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TEACHING GEOMETRY WITH DIFFERENT ACTIVITIES TO INVESTIGATE THE STUDENTS' PERCEPTIONS, ATTITUDES AND SELF-EFFICACIES*

Research article

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Abstract

The aim of this study is to determine the effect of activity-enriched geometry teaching methods on elementary school students' perceptions, attitudes and self-efficacy towards geometry. In this context, the mixed method was determined to be the research design. Within the scope of the study, a training process was carried out with 22 students who had completed sixth grade and started seventh grade. As a result of the study, where qualitative and quantitative data collection tools were used, it was concluded that there were positive developments in students' perceptions and self-efficacies, but their attitudes did not change by the end of the training process.

Keywords: attitudes towards geometry, geometry, perception, self-efficacy towards geometry

1. Introduction

In the learning process, perception, attitude and self-efficacy are of great importance (Akinsola & Olowojaiye, 2008; Pajares & Miller, 1994). Perception refers to how a person characterizes a phenomenon or situation (Lewis, 2001), and attitude is the tendency to react to the perceived phenomenon or situation. These reactions are consistent, systematic and learned over time (Fishbein & Ajzen, 1975). By definition, self-efficacy is an individuals' own judgments about their capacity to succeed (Bandura, 1995). In the context of past learning experiences, perception, attitude, and self-efficacy have a positive or negative effect on each other (Nicolaidou & Philippou, 2003; Zimmermann, 2000). For the purpose of this study, evaluating perception, attitude, and self-efficacy together may provide a more meaningful picture regarding teaching methods and learning outcomes.

In more detail, perception can be defined as “an understanding of the world constructed from information obtained by means of the senses” (Shaver, as cited in Lewis, 2001). Randolph and Blackburn (1989) defined the process of perception in three steps. The first step is to experience multiple stimuli through the five senses. The second step is to observe and select the point of focus in terms of sensors, perceived state, and context. The final step is the frame-of-reference filter that gives meaning to experiences. In these steps, the subject, also known as the perceiver, is an important element in the perception process.

Preliminary learning, personality characteristics, motivations, attitudes, beliefs, experiences and expectations of perceivers affect their perception of a situation, object or phenomenon

(Coren, Ward, & Enns, 1999; Randolph & Blackburn, 1989; Robbins, 1991). When perception is examined in the field of education, it is seen that student perception is an important element in learning and teaching processes (Biggs, 1987; Marton & Säljö, 1976). Duff and McKinstry (2007) suggest that student perception affects the approach to learning, content, and the learning environment. Also, a student's positive perception of a course or a subject contributes to their participation level as well as their academic achievement (Hiebert & Grouws, 2007; Postareff, Mattsson, & Parpala, 2018).

Lewis (1999) explains that both past and present experiences, and especially present ones, play an important role in regulating existing perceptions and creating a positive perception. Similarly, Hiebert and Grouws (2007) demonstrate that students' perceptions are related to their experiences in the lessons, emphasizing that students should be offered various learning opportunities. In terms of geometry, the geometric experience is one of the important factors in understanding geometry (Van Hiele, 1986). The diversity of these experiences may affect students' perceptions regarding the topic. Therefore, a variety of learning environments should be created to provide students with opportunities to develop a positive perception of geometry (Devichi & Munier, 2013; Doğan, Özkan, Çakır, Baysal, & Gün, 2012; Luneta, 2015; Makhubele, Nkhoma, & Luneta, 2015).

Literature shows that an awareness of the usefulness of geometric concepts or, in contrast, disliking those concepts affect success. For example, according to Sunzuma, Masocha, and Zezekwa (2013), when students dislike geometric concepts, they demonstrate low achievement, regardless of how useful geometry may be in daily life. On the other hand, Forgasiz (2005) explains that when students are aware of the benefits of geometry, they have a positive perception. Examining the concept of attitude in more detail, Fishbein and Azjen (1975, p. 6) describe it as "a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object". When it comes to mathematics, Neale (1969) describes attitude as like or dislike for mathematics, engaging in or avoiding mathematical activities, and the belief that an individual can be good at mathematics or not. The attitude towards mathematics is influenced by learning experiences (Pyzdrowski, Sun, Curtis, Miller, Winn, & Hensel, 2012). Duatepe and Ubuz (2007) explain that geometry is the specific area of mathematics courses in which students have low levels of attitude. Researchers emphasize that it is of great importance to develop students' positive attitudes toward geometry (Cantürk-Günhan & Başer, 2007; Tapia & Marsh, 2004).

Similar to attitude, self-efficacy affects students' view of geometry and their academic achievement (Bandura, 1997). For this reason, attitudes and self-efficacy are important in the process of learning geometry. Self-efficacy, like attitude and perception, is affected by past experiences, observations, and the persuasion process (Bandura, 1995). Self-efficacy, an affective domain characteristic, is the self-judgment of individuals about their capacity to succeed and is carried out by organizing activities in order to demonstrate a certain level of performance (Bandura, 1995). Self-efficacy affects the amount of effort expended to accomplish a task as well as resistance levels during difficulties (Zimmerman, 2000).

Hackett and Betz (1989, p. 262) define mathematics self-efficacy as "a situational or problem-specific assessment of an individual's confidence in her or his ability to successfully perform or accomplish a particular task or problem". When students perceive that they have satisfactorily progressed, they feel as if they can achieve new, more challenging goals (Schunk, 1990). Students with higher levels of mathematics self-efficacy prove more likely to understand mathematics and demonstrate willingness to work on math tasks (Beghetto & Baxter, 2012). In fact, there are studies showing that individuals with high self-efficacy are successful. (Hackett & Betz, 1989; Lent, Lopez & Bieschke, 1991; Multon, Brown & Lent, 1991; Schunk, 1990; Schunk & Swartz, 1993; Yenilmez & Korkmaz, 2013). Also, students' positive self-efficacy towards geometry increases their success in geometry (Erkek & Bostan, 2015; Özkan & Yıldırım, 2013).

This study aims to determine how the students' perceptions, attitudes and self-efficacies towards geometry compare before and after a variety of learning experiences. Unlike other studies in the literature, this study will present a variety of teaching methods and activities to create different educational experiences. It is thought that this will address the individual differences of students and thus play an important role in student involvement. Since the literature shows that geometry is a field which offers activity-based learning, dynamic geometry software, coding, origami, and educational games were utilized during this study. For instance, spatial ability, which is defined as the ability to perceive, imagine, organize and reacquisition objects or forms in space (Carroll, 1993), is an important element when learning or teaching geometry (Battista, Wheatley, & Talsma, 1982). Research shows a positive relationship between spatial ability and geometry achievement (Ben-Chaim, Lappan, & Houang, 1985; Cakmak, 2009; Clements & Battista, 1992; Gutierrez, 1996). For this reason, various studies have been carried out to improve spatial ability (Olkun, 2003; Sorby & Baartmans, 1996; Turğut, 2010; Yıldız & Tüzün, 2011). Furthermore, geometric construction activities lead to improved understanding of foundational geometric concepts (Kuzle, 2013). In addition, dynamic geometry software, such as Geometer's Sketchpad and GeoGebra, enable students to be active in the learning process and to increase their motivation and engagement (Dikovic, 2009; Hohenwarter & Jones, 2007; Pfeiffer, 2017). In addition to that, coding activities are one of the most popular and remarkable teaching methods in the field of geometry. Through coding, students develop skills in problem solving (Akcaoglu & Koehler, 2014; Kukul & Gök e Arslan, 2014; Shin & Park, 2014) and operational thinking (Brennan & Resnick, 2012; Grover & Pea, 2013; Ruthmann, Heines, Greher, Laidler, & Saulters, 2010), and their academic achievement increased (Taylor, Harlow, & Forret, 2010). Moreover, it has been determined that origami facilitates students' geometry skill (Arslan & Işıksal-Bostan, 2016; Boakes, 2009) and educational games increase students' motivation (Fisch, 2005; Gee, 2003; Samur, 2012), engagement (Huizenga, Admiraal, Akkerman, & ten Dam, 2009) and achievement (Ke & Grabowski, 2007; Tüzün, Yılmaz-Soylu, Karakuş, İnal, & Kizilkaya, 2009). Specific literature emphasized that educational games have an impact on various learning outcomes and skills such as problem solving (Dempsey, Lucassen, Gilley, & Rasmussen, 1993) and the transfer and application of knowledge (Barab, Scott, Siyahhan, Goldstone, Ingram-Goble, Zuiker, & Warren, 2009).

