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The Effect of the 7th Grade Students' Geometry Oriented Self-Efficacy on the Geometric Habits of the Mind

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Abstract

It is important to learn the concepts of geometry and to solve geometric problems from the lowest level to the highest level of education. Geometric habits of mind are an important factor in individuals' ability to solve geometry problems. Besides, there are affective factors affecting success. One of these factors is self-efficacy for geometry. For this reason, the aim of research is to investigate relationship between 7th grade students' self-efficacy beliefs about geometry and the geometric habits of mind. On the other hand, it was aimed to investigate whether belief in self-efficacy towards geometry predicted geometric habits of mind. This sample of the research designed in relational model consists of 115 randomly selected 7th grade students studying at a secondary school affiliated to the Ministry of Education. The research data were obtained with the "Geometry Self-Efficacy Scale" developed by Cantürk-Günhan and Başer (2007) and the "Geometric Habits of Mind Test" developed by the researchers. To analyze the data, Pearson's correlation and regression analysis are used. Findings showed that students' self-efficacy towards geometry and their average scores from the scales for geometric habits of mind were moderate. It was found that there was a positive but low relationship between the "Geometric Habits of Mind Test" and the "Geometry Self-Efficacy Scale". It has been determined that self-efficacy towards geometry predicts geometric habits of mind at some level. In line with the findings, suggestions have been made for improving and searching geometric self-efficacy of secondary school students and geometric habits of mind.

Keywords: Geometric self-efficacy, geometric habits of mind, geometry education, geometry problems, secondary school students.

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7.sınıf Öğrencilerinin Geometriye Yönelik Öz-Yeterliklerin Zihnin Geometrik Alışkanlıklarına Etkisi

Öz

Eğitimin en alt kademesinden en üst kademesine kadar geometri kavramlarını öğrenme ve geometrik problemlerini çözebilme başarısı önemlidir. Bireylerin geometri problemlerini çözebilme başarısında zihnin geometrik düşünme alışkanlıkları önemli etkendir. Geometrik düşünme alışkanlıklarının yanı sıra başarıyı etkileyen duyuşsal faktörlerde bulunmaktadır. Bu faktörlerden biri geometriye yönelik öz-yeterliktir. Bu sebeple araştırmanın amacı, 7.sınıf öğrencilerinin geometriye yönelik öz-yeterlik inançları ile zihnin geometrik alışkanlıkları arasındaki ilişkiyi araştırmaktır. Diğer yandan araştırmada geometriye yönelik öz-yeterlik inancının zihnin geometrik alışkanlıklarını yordayıp yordamadığını incelemek amaçlanmıştır. İlişkisel modelde tasarımlanan araştırmanın örneklemini Milli Eğitim Bakanlığına bağlı bir ortaokulda öğrenim görmekte olan 7. sınıf öğrencileri arasından rastlantısal olarak seçilen 115 öğrenci oluşturmaktadır. Araştırma verileri, Cantürk - Günhan ve Başer (2007) tarafından geliştirilen "Geometri Öz-Yeterlik Ölçeği" ve araştırmacılar tarafından geliştirilen "Zihnin Geometrik Alışkanlıkları Testi" ile elde edilmiştir. Verileri analiz etmek için, Pearson korelasyon analizi ve regresyon analizi kullanılmıştır. Araştırma bulguları, öğrencilerin geometriye yönelik öz-yeterlikleri ve zihnin geometrik alışkanlıklarına yönelik ölçeklerden aldıkları ortalama puanlarının orta düzeyde olduğunu göstermiştir. "Zihnin Geometrik Alışkanlıkları Testi" ile "Geometri Öz-Yeterlik Ölçeği" arasında pozitif yönde ancak düşük bir ilişkinin bulunduğuna ulaşılmıştır. Geometriye yönelik öz-yeterlik inancının zihnin geometrik alışkanlıklarını bir düzeyde yordadığı belirlenmiştir. Bulgular doğrultusunda ortaokul öğrencilerinin geometriye yönelik öz-yeterlikleri ile zihnin geometrik alışkanlıklarını geliştirmeye ve araştırmaya yönelik öneriler sunulmuştur.

Anahtar Kelimeler: Geometriye yönelik öz-yeterlik, zihnin geometrik alışkanlıkları, geometri eğitimi, geometri problemleri, ortaokul öğrencileri.

Introduction

Geometry is a discipline that helps individuals to perceive the environment they live in. The universe we live in is shaped by many geometric layouts. This geometric layout, has always been of interest in the researchers. Objects formed with different systems such as snowflakes, sun rays, honeycombs, spider webs, and conifer cones are complementary factors in the reflection of geometry in nature. By noticing these reflections in nature, individuals begin to recognize geometry with the desire to explore the universe in which they are located. With this realization, geometry education in a classroom environment is an important factor in making sense of the geometric reflections of objects in nature and creating mathematical models accordingly. For this reason, in the learning environment, it is necessary to pass on to the students the idea that geometry education is not just a formula written in books. Achieving success in geometry is also shaped according to this framework. Some of the examinations conducted in the international field show that students are not at the desired level of success in the field of geometry. According to the results of the Trends in International Mathematics and Science Study (TIMSS), geometric shapes and measurements (MEB, 2020) are the areas where we have the lowest success and ranking in Turkey's exams in 1999 and 2007. Similar results can be found in the TIMSS's 2011 and 2015 exam results. In this context, these examinations, especially

conducted at the international level, enable researchers to see the deficiencies of the education system in our country and to encourage them to work on teachers and students who are the building blocks of education.

