bir birim şeklin ardışık yansımaları sonucunda oluştuğunu keşfetmesidir. Bunu keşfeden öğrencilerin birim figüre ulaşana kadar katlama yapıp, daha sonra sadece bu küçük birimi keserek tüm modeli kağıttan çıkarmaları beklenmektedir. Öğrencilere her seferinde, gerçekten en az miktarda kesim yapıp yapmadıkları sorulmaları ve tartışma ortamı içerisinde çözümlerini karşılaştırıp sınıfça genel sonuca ulaşmaları beklenmektedir.

Sonuç olarak, etkinlikler sorgulama temelli öğretim stratejileri göz önünde bulundurularak hazırlanmış ve ders planı yapılmıştır. Öğrencilere soru sorabilecekleri, sorgulayabilecekleri, kanıt sunabilecekleri, açıklama geliştirebilecekleri, eleştirel düşünebilecekleri, başkalarının açıklamaları doğrultusunda kendi açıklamalarını değerlendirebilecekleri ve yeni bilgiye ulaşabilecekleri bir öğretim ortamı sunmak hedeflenmiştir.

Verilerin Analizi

Bu çalışmada nicel analiz yöntemleri kullanılarak Yansıma Simetrisi Başarı Testi, Geometri Tutum Ölçeği ve Geometriye Yönelik Öz-yeterlik Ölçeği ile toplanan veriler incelenmiştir. Hem betimsel hem de çıkarımsal istatistik kullanılarak veriler yorumlanmıştır. SPSS programında yapılan analizler doğrultusunda hem deney hem de kontrol grubundan elde edilen test sonuçlarına ait tanımlayıcı istatistikler yani ortalama, standart sapmaları incelenmiştir. Bunun yanı sıra, origami etkinlikleriyle zenginleştirilmiş sorgulama temelli öğretim metodu ile eğitim almış deney grubu öğrencilerinin ve geleneksel yöntemlerle eğitim almış kontrol grubu öğrencileri nin uygu-lama öncesi ve sonrasında, öntest puanları kontrol altına alındığında sontest puanları arasında anlamlı bir farklılık olup olmadığını test etmek amacıyla tek faktörlü kovaryans analizine (ANCOVA) başvurulmuştur. Daha açık bir ifadeyle, iki grubun yansıma simetrisi başarıları, geometri tutumları ve geometriye yönelik öz-yeterlikleri arasında fark olup olmadığını test etmek amacıyla her bir değişken için ANCOVA kullanılmıştır.

Sonuçlar ve Tartışma

Sorgulama Temelli Öğretim Yönteminin Yansıma Simetrisi Başarısına Etkisi

Bu çalışmada, origami etkinlikleriyle zenginleştirilmiş sorgulama temelli öğretim metodunun ortaokul 7.sınıf öğrencilerinin yansıma simetrisi konusundaki başarılarına etkisi olup olmadığı incelenmiştir. Sorgulama temelli öğretimin etkisini test etmek amacıyla öğrencilerin yansıma simetrisi başarı testi, geometri tutum ölçeği ve geometriye yönelik öz-yeterliklerine ait öntest sonuçlarının kontrol altında tutulduğu ANCOVA kullanılmıştır. Analiz sonuçları, sorgulama temelli öğretim yönteminin öğrencilerin başarıları üzerinde istatistiksel olarak anlamlı bir etkisi olduğunu göstermiştir. Daha açık bir ifadeyle, sorgulama temelli öğretim yönteminin kullanıldığı deney grubu öğrencileri, geleneksel öğretim yönteminin kullanıldığı kontrol grubu öğrencilerine kıyasla Yansıma Simetrisi Başarı Testinden daha yüksek puan almışlardır.