2. Method

2.1. Research Design

For quantitative data, the Self-Efficacy Scale for Geometry and The Attitude Towards Geometry Scale were applied to the participants' responses, both before and after the five-day training period. Semi-structured interviews were conducted with the participants to collect qualitative data. In this study, quantitative and qualitative data collection tools were used to collect data, and a convergent parallel design was adopted from mixed method research designs.

The convergent parallel design aims to concurrently collect quantitative and qualitative data and to combine the obtained data in order to better understand the research problem (Creswell, 2012). The qualitative and quantitative data used in the convergent parallel design are, however, evaluated independently and then correlated and compared in order to be able to observe results and draw conclusions (Creswell & Plano Clark, 2011). The basic logic of the convergent parallel design is to complement the weaknesses of one data collection tool with the strengths of the other, thus creating a complete picture of the entire set of data. ,

2.2. Participants

Participants were determined for the specific purpose of the study. For this reason, a purposive sampling method was adopted. According to Fraenkel and Wallen (2006), the purposive sampling method is used to select the participants that the researcher believes will provide the needed data and is purposefully determined according to the criteria that she or he needs to find the answer to the research problem. In this study, the characteristics of the participants were determined as: (a) being educated in public schools within the disadvantaged regions of the province where the training process will take place, (b) having completed sixth grade and passed to seventh grade by the date of training and (c) having high academic achievement in mathematics.

In order to identify the students with these characteristics, the schools in disadvantaged regions have been contacted following the guidance of the Provincial Directorate of National Education. Under the guidance of the headmasters and mathematics teachers in these schools, 24 students were selected with the guidance of the headmasters and mathematics teachers of these schools. Then, 2 students who did not participate in the whole training process were excluded from the study; the study was completed with 22 students (13 females and 9 males).

2.3. Training Process

The training process lasted five days, with a total of nine activities. In the process of preparing the content of each of these activities, the seventh-grade geometry learning area of MoNE (2018) Elementary and Secondary School Mathematics Curriculum was taken into consideration. Each of the activities was led by expert trainers for approximately 2.5 hours.

The aim of the activities was to provide an enriched and interesting education process including spatial skills, games, and technology, elements that could be considered inseparable from today's world. In this way, students were provided with the opportunity to develop a positive perspective towards geometry and to increase their awareness of its usefulness. Content of the training process is presented in Table 1 below.

Table 1. *Content of the training process*

Day	Activity Name	Aim	Content
1st day 1st activity	meeting by creative drama	meeting, communication and interaction	learning each other's names; developing the ability to act jointly to take part in subsequent activities; creating awareness by using the concepts of geometry in this process
1st day 2nd activity	geometry meets digital world	creating digital content that can demonstrate imagination and creativity about geometry	creating a story or a news about the history of geometry and prepare a digital scenario for it
2nd day 1st activity	learning geometry with origami	determining the elements of geometric shapes with paper folding method	determining the symmetry lines and angle - edge properties of quadrilaterals by using paper folding method, by creating concrete and visual products by using paper folding method
2nd day 2nd activity	doing geometric construction	constructing geometric shapes by using compasses and ruler	explaining the edge and angle properties of smooth polygons by using the geometric construction method; explain the properties of rectangular, parallelogram, trapezoid and rhombus by using geometric construction method
3rd day 1st activity	drawing polygon with GeoGebra	explaining the properties of polygons by using GeoGebra software	determining the angle and edge properties of polygons with geogebra which is dynamic geometry software
3rd day 2nd activity	let's examine geometric structures with computer	improving spatial location, spatial visualization and spatial orientation skills	building geometric structures, (buildings) with unit cubes and modeling them by using Geocadabra and SkecthUp softwares, analyzing how buildings look from different perspectives; create new buildings with the help of software and depict them on isometric papers
4th day 1st activity	game, gameplay and educational game	designing physical, digital and box games	informing about games and designing an educational game that can be used for geometric concepts
4th day 2nd activity	learning geometry with coding	writing codes for understanding of geometric concepts	coding algorithm, executing the algorithm with Small Basic software, drawing circle using software, calculating the length and area of the drawn circle
5th day 1st activity	geometry meets digital world-ii	increasing expression and presentation skills and to raise awareness that social media tools can be effective out-of-school learning environments	exhibiting and evaluating the scenarios of news or stories created within the scope of the first activity

2.4. Data Collection Tools

2.4.1. Semi-structured interview form

In this research, every attempt was made to put forward the perceiver's own perceptions rather than those of the researchers. For this, the participants were asked to elaborate their discourse by encouraging them to think aloud during interview. Qualitative data, before and after the activities, was obtained through a semi-structured interview form prepared by the researchers. The students were asked about the definition of geometry and geometric shape, their opinions regarding the teaching and learning of geometry, as well as geometry's usefulness. Before utilizing the interview form, the questions were presented to mathematics education experts, and various alterations were made in keeping with their opinions and suggestions. In the initial interview form, six open-ended questions were included. Following the experts' opinions, the form included ten primary questions along with explanatory questions such as "how" and "why."

2.4.2. Attitude towards geometry scale

The Attitude Towards Geometry Scale, one of the quantitative data collection tools utilized in the study, was developed by Bulut, Ekici, İşeri and Helvacı (2002). The scale is a five-point Likert-type scale and has three sub-dimensions: enjoyment, usefulness and anxiety. It consists of a total of 17 items: 11 in the enjoyment dimension, 4 in the usefulness dimension, and 2 in the anxiety dimension. Bulut et al. (2002) found the reliability coefficients to be as follows: 0.93 for the enjoyment dimension, 0.61 for the usefulness dimension, and 0.57 for the anxiety dimension. In addition, the researchers calculated the reliability coefficient for the entire scale to be 0.92.

2.4.3. Self-efficacy scale for geometry

The second quantitative data collection tool employed in the study was the Self-Efficacy Scale for Geometry, developed by Cantürk-Günhan and Başer (2007). The scale is a five-point Likert-type scale consisting of three dimensions with 25 total items. Positive self-efficacy beliefs is the first dimension of the scale and consists of 12 items. Using of geometrical knowledge is the second dimension and consists of 6 items. Finally, negative self-efficacy beliefs is the third dimension of the scale and includes 7 items. Cantürk-Günhan and Başer (2007) calculated the reliability value of the positive self-efficacy beliefs dimension to be 0.88 while a reliability value of 0.70 was calculated for both the using of geometrical knowledge dimension and the negative self-efficacy beliefs dimension. The whole scale received a reliability value of 0.90.

2.5. Validity and Reliability Data Collection Tools

Focusing on the qualitative aspect of the study, Fraenkel and Wallen (2006) defined validity as the appropriateness, meaningfulness, and usefulness of data; reliability is the consistency of the data over time, location and circumstances. In the study context, two factors that could threaten the validity of the data, as well as inferences made from the data, are researcher character and researcher bias. In order to eliminate these factors, the semi-structured interview form was standardized. To ensure the validity of the inferences resulting from the data and the analysis process of the data were presented in detail. In addition to that, reliability was considered in the context of consistency. Utilizing a standardized interview form supported consistency across all data collection. Also, because the coding was developed by three different researchers, the reliability between these encoders was checked to ensure the consistency of the inferences made in the research.

For the reliability of quantitative part of the study, the Croanbach alpha values obtained from the Attitude Towards Geometry Scale were examined. During the pre-test applications, the Croanbach alpha value obtained from the enjoyment dimension of the scale was 0.84. From the usefulness dimension the alpha value was 0.29, and from the anxiety dimension it was 0.54. On the other hand, the Croanbach alpha values obtained from the post-test application of the scale were 0.91 for the enjoyment dimension, 0.42 for the usefulness dimension, and 0.39 for the anxiety dimension. It is thought that the low reliability values obtained from the usefulness and anxiety dimensions of the scale were due to the low number of items in these dimensions. Research confirms that reliability values will be low in cases where the number of items is less than ten (Fraenkel & Wallen, 2006). The Croanbach alpha value of the whole scale, however, was calculated as 0.84 for the pre-test and 0.90 for the post-test. These values are at an acceptable level for reliability (Fraenkel & Wallen, 2006).

Furthermore, the Croanbach alpha values obtained from the Self-Efficacy Scale for Geometry were also examined. In the pre-test application of this study, the reliability coefficient value obtained for the positive self-efficacy beliefs dimension of the scale was 0.89; for the usefulness of geometrical knowledge dimension, it was 0.63; for the negative self-efficacy dimension, the reliability coefficient value was 0.60. The whole scale scored 0.91 for its reliability coefficient value. When the values obtained from the post-test applications were examined, the reliability coefficient value obtained for the positive self-efficacy beliefs dimension was 0.86; the usefulness of geometrical knowledge was 0.82; the negative self-efficacy dimension was 0.89; and the whole scale was calculated as 0.94. These values are thought to be sufficient according to Fraenkel and Wallen (2006).

2.6. Data Analysis

Mixed-method studies aim to collect qualitative and quantitative data together and to examine the present situation from various aspects (Creswell, 2012). In this context, the data obtained are analyzed and the combined results are interpreted. Quantitative and qualitative data were analyzed separately due to the convergent parallel design which is one of the mixed methods. The results of this analysis were combined and interpreted.

In this study, the pre- and post-activity data obtained with qualitative data collection tools was analyzed in keeping with the content analysis method. Creswell (2007) explained the three coding methods employed in content analysis: (a) codes are developed based only on information gathered from participants, (b) pre-determined codes are utilized and then adapted to the data, and (c) a combination of newly emerging and predetermined codes is used for analysis. Since the perception of a specific subject was examined and no similar study was found in the literature, coding was developed based on the data obtained from method (a), as described above. The analysis of data was carried out separately by researchers and then the codes were discussed until reaching a consensus. In the analysis, the data obtained from the interviews before and after the activities were analyzed at different times. Inter-coder reliability was found .82. At this point, it can be interpreted that the research provides validity (Miles & Huberman, 1994). After completion of coding, the codes under the same themes were compared with regards to similarities and differences.

Furthermore, in order to examine the effect of the training on the students' attitudes towards geometry, the pre-test mean scores obtained from the Attitude Scale Towards Geometry were compared with the post-test mean scores. In order to determine the analysis method to be used for this purpose, the normality of score distributions were examined. In this context, for the pre-test and post-test applications, it was seen that the data did not show normal distribution for the enjoyment of the test ($p_{pre\text{-}test}$= .00 <.05 and $p_{post\text{-}test}$ = .00 <.05), usefulness ($p_{pre\text{-}test}$ = .01 <.05 and $p_{post\text{-}test}$= .00 <. 05) or anxiety ($p_{pre\text{-}test}$= .00 <.05 and $p_{post\text{-}test}$= .00 <.05) dimensions.

On the other hand, for the whole scale in the pre-test ($p = .13 > .05$), the distribution was normal according to normality tests, but the distribution was not normal in the post-test ($p = .00 < .05$). For this reason, Wilcoxon Signed Rank Test was used to compare mean scores from the pre-test and post-test.

The pre-test and post-test mean scores of the Geometry Self-Efficacy Scale were compared in order to determine the effect of the training process on the students' self-efficacy towards geometry. In order to select the appropriate analysis method, the normality of the score distributions was examined. For the pre-test and post-test applications, it was determined that the distribution in the Positive Self-Efficacy dimension was not normal ($p_{pre\text{-}test} = .02 < .05$ and $p_{post\text{-}test} = .00 < .05$). On the other hand, the Using of Geometrical Knowledge dimension ($p_{pre\text{-}test} = .19 > .05$ and $p_{post\text{-}test} = .00 < .05$) and the Negative Self-Efficacy dimension ($p_{pre\text{-}test} = .16 > .05$ and $p_{post\text{-}test} = .00 < .05$) showed normal distributions in pre-test scores, whereas the distributions were not normal in the post-test scores of those dimensions. In addition, pre-test ($p = .01 < .05$) and post-test ($p = .00 < .05$) scores for the whole scale did not have normal distributions. For this reason, the Wilcoxon Signed Rank Test was used to compare the pre-test and post-test scores of both the scale and its dimensions.

Since both of these data collection tools are in the form of a five-point Likert type scale, there are five options ranging from completely agree (5 points) to disagree (1 point). For each student who participated in the pre-test and post-test applications, analyses were carried out on the total scores obtained from the scales and their dimensions.

3. Results

The first findings of the study aimed to draw a general picture of the students' perceptions about geometry before and after the activities. Therefore, the findings of the interviews on geometry were presented under four themes:

- Definition of Geometry
- Definition of Geometric Shape
- Opinions about Geometry
- Use of Geometry

Under the aforementioned themes, students were asked various questions concerning their perception of geometry. In the interviews, the following questions were asked of the students about the first theme, Definition of Geometry*:* “What is geometry?”, “How do you describe it?”, “If geometry was an animal, which would it be? Why is that?” and “If geometry was a color, which would it be? Why is that?”.

Table 2. *Questions and student answers under the theme, "definition of geometry"*

The Questions	(f) Pre-interviews	(f) Post-interviews
What is geometry? How do you describe it?	(14) shape (5) a subject / field of mathematics (3) no answer	(6) shapes and terms (6) set of shapes and terms (10) a course/subject of shapes and angles
If geometry was an animal, which would it be?	(1) fish, (1) owl, (1) giraffe, (1) chameleon, (1) bird, (1) turtle, (4) lion, (1) snake, (1) cow, (1) cat	(2) cow, (2) giraffes, (2) owl, (1) chameleon, (1) bird, (3) turtle, (2) rabbits, (2) lions, (2) ladybird, (1) fox, (1) dog, (2) snakes, (1) bear, (1) elephant
Why is that?	(3) establishing similarity with the physical characteristics of the animal (2) diversity (16) no answer	(16) establishing similarity with the physical characteristics of the animal (2) diversity (3) no answer
If geometry was a color, which would it be?	(3) blue, (3) black, (1) white, (1) red, (1) yellow, (1) purple, (1) pink, (1) brown	(4) blue, (5) black, (4) white, (2) red, (2) yellow, (2) purple, (2) rainbow, (2) pink, (2) green
Why is that?	(6) being favorite color (2) expressing diversity (2) expressing difficulty	(17) being favorite color (3) expressing diversity (5) expressing difficulty

Before the activities, the students provided answers to questions about the nature of geometry. The answers emphasized shapes, with answers such *as "It's shapes"*, *"It's something with shapes"*, *"It is a set of shapes"* or *"It is a subject of shapes and angles."* The answers given after the activities not only emphasized shapes but also the idea that geometry is an entire subject; the answers included partial definitions such as *"[geometry is] a branch of mathematics consisting of shapes"* and *"[it is a] set of shapes and terms"*. After that, the students were asked to establish a metaphor between animals and geometry. In both pre and post –interviews, the metaphors the students establish between geometry and animals vary such as bird, lion, chameleon, giraffe. One of the limited number of answers to the question of why, the student explained her/his metaphor as follows: *"There are various shapes in geometry, just as there are various shapes in a chameleon."* But in the post-interviews, they frequently established similarities between the physical characteristics of animals and geometric shapes. For example, one of the students replied: *"The bird's wings are like a triangle, its head is a circle"*, another student replied: *"I think geometry is a giraffe. Because its neck is rectangular and its body is square."* These and similar answers were accepted as an indication that the students were trying to establish similarities between the physical characteristics of animals and geometric shapes.

Similarly, with the question "If geometry was a color, which would it be?" students were expected to establish metaphors between colors and geometry. In the pre and post-interviews, most students stated that they named their favorite colors in response. One of the students explained this situation with the answer *"My favorite color is a yellow, I also like geometry. So, I would say geometry is yellow color."* In addition, students matched the meaning or feel of colors to their perception of geometry and gave the following answers: *"Geometry is a* *rainbow. Because, the rainbow is colorful. Geometry also has a lot of different things like colorful and different"*, *"Black represents a difficulty for me and geometry is a difficult issue. For this reason, geometry is black."*.

Because it is mentioned in curriculum and textbooks and it is a frequently used expression by teachers, the students were asked to define geometric shape. Under the Definition of Geometric Shape theme, the students answered the following questions: "What is a geometric shape?" and "What is the first geometric shape that comes to mind?".

Table 3. *Questions and student answers under the theme, "definition of geometric shapes"*

The Questions	(f) Pre-interviews	(f) Post-interviews
What is a geometric shape?	(2) definition by giving examples (6) definition through elements of the shape (4) definition as "mathematical shape"	(13) definition by giving examples (6) definition through elements of the shape (1) define as "a shape with a specific name"
What is the first geometric shape that comes to mind?	(7) square (7) rectangle (4) triangle (1) parallelogram (1) circle	(13) square (5) triangle (1) rectangle (2) rhombus (1) trapezoid (1) parallelogram

When asked to define geometric shape in the pre-interview, students listed the geometric shapes they knew, offered definitions that emphasized the elements of the shapes, such as *"shapes with edges"* and *"shapes composed of straight lines"* or used expressions in the form of mathematical shapes. In the post-interviews, it was determined that the majority of the students made definitions by saying the shapes they know, just like in the pre-interviews. In the pre- and post-activities interviews, the first geometric shape that most students had in mind was *"square."*

Around the opinions about geometry theme, the following questions were posed to the students: "What do you think about geometry?", "Is it difficult or easy to teach and learn?", "Why do you think like this?", "What are the difficulties?" and "What are the facilitators?"

Table 4. *Questions and student answers under the theme, "opinions about geometry"*

The Questions	(f) Pre-interviews	(f) Post-interviews
What do you think of geometry?	(2) funny (1) complex (1) easy	(8) funny (5) easy
Is it difficult or easy to teach and learn?	(10) easy (5) difficult (3) varies depending on the person (1) difficult to teach, easy to learn (1) easy to teach, difficult to learn	(8) easy (4) difficult (3) varies depending on the person (4) difficult to teach, easy to learn (4) it gets easier over time

Why do you think like this?	What are the difficulties?	(2) geometry is difficult. (2) geometry becomes complicated over time. (1) there is little opportunity to practice geometry.	(2) geometry is complicated. (5) the content of geometry is intense.
	What are the facilitators?	(2) geometry consists of shapes. (2) geometry is funny.	(2) geometry is related to daily life. (4) geometry is visual. (5) geometry is funny.

Although students were reluctant to express their views about geometry in the pre-interviews, during the post-interviews they often emphasized that it is a fun and easy subject. Some students' answers in the post-interviews are as follows: *"Before the activities, I did not know that geometry was in our lives that much. When I realized this, it started to feel easier"*, *"Geometry is a less boring topic in mathematics. It's like a game so it's fun"*. While their perceptions about the teaching and learning of geometry varied in the pre-interviews, a shift was observed in the post-interviews, and students articulated the fact that geometry is easy to teach and learn or that it becomes easier over time. Moreover, in the pre-interviews, students explained that the difficulties in teaching and learning geometry were because the students have little opportunity to practice geometry and that geometry has complex content. In the post-interviews, students presented solid reasons such as the intensity and complexity of geometry. A few answers that students emphasize on these issues are as follows: *"Before I get into geometry it feels difficult. When starting any geometry topic, I say "very complex, how do I do it". But it gets easier when I start working on it."*, *"You say something, it will not immediately remember it, but if you show it to it, it will remember it. At school, a teacher writes on the blackboard, but we do not do activities. If we do something, it will stay better in our minds"*. On the other hand, some students expressed clear reasons regarding why geometry is easy to teach and learn. Some reasons included the fact that geometry consists of shapes, it is fun, it is visual, and it relates to daily life.

Finally, students were asked the following questions about the Use of Geometry theme: "How often do you use geometry?" and "Where do you use geometry?"

Table 5. *Questions and student answers under the theme, "use of geometry"*

The Questions	(f) Pre-interviews	(f) Post-interviews
How often do you use geometry?	(9) very often (4) when required (2) sometimes (3) rarely (1) never	(16) very often (3) when required (1) sometimes (2) rarely
Where do you use geometry?	(11) in daily life (6) in courses (4) everywhere	(20) in daily life (12) in courses (2) everywhere

The frequency and usage of geometry were discussed together in pre- and post-interviews. In both sets of interviews, students stated that they use geometry very often or when required, either in daily life or in coursework. However, no clear answers were given in the pre-interviews about how geometry is used. Regarding the use of geometry in daily life, one student stated: *"My father is doing renovations and covering the floors with tiles, using the area* *calculation to determine how [many] tiles are required. That's why geometry helps him in his work"*. Similar to this statement, many students noted that family members actively use geometry in their work. Additionally, in post-interviews, many students commented that geometry is used in many places, but that only due to a change in perspective have they observed these applications.

Moreover, one of the students mentioned that: *"Actually, there was geometry everywhere, but I wasn't aware. And after attending the activities, I started to look around from that perspective. When I look around, I think, 'Is there geometry in it?"*. In the post-interviews, this comment and other similar comments from the students support the conclusion that the training process conducted in this study creates awareness of geometry. Also, when compared with pre-interviews, the effectiveness of the training process is supported by the fact that in post-interviews, students stated that they frequently use geometry in many areas.

The second finding of the study is related to the attitude towards geometry. Descriptive statistics of students' attitudes towards geometry in the pre-test and post-test applications of the study are presented in Table 6.

Table 6. *Descriptive statistics of attitude toward geometry scores*

Measurement	n	$\bar{X}$	Max.	Min.	s.d.
Pre-test_ Enjoyment dimension	22	17.36	27.00	11.00	5.01
Post-test_ Enjoyment dimension	22	15.91	29.00	11.00	5.99
Pre-test_ Usefulness dimension	22	6.77	10.00	4.00	2.18
Post-test_ Usefulness dimension	22	6.68	13.00	4.00	2.71
Pre-test_ Anxiety dimension	22	3.50	7.00	2.00	1.65
Post-test_ Anxiety dimension	22	3.10	6.00	2.00	1.51
Pre-test_ Whole scale	22	27.64	41.00	17.00	7.55
Post-test_ Whole scale	22	25.68	47.00	17.00	9.19

When Table 6 was examined, it was observed that the mean scores of students from the enjoyment dimension, with 11 items, were 17.36 and 15.91 in the pre-test and post-test, respectively. Considering that the highest score possible in this dimension is 55 and the lowest possible score is 11, the students' mean scores were extremely low. Similarly, it was observed that the mean score calculated for the usefulness dimension, with 4 items, was approximately 6.00 in both the pre-test and post-test. The mean score obtained from the anxiety dimension, with 2 items, was approximately 3.00. Students who exhibited low attitude scores in all dimensions also had lower attitude scores in the whole scale.

In addition to that, it was observed that the pre-test and post-test scores of the students were very close to each other in all three dimensions as well as the whole scale. When the means were examined in detail, it was determined that there was a decrease of approximately two points from the pre-test to the post-test in the enjoyment dimension of the scale ($\bar{X}$pre-test= 17.36; $\bar{X}$post-test= 15.91) and in the whole scale ($\bar{X}$pre-test= 27.64; $\bar{X}$post-test = 25.68). On the other hand, it was observed that the means in the dimensions of usefulness ($\bar{X}$pre-test= 6.77; $\bar{X}$post-test= 6.68) and anxiety ($\bar{X}$pre-test= 3.50; $\bar{X}$post-test= 3.10) were almost the same in pre-test and post-test applications. The results of the analysis, and whether these differences are statistically significant or not, are presented in Table 7.

Table 7. *Name of the table Comparison of attitude towards geometry scores*

Measurement	n	Mean Rank	Sum of Ranks	z	p
Pre-test_ Enjoyment dimension	22	9.92	129.00	-1.38*	.17
Post-test_ Enjoyment dimension	22	10.17	61.00		
Pre-test_ Usefulness dimension	22	7.45	82.00	-.26*	.79
Post-test_ Usefulness dimension	22	11.83	71.00		
Pre-test_ Anxiety dimension	22	5.14	36.00	-1.63*	.10
Post-test_ Anxiety dimension	22	4.50	9.00		
Pre-test_ Whole scale	22	11.29	135.50	-1.14*	.25
Post-test_ Whole scale	22	9.31	74.50		

According to Table 7, in the enjoyment dimension (z = -1.38; p = .17> .05); in the usefulness dimension (z = .26; p = .79 > .05); in the anxiety dimension (z = -1.63; p = .10> .05) and in the whole scale (z = -1.14; p = .25> .05) there were no significant differences for the pre-test and post-test mean scores of students. In other words, the training process did not affect students' attitudes towards geometry.

The third finding of the study is about self-efficacy towards geometry. When the descriptive statistics of the students' self-efficacy towards geometry were examined, it was observed that there were increases from the pre-test to the post-test mean scores in all dimensions and in the whole scale, as seen in Table 8.

Table 8. *Descriptive statistics of self-efficacy towards geometry scores*

Measurement	n	$\bar{X}$	Max.	Min.	s.d.
Pre-test_ Positive self-efficacy beliefs dimension	22	48.36	60.00	29.00	8.54
Post-test_ Positive self-efficacy beliefs dimension	22	55.18	60.00	41.00	5.47
Pre-test_Using of geometrical knowledge dimension	22	23.50	30.00	16.00	3.57
Post-test_Using of geometrical knowledge dimension	22	27.13	30.00	14.00	3.78
Pre-test_ Negative self-efficacy beliefs dimension	22	28.82	35.00	17.00	4.17
Post-test_ Negative self-efficacy beliefs dimension	22	31.68	35.00	19.00	5.10
Pre-test_ Whole scale	22	100.68	123.00	67.00	14.81
Post-test_ Whole scale	22	114.00	125.00	74.00	13.17

When Table 8 was examined in detail, it was observed that the mean scores of the students for all dimensions and the whole scale were satisfactory in both the pre-test and post-test. In other words, it can be said that the students' self-efficacy towards geometry was at an acceptable level. Also, it was seen that the mean scores obtained from the Positive Self-Efficacy dimension ($\bar{X}$pre-test = 48.36; $\bar{X}$post-test = 55.18); Using the Geometrical Knowledge dimension ($\bar{X}$pre-test = 23.50; $\bar{X}$post-test = 27.13); Negative Self-Efficacy Beliefs dimension ($\bar{X}$pre-test= 28.82; $\bar{X}$post-test= 31.68) and the whole scale ($\bar{X}$pre-test= 100.68; $\bar{X}$post-test= 114.00) increased by the end of the training process. The results of the performed analysis, for purposes of statistical significance, are presented in Table 9.

Table 9. *Comparison of self-efficacy towards geometry scores*

Measurement	n	Mean Rank	Sum of Ranks	z	0
Pre-test_ Positive self-efficacy beliefs dimension	22	8.00	8.00	-3.74*	.00
Post-test_Positive self-efficacy beliefs dimension	22	11.15	223.00		
Pre-test_Using of geometrical knowledge dimension	22	4.50	4.50	-3.77*	.00
Post-test_Using of geometrical knowledge dimension	22	10.82	205.50		
Pre-test_ Negative self-efficacy beliefs dimension	22	5.67	17.00	-3.15*	.00
Post-test_Negative self-efficacy beliefs dimension	22	10.81	173.00		
Pre-test_ Whole scale	22	3.00	3.00	-3.91*	.00
Post-test_ Whole scale	22	11.40	228.00		

According to Table 9, the differences between pre-test and post-test means were statistically significant and displayed the following scores: in the Positive Self-efficacy dimension, (z = -3.74; p = .00 <.05); in the Using the Geometrical Knowledge dimension, (z = -3.77; p = .00 <.00); in the Negative Self-Efficacy Beliefs dimension, (z = -3.15; p = .00 <.05); and across the whole scale, (z = -3.91; p = .00 <.05). In other words, it was concluded that the students' self-efficacy towards geometry after the training process was significantly higher both in whole scale scores and in all dimensions of the scale.

In addition to that, the effect sizes were calculated to see whether this difference was due to the training process. According to Fritz, Morris, and Richler (2012), r value was calculated to determine the effect size of the statistically significant differences obtained from the Wilcoxon Signed Rank Test. In this context, the effect size values obtained from this study were 0.79 for the Positive Self-Efficacy dimension of the scale, 0.80 for the Using the Geometrical Knowledge dimension, 0.67 for the Negative Self-efficacy Beliefs dimension, and 0.83 for the whole scale. Moreover, it was determined that all values expressed a large effect size (Coolican, 2009).

4. Discussion, Conclusion and Suggestion

As Hiebert and Grouws (2007) point out, students' perceptions are related to experiences. One of the purposes of this study was to determine the perceptions of students who have different experiences with geometry. For this purpose, the Self-Efficacy Scale for Geometry, the Attitude Scale Towards Geometry, and semi-structured interviews were conducted before and after the training process. The data obtained through the interviews shows that students are more willing to talk about geometry in post-interviews than in pre-interviews. Before the activities, the students did not answer the questions at all or they gave short, superficial, and limited answers. However, in the interviews conducted after the activities, the students were more comfortable in expressing their thoughts and offered long and experience-oriented answers to the questions. This change in the interview responses shows that the students were more motivated to talk about geometry after the training. This can be considered a hint that students developed a positive perception of geometry.

In the post-interviews, it is seen that the students give in-depth, mathematically based answers to the questions about the definition of geometry and geometric shape. Also, in these interviews, the diversity of the metaphors that the students selected along with the connection of these metaphors to the structure and content of geometry were remarkable findings. Considering that, this change is due to geometry activities, these results, then, are consistent with the fact that geometric experience is an important factor in understanding geometry (Van Hiele, 1986).

When the participants' views about the learning and teaching of geometry were examined, the pre-interviews showed that students' limited experience with geometry contributed to the view that geometry is difficult. These expressions lead to the conclusion that students' past experiences with geometry are limited and/or negative. The fact that students initially abstained from talking about geometry and that their perceptions were negative can be explained by the fact that both past and present experiences play a major role in perception (Lewis, 1999). In the interviews conducted after the training process, it was seen that most of the students stated that geometry was easy to learn and teach; the reasons for this were contained in expressions emphasizing the content of the activities, the relationship between geometry and daily life, and the pure enjoyment in geometry. This supports the finding that experience that plays an important role in the regulation of perception (Johnson, as cited in Lewis, 2001; Lewis, 2001).

As in the area of perception, students show more positive self-efficacy towards geometry after the training process. In other words, according to the data obtained within the scope of this study, positive self-efficacy scores increased significantly after the training process. The positive self-efficacy scores of the students compare similarly with results of other studies employing the same data collection tool. (Gülten, 2012; Gülten & Soytürk, 2013; Günhan & Özen, 2010). In this context, the positive self-efficacy towards geometry coincides with the literature (Mogari, 1999).

Although there is some evidence in the literature stating that different teaching methods do not have an effect on self-efficacy towards geometry (Günhan & Özen, 2010), in this study, it was determined that significant changes in self-efficacy towards geometry occurred following the training process. This finding coincides with the findings of Şeker and Erdoğan (2017) and Contay and Duatepe Paksu (2018), who conclude that the perception of self-efficacy towards geometry changes as a result of different teaching methods. Although the study of Şeker and Erdoğan (2017) demonstrates decreasing scores after the experiment process, in this study the negative self-efficacy scores increased after the training process. In this respect, the findings are consistent with the literature for all dimensions and the whole scale except in the negative self-efficacy dimension, where there is no overlap. This finding may relate to student awareness and their growing understanding regarding the comprehensive nature of geometry.

A further topic explored in this study is whether students' attitudes towards geometry are altered after the training process. According to the findings, students have low attitude scores towards geometry in the three dimensions (enjoyment, usefulness and anxiety) of the data collection tool. This finding is consistent with the results of Bal (2011). Bal (2011) explained that students with negative attitudes have difficulty in geometry. In addition, no significant difference was observed between the pre-test and post-test in the attitude scores of the students in this study. In other words, as a result of the five-day education process, there was no change in students' attitudes towards geometry. Two reasons explain these results. First, a long period of time is required for attitude change. New knowledge and experiences attribute to this change, but it is a slow process (Tavşancıl, 2006). This idea is supported by Leach (2009) as well as by Scott, Leritz, & Mumford (2004). In this study's training process, students gained various knowledge and experience, but it was determined that the five-day process was not sufficient to cause a change in attitudes. Secondly, attitude does not change among individuals in certain age ranges. Bergeson, Fitton, and Bylsma (2000) suggest that the attitudes of students, especially between grades 7–12, are constant. Since the students who enrolled in this study had completed sixth grade and passed to seventh grade, it is thought that their attitudes did not change simply due to their specific ages.

In the literature, it is shown in various studies that the attitude towards geometry did not change where different teaching methods were tried (Boakes, 2009; Kale, 2007; Takıcak, 2012). For example, Kale (2007) examined seventh grade students' attitudes towards geometry by using drama-based and cooperative learning environments, and it was concluded that there was no significant difference in students' attitudes towards geometry after both methods. Takıcak (2012), in his study conducted with eighth grade students, examined the effect of origami-based mathematics lessons on the attitude towards geometry. As a result, it was concluded that the lessons taught with origami activities had no effect on the attitude towards geometry, and it was observed that some students' attitude scores decreased after the experiment process. The reason stated was inconsistent student answers in the attitude test. Similarly, in other studies examining students' attitudes towards geometry, it was observed that there were no significant differences at the end of the education process (Boyraz, 2008; Çalışkan, 2016; Eryiğit, 2010). Like the studies mentioned above, this study employed origami, creative drama and technology-supported geometry activities. Yet, as a result of the process, no change was observed in students' attitudes towards geometry. In this respect, the findings of this study are similar to those of the literature.

These results can inform us about the need and desire of the students to develop positive perception, which is a critical element for student participation and success. Students' perceptions of geometry can be positively changed positively when learning environments and content are designed with students in mind. Changes in geometry teaching methods can also facilitate perception change among students.

As a result of this study's scope, one suggestion is to train students while keeping in mind the goals of positive self-efficacy and attitude. Because students' attitudes are affected by teachers' attitudes and teaching methods (Aiken, 1972; Carter & Norwood, 1997; Sunzuma et al., 2013), teachers and prospective teachers should maintain positive attitudes and self-efficacy. If teachers and prospective teachers have positive attitudes towards geometry, they will reflect this in the teaching process and can, therefore, train their students to have positive attitudes as well. Another suggestion centers around the learning environment. It can be said that students can develop positive attitudes towards geometry if their learning environments are active and the activities are related to daily life. Finally, it can be said that positive attitude and self-efficacy, when developed at an early age, will bring about academic success.

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References

Aiken, L. R. (1972). Research on attitudes toward mathematics. *The Arithmetic Teacher, 19*(3), 229-234.

Akcaoglu, M., & Koehler, M. J. (2014). Cognitive outcomes from the Game-Design and Learning (GDL) after-school program. *Computers & Education*, *75*, 72-81.

Akinsola, M. K., & Olowojaiye, F. B. (2008). Teacher instructional methods and student attitudes towards mathematics. *International Electronic Journal of Mathematics Education*, *3*(1), 60-73.

Anıkaydın, Ö. (2017). *Students oriented geometry self- efficacy beliefs, attitudes and geometry investigation of relationship between levels of geometric thinking* (Master's thesis). Adnan Menderes University, Aydın, Turkey.

Arslan, O., & Isiksal-Bostan, M. (2016). Turkish prospective middle school mathematics teachers' beliefs and perceived self-efficacy beliefs regarding the use of origami in mathematics education. *Eurasia Journal of Mathematics, Science & Technology Education*, *12*(6), 1533-1548.

Beghetto, R. A., & Baxter, J. A. (2012). Exploring student beliefs and understanding in elementary science and mathematics. *Journal of Research in Science Teaching, 49*(7), 942-960.

Bal, A. P. (2011). Geometry thinking levels and attitudes of elementary teacher candidates. *Inonu University Journal of the Faculty of Education*, *12*(3), 97-115.

Bandura, A. (1995). *Self-efficacy in changing societies.* Cambridge: Cambridge University Press.

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

Barab, S. A., Scott, B., Siyahhan, S., Goldstone, R., Ingram-Goble, A., Zuiker, S. J., & Warren, S. (2009). Transformational play as a curricular scaffold: Using videogames to support science education. *Journal of Science Education and Technology*, *18*(4), 305.

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

Ben-Chaim, D., Lappan, G., & Houang, R. T. (1985). Visualizing rectangular solids made of small cubes: Analyzing and effecting students' performance. *Educational Studies in Mathematics*, *16*(4), 389-409.

Bergeson, T., Fitton, R., & Bylsma, P. (2000). *Teaching and learning mathematics using research to shift from the "yesterday" mind to the "tomorrow" mind.* Washington State: State Superintendent of Public Instruction.

Biggs, J. B. (1987). *Student approaches to learning and studying.* Melbourne: Australian Council for Educational Research.

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

Boyraz, Ş. (2008). *The effects of computer based instruction on seventh grade students' spatial ability, attitudes toward geometry, mathematics and technology* (Master's thesis). Middle East Technical University, Ankara, Turkey.

Bulut, S., Ekici, C., İşeri, A. İ., & Helvacı, E. (2002). A Scale for Attitudes Toward Geometry. *Education and Science, 27*(125), 3-7.

Cantürk-Günhan, B., & Başer, N. (2007). The development of self-efficacy scale toward geometry. *Hacettepe University Journal of Education, 33*, 68-76.

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

Carter, G., & Norwood, K. S. (1997). The relationship between teacher and student beliefs about mathematies. *School Science and Mathematics, 97*(2), 62-67.
Clements, D. H., & Battista, M. T. (1992). Geometry and spatial reasoning. In D. A. Grouws (Ed.), *The Handbook on Research in Mathematics Teaching and Learning.* New York, NY; Macmillan.
Contay, E. G, & Duatepe-Paksu, A. (2018). The effect of journal writing on achievement and geometry self-efficacy of 8th grade students. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, *12*(2), 167-198.
Coolican, H. (2009). *Research methods and statistics in psychology.* London, United Kingdom: Hodder.
Coren, S., Ward, L. M., & Enns, J. T. (1999). *Sensation and perception*. New York: Harcourt.
Creswell, J.W. (2007). *Qualitative inquiry and research design: choosing among five traditions*. Thousand Oaks, CA: Sage.
Creswell, J.W., (2012). E*ducational research planning, conducting and evaluating, quantitative and qualitative research (4th edition).* Boston, MA: Pearson.
Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research.* Thousand Oaks, CA: Sage.
Çalışkan, M. (2016). *Researching the effects of the instruction of the solid matters assisted with dynamic geometry softwares on the 7th graders' attitudes towards geometry and spatial thinking* (Master's thesis). Dokuz Eylül University, İzmir, Turkey.
Dempsey, J., Lucassen, B., Gilley, W., & Rasmussen, K. (1993). Since Malone's theory of intrinsically motivating instruction: What's the score in the gaming literature?. *Journal of Educational Technology Systems*, *2*(2), 173-183.
Devichi, C., & Munier, V. (2013). About the concept of angle in elementary school: Misconceptions and teaching sequences. *The Journal of Mathematical Behavior, 32*(1), 1-19.
Doğan, A., Özkan, K., Çakir, N. K., Baysal, D., & Gün, P. (2012). Students' misconceptions about trapezium through primary levels. *Usak University Journal of Social Sciences, 5(1),* 104- 116.
Dikovic, L. (2009). Implementing dynamic mathematics resources with GeoGebra at the college level. *International Journal of Emerging Technologies in Learning, 4*(3), 51-54.
Duatepe-Paksu, A., & Ubuz, B. (2007). The development of a geometry attitude scale. *Academic Exchange Quarterly*, *11*(2), 205-210.
Duff, A., & McKinstry, S. (2007). Students' approaches to learning. *Issues in Accounting Education, 22*(2), 183-214.
Erkek, Ö., & Işiksal-Bostan, M. (2015). The role of spatial anxiety, geometry self-efficacy and gender in predicting geometry achievement. *Elementary Education Online, 14*(1), 164-180.
Eryiğit, P. (2010). *The effect of utilizing the three-dimensional dynamic geometry software in geometry teaching on 12th grade students, their academic standings, their attitude towards geometry* (Master's thesis). Dokuz Eylül University, İzmir, Turkey.
Fisch, S. M. (2005). Making educational computer games "educational*". Proceedings of the 2005 conference on Interaction design and children* (pp. 56-61). New York, NY, USA: ACM.
Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, ıntention, and behaviour: an ıntroduction to theory and research. Reading.* USA, MA: Addison-Wesley Publishing Company.
Forgasız, H. (2005). Gender and mathematics: Re-igniting the debate. *Mathematics Education Research Journal, 17*(1), 1–2.

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

Fritz, C. O., Morris, P. E. & Richler, J. J. (2012). Effect size estimates: current use, calculations, and interpretation. *Journal of Experimental Psychology: General, 141*(1), 2-18.

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*? New York: Palgrave MacMillan.

Grover, S., & Pea, R. (2013). Computational thinking in K–12: A review of the state of the field. *Educational Researcher*, *42*(1), 38-43.

Gutiérrez, A. (1996). Visualization in 3-dimensional geometry: In search of a framework. In L. Puig & A. Guttierez (Eds.), In *Proceedings of the 20th conference of the International Group for the Psychology of Mathematics Education* (Vol. 1, pp. 3–19). Valencia: Universidad de Valencia.

Gülten, D. Ç. (2012). Investigating second level primary students' learning styles and geometry self-efficacy in terms of certain variables. *International Journal of Social Sciences & Education*, *3*(2), 264-277.

Gülten, D., & Soytürk, İ. (2013). The relation between 6th grade elementary school students' self-efficacy beliefs and academic achievement in geometry. *Mehmet Akif Ersoy University Journal of Education Faculty*, *25*, 55-70.

Günhan, B. C., & Özen, D. (2010). The Application of Drama Method on Prisms Subject. *Buca Faculty of Education Journal*, *27*, 111-122.

Günhan-Cantürk, B., & Başer, N. (2007). The development of self-efficacy scale toward geometry. *Hacettepe University Journal of Education,* 33, 68-76.

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education, 20*(3), 261–273.

Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. In F. K. Lester (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 371-404). Greenwich, CT: Information Age.

Huizenga, J., Admiraal, W., Akkerman, S., & Dam, G. T. (2009). Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning, 25*(4), 332-344.

Hohenwarter, M., & Jones, K. (2007). Ways of linking geometry and algebra, the case of Geogebra. *Proceedings of the British Society for Research into Learning Mathematics*, *27*(3), 126-131.

Kale, N. (2007). *A comparison of drama-based learning and cooperative learning with respect to seventh grade students' achievement, attitudes and thinking levels in geometry (*Master's thesis). Middle East Technical University, Ankara, Turkey.

Ke, F. & Grabowski, B. 2007. Game playing for maths learning: Cooperative or not? *British Journal of Educational Technology. 38*(2), 249–259.

Kukul, V., & earslan, Ş. (2014). Investigating the problem-solving skills of students attended scratch programming course. *8th International Computer & Instructional Technologies Symposium.* Retrieved from https://www.researchgate.net/profile/Sahin_Goekcearslan/publication/281614198_SCRATCH_ILE_PROGRAMLAMA_EGITIMI_ALAN_OGRENCILERIN_PROBLEM_COZME_BECERILERININ_INCELENMESI_INVESTIGATING_THE_PROBLEM_SOLVING_SKILLS_OF_STUDENTS_ATTENDED_SCRATCH_PROGRAMMING_COURSE/links/55efe5cd08aedecb68fdd035.pdf

Kuzle, A. (2013). Construction with various tools in two geometry courses in the United States and Germany. In B. Ubuz, C. Haser, & M. A. Mariotti (Eds.), *Proceedings of the Eight*

Conference of European Research in Mathematics Education (pp. 675-684.). Ankara, Turkey: Middle East Technical University.

Leach, C.E. (2009). *An investigation of training in creative problem solving and its relationship to affective and effective idea generation of entrepreneurial learners* (Doctoral dissertation). Nova Southeastern University, FL, USA.

Lent, R. W., Lopez, F. G., & Bieschke, K. J. (1991). Mathematics self-efficacy: Sources and relation to science-based career choice. *Journal of Counseling Psychology, 38*(4), 424–430.

Lewis, A. (1999). *Past and present perceptions surrounding mission education: a historical-metabletical overview* (Doctoral dissertation). University of Stellenbosch, Stellenbosch, South Africa.

Lewis, A. (2001). The issue of perception: some educational implications. Educare, *30*(1), 272-288.

Luneta, K. (2015). Understanding students' misconceptions: An analysis of final Grade 12 examination questions in geometry. *Pythagoras*, *36*(1), 1-11.

Makhubele, Y., Nkhoma, P., & Luneta, K. (2015). Errors Displayed by Learners in The Learning of Grade 11 Geometry. *ISTE International Conference on Mathematics, Science and Technology Education.* Retrieved from https://www.researchgate.net/profile/Kwanele_Booi/publication/301690956_The_impact_of_knowledge_gaps_in_conceptualisation_and_drawing_skills_in_the_first_year_Life_Sciences_education/links/58bdc4cbaca27261e52e9523/The-impact-of-knowledge-gaps-in-conceptualisation-and-drawing-skills-in-the-first-year-Life-Sciences-education.pdf#page=40

Miles, M, B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded Sourcebook.* Thousand Oaks, CA: Sage.

Marton, F., & Säljö, R. (1976). On qualitative differences in learning: I—Outcome and process. *British journal of educational psychology*, *46*(1), 4-11.

Mogari, D. (1999). Attitude and Achievement in Euclidean Geometry. Retrieved from http://math.unipa.it/~grim/EMogari9.

MoNE. (2018). Mathematics Course Curriculum (1st-8th Grades). Ankara: MEB.

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology, 38*(1), 30-38.

Neale, D. C. (1969). The role of attitudes in learning mathematics. *The Arithmetic Teacher, 16*(8), 631-640.

Nicolaidou, M., & Philippou, G. (2003). Attitudes towards mathematics, self-efficacy and achievement in problem solving. *European Research in Mathematics Education III. Pisa: University of Pisa*, 1-11.

Olkun, S. (2003). Comparing computer versus concrete manipulatives in learning 2d geometry. *Journal of Computers in Mathematics and Science Teaching*, *22*(1), 43-46.

Özkan, E., & Yıldırım, S., (2013). The relationships between geometry achievement, geometry self-efficacy, parents' education level and gender. *Ankara University, Journal of Faculty of Educational Sciences, 46*(2), 249-261.

Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of educational psychology*, *86*(2), 193-203.

Pfeiffer, C. (2017). *A study of the development of mathematical knowledge in a GeoGebra-focused learning environment* (Doctoral dissertation). University of Stellenbosch, Stellenbosch, South Africa.

Postareff, L., Mattsson, M., & Parpala, A. (2018). The effect of perceptions of the teaching-learning environment on the variation in approaches to learning–Between-student differences and within-student variation. *Learning and Individual Differences*, *68*, 96-107.

Pyzdrowski, L. J., Sun, Y., Curtis, R., Miller, D., Winn, G., & Hensel, R. A. (2013). Readiness and attitudes as indicators for success in college calculus. *International Journal of Science and Mathematics Education*, *11*(3), 529-554.

Randolph, W. A., & Blackburn, R. S. (1989). *Managing organizational behavior*. Homewood, IL: Irwin.

Robbins, S.P. (1991). *Organizational behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Ruthmann, A., Heines, J. M., Greher, G. R., Laidler, P., & Saulters, I. C. (2010). Teaching computational thinking through musical live coding in scratch. *In Proceedings of the 41stACM technical symposium on computer science education* (pp. 351-355). New York, NY, USA: ACM.

Samur, Y. (2012). *Measuring engagement effects of educational games and virtual manipulatives on mathematics* (Doctoral dissertation). Virginia Polytechnic Institute and State University, Virginia, USA.

Schunk, D. H. (1990). Goal setting and self-efficacy during self-regulated learning. *Educational psychologist*, *25*(1), 71-86.

Schunk, D. H., & Swartz, C. W. (1993). Goals and progress feedback: Effects on self-efficacy and writing achievement. *Contemporary Educational Psychology, 18*(3), 337-354.

Scott, G., Leritz, L. E., & Mumford, M. D. (2004). Types of Creativity Training: Approaches and Their Effectiveness. *The Journal of Creative Behavior, 38*(3), 149-179.

Shin, S., & Park, P. (2014). A study on the effect affecting problem solving ability of primary students through the Scratch programming. *Advanced Science and Technology Letters*, *59*, 117-120.

Sorby, S. A., & Baartmans, B. J. (1996). A Course for the Development of 3-D Spatial Visualization Skills. *Engineering Design Graphics Journal*, *60*(1), 13-20.

Sunzuma, G., Masocha, M., & Zezekwa, N. (2013). Secondary school students' attitudes towards their learning of geometry: a survey of Bindura urban secondary schools. *Greener Journal of Educational Research, 3*(8), 402-410.

Şeker, H. B., & Erdoğan, A. (2017). The Effect of Teaching Geometry with GeoGebra Software on Geometry Lesson Achievement and Geometry Self-Efficacy. *International Journal of Society Researches*, *7*(12), 82-97.

Takıcak, M. (2012). *The effect of origami based instruction on the 8th grade students' triangle unit academic achievement and attitudes toward geometry* (Master's thesis). Kastamonu University, Kastamonu, Turkey.

Tapia, M., & Marsh, G. E. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly*, *8*(2), 16-22.

Tavşancıl, E. (2006). *Tutumların ölçülmesi ve SPSS ile veri analizi* [Measurement of attitudes and data analysis with SPSS]. *Ankara, Turkey: Nobel*.

Taylor, M., Harlow, A., & Forret, M. (2010). Using a computer programming environment and an interactive whiteboard to investigate some mathematical thinking. *Procedia-Social and Behavioral Sciences*, *8*, 561-570.

Turğut, M. (2010). *The effect of technology assisted linear algebra instruction on pre-service primary mathematics teachers' spatial ability* (Doctoral dissertation). Dokuz Eylül University, İzmir, Turkey.

Tüzün, H., Yılmaz-Soylu, M., Karakuş, T., İnal, Y., & Kizilkaya, G. (2009). The effects of computer games on primary school students' achievement and motivation in geography learning. *Computers & Education, 52*, 68-77.

Van Hiele, P. M. (1986). Is It Possible to Test Insight? *Structure and insight A theory of mathematics education*.

Yenilmez, K., & Korkmaz, D. (2013). Relationship between 6th, 7th and 8th grade students' self-efficacy towards geometry and their geometric thinking levels. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, *7*(2), 268-283.

Yıldız, B., & Tüzün, H. (2011). Effects of using three-dimensional virtual environments and concrete manipulatives on spatial ability. *Hacettepe University Journal of Education*, *41*, 498-508.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology*, *25*(1), 82-91.