Researchers generally focused on studies about examining teacher competencies and teachers' geometric thinking levels (İlhan and Oral, 2012; Toluk-Uçar, 2009; Uygun, Ergen and Öztürk, 2011), students' geometric thinking levels (Duatepe-Paksu, 2013; Kılıç, 2003; Yenilmez and Korkmaz, 2013); students' and teachers' geometric habits of the mind (Bülbül, 2016; Bülbül and Güven, 2019; Bülbül and Güven, 2020; Bülbül and Güler, 2021; Köse and Tanışlı, 2014; Özen, 2015; Uygan, 2016) and the relationship between affective components and success (Erşen, 2017; Gülten and Soytürk, 2013). In order to develop students ability to relate from different angles, to gain the skills to think, to question and to explore, geometric learning theories should be utilized. The geometric habits of the mind are one of these theories. Adopting the geometric habits of the mind (GHoM) have been an effective way in increasing students' success in solving geometry questions. GHoM, is the ability of the individual to use his / her strategies to solve the problem when faced with one. Research has been conducted that the individual's geometric thinking habits and their ability to use them in problems increase the success of geometry (Bülbül, 2016; Özen, 2015; Uygan, 2016).

The concept of GHoM is introduced to the literature by Goldenberg, Cuoco and Mark's study (1998), the most comprehensive study on this subject is "Fostering Geometric Thinking: a Guide for Teachers, Grades 5-10", which was a result of a project by Driscoll, DiMatteo, Nikula and Egan (2007). Driscoll et al. (2007) state that there are four main components of individuals who have geometric habits of mind. These components are reasoning with relationships, generalizing geometric ideas, investigating invariants and balancing exploration and reflection. The reasoning with relationships component includes searching for relationships between different dimensional geometric shapes and objects. Individuals with this component can explain similar or non-similar properties among the geometric shapes. Generalizing geometric ideas component, intends to describe the general situations that might come up regarding the geometric concept. Individuals with this component can consider special situations related to the subject and make generalizations for new situations by considering different examples after special situations. They form assumptions and test the assumptions, they are in the process of reaching a generalization by drawing conclusions about these assumptions. The component of investigating invariants analyzes which properties of a geometric shape change as a result of a rotation and which ones remain the same. Individuals with the component of balancing exploration and reflection can draw shapes, play with shapes, and can explore the shapes through predictions or intuitions. People who have this component can identify intermediate steps better by questioning themselves with each step in the solution process (Driscoll et al, 2007; Driscoll, DiMatteo, Nikula and Egan, 2008).

Different approaches are exhibited for each component of the geometric habits of the mind. Driscoll et al. (2007) stated the approaches used based on the questions asked in the process while using the components of GHoM. In the table below, questions about the process are given.

Table 1
Components of the Geometric Habits of the Mind

Geometric Habits of Mind	**Questions asked in the process**
Reasoning with relationships component	"How are the similar aspects of the figures?", "How are the differences of the shapes?", "What are the other shapes that fit the definition?", "What would happen if we thought of this relationship in a different dimension?"
Generalizing geometric ideas component	"Does this happen in every situation?", "If so why?", "Can I find other examples suitable for this definition?", "Does this happen in other dimensions?"
Investigating invariants component	"What has changed? Why is that?", "What hasn't changed? Why is that?"
Balancing exploration and reflection	"What if I add to a shape, cut it into pieces, or go back from the end?" "What does my action tell me?", "How do the approaches I used before to solve the problem contribute to my current approach to solution?", "What intermediate steps can help me?"

Source: Driscoll et al. (2007)

Marshall (2004) stated that habits of minds have effected the cognitive and affective dimensions in the problem-solving process. Bülbül (2021), investigated the effects of affective factors, gender, grade level, and academic achievement on prospective mathematics teachers' (PTs) beliefs about the geometric habits of the mind. In this study, GHoM was examined in terms of cognitive and affective factors. As a result of the study, a significant positive relationship was found between the PTs' self-efficacy regarding to geometry and their beliefs about geometric habits of mind. Additionally a negative, moderate and significant relationship was found between the attitudes of the PTs towards geometry and their beliefs about geometric habits of mind. In this respect, GHoM are expected to be influenced by affective dimension factors such as interest, attitude, belief and self-efficacy. Among these affective characteristics, there is an important relationship between self-efficacy belief with behavior; students are known to be more willing and positive to learn geometry if they have the belief that they can learn geometry (Cantürk-Günhan and Başer, 2007; Erşen, 2017).

In this context, it reveals the tendency of individuals with high self-efficacy towards different ways of thinking depending on their learning impulse. For this reason, these individuals are expected to resort to different solutions in the problem solving process. In this process, individuals resort to their habits of thinking while using solution approaches. One of the habits that individuals can utilize in geometry constitute the subcomponents of the geometric habits of the mind. Based on the relationship between self-efficacy and success in research, individuals are expected to make more effort to reach the result of the problem by making more effort to achieve the result of the problem, to make generalization of geometric ideas, to generalize geometric ideas, to search for the invariants, to discover and to reflect on the problem.