Sorgulama temelli öğretim ile ilgili çalışmaların çoğu fen bilimleri, fizik, kimya ve biyoloji alanında yapılmıştır. Sorgulama yaklaşımının etkilerini test etmek üzerine hazırlanan bu deneysel çalışmalarda araştırmacılar genellikle laboratuvar etkinlikleriyle sorgulama ve araştırma yoluna gidilmiştir. Bu çalışmada olduğu gibi hem Türkiye'de yapılan (Türkmen, 2009; Sağlamer-Yazgan, 2013; Tatar, 2006; Sakar, 2010; Fansa, 2012; Göksu, 2011; Akpullukçu, 2013; Sarı & Bakır-Güven, 2013; Çalışkan, 2008; Çelik, 2012; Kula, 2009; Altunsoy; 2008; Sever & Güven, 2014), hem de diğer ülkelerde yapılan çalışmalar (Ferguson, 2010; Maxwell, Lambeth & Cox, 2015; Abdi, 2014; Taylor & Bilbrey, 2012; Johnston, 2014; Njoroge, Changeiywo, & Ndirangu, 2014) sonucunda sorgulama temelli öğretim yaklaşımının öğrenci başarıları üzerinde olumlu bir etkisi olduğu görülmüştür. Her ne kadar bu çalışmalarda kullanılan materyal, strateji, sorgulamanın kullanıldığı ders ve konu farklı olsa da, sorgulama yaklaşımı ve uygulanırken göz önünde bulundurulması gereken stratejiler aynıdır. Sonuç olarak, yapılan çalışmalar doğrultusunda öğrenci başarılarını arttırdığı göz önünde bulundurulan sorgulama temelli öğretim yaklaşımının etkili bir öğretim yöntemi olduğu kabul edilmektedir.

Sorgulama temelli yöntemin başarıyı olumlu yönde etkilemesinin çeşitli olası nedenleri vardır. Bunların birisi öğrencilerin ders esnasında hep aktif durumda olmaları olabilir. Bu durum sorgulama yaklaşımının doğasından kaynaklanmaktadır. Çünkü sorgulama yöntemi öğrencilerin gözlem yapma, problem üzerinde çalışma, soru sorma, varsayımlarda bulunma, veri toplama, bulgularını sunma ve önceki bilgileriyle ilişki kurmalarını gerektirir (Artigue & Blomhoej, 2013). Böylece, ezberden yapmaktan ziyade, öğretim esnasında hep aktif olmaları öğrencilerin yansıma simetrisi konusunu anlamlandırmasına olanak sağlamış olabilir (Brown & Campione, 1986). Buna ek olarak, sorgulama yaklaşımının gerektirdiği gibi öğrencilerden ders esnasında çözümlerini açıklamaları, matematiksel gerekçelere dayandırarak desteklemeleri, arkadaşlarının açıklamaları doğrultusunda kendi çıkarımlarını sorgulamaları, tartışmaları ve genel bir doğruda buluşmaları beklenmiştir. Bundan dolayı, ders esnasında öğrenciler arası iletişim kaçınılmaz olmuştur. Böylece, öğrencilerin aktif oluşu, arkadaşları ile iletişimi ve matematiksel gerekçeler kullanarak tartışma yapabilmeleri onların başarılarında artışa neden olmuş olabilir.

Öğrenci başarılarının artmasındaki diğer bir neden ise origaminin kendisi olabilir. Origami öğrencilerin bir parça kağıt üzerinde somut bir şekilde çalışmalarına olanak sağladığından, öğrenciler bir çok matematik konusunu origami üzerinde anlamlandırabilmektedir (Wares, 2016). Piaget (1965)' e göre, öğrenciler bilişsel olarak yeterince olgunlaşmamış olduğundan, doğrudan anlatım ile soyut bilgileri anlamada zorluk çekerler. Somut materyaller ise öğrencilerin matematiksel ilişki kurabilmelerine ve kendi bilişsel modellerini geliştirmelerine olanak sağlar (Ojose & Sexton, 2009). Bu bağlamda kullanıma hazır materyal oluşundan ve soyut kavramları somutlaştırarak görselleştirme becerilerini geliştirdiği için, origami somut materyal olarak kabul edilebilir (Haga, Fonacier, & Isoda, 2008). Örneğin, tilki ve tavşan etkinliğinde öğrencilerin ilk katlamanın ardından yapılacak olan diğer katlamaların iki farklı kat izine sebep olacağını fark etmeleri için uzamsal olarak düşünmeleri gerekmektedir. Yalnız ellerine verilen modellerle çalışırken bunu görselleştirmenin yanı sıra somut olarak da deneyerek keşfedebilmişlerdir. Bu modeller öğrencilerin somut olarak yansıma simetrisini anlamlandırmalarını sağladığından, başarılarının artmasını sağlamış olabilir.

