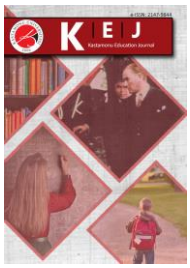
**Kastamonu Education Journal**, 2024, Vol. 32, No: 2, 370-382
doi: 10.24106/kefdergi.1473681



|Research Article / Araştırma Makalesi|

# Examination of Inquiry Learning Skills toward Geometry in terms of Various Variables

# Geometriye Yönelik Sorgulayıcı Öğrenme Becerilerinin Çeşitli Değişkenler Bağlamında İncelenmesi[1]

**Diler KEDİKLİ[2], Yasemin KATRANCI[3]**

**Keywords**
1. Geometry
2. Inquiry learning skills
3. Middle-schoolers

**Anahtar Kelimeler**
1. Geometri
2. Sorgulayıcı öğrenme becerileri
3. Ortaokul öğrencileri

**Received/Başvuru Tarihi**
30.04.2023

**Accepted / Kabul Tarihi**
16.03.2024

## Abstract

*Purpose:* Questioning, discovering, generalizing, verifying, and disproving are fundamental aspects of geometry teaching. As seen, the inquiry is at the geometry's core. According to this, inquiry learning toward geometry is a student-centered learning process that allows the student to construct geometric information and to create permanent learning by actively using inquiring skills such as hypothesizing, proving, and disproving in the geometry learning process. To see this process in detail, the purpose of this study is to examine middle-schoolers' levels of inquiry learning skills toward geometry, as well as their relationship to various variables.

*Design/Methodology/Approach:* In the survey model, 312 middle school students participated in the study. Data were collected using the Inquiry Learning Skills Scale for Geometry and Demographic Information Form.

*Findings:* It has been determined that middle-schoolers have a high level of inquiry learning skills toward geometry. As a result, inquiry learning skills toward geometry were found to significantly differ by gender, father's educational status, year-end achievement score, asking questions, using materials in the lesson, and associating geometry with daily life. However, there was no significant difference between these skills and the grade level and mother's education status.

Highlights: By using concrete abstract materials or models related to daily life in lessons, teachers can attract students' interest, arouse curiosity in students, and encourage students to use and develop their inquiry learning skills. In addition to educational activities at school, parents can contribute to the development of certain skills such as observation and questioning by creating opportunities for their children to participate in scientific activities at home or in their social environment and exposing them to different stimuli.

## Öz

*Çalışmanın Amacı:* Geometri öğretiminin temel unsurları arasında; sorgulama, keşfetme, genelleme, doğrulama ve aksini ispatlama yer almaktadır. Görüldüğü gibi sorgulama geometrinin özündedir. Bu öze göre geometriye yönelik sorgulayıcı öğrenme, öğrencinin geometri öğrenme sürecinde hipotez kurma, ispatlama ve aksini ispatlama gibi sorgulama becerilerini aktif bir şekilde kullanarak geometrik bilgileri zihinde yapılandırmasına ve kalıcı öğrenmeler oluşturmasına olanak sağlayan öğrenci merkezli bir öğrenme sürecidir. Bu süreci detaylı olarak görebilmek adına bu çalışmada, ortaokul öğrencilerinin geometriye yönelik sorgulayıcı öğrenme beceri düzeylerinin belirlenmesi ve bu becerilerin çeşitli değişkenler açısından incelenmesi amaçlanmıştır.

*Materyal ve Yöntem:* Çalışma genel tarama modelinde 312 ortaokul öğrencisi ile yürütülmüştür. Veriler, Geometriye Yönelik Sorgulayıcı Öğrenme Becerileri Ölçeği ve Demografik Bilgi Formu ile toplanmıştır.

*Bulgular: S*onuçta; ortaokul öğrencilerinin geometriye yönelik yüksek düzeyde sorgulayıcı öğrenme becerilerine sahip oldukları belirlenmiştir. Geometriye yönelik sorgulayıcı öğrenme becerileri ile cinsiyet, baba eğitim durumu, yılsonu başarı puanı, soru sorma, materyal kullanımı ve günlük yaşamla ilişkilendirme arasında anlamlı bir farkın olduğu sonucu elde edilirken bu beceriler ile sınıf seviyesi ve anne eğitim durumu arasında anlamlı bir fark yoktur.

*Önemli Vurgular:* Öğretmenler derslerde somut-soyut materyaller ya da günlük yaşamla ilgili modeller kullanarak öğrencilerin ilgilerini çekebilir, öğrencide merak uyandırabilir ve bu sayede öğrencileri sorgulayıcı öğrenme becerilerini kullanmaya ve geliştirmeye teşvik edebilir. Okuldaki eğitim-öğretim faaliyetlerinin yanı sıra ebeveynler evde ya da sosyal çevrelerinde çocuklarının bilimsel aktivitelere katılmaları için fırsatlar yaratıp onları farklı uyaranlara maruz bırakmak yoluyla gözlem yapma ve soru sorma gibi birtakım becerilerinin gelişimine katkıda bulunabilir.

[1] This study was produced from a master's thesis titled *"Examination of middle school students' inquiry learning skills toward geometry"* prepared by Diler KEDİKLİ under the supervision of Yasemin KATRANCI.

[2] Ministry of National Education, Elazığ, Turkiye; https://orcid.org/0000-0003-3868-8050

[3] **Corresponding Author:** Kocaeli University, Faculty of Education, Department of Mathematics and Science Education, Kocaeli, Turkiye; https://orcid.org/0000-0002-0916-2407

**Citation/Alıntı:** Kedikli, D., & Katrancı, Y. (2024). Examination of inquiry learning skills toward geometry in terms of various variables. *Kastamonu Education Journal, 32*(2), 370-382. doi: 10.24106/kefdergi.1473681

## INTRODUCTION

Geometry explicitly or implicitly includes a seeing process, which includes several stages that start with physical-neural skills and continue with higher cognitive skills (such as conceptual thinking, reasoning, deduction, and inference) (Gal & Linchevski, 2010). In the curriculum published by the Ministry of National Education (MoNE) for the mathematics course for teaching these few stages, it is emphasized that students are active participants in the mathematics learning process (MoNE, 2018a). The reason for this is that geometry is excluded from mathematics courses in schools in our country and is taught as a separate course. Similarly, it is urgently recommended that the traditional geometry teaching model be changed to one that is more beneficial for teachers and students. Specifically, it is recommended to provide opportunities to explore geometry to enable students to understand the subject in depth and in connection with other areas of mathematics (Mensah-Wonkyi & Adu, 2016). In the geometry learning process, it should be emphasized that students are directed to produce hypotheses, conduct experiments, and obtain results to answer the hypothesis (Salim & Tiawa, 2015). Moreover, questioning, discovering, generalizing, verifying, and proving the contrary are essential elements in the study and teaching of Euclidean geometry (Soldano et al., 2019). As it can be seen, since questioning is at the core of geometry, inquiry learning should be focused on in geometry teaching. Studies in the literature emphasize the effect of inquiry learning on learning mathematics and geometry (Erbaş & Yenmez, 2011; Ferguson, 2010; Kandil & Işıksal-Bostan, 2019; Katrancı & Şengül, 2020; Novák & Nováková, 2014). Mensah-Wonkyi and Adu (2016), on the other hand, emphasized the importance of the inquiry learning strategy for students, stating that students who learn by questioning are more successful than those who memorize. Inquiry prompts students to think and gets them used to asking themselves questions. Thus, arousing interest and curiosity in students reveals the importance of inquiry in learning and teaching (Tanışlı, 2013). From this point of view, it is valuable to consider inquiry learning not only as a teaching strategy but also as a learning strategy. Thus, it is important to investigate students' inquiry learning skills levels and under which variables these skills differ. Salim and Tiawa (2015) state that the structured inquiry model supports the active and creative participation of students in the processes of researching, examining, and developing geometry concepts and principles. Thus, it is stated that it encourages students to develop intellectual skills in problem-solving. Hardianti et al. (2017) emphasized that the process-oriented guided inquiry model is one of the learning models that can improve geometric thinking skills. With this encouragement and emphasis, inquiry learning toward geometry needs to be addressed in detail. In the curriculum and assessment standards report for school mathematics by the National Council of Teachers Mathematics (NCTM), it is stated that geometry education at the $5^{th}$-$8^{th}$ grade level connects the processes that start informally in the preschool period to the formal processes at the $9^{th}$-$12^{th}$ grade level (NCTM, 1989). From this point of view, geometry education in middle school, which acts as a bridge between pre-school and high school education, contains a very critical period for students. In this context, it was considered important to examine the inquiry learning skills of middle-schoolers toward geometry. With this importance and necessity, this study focuses on inquiry learning about geometry in the context of various variables.