In this direction, it is noteworthy to investigate the relationship between self-efficacy, which is effective in individuals' success and geometric habits of the mind. In the literature, there are no studies investigating the relationship between geometric habits of the mind and geometry self-efficacy. In the success of an individual to solve the geometry problem, the higher the self-efficacy beliefs like the rings of the chain, the more ability to use the geometric habits of the different mind is expected. Based on the definition of Bandura (1986), an individual with high self-efficacy has a high judgment of problem solving. It enables these variables to work together effectively by reconciling variables such as self-efficacy belief, skill, ability, and knowledge (Pajares and Miller, 1994; Teti and Gelfand, 1991). In this respect, it is important to examine whether middle school 7th grade students realize the solution process by using different components of the geometric habits of the mind depending on their self-efficacy towards geometry. Therefore, our study aimed to investigate the relationship between self-efficacy beliefs in geometry and geometric habits of the mind by examining them. Considering the importance of geometry; It is thought that the research findings about this situation of secondary school students in the geometry learning process will contribute to the learning process of the students, teachers and the literature. In line with this purpose, the following research problems were examined in the study.

i) Is there a relationship between student's geometric habits of mind and their geometric self-efficacy?

ii) Is the geometric self-efficacy of the students a meaningful predictor of their geometric habits of the mind?

Literature

Self-efficacy for Geometry

There are studies investigating the development of geometry self-efficacy according to experimental research patterns. It is seen from these studies that self-efficacy towards geometry is positively influenced by different teaching methods used in mathematics lessons (Cantürk-Günhan, 2006; Çontay, 2012; Faydalı, 2018). In her study, Cantürk-Günhan (2006) aimed to investigate the applicability of Problem-Based Learning in mathematics in the second year of elementary education. The Problem-Based Learning method was found to increase students' level of geometric thinking, positively affect their self-efficacy beliefs for geometry, improve their critical thinking skills, create positive attitudes towards mathematics and increase their gain level. In her study, Çontay (2012) aimed to determine the impact of writing activities on 8th grade students' achievements in surface areas and volumes of geometric objects and their self-efficacy beliefs towards geometry. As a result of the research, positive findings were obtained in the achievements of the experimental group students about the surface areas and volumes of geometric objects and their self-efficacy beliefs about geometry. Faydalı (2018), investigated the impact of using differentiated teaching approaches for teaching area, circumference and volume in a mathematics course to 6th grade students, have on students' motivation for mathematics, geometric self - efficacy and their attitudes to geometry as opposes to courses taught with the traditional method. As a result of the research, it was seen that differentiated teaching approach practices caused a significant increase in

motivation scores of the students of the experimental group, a positive effect on geometry self-efficacy and geometry attitudes.

Components such as self-efficacy, attitude, belief, and motivation have an effect on students' academic success towards a subject. Looking at the literature, there are also studies investigating the relationship between geometry-related self-efficacy and other components that affect teaching (Gülten and Soytürk, 2013; Yenilmez and Korkmaz, 2013). In their studies, Gülten and Soytürk (2013) investigated the relationship between geometric self - efficacy and academic achievements. In this context, in the research, it was observed that the achievement of lesson of 6th grade students were related with geometry self-efficacy. Yenilmez and Korkmaz (2012) aimed to determine the relationship between primary school students' geometry self-efficacy and geometric thinking levels by examining them. The findings showed that self-efficacy towards geometry differed significantly according to mathematics achievement, gender and grade levels. In addition, the findings showed that the self-efficacy and geometric thinking level towards geometry had a significant and positive relationship.

According to Bandura (1986), the concept of self-efficacy is as an individual's view of their own capacity to succeed by making the necessary preparations for a particular performance. Self-efficacy also describes the judgments of an individual to perform a specific activity (Siegle, 2003). In this case, individuals with high self-efficacy tend to succeed and learn new things, whereas with low self-efficacy are expected to have the opposite situations. The increasing interest, motivation, attitude and motives of the individual who is willing to learn new things forms the basis for understanding the subject in the best way. As a natural consequence of this, success is expected to be inevitable. Bandura (1995) stated that self-efficacy beliefs have effects on cognitive processes. Individual goals, beliefs about efficacy are effective in determining expectations about the outcome. Studies show that individuals' self-efficacy beliefs are effective on academic achievement (Schunk, 1983; Pajares and Miller, 1994; Çağırgan Gülten and Soytürk, 2013). Since self-efficacy is a perception of one's own capacity, individuals who are successful in mathematics and geometry lessons are expected to have a high self-efficacy perception towards these lessons (Erdoğan et al., 2011). The effect of self-efficacy on cognitive processes can be examined in different areas. Zimmerman (1995) stated that self-efficacy is related to different multidimensional fields. In this respect, self-efficacy belief in geometry for geometry, which is an important interdisciplinary field of mathematics, may differ from other fields. The results of the research conducted by Özkan (2010) show that there is a positive correlation between self-efficacy and geometry success and that self-efficacy belief is a significant provider of geometry success.