Tüm bunların yanı sıra, bu çalışmaya katılan 7. sınıf öğrencileri, 2.,3. ve 4. sınıflarda simetriye dair bilgiler öğrenmişleridir. Bu sınıf seviyelerindeki kazanımlar daha çok simetriyi açıklama, verilen şekli bir doğruya göre yansıtma ve bir şeklin simetri eksenini bulmaya dair işlemsel bilgileri içermektedir (MEB, 2009). Bu kazanımlara ilişkin açıklamalar ve örnek etkinlikler incelendiğinde, simetrinin öğrencilere van Hiele geometrik düşünme düzeyine göre görselleştirme (Düzey 0) seviyesinde öğretilmesinin hedeflendiği görülmektedir. Bu düzeyde öğrenciler şekilleri tanımlar, karşılaştırır ve sınıflandırırlar (Van de Walle, Karp & Williams, 2013). Öğrenciler kendilerine verilen şekilleri inceler ve formel olmayan kendi belirledikleri özellikler doğrultusunda kıyaslar. Bu açıklamalar doğrultusunda, çalışmaya katılan öğrencilere daha önce öğretilen kazanımların bu düzeyde olduğu görülmektedir. Diğer taraftan, 7.sınıf kazanımlarına bakıldığında öğrencilerden yansıma simetrisini şekillerin hareketi açısından açıklamaları, bu hareketleri yansımanın özelliklerini açığa çıkaracak şekilde gerekçelendirmeleri beklenmektedir (MEB, 2013). Kazanımlara dair açıklamalar incelendiğinde öğrencilerin van Hiele geometrik düşünme düzeylerine göre analiz (Düzey 1) ve informel çıkarım (Düzey 2) seviyesine taşınmalarının hedeflendiği görülmektedir. Analiz düzeyinde öğrenciler bir şekli tanır, özelliklerine göre tanımlar, örneğin verilen bir kareden ziyade tüm karelerden genelleme yaparak bahsedebilir. İnformel çıkarım düzeyinde ise, öğrenciler şekiller ve şekillerin özellikleri arasındaki ilişkileri açıklayabilmektedir. "Neden" ve "Eğer şöyleyse" gibi sorularla öğrencilerin "eğer-ise" şeklinde akıl yürütmesi sağlanabilir. Böylelikle en az sayıda özellik belirterek bir şekli tanımlayabilirler. Örneğin, dört eş kenarın ve en az bir dik açının bir kare belirttiğini ifade edebilirler. Bu durumda, sorgulama temelli eğitim yönteminin kullanıldığı bu çalışmada, 7. sınıf öğrencilerinin yansıma simetrisi konusunu öğrenmeleri için geliştirilen etkinlikler basitten zora doğu hazırlanarak öğrencilerin geometrik düşünme düzeylerinin artması sağlanmış olabilir. Burada basit olarak adlandırılan etkinliklerde öğrencilerin yansımayı fark etmeleri ve özellikleriyle birlikte tanımlamaları beklenirken (Düzey 1), biraz daha zor olarak adlandırılan etkinliklerde öğrencilerin tartışması, çıkarım yapmaları, çıkarımlarını değerlendirmeleri, eleştirel düşünmeleri ve yansımanın daha önce bilmedikleri özelliklerini fark etmeleri (Düzey 2) beklenmektedir. Örneğin, tereyağlı tost etkinliğinde öğrencilerden gayri ihtiyari olarak katlama yapmaları ve yaptıkları bu hareket sonucunda katlama ile yansımayı ilişkilendirmeleri beklenmiştir. Bu süreçte öğrencilere, neden ve nasıl katladıklarına dair sorulan sorular, öğrencilerin yansıma simetrisinin özelliklerini keşfetmeleri ve açıklamalarını desteklemeleri sağlanmıştır (Düzey 1). Daha zor olan boyalı mendil etkinliğinde ise, öğrenciler önce analiz düzeyinde olan yatay, dikey ve çapraz katlamaların sonucunu yorumlamışlardır. Ardından, birden fazla katlama sonucunda oluşan lekeyi bulmaları ve bulunan farklı sonuçların nedenlerini tartışmaları istenmiştir. Böylece öğrencilerin informel çıkarım düzeyine çıkarılmış oabileceği düşünülmüştür. Aynı şekilde, origami tabanlı öğretimin etkileri üzerinde yaptığı çalışmada Dağdelen (2012), origaminin öğrencilerin van Hiele geometrik düşünce düzeylerinde artışa neden olduğunu göstermiştir. Sonuç olarak, bu bilgiler ışığında mevcut çalışmada öğrencilerin geometrik düşünce düzeylerinin artmış olabileceği ve bu artışın öğrencilerin başarılarının artmasını sağlamış olabileceği düşünülmektedir.