### Inquiry Learning Toward Geometry (ILTG)

Inquiry is a way of thinking and approaching new knowledge (Gillon & Stotter, 2011). In this way, inquiry learning is a student-centered learning and teaching method (Gençtürk & Türkmen, 2007) in which students are introduced to mathematical and scientific inquiry methods (Maaß & Artigue, 2013). It is considered an integral aspect of problem-solving (Laxman, 2013). Inquiry learning skills enable students to ask questions and form hypotheses for solutions, design experimental setups to realize their hypotheses, perform data collection recording steps, analyze the data obtained because of this process, and construct knowledge themselves (Balım et al., 2008). Through inquiry skills, students are encouraged to recognize problems, make assumptions, test assumptions, develop proofs or solutions, and explain their ideas in the context of mathematics (Kogan & Laursen, 2014). Inquiry learning toward geometry can be defined as a student-centered learning process that enables students to construct geometric knowledge in their minds and create permanent learning by actively using inquiry skills such as hypothesizing, proving, and disproving in the geometry learning process (Kedikli, 2022). Within the framework of all these definitions, inquiry learning for geometry is an active learning process in which students construct geometric knowledge in their minds by questioning geometric knowledge and using various inquiry skills such as hypothesizing and proving. It is thought that analyzing these skills in the context of various variables will help us understand them better.

### Inquiry Learning Toward Geometry and Various Variables

It is usual for inquiry learning skills to be affected positively or negatively by various variables and to affect lifelong learning (İnel-Ekici, 2017). Considering the importance of inquiry learning in mathematics and therefore geometry education and the importance of inquiry skills in this process, it is important to determine the inquiry learning skills toward geometry and to determine to what extent they are affected by which variables. Nehring et al. (2015) stated that different personal characteristics of students may contribute to a higher manifestation of scientific inquiry skills. These variables can be considered as some demographic characteristics of individuals, such as gender and parental education status. In fact, some studies show that gender has become a factor affecting students' learning outcomes in mathematics due to the biological differences between male and female brains (Erawati, 2020). This situation in mathematics is also valid for geometry at the middle school level. This is because geometry topics at this level are within the scope of the mathematics course. In addition, it is usual to think that the individual's experience of cognitive processes will increase as his/her age progresses and the grade level changes

accordingly. Eccles (2005), on the other hand, argues that there is a link between the educational level of the parents and the achievement of the children indirectly through the effect of family income, where the family can live and the occupation of the parents as possible consequences of this. As stated before, geometry is within the scope of middle school mathematics courses. In this context, the cognitive and affective processes that students have about geometry can be predicted through mathematics achievement. It is possible to say that geometry includes inquiry learning skills by its nature. Soldano et al. (2019) also mentioned that inquiry, discovery, generalization, verification, and refutation are the basic elements of Euclidean geometry. In this light, it is possible to examine the relationship between students' mathematics achievement and their inquiry learning skills toward geometry. On the other hand, inquiry is about asking questions and being curious, and the ability to ask questions is the basis of inquiry learning (Delcourt & McKinnon, 2011). Inquiry learning is considered by Perry and Richardson (2001) as searching and analyzing information by asking questions and transforming the collected data into meaningful information. In this context, it can be assumed that it would not be possible to separate students' asking questions in the lesson from inquiry learning skills. On the other hand, the results of the studies show that the use of materials in mathematics lessons enables the acquisition of skills such as learning by exploring and experimenting as well as geometry achievement, self-efficacy, and attitude (Baki & Özpınar, 2007; Demir, 2019; Okuyucu & Erdoğan, 2021; Yaman & Şahin, 2014). Enriching mathematics lessons with various materials (concrete materials, dynamic software, etc.) and associating them with situations from daily life positively contribute to geometry achievement (Adelabu et al., 2019; Alkhateeb & Al-Duwairi, 2019; Chan & Leung, 2014; Doğan & İçel, 2011; Ganesan & Eu, 2020; Güven, 2012; Zengin et al., 2012). It is usual to think that learning environments supported in this way can motivate a sense of curiosity in students and thus create a tendency to question. In this direction, it is important to investigate students' inquiry learning skills toward geometry in the context of differentiation according to the use of materials in lessons and associating geometry with daily life. The following studies are available in the relevant literature.

### Literature Review

Studies examining middle-schoolers, prospective teachers, and teachers' levels of inquiry skills, as well as the factors that influence these skills, can be found in the literature (Abalı-Öztürk et al., 2017; Al-Afifi & Ambusaidi, 2014; Aldan-Karademir et al., 2019; Alkış-Küçükaydın, 2020; Balbağ & Aynur, 2020; Bedir, 2017; Elmalı & Yıldız, 2017; Evren, 2012; Gümüşdağ & Aydoğan, 2020; Işık, 2011; İnel-Ekici, 2017; Okumuş & Yetkil, 2020; Öner, 2019; Şahin et al., 2017; Vekli, 2021; Yavuz et al., 2018; Yılmaz & Karamustafaoğlu, 2015). In their study, Al-Afifi and Ambusaidi (2014) examined the relationship between the levels of inquiry and logical thinking skills of 182 tenth-grade students studying in Oman and the gender-related differences among students. The data of the study were collected using the Inquiry Skills Test. The results show that tenth-grade students have very low levels of both inquiry skills. In addition, it was found that there was a significant difference in favor of girls in activity and experiment design skills and in favor of boys in interpretation skills. Gençtürk and Türkmen (2007) stated that the achievement of the students who were educated with the inquiry method was higher than that of the students who were educated with the traditional method, and these students were more likely to participate in science lessons. This study aimed to investigate the inquiry learning skill levels of middle-schoolers toward geometry and to examine these skills according to various variables (gender, grade-level, mother's (MES) and father's (FES) education status, year-end mathematics achievement score (MAS), asking questions in lessons, and using materials in mathematics lessons). The sub-problems sought to be answered in line with the aim of the study are as follows:

1. What is the level of middle-schoolers' inquiry-learning skills toward geometry?
2. Do middle-schoolers' inquiry learning skills toward geometry differ in terms of various variables (gender, grade level, parental education levels, year-end mathematics achievement score, asking questions in lessons, and using materials)?

## METHOD/MATERIALS

Survey research is the description of situations, events, or variables in nature without any external intervention (Tuncer, 2020). In this type of research, the researcher collects data to determine certain characteristics (attitudes, ideas, etc.) of a universe. In this context, the survey research describes, defines, and reveals what is what and generalizations are made for the universe (Hocaoğlu & Akkaş-Baysal, 2019). This study was conducted using the survey model in line with its purpose.

### Participants

Convenient sampling, a type of purposive sampling, was used to determine the group that would be included in the study. In this sampling, the researcher takes the sampling elements that he/she can easily reach (Özen & Gül, 2007). The participants consisted of middle-schoolers studying in three different public schools in the province where one of the researchers was working. 26.28% (N=82), 25.96% (N=81), 25.00% (N=78), and 22.75% (N=71) of the students were studying in the fifth, sixth, seventh, and eighth grades, respectively. In addition, 49.35% (N=154) of the students were female and 50.64% (N=158) were male. Therefore, 312 middle-schoolers participated in the study.

### Data Collection Tools and Obtaining Data

Data for this research were collected using the Inquiry Learning Skills Scale for Geometry (ILSSG) and the Demographic Information Form (DIF). The DIF includes questions about students' gender, grade level, parental education status, year-end

mathematics achievement scores, their questioning in mathematics lessons, the effect of using materials in mathematics lessons, and associating geometry with daily life on their questioning (yes/no). The data collected through this form constitute the independent variables in determining middle-schoolers' inquiry learning skills toward geometry.

The ILSSG developed by Kedikli and Katrancı (2022) is organized in a five-point Likert type and includes 12 items. The scale consists of two factors: positive perceptions toward inquiry (PTI+) and negative perceptions toward inquiry (PTI-). Cronbach's alpha (CA) coefficients for the factors and the whole scale are 0.785, 0.635, and 0.818, respectively. In cases where a scale developed in a previous study is used, repeating the confirmatory factor analysis (CFA) is recommended (Orçan, 2018). In this context, CFA was repeated in this study, and CA coefficients were calculated. When the findings of the CFA were analyzed, the $X^2$/df ratio (1.80≤2.50), NFI value (0.92≥0.90), NNFI value (0.95≥0.95), and CFI value (0.96≥0.95) is interpreted as excellent fit (Kline, 2005; Sümer, 2000; Thompson, 2004). The RMSEA value (0.05≤0.07), RMR value (0.07<0.08) and SRMR value (0.05<0.08) indicate good fit (Brown, 2006; Steiger, 2007). Based on the CFA findings, it was proved that the scale showed good/excellent fit, and the factors of the scale were confirmed for this study. CA coefficients of the scale were calculated as 0.726, 0.631, and 0.756 for the factors and the whole scale, respectively. In this context, the scale was proven to be highly valid and reliable (Yıldız & Uzunsakal, 2018), and it was decided that it was appropriate to use it for this study.

The data of this research were obtained in the 2020-2021 academic year, between the first and third weeks of March, using ILSSG and DIF during a class hour (30') deemed appropriate for pandemic conditions. In this framework, data were collected from 442 middle-schoolers studying in three different public middle schools. After the data were collected, 130 scales that were left unanswered, incompletely filled, or randomly marked were not included in the study in order not to negatively affect the validity and reliability of the data.

## Data Analysis

The IBM SPSS Statistics 20 package program was used in the data analysis process, and the significance level was set as 0.05. The mean scores of the students from The ILSSG were evaluated as 1.00-1.80 very weak, 1.81-2.60 weak, 2.61-3.40 medium, 3.41-4.20 high, and 4.21-5.00 very high according to the range they were in. The normality of the data was examined with the Kolmogorov-Smirnov test because the dataset was more than 50 (p=0.004<.05) and it was decided to continue the study with nonparametric tests. In this context, the Mann Whitney-U (MW-U) test was conducted to investigate the difference between the measurement results of two unrelated groups, including gender, the effect of asking questions in mathematics lessons, the use of materials in mathematics lessons, and the effect of associating geometry with daily life on asking questions (Kilmen, 2015). In the analyses performed for the variables of grade level, parental education status, and year-end mathematics achievement score, the Kruskal Wallis-H (KW-H) test was used to determine whether there was a significant difference between the measurement results of more than two unrelated groups. In case of a difference in the tests, effect sizes were calculated. In the interpretation of the calculated effect sizes, r=0.1 was considered as low, r=0.3 as medium and r=0.5 as large (Cohen, 1988; quoted from Kilmen, 2015).

## FINDINGS

The data obtained because of the analyses conducted to determine the level of inquiry learning skills of middle-schoolers toward geometry are shown in Table 1.

**Table 1. ILSTG levels**

| | N | $\bar{X}$ | df | Min. | Max. |
|---|---|---|---|---|---|
| PTI+ | 312 | 3.74 | 0.6 | 1.67 | 5.00 |
| PTI- | 312 | 3.68 | 0.7 | 1.60 | 5.00 |
| ILSSG | 312 | 3.69 | 0.6 | 1.83 | 5.00 |

The mean score of middle-schoolers' inquiry learning skills toward geometry is 3.69, as shown in Table 1. It is noted that the mean PTI+ factor score is 3.74, whereas the mean PTI- factor score is 3.68. Table 2 shows the MW-U test findings regarding the gender differential of middle-schoolers' inquiry learning skills toward geometry.

**Table 2. ILSTG and gender**

| | Gender | N | Mean Rank | Total Rank | U | Z | p |
|---|---|---|---|---|---|---|---|
| PTI+ | F | 154 | 170.59 | 26271.50 | 9995.500 | -2.735 | .006 |
| | M | 158 | 142.76 | 22556.50 | | | |
| PTI- | F | 154 | 183.89 | 28319.50 | 7947.500 | -5.314 | .000 |
| | M | 158 | 129.80 | 20508.50 | | | |
| ILSSG | F | 154 | 181.27 | 27915.50 | 8351.500 | -4.793 | .000 |
| | M | 158 | 132.36 | 20912.50 | | | |

According to Table 2, inquiry learning skills toward geometry, both in the factors and in the whole scale, differ significantly according to gender. The mean ranks of female students are higher both in the whole scale and in the factors. When the effect size of this difference was analyzed, it was seen that gender had a moderate effect on inquiry learning skills toward geometry

(p<.05; r=0.27<0.30). In Table 3, the results of the KW-H test are shown in relation to the differentiation of middle schoolers' inquiry learning skills toward geometry by grade level.

**Table 3. ILSTG and grade level**

| | Grade Level | N | Mean Rank | df | $X^2$ | p |
|---|---|---|---|---|---|---|
| PTI+ | 5 | 82 | 189.26 | 3 | 22.104 | .000 |
| | 6 | 81 | 164.37 | | | |
| | 7 | 78 | 142.53 | | | |
| | 8 | 71 | 125.04 | | | |
| PTI- | 5 | 82 | 174.35 | 3 | 6.685 | .083 |
| | 6 | 81 | 162.23 | | | |
| | 7 | 78 | 142.23 | | | |
| | 8 | 71 | 145.02 | | | |
| ILSSG | 5 | 82 | 185.52 | 3 | 16.910 | .001 |
| | 6 | 81 | 164.11 | | | |
| | 7 | 78 | 140.92 | | | |
| | 8 | 71 | 131.42 | | | |

According to Table 3, the PTI+ factor and the whole scale varied significantly according to the grade level of middle schoolers. Rank averages revealed that fifth grade students had the highest scores in both factors and the whole scale. When the effect size of the difference in the overall scale was examined, it was determined that the grade level variable affected the inquiry learning skills toward geometry at a moderate level (p<.05; r=0.22<0.30). The KW-H test was used to test whether middle-schoolers' inquiry learning skills toward geometry differed in terms of their MES. The findings are presented in Table 4.

**Table 4. ILSTG and MES**

| | MES | N | Mean Rank | df | $X^2$ | p |
|---|---|---|---|---|---|---|
| PTI+ | Illiterate | 14 | 161.57 | 4 | 4.095 | .393 |
| | Primary School (PS) | 108 | 157.25 | | | |
| | Middle School (MS) | 120 | 147.42 | | | |
| | High School (HS) | 59 | 175.11 | | | |
| | University | 11 | 142.00 | | | |
| PTI- | Illiterate | 14 | 185.68 | 4 | 9.936 | .042 |
| | PS | 108 | 160.62 | | | |
| | MS | 120 | 138.35 | | | |
| | HS | 59 | 173.14 | | | |
| | University | 11 | 187.68 | | | |
| ILSSG | Illiterate | 14 | 184.29 | 4 | 7.308 | .121 |
| | PS | 108 | 156.90 | | | |
| | MS | 120 | 142.59 | | | |
| | HS | 59 | 177.20 | | | |
| | University | 11 | 157.86 | | | |

Table 4 shows that middle-schoolers' positive perceptions toward inquiry and their inquiry learning skills toward geometry do not differ in terms of their MES. However, there is a difference in the PTI- factor according to the MES. The effect of this difference was found to be quite low (p<.05; r=0.004<0.10). The findings regarding the examination of middle-schoolers' inquiry learning skills toward geometry in the context of FES are shown in Table 5.

**Table 5. ILSTG and FES**

| | FES | N | Mean Rank | df | $X^2$ | p |
|---|---|---|---|---|---|---|
| PTI+ | Illiterate | 3 | 115.50 | 4 | 13.663 | .008 |
| | PS | 64 | 154.93 | | | |
| | MS | 109 | 134.40 | | | |
| | HS | 103 | 174.36 | | | |
| | University | 33 | 180.52 | | | |
| PTI- | Illiterate | 3 | 191.33 | 4 | 10.980 | .027 |
| | PS | 64 | 149.69 | | | |
| | MS | 109 | 144.89 | | | |
| | HS | 103 | 157.53 | | | |
| | University | 33 | 201.67 | | | |
| ILSSG | Illiterate | 3 | 163.50 | 4 | 13.231 | .010 |
| | PS | 64 | 154.96 | | | |
| | MS | 109 | 135.65 | | | |
| | HS | 103 | 167.06 | | | |
| | University | 33 | 194.76 | | | |

According to Table 5, it is seen that middle-schoolers' inquiry learning skills toward geometry differ in both factors and the whole scale according to their father's education status. According to the mean ranks, the students with the highest mean ranks in both factors and in the whole scale are the children of university graduate fathers. The effect of the difference obtained was determined to be at a low level (p<.05; r=0.13<0.30). The test findings obtained according to the year-end mathematics achievement score of middle-schoolers' inquiry learning skills toward geometry are given in Table 6.

**Table 6. ILSTG and MAS**

| | MAS | N | Mean Rank | df | $X^2$ | p |
|---|---|---|---|---|---|---|
| PTI+ | 55-69 | 73 | 129.55 | 2 | 23.888 | .000 |
| | 70-84 | 90 | 135.46 | | | |
| | 85-100 | 149 | 182.41 | | | |
| PTI- | 55-69 | 73 | 126.62 | 2 | 20.633 | .000 |
| | 70-84 | 90 | 141.85 | | | |
| | 85-100 | 149 | 179.99 | | | |
| ILSSG | 55-69 | 73 | 123.79 | 2 | 31.695 | .000 |
| | 70-84 | 90 | 133.67 | | | |
| | 85-100 | 149 | 186.31 | | | |

According to Table 6, middle-schoolers' inquiry learning skills toward geometry differ significantly on the whole scale and in both factors. According to the rank averages, the group with the highest score was the students whose year-end mathematics achievement score was between 85 and 100. The effect of this difference was found to be significant (p=<.05; r=0.308<0.50). The findings obtained according to the inquiry learning skills of middle-schoolers toward geometry in terms of asking questions in lessons are presented in Table 7.

**Table 7. ILSTG and asking questions during lessons**

| | Asking questions | N | Mean Rank | Total Rank | U | Z | p |
|---|---|---|---|---|---|---|---|
| PTI+ | Yes | 209 | 166.20 | 34736.50 | 8735.500 | -2.717 | .007 |
| | No | 103 | 136.81 | 14091.50 | | | |
| PTI- | Yes | 209 | 165.42 | 34572.00 | 8900.000 | -2.496 | .013 |
| | No | 103 | 138.41 | 14256.00 | | | |
| ILSSG | Yes | 209 | 168.20 | 35153.50 | 8318.500 | -3.266 | .001 |
| | No | 103 | 132.76 | 13674.50 | | | |

When Table 7 is analyzed, it is seen that according to the answers given by middle-schoolers, their positive-negative perceptions toward inquiry and their inquiry learning skills toward geometry differed significantly in the context of asking questions in the lessons. The effect of this difference was found to be at a low level (p<.05; r=0.18<0.30). In addition, the mean ranks of the students who stated that they asked questions were higher. The findings related to the differentiation level of middle-schoolers' inquiry learning skills toward geometry according to whether their teachers use materials in mathematics lessons are shown in Table 8.

**Table 8. ILSTG and the use of materials in mathematics lessons**

| | Use of Materials | N | Mean Rank | Total Rank | U | Z | p |
|---|---|---|---|---|---|---|---|
| PTI+ | Yes | 103 | 180.20 | 18560.50 | 8322.500 | -3.270 | .001 |
| | No | 209 | 144.82 | 30267.50 | | | |
| PTI- | Yes | 103 | 177.67 | 18299.50 | 8583.500 | -2.920 | .004 |
| | No | 209 | 146.07 | 30528.50 | | | |
| ILSSG | Yes | 103 | 182.89 | 18837.50 | 8045.500 | -3.631 | .000 |
| | No | 209 | 143.50 | 29990.50 | | | |

When Table 8 is analyzed, it was found that the positive-negative perceptions of the middle-schoolers toward inquiry and their inquiry learning skills toward geometry differed significantly according to their teachers' use of materials in the lessons. The effect of the difference obtained for the overall scale was found to be at a moderate level (p<.05; r=0.20<0.30). According to the rank averages, the scores of the students who stated that they asked more questions when materials were used in the lessons were higher. The findings related to the determination of whether the inquiry learning skills of middle-schoolers toward geometry differ according to the association of geometry with daily life are shown in Table 9.

**Table 9. ILSTG and associating geometry with daily life**

| | Association | N | Mean Rank | Total Rank | U | Z | p |
|---|---|---|---|---|---|---|---|
| PTI+ | Yes | 148 | 183.08 | 27095.50 | 8202.500 | -4.963 | .000 |
| | No | 164 | 132.52 | 21732.50 | | | |
| PTI- | Yes | 148 | 173.70 | 25707.00 | 9591.000 | -3.210 | .001 |
| | No | 164 | 140.98 | 23121.00 | | | |
| ILSSG | Yes | 148 | 182.99 | 27082.00 | 8216.000 | -4.932 | .000 |
| | No | 164 | 132.60 | 21746.00 | | | |

According to Table 9, the answers of middle-schoolers show that their positive-negative perceptions of inquiry and their inquiry learning skills of geometry differ significantly according to whether geometry is associated with daily life in the lessons. On the other hand, when the rank averages are analyzed, the scores of the students who stated that they asked more questions when geometry was associated with daily life in the lessons were higher. Associating lessons with daily life has a moderate effect ($p<.05$ $r=0.27<0.30$) on inquiry learning skills toward geometry.

## RESULT and DISCUSSION

Because of the analyses, middle-schoolers' inquiry learning skills toward geometry were found to be at a high level. When the literature was examined, no results were encountered regarding the inquiry learning skill levels of middle-schoolers toward geometry. However, Aldan-Karademir et al. (2019) found that the inquiry skills of prospective teachers studying in various programs were above the medium level. Tanışlı (2013) examined the inquiry skills of prospective elementary mathematics teachers and pointed out that they were not at a sufficient level. In the literature, the results of studies with prospective teachers show that inquiry skills are good/high level and positive (Abalı-Öztürk et al., 2017; Balbağ & Aynur, 2020; Bedir, 2017; Şahin et al., 2017; Yavuz et al., 2018; Yılmaz & Karamustafaoğlu, 2015). Katrancı and Şengül (2020) concluded that middle-schoolers' inquiry learning skills toward mathematics were high. It is a remarkable result that inquiry skills and inquiry learning skills were evaluated as moderate/good/high/sufficient in studies in the literature although the samples of these vary. In this context, it can be interpreted that the relevant results of this study support the literature. In addition, in most studies, inquiry skills were examined in the context of prospective teachers and in the field of science. However, it is important to consider inquiry learning not only as a teaching strategy in the field of science but also as a geometry learning strategy. In addition, it is obvious that there is a lack of exemplary studies in the literature on geometry. In this context, in terms of discussing the results and contributing to the literature and considering the possibility that today's students are the teacher candidates of the future, it is thought that it is important to diversify the studies and to take measures in line with the results. On the other hand, although students' inquiry learning skills toward geometry were found to be high in this study, the results of our country's large-scale international exams, PISA (Programme for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study), as well as the High School Transition System (LGS) exam in mathematics are not very encouraging (MoNE, 2015; 2019; 2020). This may be because the results regarding inquiry learning skills for geometry were obtained from students' own perceptions.

It was found that middle-schoolers' inquiry learning skills toward geometry differed significantly in favor of female students. When the related literature is examined, it is encountered with studies in which results are obtained that gender variable has no effect on inquiry learning skills (Abalı-Öztürk et al., 2017; Evren, 2012; Öner, 2019; Şahin et al., 2017; Yılmaz & Karamustafaoğlu, 2015). In addition to these studies, there are studies in which inquiry/inquiry learning skills differ according to gender. The results of these studies also vary. In some related studies, it was concluded that the significant difference was in favor of girls (Balbağ & Aynur, 2020; Çakmak et al., 2016; Gümüşdağ & Aydoğan, 2020; Işık, 2011; İnel-Ekici, 2017; Katrancı & Şengül, 2020; Vekli, 2021). However, although there are some studies, results in favor of men have also been obtained in some studies. For example, Nehring et al. (2015) reported that boys performed better than girls in the inquiry. In a significant part of the studies conducted with prospective teachers in the literature, it is noteworthy that the inquiry skills of female prospective teachers are higher than those of male prospective teachers. This result was also found in studies conducted with middle school students. This shows that the related results of this study are supported by the literature. In addition, this result coincides with the results of studies examining the relationship between gender and different variables in geometry (Armstrong, 1981; Özcan, 2020). Gümüşdağ and Aydoğan (2020) stated that because of the more active participation of female students in the learning process, they can work in harmony with each other, communicate well with their teachers, and they think that this situation leads to their perception of inquiry skills more than male students. In addition, it can be thought that female students are more interested and curious about the lessons; their attitudes differ from those of male students; therefore, their perceptions of inquiry learning skills are higher than those of male students. It was observed that as the grade level increased, middle-schoolers' positive perceptions toward inquiry and their inquiry learning skills toward geometry decreased. When the related literature is examined, it is noticed that there are studies that do not overlap with the results of this study and that the results that inquiry/inquiry learning skills do not differ significantly based on class variable (Elmalı & Yıldız, 2017; Öner, 2019; Yılmaz & Karamustafaoğlu, 2015). However, on the contrary, it can be said that the number of studies containing the results that these skills differ significantly depending on the grade level is higher (Aldan-Karademir et al., 2019; Balbağ & Aynur, 2020; Bedir, 2017; Işık, 2011; İnel-Ekici, 2017; Okumuş & Yetkil, 2020; Şahin et al., 2017). It can be said that the results of the studies conducted with middle-schoolers (Işık, 2011; Katrancı & Şengül, 2020; Okumuş & Yetkil, 2020) are in parallel with the result of this study regarding the decrease in inquiry learning skills as the grade level increases. Doğan et al. (2020) stated in their study that the development of understanding toward scientific inquiry starts in primary school years. In this direction, it can be said that the fact that there is no difference according to grade level shows that the education given to students in middle schools does not contribute to their inquiry learning skills. Vekli (2021) listed three factors that may have caused this result. The first is the complexity of the subjects, which depends on the grade level and the difficulty of students in questioning abstract concepts. Second, due to the complexity of the subjects, inquiry-based activities are less included in the learning process. Third, it is summarized as students spending time on multiple-choice test-type questions rather than on inquiry-based activities such as experiments and research. At this point, it can be said that the students' sense of curiosity diminished as they got older during

middle school education. Various interpretations can be made, such as that this feeling is not supported by teachers or that the system blunts the tendency toward inquiry in students. To investigate the reasons underlying this situation and to take the necessary measures, more comprehensive studies, especially qualitative and quantitative studies, can be conducted in a mixed design. It can be conducted with students selected from different grade levels, and the variables that cause this result can be analyzed to contribute to the literature.

There was a difference in the PTI- factor of middle-schoolers between students whose mothers graduated from middle school and high school, with the difference favoring students whose mothers' education status was high school. In addition, a significant difference was found in the whole scale and factors according to the father's education status. In the literature, it is seen that Aldan-Karademir (2013) found no significant difference in the inquiry skills of prospective teachers in terms of the mother's education status. According to the father's education status, there was no difference in the sub-dimensions of acquiring knowledge and controlling knowledge, but there was a difference in the sub-dimension of self-confidence. It is a result obtained in the studies in the literature that inquiry skills do not differ in terms of parents' education status (Balbağ & Aynur, 2020; Çakmak et al., 2016). On the other hand, results have also shown that these skills change according to the educational level of the parents (İnel-Ekici, 2017; Vekli, 2021). The results of this study coincide with those of the studies in which differences were obtained. It is usual for students' attitudes, achievement, self-efficacy, and similar situations to differ according to their parents' educational level. In the studies, it is seen that a father's educational level causes a statistically significant difference (Kaba et al., 2016; Kaba & Özdişci, 2018). This may be because parents with a higher level of education approach their children more consciously or support their tendency to ask questions/inquiry in daily life. In this context, it is important for parents to be interested in their children's educational activities regardless of their educational level.

It is among the results reached in the literature that inquiry skills vary according to academic achievement (Çakmak et al., 2016; İnel-Ekici, 2017; Katrancı & Şengül, 2020; Vekli, 2021). In this context, the results of the studies are parallel to the relevant result of this study. Nehring et al. (2015) stated that cognitive variables play an important role in predicting inquiry skills. Furthermore, research in the literature has revealed a positive relationship between inquiry learning and academic achievement (Abdi, 2014; Korkman & Metin, 2021; Uzezi & Zainab, 2017). Based on the results of the studies, it can be said that inquiry learning increases student achievement. In this context, the ability of students who gain inquiry learning skills in the inquiry learning process to use these skills effectively may have enabled them to learn better and increase their success. Katrancı and Şengül (2020) also considered this situation of students with high academic achievement as a natural consequence of the fact that their levels of conceptual learning and making connections between concepts are superior to other students in the context of problem-solving and evaluating the results. In addition, Almeida (2012) mentioned that students' low levels of inquiry and explanation are associated with low achievement.

It was observed that the inquiry learning skills of middle-schoolers differed significantly according to their level of questioning. It was noticed that the mean scores of the students who stated that they asked questions in the lessons were higher. Students' ability to ask inquiring questions to their teachers will enable them to be active learners and increase their academic success. Questions are seen as the essence of inquiry-based learning and are considered to be at the center of the general learning process (Becker, 2000). In this context, it can be accepted that students who express that they ask more questions have high inquiry learning skills. It can be thought that students' endeavor to obtain information by asking questions when they are confused or curious about learning improves their inquiry learning skills. Kazeni et al. (2018) emphasized that low performance in questions related to inquiry skills indicates that students lack high-level thinking skills. In this context, it can be said that this statement can explain the high level of inquiry learning skills of students who stated that they asked questions. Kong (2015) suggests that students should be exposed to inquiry-based assessment questions more frequently to experience the process of scientific inquiry more naturally. On the other hand, Kazeni et al. (2018) stated that the use of ineffective teaching and learning methods may partially explain the low performance in questions related to inquiry skills. In parallel, Van Zee et al. (2001) found that students asked more questions in a classroom environment where inquiry-based activities were included. From this perspective, it is predicted that exposing students to inquiry-based activities or questions in the lessons will be useful in developing inquiry learning skills.

Middle-schoolers' asking questions differed significantly according to the use of materials in the lessons. İnan (2006) stated that mathematics teaching with traditional methods is aimed at helping students find answers to questions with a single predetermined correct answer. In addition, it is claimed that a narrow and closed environment is presented while investigating the solutions to the questions. On the other hand, it is stated that instructional materials provide students with open and enquiring environments and thus provide the opportunity to work freely. In this case, it can be considered that the lessons supported by the materials attracted the attention of the students who were bored with the monotonous lesson environment and that the students were exposed to different stimuli in these environments. In addition, it can be thought that they can be more flexible; in some cases, they can try to make sense of the material and thus ask more questions. For this reason, it can be said that students use inquiry learning skills more frequently in lessons where materials are used. Tang et al. (2019) stated that inquiry-based teaching strategies require students to actively use experimental materials and associate new knowledge with their daily lives outside school. It is assumed that students' inquiry skills can be increased by using materials in lessons.

The findings show that middle-schoolers' inquiry learning skills toward geometry differ significantly depending on whether geometry is associated with daily life in the courses. It is possible to say that associating geometry, which consists of abstract

concepts, with daily life arouses a sense of connection, desire to understand, and curiosity in students, and this situation creates the urge to ask questions in students. MoNE (2018b) also states that the most important power that encourages individuals to learn is the sense of curiosity. As the variety of associations with daily life increases during the lesson, it can be thought that the situations that the student needs to construct and associate in his/her mind will increase, and in parallel, inquiry situations may develop. In this context, it can be accepted that making associations is important for the development of inquiry learning skills.

## FUTURE DIRECTIONS

In addition to collecting data with ILSSG, interviews (such as activity-based interviews, semi-structured interviews, etc.) can be conducted with students to examine their inquiry learning skills toward geometry. The records of the relevant interviews can be analyzed, and evaluations can be made in the context of content analysis.

To explain the relationship between gender variables and inquiry learning skills, qualitative analyses can be carried out by conducting studies designed with appropriate methods where qualitative data can be obtained.

To determine the reasons for the negative change in inquiry learning skills depending on the change in grade level and to determine the variables that cause students to regress in terms of inquiry learning skills, the curriculum, mathematics textbooks, and even the problem situations and instructions in the textbooks can be examined with an appropriate method such as content analysis, and a report on the current situation can be presented.

The study can be repeated at different grade levels and with different samples, and by conducting studies enriched with qualitative methods as well as quantitative approaches, the results related to inquiry learning skills can be diversified and contributed to the literature to discuss the results and bring new views to the field.

## LIMITATIONS AND RECOMMENDATIONS

In this study, in which students' inquiry learning skills toward geometry were examined, the results were reached by interpreting the quantitative data obtained from students' perceptions. This situation can be considered a limitation of the study. In addition, the study was limited to 442 students who participated in the study. Studies can be conducted with larger samples.

#### Recommendations for teachers considering the relevant results of the study

By using concrete-abstract materials or models related to daily life in lessons, teachers can attract students' interest, arouse curiosity in students, and thus encourage students to use and develop their inquiry learning skills.

Teachers can encourage other students to ask questions through their attitudes toward students who frequently ask questions in lessons. In addition, it can be thought that the teacher's knowledge of the technique of asking questions in the lessons can be useful in setting an example for the students. In some cases, students can be motivated to think of creative questions by directing them to ask questions to the class in the role of the teacher.

#### Recommendations for parents

In addition to educational activities at school, parents can contribute to the development of certain skills such as observation and questioning by creating opportunities for their children to participate in scientific activities at home or in their social environment and exposing them to different stimuli.

In addition, parents can make students question the geometric shapes, objects, and concepts they encounter to acquire a basic level of inquiry skills for learning geometry. For example, awareness can be aroused with concepts from daily life such as which geometric object a refrigerator is similar to, which geometric shape can be associated with the shape of a pizza, why the square paper is given that name, or what distinguishes a matchbox from a tennis ball.

## Declaration of Conflicting Interests

There are no conflicts of interest.

## Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

## Statements of Publication Ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been carefully observed.

## Researchers' Contribution Rate

All authors contributed equally to this article.

## Ethics Committee Approval Information

Ethical permission (11/11/2020-10017888-100) was obtained from the Kocaeli University, Science and Engineering Sciences Ethics Committee institution for this research.

## REFERENCES


Abalı-Öztürk, Y., Bilgen, Z., & Bilgen, S. (2017). Sorgulama becerileri ile kendi kendine öğrenme becerileri arasındaki ilişki: Temel eğitim öğretmen adaylarına yönelik bir araştırma. *Sinop Üniversitesi Sosyal Bilimler Dergisi, 1*(2), 179-214.

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

Adelabu, F. M., Makgato, M., & Ramaligela, M. S. (2019). The importance of dynamic geometry computer software on learners' performance in geometry. *Electronic Journal of E-Learning, 17*(1), 52-63.

Al-Afifi, M., & Ambusaidi, A. (2014). The relationship between level of inquiry skills and logical thinking abilities among tenth grade Omani students. *An-Najah University Journal of Research (Humanities), 28*(11), 2521-2556.

Aldan-Karademir, Ç. (2013). *Öğretmen adaylarının sorgulama ve eleştirel düşünme becerilerinin öğretmen öz yeterlik düzeyine etkisi* [Yayımlanmamış doktora tezi]. Adnan Menderes Üniversitesi.

Aldan-Karademir, Ç., Çaylı, B., & Deveci, Ö. (2019). Öğretmen adaylarının sorgulama becerileri ile meraklılık düzeylerinin incelenmesi. *İlköğretim Online, 18*(3), 1157-1171.

Alkhateeb, M. A., & Al-Duwairi, A. M. (2019). The effect of using mobile applications (GeoGebra and Sketchpad) on the students' achievement. *International Electronic Journal of Mathematics Education, 14*(3), 523-533.

Alkış-Küçükaydın, M. (2020). Sınıf öğretmeni adaylarının sosyobilimsel konulara yönelik tutumları ile sorgulama becerileri arasındaki ilişkinin incelenmesi. *Milli Eğitim Dergisi, 49*(225), 181-200.

Almeida, P. A. (2012). Can i ask a question? The importance of classroom questioning. *Procedia-Social and Behavioral Sciences, 31*, 634-638.

Armstrong, J. M. (1981). Achievement and participation of women in mathematics: Results of two national surveys. *Journal for Research in Mathematics Education, 12*(5), 356-372.

Balbağ, M. Z., & Aynur, D. (2020). Fen bilgisi öğretmen adaylarının sorgulama becerilerinin bazı değişkenler açısından incelenmesi. *Uluslararası Sosyal Alan Araştırmaları Dergisi, 9*(1), 48-62.

Baki, A., & Özpınar, İ. (2007). Logo destekli geometri öğretimi materyalinin öğrencilerin akademik başarılarına etkileri ve öğrencilerin uygulama ile ilgili görüşleri. *Çukurova Üniversitesi Eğitim Fakültesi Dergisi,* 3(34), 153-163.

Balım, A. G., İnel, D., & Evrekli, E. (2008). Fen öğretiminde kavram karikatürü kullanımının öğrencilerin akademik başarılarına ve sorgulayıcı öğrenme becerileri algılarına etkisi. *İlköğretim Online, 7*(1), 188-202.

Becker, R. R. (2000). The critical role of students' questions in literacy development. *Educational Forum, 64*(3), 261-271.

Bedir, T. (2017). *Öğretmen adaylarının sorgulama becerileri ile üstbilişsel farkındalık düzeylerinin incelenmesi* [Yayımlanmamış yüksek lisans tezi]. Bartın Üniversitesi.

Brown, T. A. (2006). *Confirmatory factor analysis for applied research* (1st ed.). Guilford.

Chan, K. K., & Leung, S. W. (2014). Dynamic geometry software improves mathematical achievement: Systematic review and meta-analysis. *Journal of Educational Computing Research, 51*(3), 311-325. https://doi.org/10.2190/EC.51.3.c

Çakmak, Z., Taşkıran, C., & Bulut, B. (2016). A study on the inquiry skills of social studies teacher candidates. *International Journal of Learning and Teaching, 2*(1) 58-62.

Delcourt, M. A., & McKinnon, J. (2011). Tools for inquiry: Improving questioning in the classroom. *Learning Landscapes, 4*(2), 145-159.

Demir, Ö. (2019). *Geometrik cisimlerin öğretiminde somut materyal kullanımının öğrencilerin başarısına, tutumlarına ve öz-yeterliğine etkisi* [Yayımlanmamış yüksek lisans tezi]. Bartın Üniversitesi.

Doğan, N., Han-Tosunoğlu, Ç., Özer, F., & Akkan, B. (2020). Ortaokul öğrencilerinin bilimsel sorgulama görüşleri: Cinsiyet, sınıf düzeyi ve okul türü değişkenlerinin incelenmesi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 49*, 162-189. https://doi.org/10.9779/pauefd.515080

Doğan, M., & İçel, R. (2011). The role of dynamic geometry software in the process of learning: GeoGebra example about triangles. *Journal of Human Sciences, 8*(1), 1441-1458.

Eccles, J. S. (2005). Influences of parents' education on their children's educational attainments: The role of parent and child perceptions. *London Review of Education, 3*(3), 191-204.

Elmalı, Ş., & Yıldız, E. (2017). Fen bilgisi öğretmen adaylarının sorgulama becerileri, epistemolojik inançları ve öğrenme stilleri. *Adnan Menderes Üniversitesi Eğitim Fakültesi Eğitim Bilimleri Dergisi, 8*(2), 92-108.

Erawati, N. K. (2020, September 20-21). Mathematics learning outcomes based on gender in the inquiry learning model [Conference presentation]. *3rd International Conference on Innovative Research across Disciplines*. Bali, Indonesia.

Erbaş, A. K., & Yenmez, A. A. (2011). The effect of inquiry-based explorations in a dynamic geometry environment on sixth grade students' achievements in polygons. *Computers & Education, 57*(4), 2462-2475.

Evren, B. (2012). *Fen ve teknoloji öğretiminde sorgulayıcı öğrenme yaklaşımının öğrencilerin sahip oldukları eleştirel düşünme eğilim düzeylerine ve fen ve teknoloji dersine yönelik tutumlarına etkisi* [Yayımlanmamış yüksek lisans tezi]. Adnan Menderes Üniversitesi.

Ferguson, K. (2010). *Inquiry based mathematics instruction versus traditional mathematics instruction: The effect on student understanding and comprehension in an eighth grade pre-algebra classroom* [Unpublished master thesis]. Cedarville University.

Gal, H., & Linchevski, L. (2010). To see or not to see: Analyzing difficulties in geometry from the perspective of visual perception. *Educational Studies in Mathematics, 74*(2), 163-183.

Ganesan, N., & Eu, L. K. (2020). The effect of dynamic geometry software geometer's sketchpad on students' achievement in topic circle among form two students. *Malaysian Online Journal of Educational Technology*, *8*(2), 58-68.

Gençtürk, H. A., & Türkmen, L. (2007). İlköğretim 4. sınıf fen bilgisi dersinde sorgulama yöntemi ve etkinliği üzerine bir çalışma. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 27*(1), 277-292.

Gillon, K., & Stotter, J. (2011). Inquiry learning with senior secondary students: Yes it can be done! *Access*, *25*(3), 14-19.

Gümüşdağ, H., & Aydoğan, M. (2020). Examination of questioning skills of students in physical education and sports schools in terms of some variables. *The Online Journal of Recreation and Sports*, *9*(2), 36-48.

Güven, B. (2012). Using dynamic geometry software to improve eight grade students' understanding of transformation geometry. *Australasian Journal of Educational Technology, 28*(2), 364-382.

Hardianti, D., Priatna, N., & Priatna, B. A. (2017). Analysis of geometric thinking students' and process-guided inquiry learning model. *Journal of Physics: Conference Series, 895*(1), 012088.

Hocaoğlu, N., & Akkaş-Baysal, E. (2019). Nicel araştırma modelleri-desenleri. İçinde G. Ocak (Ed.), *Eğitimde bilimsel araştırma yöntemleri* (s. 66-119). Pegem.

Işık, G. (2011). *İlköğretim 6., 7. ve 8. sınıf öğrencilerinin öğrenme stilleri ile öğrencilerin sorgulayıcı öğrenme becerileri arasındaki ilişkinin belirlenmesi* [Yayımlanmamış yüksek lisans tezi]. Adnan Menderes Üniversitesi.

İnan, C. (2006). Matematik öğretiminde materyal geliştirme ve kullanma. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 7*, 47-56.

İnel-Ekici, D. (2017). Ortaokul öğrencilerinin bilimsel sorgulama becerileri algılarını etkileyen faktörlerin incelenmesi. *Kastamonu Eğitim Dergisi, 25*(2), 497-516.

Kaba, Y., Boğazlıyan, D., & Daymaz, B. (2016). Ortaokul öğrencilerinin geometriye yönelik tutumları ve öz-yeterlikleri. *The Journal of Academic Social Science Studies, 52*(Winter-I), 335-350. http://dx.doi.org/10.9761/JASSS3727

Kaba, Y., & Özdişci, S. (2018, Nisan 18-22). Ortaokul öğrencilerinin görsel matematik okuryazarlığı öz-yeterlik algıları ile geometriye yönelik tutumları arasındaki ilişki [Bildiri sunumu]. *27. Uluslararası Eğitim Bilimleri Kongresi (ICES-UEBK)*, Antalya, Türkiye.

Kandil, S., & Işıksal-Bostan, M. (2019). Effect of inquiry-based instruction enriched with origami activities on achievement, and self-efficacy in geometry. *International Journal of Mathematical Education in Science and Technology, 50*(4), 557-576. https://doi.org/10.1080/0020739X.2018.1527407

Katrancı, Y., & Şengül, S. (2020). Ortaokul öğrencilerinin matematiğe yönelik sorgulayıcı öğrenme becerilerinin problem çözmeye yönelik sorgulama, değerlendirme, nedenleme ve yansıtıcı düşünme becerileri açısından değerlendirilmesi. *Eğitim ve Bilim, 45*(201), 55-78. http://dx.doi.org/10.15390/EB.2020.7765

Kazeni, M., Baloyi, E., & Gaigher, E. (2018). Effectiveness of individual and group investigations in developing integrated science inquiry skills. *South African Journal of Education, 38*(3), 1-12.

Kedikli, D. (2022). *Ortaokul öğrencilerinin geometriye yönelik sorgulayıcı öğrenme becerilerinin incelenmesi* [Yayımlanmamış yüksek lisans tezi]. Kocaeli Üniversitesi.

Kedikli, D., & Katrancı, Y. (2022). Inquiry learning skills in geometry: A scale development. *Acta Didactica Napocensia, 15*(1), 61-73. https://doi.org/10.24193/adn.15.1.6

Kilmen, S. (2015). *Eğitim araştırmaları için SPSS uygulamalı istatistik* (2. bs.). Edge.

Kline, R. B. (2005). *Principles and practice of structural equation modeling* (2nd ed.). Guilford.

Kogan, M., & Laursen, S. L. (2014). Assessing long-term effects of inquiry-based learning: A case study from college mathematics. *Innovative Higher Education, 39*(3), 183-199.

Kong, Y. T. (2015). Application of inquiry-based science assessment in Korean elementary students (I). *International Information Institute (Tokyo), 18*(5(A)), 1623-1630.

Korkman, N., & Metin, M. (2021). The effect of inquiry-based collaborative learning and inquiry-based online collaborative learning on success and permanent learning of students. *Journal of Science Learning, 4*(2), 151-159.

Laxman, K. (2013). Infusing inquiry-based learning skills in curriculum implementation. *International Journal for Lesson and Learning Studies, 2*(1), 41-55.

Maaß, K., & Artigue, M. (2013). Implementation of inquiry-based learning in day-to-day teaching: A synthesis. *ZDM: The International Journal of Mathematics Education, 45*(6), 779-795.

Mensah-Wonkyi, T., & Adu, E. (2016). Effect of the inquiry-based teaching approach on students' understanding of circle theorems in plane geometry. *African Journal of Educational Studies in Mathematics and Sciences, 12*, 61-73.

Millî Eğitim Bakanlığı (MEB) (2015). *Uluslararası öğrenci değerlendirme programı PISA 2015 ulusal raporu.* MEB Ölçme Değerlendirme ve Sınav Hizmetleri Genel Müdürlüğü, 36-42.

Millî Eğitim Bakanlığı (MEB) (2018a). *Matematik dersi öğretim programı (ilkokul ve ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. sınıflar).* Talim ve Terbiye Kurulu Başkanlığı.

Millî Eğitim Bakanlığı (MEB) (2018b). *Hayat bilgisi dersi öğretim programı (ilkokul 1, 2 ve 3. sınıflar).* Talim ve Terbiye Kurulu Başkanlığı.

Millî Eğitim Bakanlığı (MEB) (2019). PISA 2018 Türkiye ön raporu. *Millî Eğitim Bakanlığı, 10*, 57-78.

Millî Eğitim Bakanlığı (MEB) (2020). TIMSS 2019 Türkiye ön raporu. *Millî Eğitim Bakanlığı, 15*, 33-54.

National Council of Teachers of Mathematics (NCTM) (1989). *Curriculum and evaluation standards for school mathematics*. NCTM.

Nehring, A., Nowak, K. H., zu Belzen, A. U., & Tiemann, R. (2015). Predicting students' skills in the context of scientific inquiry with cognitive, motivational, and sociodemographic variables. *International Journal of Science Education, 37*(9), 1343-1363. https://doi.org/10.1080/09500693.2015.1035358

Novák, B., & Nováková, E. (2014). Inquiry based mathematics education (IBME) and its reflection by primary school teachers. *Scientific Issues of Jan Długosz University in Częstochowa Mathematics, 19*, 121-127.

Okumuş, S., & Yetkil, K. (2020). Ortaokul öğrencilerinin sorgulama becerilerinin değerlendirilmesi. *Bayburt Eğitim Fakültesi Dergisi, 15*(30), 508-526. https://doi.org/10.35675/befdergi.740348

Okuyucu, Ü., & Erdoğan, E. Ö. (2021). Altıncı sınıf matematik dersinde materyal destekli bir öğretim ortamında hacim kavramına giriş. *International Journal of Educational Studies in Mathematics, 8*(2), 77-97. https://doi.org/10.17278/ijesim.828659

Orçan, F. (2018). Exploratory and confirmatory factor analysis: Which one to use first? *Journal of Measurement and Evaluation in Education and Psychology, 9*(4), 413-421. https://doi.org/10.21031/epod.394323

Öner, G. (2019). *Ortaokul öğrencilerinin FETEMM'e yönelik tutum, algı, problem çözme ve sorgulayıcı öğrenme becerileri arasındaki ilişkilerin incelenmesi* [Yayımlanmamış yüksek lisans tezi]. Tokat Gaziosmanpaşa Üniversitesi.

Özcan, B. N. (2020). Sınıf öğretmeni adaylarının matematik ve geometriye karşı tutumları arasındaki ilişkinin incelenmesi. *Türk Eğitim Bilimleri Dergisi, 18*(2), 926-939.

Özen, Y., & Gül, A. (2007). Sosyal ve eğitim bilimleri araştırmalarında evren-örneklem sorunu. *Atatürk Üniversitesi Kazım Karabekir Eğitim Fakültesi Dergisi,* 15, 394-422.

Perry, V. R., & Richardson, C. P. (2001, October 10-13). The New Mexico tech master of science teaching program: An exemplary model of inquiry-based learning [Conference presentation]. *31st ASEE/IEEE Frontiers in Education Conference*. Reno, United States of America.

Salim, K., & Tiawa D. H. (2015). Implementation of structured inquiry based model learning toward students' understanding of geometry. *International Journal of Research in Education and Science (IJRES), 1*(1), 75-83.

Soldano, C., Luz, Y., Arzarello, F., & Yerushalmy, M. (2019). Technology-based inquiry in geometry: Semantic games through the lens of variation. *Educational Studies in Mathematics, 100*(1), 7-23. https://doi.org/10.1007/s10649-018-9841-4

Steiger, J. H. (2007). Understanding the limitations of global fit assessment in structural equation modeling. *Personality and Individual Differences, 42*, 893-898.

Sümer, N. (2000). Structural education models. *Turkish Psychological Articles, 3*(6), 49-74.

Şahin, Ç., Arcagök, S., Çetin, Ş., Mertol, H., & Boran, G. (2017). Sınıf öğretmeni adaylarının sorgulama becerilerinin incelenmesi. *Gazi Eğitim Bilimleri Dergisi, 3*(3), 17-28.

Tang, N. E., Tsai, C. L., Barrow, L., & Romine, W. (2019). Impacts of enquiry-based science teaching on achievement gap between high-and-low ses students: Findings from PISA 2015. *International Journal of Science Education, 41*(4), 448-470. https://doi.org/10.1080/09500693.2018.1555726

Tanışlı, D. (2013). İlköğretim matematik öğretmeni adaylarının pedagojik alan bilgisi bağlamında sorgulama becerileri ve öğrenci bilgileri. *Eğitim ve Bilim, 38*(169), 80-95.

Thompson, B. (2004). *Exploratory and confirmatory factor analysis: Understanding concepts and applications* (1st ed.). American Psychological Association.

Tuncer, M. (2020). Nicel araştırma desenleri. İçinde B. Oral, & A. Çoban (Eds.), *Kuramdan uygulamaya eğitimde bilimsel araştırma yöntemleri* (s. 205-227). Pegem.

Uzezi, J. G., & Zainab, S. (2017). Effectiveness of guided-inquiry laboratory experiments on senior secondary schools students' academic achievement in volumetric analysis. *American Journal of Educational Research, 5*(7), 717-724.

Van Zee, E. H., Iwasyk, M., Kurose, A., Simpson, D., & Wild, J. (2001). Student and teacher questioning during conversations about science. *Journal of Research in Science Teaching, 38*(2), 159-190.

Vekli, G. S. (2021). What factors affect middle school students' perceptions of inquiry learning towards science? *Pedagogical Research, 6*(4), em0108. https://doi.org/10.29333/pr/11301

Yaman, H., & Şahin, T. (2014). Somut ve sanal manipülatif destekli geometri öğretiminin 5. sınıf öğrencilerinin geometrik yapıları inşa etme ve çizmedeki başarılarına etkisi. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 14*(1), 202-220.

Yavuz, G., Arslan, Ç., & Batdal-Karaduman, G. (2018). Matematik öğretmeni adaylarının sorgulama becerileri ile matematik öğretmeye yönelik kaygıları arasındaki ilişki. *Electronic Turkish Studies, 13*(11) 1461-1471. http://dx.doi.org/10.7827/TurkishStudies.13360

Yıldız, D., & Uzunsakal, E. (2018). Alan araştırmalarında güvenilirlik testlerinin karşılaştırılması ve tarımsal veriler üzerine bir uygulama. *Uygulamalı Sosyal Bilimler Dergisi, 1*, 14-28.

Yılmaz, Z., & Karamustafaoğlu, S. (2015). Öğretmen adaylarının sorgulama becerilerinin farklı değişkenler açısından incelenmesi. *Dicle Üniversitesi Ziya Gökalp Eğitim Fakültesi Dergisi, 25*, 347-363.

Zengin, Y., Furkan, H., & Kutluca, T. (2012). The effect of dynamic mathematics software GeoGebra on student achievement in teaching of trigonometry. *Procedia-Social and Behavioral Sciences, 31*, 183-187.