Individuals are expected to overcome a geometry problem by making use of the geometrical habits of the mind to use their judgments and knowledge about geometry in solving geometry problems. Therefore, a meaningful relationship is expected between the self-efficacy belief towards geometry and the geometric habits of the mind. No research has been reached on how the belief in self-efficacy in geometry changes according to the geometric habits of the mind of individuals. The relationship between the geometrical thinking levels of Van-Hiele and the self-efficacy, as well as the relationship between self-efficacy beliefs and the use of

geometrical habits of different minds is one of the subjects to be investigated. Therefore, the self-efficacy belief towards geometry, which is one of the effective affective factors in learning with the geometric habits of the mind, is one of the components that creates the research problem. Therefore, self-efficacy beliefs about geometry, one of the factors affecting learning with the geometric habits of the mind, are the components that form the research problem.

Geometric Habits of the Mind

In the literature we can come across many studies about habits of mind. The first of these studies was conducted by Driscoll and his colleagues (Driscoll et al., 2007), who came up with this concept. On top of that, in 2004, Driscoll et al. started a project called Fostering Geometric Thinking (FGT) in secondary schools. As a result of the project work carried out between 2004-2008, the Geometric Habits of the Mind (GHoM) was introduced. With this theory, GHoM components have been introduced to enable students to have a productive geometric thinking. With the introduction of the GHoM theoretical framework by Driscoll et al, different studies have been conducted in the national literature according to qualitative and quantitative research patterns. These researches were mainly done with teachers and prospective teachers.

If studies with prospective teachers are examined; in Köse and Tanışlı (2014), determining the geometric habits of the classroom teacher candidates studying in the third grade, Bülbül (2016) determined how a learning environment prepared by focusing problem solving of the prospective mathematics teachers contributes to the development of geometric habits of mind; Bülbül and Güven (2019) investigated the relationship between pre-service teachers' geometric habits of mind and mathematics achievement, Bülbül and Güven (2020) investigated how geometric habits of mind elementary mathematics teacher candidates changed from the first year of the university to the last year, Bülbül (2021) it aimed to determine the relationship between prospective teachers' (PTs) beliefs about the geometric habits of the mind and affective factors, gender, grade level and academic achievement. Köse and Tanışlı (2014) collected data using four open-ended geometry problems related to the concepts of environment and space. When the data were analyzed descriptively according to the GHoM theoretical framework, it was seen that the elementary teacher candidates did not have different GHoM components. Bülbül (2016) created a learning environment based on thinking habits by organizing geometry lessons at the undergraduate level in the context of activities and problems that include geometric habits of mind. In line with the research, it was observed that the geometric habits of mind that pre-service teachers had at the end of the application developed according to the geometric habits of mind that they had at the beginning. As a result of his research, Bülbül and Güven (2019) found a positive and significant relationship between the candidate teachers' math lesson scores and the mind's geometric habits tests. Bülbül and Güven (2020) 31 teacher candidates enrolled in a public university, formed the participants of the study using the longitudinal research method. The data were collected with a data collection tool consisting of four open-ended problems covering each geometric habits of mind. As a result of the research, it was found that teacher candidates used their habits of discovery and reflection more

often than the first grade. As a result of the research conducted by Bülbül (2021) with 264 prospective teachers, a positive relationship was found between PTs self-efficacy towards geometry and their beliefs about academic achievement and geometric habits of the mind. In addition, a negative, moderate and significant relationship was found between PTs attitudes towards geometry and their beliefs about geometric habits of the mind.

Studies with teachers are also seen in the national literature. Özen (2015) aimed to determine the development of middle school mathematics teachers' geometric thinking, Tolga and Cantürk-Günhan (2019), the geometric habits of middle school mathematics teachers' mind. Özen (2015) required research as a lesson model. In the 2013-2014 academic year, a five-week seminar process was held with five mathematics teachers working at various schools in the city center of Aydın. In this seminar, the teachers' lecture model was explained with the Geometric Habits of the Mind (GHoM) framework and applications that developed GHoM-based geometric thinking were done. After the lessons, it was found that teachers take geometric habits into account and reflect them in their individual lessons. In the studies of Tolga and Cantürk-Günhan (2019), eight open-ended questions were asked to teachers, including the subcomponents of the geometric habits of the mind. As a result of the research, teachers showed partially similar habits in solving questions; It was observed that they had more difficulty in showing the component of balancing the discovery and reflection than other components. Studies with secondary and high school students are also seen in the national literature. Uygan (2016), in his research, investigated the development of reasoning processes of 7th grade students in the dynamic geometry software (DGS) within the scope of the geometric habits of mind and the relationship between the geometric thinking habits of the tenth grade students and their attitudes towards geometry. Uygan (2016) conducted the research among 21 students in a middle school by selecting six students as focus participants. After the teaching process, it was revealed that the participants constructed different usage schemes for DGS in solving GHoM-based problems and made progress in GHoM components with the help of DGS tools. Erşen (2017) as a result of the research; has reached the finding that attitude towards geometry is a significant predictor of geometric thinking habits. Erşen, Ezentaş and Altun (2018) conducted a quasi-experimental research on the development of 10th grade students' geometric habits of the mind. In the study, it was found that the different teaching performed with the experimental group students contributed to the development of the geometric habits of the mind.