Bunların yanı sıra, sorgulama temelli öğretim iç içe oldukları savunulan problem çözme yaklaşımı (Artigue & Blomhøj, 2013) da bu çalışmanın bir diğer boyutudur. İlgili çalışmalara bakıldığında problem çözmenin matematik öğretiminde etkili bir yöntem olduğu görülmektedir (Hammorui, 2003; Özkaya, 2002; Ubuz, 1991). Bundan dolayı, mevcut çalışmada, etkinlikler problem durumları içinde sunulmuştur. Böylece, öğrencilerden doğrudan katlama yapmalarını istemek yerine, onların problemleri çözmek için verilen modelleri katlamaya ihtiyaç duymaları sağlanmıştır. Sonuç olarak öğrencilere problem üzerinde çalışabilecekleri sorgulama temelli öğretim ortamı sağlanmıştır. Ayrıca, problemler oluşturulurken gerçek hayat durumları göz önünde bulundurulmuştur. Tandoğan ve Akınoğlu (2006), öğrencilerin gerçek yaşam durumları üzerine kurulmuş problemlerin, öğrencilerin daha aktif olmasını sağlayacağını belirtmiştir. Başka bir deyişle, eğer öğrencilerin matematik öğrenmeleri isteniliyorsa, soyut kavramları gerçekçi bir yaklaşımla anlayabilmeleri için gerçek hayat durumlarıyla zenginleştirilmiş problemler üzerinde çalışmalarını faydalı olacaktır (Artigue & Blomhøj, 2013). Bu bilgiler ışığında, etkinlikler öğrencilerin daha önce karşılaşmış olabilecekleri günlük hayat durumları üzerine kurulmuştur. Böylece, öğrencilerin her gün karşılaştıkları ya da farkında olmadan yaptıkları işlerde yansımayı fark etmeleri ve bu etkinlikleri tamamlarken matematiksel kavramları anlamaları sağlanmıştır. Bundan dolayı da, öğrencilerin başarılarında artış olmuş olabilir.

Sorgulama Temelli Öğretim Yönteminin Geometri Tutumuna Etkisi

Sorgulama temelli öğretimin öğrenci başarısına etkisinin yanı sıra, tutum gibi duyuşsal alan davranışlarına da etki etmektedir. Erişilebilir çalışmalar ışığında, öğretimsel stratejilerin öğrenci eğilimleri ve duyuşsal tepkileri yani tutumları üzerinde önemli rol oynadığı görülmüştür. Bu açıdan, sorgulama temelli öğretim yönteminin kimya, biyoloji gibi alanlarda olduğu gibi (Altunsoy, 2008; Sakar, 2010), öğrencilerin geometri tutumlarını geliştirmede etkili olabileceği düşünülmüştür. Sonuç olarak, origami etkinlikleriyle zenginleştirilmiş sorgulama temelli öğretim metodunun ortaokul 7.sınıf öğrencilerinin geometriye karşı tutumlarına etkisi olup olmadığı incelenmiştir. Yapılan ANCOVA analizi sonucunda, sorgulama temelli öğretim yönteminin kullanıldığı deney grubu öğrencilerinin, geleneksel öğretim yönteminin kullanıldığı kontrol grubu öğrencilerine kıyasla Geometri Tutum Ölçeğinden daha yüksek puan almış oldukları görülmüştür.

İlgili çalışmalarda ve öğretim programlarında yapılandırmacı ve sorgulama temelli öğretimin önemi vurgulanmasına rağmen, sınıflarda hala geleneksel yaklaşımla öğretim sürmektedir (Doğan, 2006). Bundan dolayı, öğrenciler, öğretmen merkezli öğretim dışındaki öğretim yöntemlerine aşina olmayabilir. Mevcut çalışmada, öğrenciler bu tarz öğretim yaklaşımlarına açık olmamalarına rağmen yeniliklere ve farklı yöntemlere açık olmaları sayesinde planlanan sorgulama temelli öğretim yöntemi başarı ile uygulanmıştır. Yapılan çalışmalarda gönüllülük, etkinliklerde isteklilik ve açık olmayı beraberinde getirdiğinden dolayı (Drijvers et al., 2013), bu çalışmada öğrencilerin etkinliklere açık olduğu söylenebilir. Bu sayede, planlanan öğretim yöntemi öğrencilerin aktif katılımıyla başarı ile tamamlanmıştır. Bu durum öğrencilerin geometri tutumlarında da artışa neden olmuş olabilir.