According to the literature described above, researches on the study and development of the GHoM can be seen. Researchs show that the geometric habits of the mind can be developed (Driscoll et al. 2007; Bülbül, 2016). These studies show that the geometric habits of the mind develop when the individuals are approached with the problems in which different components should be used in the teaching process. It is thought that individuals need to move forward in a goal-oriented, willing manner in order to use different components. The success of individuals in solving geometry problems can improve according to the components that affect learning such as self-efficacy, attitude, interest, and ability of the learners. Therefore, it is inevitable for individuals who progress towards the goal and solution-oriented

to use different thinking structures in the solution process due to their high self-efficacy.

In this direction, it is worth investigating how there is a relationship between affective and cognitive factors of learning. When the studies are examined, there is a study investigating the relationship between pre-service teachers' self-efficacy towards geometry and belief in geometric habits of the mind (Bülbül, 2021) and studies investigating the relationship between 10th grade students' geometric habits of mind and their attitudes towards geometry (Erşen, 2017). In the literature, there is no research on whether the self-efficacy towards geometry, which is one of the affective factors for middle school students, affects the use of geometric habits of the mind used in solving geometry problems. The geometric habits of the mind are the habits that individuals use while reaching the result in the process of problem solving. The ability of individuals to solve geometry problems varies according to the mental structures formed in students' minds.

Therefore, the more different students can use the geometric habits of the mind, the more success in problem solving is expected. The higher the self-efficacy of individuals, the higher the act of achievement is expected. Therefore, in this study, it was aimed to investigate the relationship of 7th grade students' self-efficacy towards geometry with the geometric habits of the mind and whether self-efficacy is a predictor of the mind's geometry habits. This research will guide teachers, students and researchers about the geometric habits of the mind and their beliefs about self-efficacy, and shape the teaching environment in this direction.

Method

The study is used to the relational pattern method to determine the relationship between the geometric habits of mind of 7th grade students and their geometric self-efficacy. Relational screening methods; appropriate for research models aimed at examining the presence or degree of co-exchange between two and more variables (Cohen, Manion and Morrison, 2007).

Participants

The research is conducted in the 2018-2019 school year with the participation of a total of 115 secondary school students in seventh grade 62 of whom were female and 53 of whom were male. Participants were determined using the criterion sampling method, one of the purposeful sampling methods, from the branches in a secondary school in the Central Anatolia Region. The criterion used in the selection of students is that students are studying in the 7th grade. The reason for selecting the 7th grades is because; the subjects of subtends and angles, polygons, circles and the appearance of objects from different directions were already studied. Thus, it is possible to examine different problems for the geometric habits of mind.

Data Collection Tools

In the research, the "Geometric Habits of Mind Test" developed by researchers and "Geometry Self-Efficacy Scale" developed by Cantürk-Günhan and Başer (2007) were used as a data collection tool. Information on measuring tools is listed below in subheadings.

Geometric Habits of Mind Test: Geometric Habits of Mind Test was applied to determine the geometric habits of mind of 7th grade secondary school students. This test contains 10 open-ended geometry questions. In order to ensure the validity of the geometric habits of mind test, firstly a pilot study was carried out on the problem of whether the problems in the measuring tool represent the area to be measured. The aim of the pilot study is to determine the items that the Geometric Habits of Mind Test should measure and to develop a reliable and valid measurement tool. While developing the questionnaire, it is considered beneficial to pilot a small group to be selected from the target audience, if possible, in order to evaluate the comprehensibility of the instructions and questions, the response time and the general implementation status before the implementation with the large group (Büyüköztürk et al., 2014). For this reason, the problems in the test were solved with a group of students who were not included in the main research process and in-depth interviews were made about how they solved them. Thus, it was examined whether the problems were compatible with the geometric thinking habits indicators determined by the researcher. In order to ensure the validity of the geometric habits of mind tests, expert opinions were consulted on whether the problems in the measuring tool were suitable for the purpose of measurement and whether they represented the area to be measured. After the pilot study, it was examined and evaluated by two experts according to their consensus and differences of opinion. As a result of the examinations of the experts, it was seen that the two questions were made more understandable and the other questions were more clear and understandable by the students. As a result of their analysis, it was determined that there are problems that reflect the geometric habits of the mind while reading the papers. Then, the language, level, appearance, content and scope validity of the geometric thinking habits test consisting of open-ended problems was obtained by taking the opinions of 2 expert mathematics educators who have completed their doctorate and 4 secondary school mathematics teachers regarding the test.

Each question in the Geometric Habits of Mind Test used in the research requires using one or more of the geometric habits of the mind. While the test was developed for determining the geometric habits of the mind, validity and reliability studies were performed using the Rasch analysis. As a result of the studies, the reliability coefficient of the said data collection tool was found to be 0.76. This coefficient is available in the relevant literature (Büyüköztürk, 2014). Below are the problems in the test which components of GHoM are expected to be used:

The contents of the problems and the geometric habits of the mind in possible solutions are given in Table 2. The definition of possible solutions here is the solution expected from the student. Apart from possible solutions, if the student's solution is different, different thinking habits may arise. In this case, the scoring used in the solution of the problem was made accordingly.

While scoring the evaluated test, it is evaluated on the graded scoring scale by Bülbül (2016) the points she got on a question. With this rating scoring scale, scoring is made depending on how many GHoM components individuals use.

Table 2
Features of the Test of Geometric Habits of the Mind Developed by Researchers

Problem No	Content of the Problem	Geometric Habits of the Mind Trying to Determine for Possible Solutions
1	It is a question to calculate the area of the parallelogram. It is expected to reach the right solution by determining the changing and unchanging features when making a certain transformation.	Reasoning with a relationship and investigating invariants
2	It is an expected problem to reach the generalization of the area calculation by making use of the diagonal lengths of the quadrilaterals.	Reasoning with a relationship and exploration and reflection
3	It is a problem to discover the number of pi by comparing the circumference and diameter length based on the radius and circumference of the circles.	Reasoning with a relationship and generalizing geometric ideas
4	Uniform polygons are expected to reach the rules about the properties of polygons depending on the number of edges.	Reasoning with a relationship and generalizing geometric ideas
5	It is a problem to calculate the number of edges according to the outer angle of regular polygons.	Reasoning with a relationship, generalizing geometric ideas and investigating invariants
6	When parallelogram is created from a given rectangle, it is a problem based on determining the changes in height, perimeter and area measurements.	Generalizing geometric ideas component and investigating invariants
7	According to the views of the building, which is formed with unit cubes, it is desired to see how the structure is.	Reasoning with a relationship
8	It is expected to find the height of the prism by making use of the unit cubes in the base plane of a given rectangular prism.	Reasoning with a relationship, investigating invariants and exploration and reflection
9	It is a problem that a trapezoidal shape is desired to calculate the area. It is expected to reach the right solution by making additional drawing into the slate by making use of the properties that do not change.	Reasoning with a relationship, investigating invariants and exploration and reflection
10	It is a problem that it is desired to calculate the area size and determine the change in the area according to the base length of the slab and the length of the height.	Reasoning with a relationship, generalizing geometric ideas and investigating invariants

Geometry Self-Efficacy Scale: The Geometric Self-Efficacy Scale consisting of 25 items; it was developed by Cantürk-Günhan and Başer (2007). Each level of quality expressed by each of the items that make up the scale is created with a five-point Likert-type scale. To determine the structural validity of the scale, Kaiser Meyer (0.89) and Barlet analysis [$p < .01$] were used. Based on this result, the scale was detected to consist of three factors using the Varimax rotation technique. Twelve of the substances were included in the factor "Positive Self-Efficacy Beliefs", six in "Use of Geometry Knowledge" and seven in "Negative Self-Efficacy Beliefs". The internal consistency level of the scale is calculated as 0.87 with the Cronbach Alpha value, while the Cronbach Alpha value calculated for this research is 0.76.

Data Analysis

In the study, 7th grade students' "Geometric Habits of Mind Test" scores were used in the graded scoring scale developed by Bülbül (2016). The scores according to the rating scoring scale was determined as follows (Bülbül, 2016):

0 Point: If no habit was used, 0 point was obtained.

1 Point: Only 1 habit was used, but if the correct solution could not be reached, 1 point was obtained.

2 Point: If more than one habit was used, if no solution was reached, 2 point was obtained.

3 Point: If the solution of the problem was reached by using one and more habits, 3 point was obtained.

According to the GHoM components, the highest score that students can get from the developed scale is 30 and the lowest score is 0. Below were the answers given by a student to the fourth problem in the test. The correct solution had been reached with the generalization component by using the reasoning component between the number of edges of the polygons given in the solution and the dimensions. The student had reached the right solution by using the geometrical habit of more than one mind. For this reason, the student got 3 points from this problem. In this way, each problem was scored according to the scoring scale.

4. Below is a table based on the number of sides of a regular polygon. Find the requested information by filling out the table.

Regular polygon	Number of sides	The number of triangles formed by a diagonal	Sum of interior angles	An inside angle measure	An outside angle measure
Square	4	2	360°	90°	90°
Regular pentagon	5	3	540°	108°	72°
Regular hexagon	6	4	720°	120°	60°
….	…..	…..	…..	…..	….
n-gene	n	n-2	(n-2).180°	$\frac{(n-2).180°}{n}$	$\frac{360°}{n}$

Figure 1. Sample evaluation of a student's answers

The data were analyzed in SPSS 20.00 statistics program according to the students' scores obtained from the tests. To be able to determine the relationship between students' geometric habits of mind and their geometric self-efficacy, Simple Linear Correlation Analysis (Pearson Correlation Coefficient) was used and to demonstrate the power of geometric self-efficacy over geometric habits of mind, Simple Regression analysis was used.

Results

The data collected in the research are analyzed and the results are explained in the following tables in order.

Table 3
Descriptive Analysis of the Scores Obtained From the Geometric Habits of Mind Test

Variable	N	Lowest	Highest	Mean	ss
Geometric Habits of Mind	115	3	28	15.32	5.61

When we look at the data in Table 3, it is observed that the average score of the students from the "Geometric Habits of Mind Test" scale is (15.32). Considering this, it can be said that students' geometric thinking habits success is moderate.

Table 4
Descriptive Analysis of the Scores Obtained From the Geometric Self-Efficacy Scale

	Mean	*Standard deviation*	*N*
Positive self-efficacy beliefs	46.33	8.45	115
Negative self-efficacy beliefs	19.43	5.68	115
Use of Geometry Knowledge	21.59	4.55	115
Geometric Self-Efficacy	87.60	12.807	115

According to the data in Table 4, the average of the scores obtained by the students from the components of the Geometry Self-Efficacy Scale is the average of "Positive Self-Efficacy Beliefs" (46.33), the average of "Negative Self-Efficacy Beliefs" (19.43), "Use of Geometry Knowledge" the average of the scores was calculated as (21.59).

Table 5
Pearson Product Moment Multiplication Correlation Analysis Results Between 7th Grade Students' Geometric Habits of Mind Test and Their Geometric Self-Efficacy Scale Scores

Dependent Variables		Positive Self-Efficacy Beliefs	Negative Self-Efficacy Beliefs	Use of Geometry Knowledge
Geometric Habits of Mind	r	.282	.158	.086
	N	115	115	115
	P	.002	.092	.360

As shown in Table 5, Pearson Product Moments Multiplication Correlation analysis results were presented for the evaluation of the relationship between "Geometric Habits of Mind Test" scores and "Geometry Self-Efficacy Scale" scores. Accordingly, between "Geometric Habits of Mind Test" and "Positive Self-Efficacy Beliefs" ($r = .282$) were found to have a positively low correlation, and the relationship was statistically significant ($p < .05$). Moreover between "Geometric Habits of Mind Test" and "Negative Self-Efficacy Beliefs" ($r = .158$), between "Geometric Habits of Mind Test" and "Use of Geometry Knowledge" ($r = .086$) were found to have a positively low correlation, but the relationship was not statistically significant ($p > .05$).

The results of the regression analysis for the question "Is the geometric self-efficacy of the students a meaningful predictor of their geometric habits of the mind?" are included in Table 6.

Table 6
Simple Regression Analysis for Estimating Geometric Habits of Mind

Independent Variable	B	Standard error	t	F	R	R^2	p
				10,040	.286	.082	
Stable	4.356	3.497	1.246				0.216
Geometric Self-Efficacy	0.125	0.040	3.169**				0.002**

N=115; **p<.01

As presented in the table, as a result of simple regression analysis, it has been seen that the self-efficacy belief towards geometry has the power to predict the geometric habits of the mind .082. In addition to Simple Regression Analysis, Multiple Regression Analysis was also performed in order to demonstrate the power that the lower dimensions of the attitude scale have over to predicting the geometric thinking habit.

In this context, Multiple Regression Analysis results of "Positive Self-Efficacy Beliefs", "Use of Geometry Knowledge" and "Negative Self-Efficacy Beliefs" are included in Table 7.

Table 7
Standard Multiple Regression Analysis Results for Predicting the Geometric Habits of Mind

	B	Standard Error	β	T	P	Binary r	Partial R
Stable	4.632	3.568	-	1.298	0.068	-	-
Positive Self-Efficacy Beliefs	0.190	0.067	0.285	2.813	0.953	0.282	0.258
Negative Self-Efficacy Beliefs	0.136	0.090	0.137	1.504	0.361	0.158	0.141
Use of Geometry Knowledge	-0.34	0.125	-0.027	-0.268	0.124	0.086	-0.025
R= 0.316 $F_{(3,111)}$=4.098	R^2=0.100 p=0.008						

According to the Table 7, when the partial and binary correlations between the predictive variables and the dependent variable are examined, there is a positive and low-level relationship between the "Geometric Habits of Mind Test" scores and the "Positive Self-Efficacy Beliefs" (r = 0.282), and when the other variables are checked, the correlation between the two variables is calculated as R=0.258. There is a positive low level (r = 0.158) relationship between "Negative Self-Efficacy Beliefs" and "Geometric Habits of Mind Test" scores. When other variables are checked, it is seen that the correlation between the two variables is calculated as R = 0.141. There is a positive and low level (r = 0.086) relationship between the "Use of Geometry

Knowledge" and the "Geometric Habits of Mind Test". When the other two variables are controlled, it is seen that the correlation between the variables is negative and low R = -0.025.

As a result of the analysis, it was found that there was a significant relationship between the variables of "Positive Self-Efficacy Beliefs", "Using Geometry Knowledge", "Negative Self-Efficacy Beliefs" and scores of the "Geometric Habits of Mind Test" ($p = .008 < .01$). It is seen that the sub-dimensions of self-efficacy towards geometry significantly predicted the geometric habits of the mind. ($R^2 = 0.100$, $p = .008 < .01$). The power of self-efficacy towards geometry to predict the geometric habits of the mind is 0.100 and 10% of the geometric habits of mind score can be explained by the scores the students got from the geometry self-efficacy scale.

Conclusions and Discussion

When the 7th grade students' average scores for their self-efficacy and geometric habits of the mind tests were examined, it was observed that the scores they received from the scales were moderate. In the geometry-oriented self-efficacy scale, it can be said that students' average success on the "Positive Self-Efficacy Beliefs" and "Use of Geometry Knowledge" tests is high and their average success on the "Negative Self - Efficacy Beliefs" test is moderate. When the studies in the literature are examined, it is seen that the scores of the self-efficacy scores for geometry and the scores of the measurements of the geometric habits of the mind are average and above. The reason for the average scores of the students' self-efficacy towards geometry and its sub-dimensions to be medium and high may be that students can see the equivalence of geometric shapes more easily in daily life and nature. Seeing the equivalent of geometry in daily life more easily and making concrete examples may have been effective in the medium and high level of self-efficacy beliefs towards geometry. Duatepe-Paksu (2013); Erkek and Işıksal-Bostan (2015) stated that self-efficacy evaluations for geometry are moderate in support of the outcome of our study. Berkant and Çadırlı (2019); in their research, they found that secondary school students' self-efficacy belief scores for geometry were above the arithmetic average. In the study of Erşen (2017) with 10th grade students, the fact that students reach the finding that the average of geometrical habits test scores of the mind is at a medium level supports the research result.

A low level of positive correlation was found between the "Geometric Habits of Mind Test" scores where the geometric habits of the mind were investigated and the scale scores where the geometric self-efficacy belief was investigated. This means that the students' "Positive Self-Efficacy Beliefs", "Use of Geometry Knowledge" and "Negative Self-Efficacy Beliefs" increase in parallel with their "Geometric Habits of Mind Test" scores. Between the geometric habits of the mind and the belief in geometric self-efficacy, the two variables also low affect each other. Accordingly, student studies to improve the geometric habits of the mind will positively affect the self-efficacy towards geometry. In the literature, there is no research in which geometric habits of mind and geometric self-efficacy are used together at secondary school level. In the study conducted by Bülbül (2021), the relationship between pre-service teachers' self-efficacy towards geometry and their beliefs about the factors affecting their geometric thinking habits was investigated. A positive and significant

relationship was found between pre-service teachers' self-efficacy towards geometry, their academic achievement and their beliefs about the factors affecting their geometric thinking habits. When other studies in the literature are examined, studies to examine the geometric habits of the mind and its self-efficacy towards geometry were conducted with separate variables. The results we have found here contribute to the studies investigating the relationship between self-efficacy and other theories developed for geometric thinking at different points. Yenilmez and Korkmaz (2013), found that there was a statistically significant and positively low correlation between geometric self-efficacy and Van - Hiele geometric thinking levels. In our study, a positive and low level relationship was found between "Positive Self-Efficacy Beliefs", "Using Geometry Knowledge" and geometric thinking levels, and no significant relationship was found in the "Negative Self-Efficacy Beliefs" sub-dimension. The positively low-level relationship between the "Positive Self-Efficacy beliefs" and "Use of Geometry Knowledge" sub-dimensions are similar to the relationship between the geometric habits of the mind and its sub-dimensions. Similarly in a study by Deringöl (2020), examined the relationship between mathematics lecture notes with visual competence and self-efficacy towards geometry and reached a meaningful relationship between them. A significant relationship was found between the quality of middle school students' notes during the mathematics course and their self-efficacy perceptions of visual mathematics literacy and self-efficacy towards geometry. Other studies have shown that geometric thinking habits are associated with affective factors such as belief, attitude, and self-efficacy (Bülbül, 2016; Costa and Kallick, 2000).

Another finding that we've found as a result of this research was whether geometric self-efficacy belief was a predictor of the geometric habits of the mind. As a result of the analysis, it was found that the power of geometric self-efficacy to procedure the geometric habits of the mind was 0.100. 10% of the score on the "Geometric Habits of Mind Test" is explained by the scores students receive on their geometric self-efficacy scale. According to this finding, the success of self-efficacy predicts the geometric habits of the mind slightly. This suggests that the students' geometric self-efficacy beliefs should develop from an early age. The value of the predictive power reached according to the research result, if the belief in self-efficacy had been developed, the mind might have had a stronger hold on its geometric habits. Also, this finding can differ according to the sampling group and measurement instruments. Therefore, geometric self-efficacy belief's power over geometric habits of the mind can be explored through studies with students at different levels. In the literature, in a study conducted with 10th grade students, it is seen that attitude towards geometry, one of the affective factors, is a significant predictor of geometric thinking habits (Erşen, 2017). This finding shows that as students' attitudes towards geometry increase, their success in geometric thinking habits also increases. In other studies, it was stated that geometric thinking habits are related to affective dimensions such as belief, attitude and self-efficacy (Bülbül, 2016; Bülbül, 2021; Costa and Kallick, 2000; Marzano, Pickering and McTighe, 1993).

Suggestions

When we look at the studies in the literature, there are a limited number of studies that determine the geometric thinking habits of students (Bülbül, 2016; Bülbül and Güven, 2019; Bülbül and Güven, 2020; Bülbül and Güler, 2021; Özen, 2015; Driscoll et al., 2007; Driscoll et al., 2008; Goldenberg, Cuoco and Mark, 1998). It is thought that increasing the studies on this subject will be effective in determining the reasons for the students' failures in geometry and increasing their success in geometry. Another conclusion is that there are a limited number of studies examining students' geometric self-efficacy together with other variables in both national and international studies (Bindak, 2004; Özkeleş-Çağlayan, 2010); so in this context, it is thought that qualitative and quantitative researches examining the geometric habits of the mind and self-efficacy towards geometry, which is an important branch of mathematics, should be increased. While this research is carried out with 7th grade students, similar studies can be conducted with students at different levels of education. However, in this research, only the self-efficacy of affective dimensions that affect geometric thinking habits is dealt with. In future studies, the relation of the geometric habits of the mind with different cognitive or sensory dimensions can be examined. As a result of the research, a low level of significant correlation was found between self - efficacy and GHoM. By conducting experimental research with different teaching methods, the change of both variables and the relationship between them can be examined.

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Araştırmanın Etik Taahhüt Metni

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