Buna ek olarak, yaratıcılık ve akıl yürütme de matematik tutumunu arttıran etkenlerdendir (Putney & Cass, 1998). Ayrıca, somut materyaller de geometri tutumunu artırmada önemli rol oynamaktadır (Sowell, 1989). Bu etkenler açısından bakıldığında, bu özellikleri içinde barındıran origami, sorgulama temelli öğretim esnasında materyal olarak kullanılmıştır. Origaminin öğrencilerin tutumları üzerindeki etkilerini inceleyen çalışmalar, origami tabanlı öğretimin öğrenci tutumlarını artırdığını göstermiştir (Çakmak, 2009; Şimşek, 2012; Takıcak, 2012). Origami etkinlikleriyle ders işlerken, öğrencilerden sorgulama yaklaşımı ışığında yaratıcılıklarını ve akıl yürütmelerini sınıf tartışması esnasında göstermeleri beklenmiştir. Örneğin, tilki oluşturma etkinliğinde, öğrenciler ilk başta verilen çizgilerden rastgele katlamaya başlamış ve hiç bir matematiksel yaklaşım göstermemişlerdir. Yalnız bu figürü oluştururken matematik bilgilerinden faydalanmaları gerektiği söylenince durup çizgileri incelemeye başlamışlardır. Öğrenciler kendi çözümlerini kendi açıklamalarıyla, somut materyal vasıtasıyla ve matematiksel akıl yürütme ile açıklamışlardır. Kendi ürünlerini kendileri oluşturduğu ve yaratılıklarını sergiledikleri için, geometri tutumlarında artış gözlenmiş olabilir.

Bu çalışmada dikkat çeken diğer bir nokta ise, öğrencilerin verimli eğilime (tavra) sahip oluşlarıdır. Verimli eğilim (tavır) öğrencilerin bir görevi tamamlamaya ve anlamaya çabalaması, üzerinde uğraştığında başarabileceğine inanması anlamına gelmektedir (Van de Walle, Karp & Williams, 2013). Bu çalışma esnasında dikkat çeken ise, öğrencilerin alışık olmadıkları bu origami etkinliklerini çözerken yapabileceklerine inanmalarıydı. Yer yer zorlanmalarına ve hata yapmalarına rağmen öğrencilerin hala hevesli oluşu, etkinliği tamamlayan arkadaşlarının yardım tekliflerini reddedişleri dikkati çekmiştir. Herhangi bir destek sunulmaya kalktığında öğrenciler "Hayır, söyleme, ben yapacağım" şeklinde bir tutum sergilemişlerdir. Sonuç olarak, öğrencilerin verimli eğilime (tavra) yani "ben yapabilirim" tutumuna sahip oldukları gözlenmiştir. Onların bu eğiliminin, geometri tutumlarının artmasında etkili olmuş olabilir.

Sorgulama Temelli Öğretim Yönteminin Geometriye Yönelik Öz-Yeterliğe Etkisi

Tutumun yanı sıra, öğrencilerin bilişsel davranışlarından biri de öz-yeterlik algılarıdır. Öz-yeterlik öğrencilerin verilen bir görevi yerine getirebilecekleri ve becerilerine dair inançlarını ifade eder (Bandura, 1997). Bandura (1986) öz-yeterliği sabit olmayan, yeni durumlara ve deneyimlere göre değişebilen bir inanç olarak açıklamıştır. Biliş üzerine yapılan araştırmalar, matematik başarısını artırmada öz-yeterlik algılarının önemine dikkat çekmektedir. Bu bağlamda, yapılan çalışmada sorgulama temelli öğretim metodunun öğrencilerin öz-yeterlikleri üzerindeki etkisi de araştırılmıştır. Yapılan ANCOVA analizi sonucunda ise sorgulama temelli öğretim yönteminin kullanıldığı deney grubu öğrencilerinin, geleneksel öğretim yönteminin kullanıldığı kontrol grubu öğrencilerine kıyasla Geometriye Yönelik Öz-Yeterlik Ölçeğinden daha yüksek puan almış oldukları görülmüştür.

Bu çalışmada olduğu gibi, farklı alanlarda yapılan birçok çalışmada da, sorgulama temelli öğretimin öz-yeterlik üzerinde olumlu etkilerinin olduğu ortaya koyulmuştur (Usta-Gezer, 2014; Kocagül, 2013; Özdilek & Bulunuz, 2009; Laipply, 2004; Roster, 2006; Thrift, 2007; Tuan, Chin, Tsai & Cheng, 2005). Yapılan çalışmalar göz önüne alındığında, öğrencilerin öz-yeterlik algılarındaki artışa sorgulama temelli öğretim esnasında öğretmenin yapmış olduğu rehberliğin etki etmiş olabileceği vurgulanmıştır (Laipply, 2004). Bu çalışmada da, etkinlikler esnasında öğretmen öğrencilerin sorgulamalarına ve akıl yürütmelerine olanak sağlayacak sorular sorarak onları yönlendirmiştir. Öğrenciler deneme yanılma yoluyla çözüme gitmeye çalıştıklarında ise araştırmacı tarafından çözümlerini matematiksel olarak açıklamaları gerektiği vurgulanmıştır. Bu tarz sorular ve yönlendirmeler öğrencilerin, etkinlikten kopmamalarına, matematiksel iletişim kurabilmelerine olanak sağladığından öz-yeterlik algıları yükselmiş olabilir.

Bunun yanı sıra, öz-yeterlikteki artış, öz-yeterlik inançlarına etki eden dört faktörden kaynaklanmış olabilir. İlk faktör olan geçmiş deneyimler, öğrencilerin başarı ya da başarısızlıklarından kaynaklanmaktadır Bu çalışma esnasında, öğrenciler katlayabildiklerini, kendi ürünlerini oluşturabildiklerini ve matematiksel ilişki kurabildiklerini gördükçe öz-yeterlikleri artmış olabilir. İkinci faktör olan gözleme dayalı deneyimler sonucunda ise, onların arkadaşlarını gözlemlemelerini, onların yapabildiklerini gördükçe kendilerinde de yapma hırsı bulmaları ve böylece etkinliklere daha dikkatli ve istekli oluşları öz-yeterliklerine etki etmiş olabilir. Üçüncü faktör olan ikna süreci ile, araştırmacı tarafından öğrencilere destek olunması, onları yapabilecekleri konusunda desteklemeleri ve güdülemeleri etkili olmuş olabilir. Son olarak ise duyuşsal süreçlerden olan korku, heyecan gibi duygular da öz-yeterliği etkileyebilir. Sınıf içerisindeki durumları göz önüne alındığında, öğrencilerin genel olarak hevesli olduğu, derste zevk aldıkları gözlemlenmiştir. Tüm bu faktörler, öz-yeterliğin artmasında rol oynamış olabilir.

Öneriler

Bu çalışmanın örneklemi uygunluğuna göre seçilmiş olup, aynı çalışma seçkisiz örnekleme yöntemi ile belirlenen katılımcılarla tekrar edilebilir. Böylece çalışma diğer örneklemlere ve evrene genellenebilir. Ayrıca çalışmanın örneklemi devlet okulundan seçilmiş olduğundan, bir sonraki çalışma özel okulda uygulanıp sonuçlar karşılaştırılabilir. Bunların yanı sıra öğrencilerin cinsiyetleri, sınıf seviyeleri ve sosyo-ekonomik düzeyleri göz önünde bulundurularak karşılaştırma yapılabilir.

Başka bir bakış açısıyla aynı çalışma, öğrencilerin geometriye yönelik tutumları ve öz-yeterliklerini daha iyi açıklayabilmek için ders esnasında video görüntü alınması, sınıfta gözden kaçmış olabilecek davranışların gözlemlenebilmesi için faydalı olabilir. Ayrıca yapılacak olan benzer çalışmalar yarı yapılandırılmış görüşmelerle desteklenebilir. Video ya da ses kaydı ile öğrencilerden toplanan görüşme sonuçları, onların duyuşsal davranışlarını yorumlamada daha destekleyici kanıtlar sunabilir. Aynı şekilde, öz-yeterliğe etki eden faktörlere dair sorulabilecek sorular, sorgulama temelli öğretim esnasında öz-yeterliğin artmasına neden olan faktörün belirlenmesine yardımcı olabilir.

Appendix I:

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ■

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Kandil
Adı : Semanur
Bölümü : İlköğretim Fen ve Matematik Eğitimi

TEZİN ADI: An Investigation Of The Effect Of Inquiry-Based Instruction Enriched With Origami Activities On The 7th Grade Students' Reflection Symmetry Achievement, Attitudes Towards Geometry And Self-Efficacy In Geometry

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: