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Research Article

Investigation of the relationship between secondary school students' geometry achievements, anxiety and attitudes towards geometry[1]

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Abstract

In international evaluations of mathematics achievement, it is noted that geometry in terms of achievement has mostly changed over the years. Still, it is a sub-learning field with the lowest scores. The underlying reason for this failure may be the affective characteristics of students such as anxiety and attitude. This research was conducted to examine the geometry achievements, geometry anxieties, and attitudes of secondary school students. The design of the research is quantitative and the model used is the relational screening model. The sample of the research consists of three hundred and forty students who are studying in seventh and eighth grade in private and public schools in Kars in the 2022-2023 academic year. Students were selected using the appropriate sampling method because it is economical in terms of time and accessibility. As data collection tools, the Attitude Scale Towards Geometry at the Secondary School Level, the Geometry Anxiety Scale for Secondary School Students, and the Demographic Information Form containing the personal information of the participants were used. The data collection tools were applied to the students by the researcher after the necessary permissions were obtained. It is indicated that in the research, geometry achievement, anxiety, and attitude do not differ according to gender and class level, but geometry achievement differs according to the state of education of parents. Also, geometry achievement, anxiety, and attitude differ according to the school being taught. When examining the correlations between the variables, it was concluded that there is a negative and significant relationship between geometry attitude and anxiety, as well as between geometry achievement and anxiety, while there is a positive and significant relationship between geometry attitude and success.

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Introduction

The Monitoring and Evaluation of Academic Skills in Turkey (ABİDE) and the Trends in International Mathematics and Science Study (TIMSS) demonstrate that mathematics holds critical importance in assessing students' achievements (Ministry of National Education [MoNE], 2020). Mathematics, as the science of abstract objects/structures, is often perceived by students as complex and difficult to understand. (Işık and Konyalıoğlu, 2005). According to data from the Programme for International Student Assessment (PISA) covering the period from 2003 to 2022, while Turkey's

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mathematics achievement has increased, it has remained below the OECD (Organisation for Economic Co-operation and Development) average. However, in 2022, Turkey's mathematics achievement surpassed the overall average. According to TIMSS data, Turkey has improved its mathematics achievement over time and has come close to the scale average in 8th grade with 496 points (MoNET, 2020). According to ABIDE, the rate of demonstrating below basic and basic proficiency in mathematics among students in Turkey is quite high (ERG, 2020). TIMSS data indicates that geometry has shown slight changes over the years but generally remains an area of weakness (MEB, 2020). Geometry, as a branch that examines shapes and their properties (Kavaklı et al., 2023), includes topics such as lines and angles, polygons, transformation geometry, and circles. Some students express that they enjoy numbers and operations but struggle with geometry. Overall, students understand geometry topics less than other sub-disciplines of mathematics (Yenilmez and Yaşa, 2008). The reason for students' struggles in geometry may be related to their perceptual characteristics, as indicated in TIMSS mathematics achievement (Sarıer, 2020), and may be associated with perceptual characteristics such as attitudes and anxiety towards geometry. Studies have demonstrated a positive relationship between attitude towards geometry and geometry achievement (Özkeleş & Çağlayan, 2010; Ünlü, 2014; Poçan et al., 2020), as well as a negative relationship between geometry anxiety and achievement (Akarca, 2019).

Students often associate mathematics with difficulties they hear from their parents and may develop biases against mathematics before starting school. This situation can lead to the emergence of mathematics anxiety. Cüceloğlu (2003) defines anxiety as a state of mind where negative feelings or fears dominate, the predominant feeling being the belief that something bad will happen. Mathematics anxiety often begins in elementary school and continues for years, causing students to step back from mathematics topics (Şentürk, 2010). Students' mathematics anxieties affect their attitudes towards this course (Şimşek et al., 2017). Attitude is defined as the unique tendency to regulate one's thoughts, feelings, and behaviors towards an object (Özabacı and Yenilmez, 2003). According to another definition, attitude is developing a positive or negative attitude towards an object or situation (Turanlı et al., 2008). Based on these definitions, the reaction developed towards a specific situation can be defined as an attitude, whether positive or negative. Neale (1969) defines mathematics attitude as the desire to solve or avoid a mathematical problem when encountered, whether one likes mathematics or not, and whether one believes mathematics will contribute to us. "Different attitudes can be exhibited towards geometry from mathematical attitude." (Bulut et al., 2002). Bindak (2004) defines geometry attitude as a person's cognitive, behavioral, and emotional approach to issues related to geometry, the geometry teacher, and himself/herself. It is stated that affective characteristics such as mathematics anxiety and attitude are associated with mathematics achievement (Şentürk, 2010). According to the TIMSS 2019 report, students' achievement in geometry, one of the subfields of mathematics, is quite low (MEB, 2020). This failure lies behind students' cognitive and affective characteristics (Ünlü, 2014). Anxiety and attitude toward geometry affect geometry achievement (Özkan, 2010).

Mathematics anxiety can prevent students from fully demonstrating their potential and lead to failure in mathematics. Research shows that mathematics anxiety negatively affects students' mathematics performance (Bekdemir, 2009; Bozkurt, 2012; Sapma, 2013; Al Mutawah, 2015; Barroso et al., 2021). A similar study shows that as mathematics achievement of secondary school students increases, mathematics anxiety decreases (Özabacı and Yenilmez, 2003). Studies investigating the relationship between mathematics anxiety and achievement also bring to mind the relationship between geometry anxiety and geometry achievement. Akarca (2019) developed a scale to measure geometry anxiety for secondary school students. In this study, a negative relationship was found between students' attachment to school and grade point average and geometry anxiety, geometry anxiety did not differ according to parental education level, those who liked mathematics had lower geometry anxiety, girls had higher geometry anxiety than boys, and preschool education was not associated with geometry anxiety. Studies on secondary school students' geometry anxiety are limited to scale development studies (Sağlam et al., 2011; Akarca, 2019). Another affective variable that affects students' educational achievements is attitude. Students who develop a positive attitude towards mathematics are highly likely to be successful in this course (Taşdemir, 2008). In a study conducted by Koca (2011) with 8th-grade students, it was found that mathematics attitude did not differ according to gender, but similar to the conclusion in Şentürk's (2010) study, those satisfied with the mathematics teacher had a more positive attitude towards mathematics, and learning styles

also affected mathematics attitude. Research has shown that as mathematics attitude increases, mathematics achievement also increases (Savaş et al., 2010; Çavdar and Şahan, 2019; Tabuk, 2019). Students often feel fear and dissatisfaction towards geometry (Bulut et al., 2002). This situation has brought research on attitudes toward geometry to the agenda. Significant differences may exist in students' attitudes towards mathematics and geometry (Bulut et al., 2002). Some studies have been conducted to determine attitudes towards geometry (Özdişci and Katrancı, 2019; Bulut et al., 2002). In light of studies indicating the relationship between anxiety and attitude with mathematics achievement, it is evident that geometry achievement is affected by attitude and anxiety variables. However, it is envisaged that it is important to conduct a study in which all variables are considered together to see this situation. Knowing the relationships between these variables will be extremely important to determine the direction and extent to increase students' geometry achievement. It is thought that the relevant study will contribute to the increase in studies on geometry in the literature and encourage researchers in this regard. In this context, the aim of the study is determined as examining the relationships between secondary school students' geometry achievement, anxiety, and attitude towards geometry. In line with this aim, answers were sought to the following problems and sub-problems.

"What is the relationship between secondary school students' geometry achievement, geometry anxiety, and attitude towards geometry?"

Sub-Problems

Is there any relationship between secondary school students' geometry achievement, anxiety, and attitude;

- According to gender
- According to the mother's educational level
- According to the father's educational level
- According to grade level
- According to the school type, is there a significant difference?
- Is there a significant relationship between them?

Method

Research Model

The study aims to investigate the relationships between different variables. Therefore, the research is in quantitative research design, and the relational survey model, one of the survey models, has been chosen to be used in the research. The survey model takes a situation that has been or is currently happening as it is (Bahtiyar and Can, 2017). The relational survey model is a research model that examines how variables can affect a given situation and the degree of relationship between them (Kaya et al., 2012). The relational survey model is used since the level and direction of the relationship between students' existing geometry achievement, anxiety and attitude will be examined in the current study.

Population and Sample

The population of this study consists of all 7^{th} and 8^{th} grade students in the province of Kars. The sample of this study consists of 340 students studying in the 7^{th} and 8^{th} grades from 8 secondary schools in the center of Kars province. The studied sample was selected using the convenience sampling method for its time efficiency and easy accessibility (Büyüköztürk et al., 2012). According to Piaget, children enter the stage of abstract thinking from the age of 11, and they grasp abstract concepts better during this period (Karaşan, 2019). 7^{th} and 8^{th} grade students, who have already encountered geometry were considered suitable for the research since it is thought that students in the abstract thinking phase will be more aware of abstract concepts like anxiety and attitude, and how these concepts reflect in geometry.

Table 1. Frequency values of variables

Variables	Categories	f	%
Gender	Girl	176	51,8
	Boy	164	48,2
Grade	7	174	51,2
	8	166	48,8
School Type	Private	64	18,8
	Public	276	81,2
Mother's Educational level	Illiterate	8	2,4
	Primary School	72	21,2
	Secondary School	80	23,5
	High School	98	28,8
	University	59	17,4
	Postgraduate	23	6,8
Father's Educational Level	Illiterate	6	1,8
	Primary School	47	13,8
	Secondary School	56	16,5
	High School	95	27,9
	University	98	28,8
	Postgraduate	38	11,2
Total		340	100

When examining Table 1, it is observed that 51.8% of the sample consists of girls and 48.2% consists of boys. The majority of the sample is made up of female students. When looking at the sample distribution by grade level, 51.2% of the sample consists of 7th graders, while 48.8% consists of 8th graders. The number of 7th grade students is higher. When classified by school type, 18.8% of the sample attends private schools, while 81.2% attends public schools. The largest portion of the sample consists of students from public schools. Regarding the mothers of the students, 2.4% are illiterate, 21.2% are elementary school graduates, 23.5% are secondary school graduates, 28.8% are high school graduates, 17.4% are university graduates, and 6.8% are postgraduate graduates. When looking at the mothers' educational level in the sample, it is seen that the majority are high school graduates. As for the fathers of the students, 1.8% are illiterate, 13.8% are elementary school graduates, 16.5% are secondary school graduates, 27.9% are high school graduates, 28.8% are university graduates, and 11.2% are postgraduate graduates. When looking at the fathers' educational level in the sample, it is seen that the majority are university graduates.

Data Collection Tools

In this study, the Geometry Anxiety Scale (GAS) developed by Akarca (2019) for secondary school students was used. GAS consists of 12 items, is single-factorial, and doesn't contain reverse items. The rating of the scale is "Not suitable at all", "Not suitable for me", "Suitable for me", and "Completely suitable for me". In Akarca's (2019) study, Cronbach's alpha internal consistency reliability coefficient of the scale was found to be 0.894. In this study, Cronbach's alpha internal consistency reliability coefficient was calculated as 0.911. The scale developed by Katrancı and Özdişci (2019) to measure secondary school students' attitudes toward geometry was used in the research. The scale consists of 24 items, is in a 5-point Likert format, and the options are ranked as "Strongly disagree", "Disagree", "Partially agree", "Agree", and "Completely agree". The scale has 3 subscales: positive attitudes (9), negative attitudes (5), and technology (10). Items 5, 9, 12, 22, and 24 of the scale are reversed. In the scale development study of Katrancı and Özdişci (2019), Cronbach's alpha internal consistency reliability coefficient was found to be 0.886. In this study, Cronbach's alpha internal consistency reliability coefficient was calculated as 0.896 using a statistical package program. A personal information form was used to learn some characteristics of the students. These characteristics are gender, school attended, grade level, mother's educational level, father's educational level, and the previous year's 2nd semester 2nd mathematics exam grade. Geometry achievement was determined by the score obtained from a written exam consisting entirely of outcomes related to the sub-learning area of geometry, which was prepared based on the opinions of two experts. This written exam was the second mathematics exam those students took in the second semester of the previous year.

Data Analysis

The data obtained through a statistical package program were analyzed. The responses that students were given to the scale items were coded using this statistical program. The Geometry Attitude Scale, which contains reverse items, was reverse-scored. The personal characteristics of the students constituting the sample were indicated with frequency (n) and percentage (%) values. Firstly, it was decided to use parametric analysis for geometry attitude with the Skewness-Kurtosis test, and non-parametric analysis for geometry anxiety, achievement, and belief. Kolmogorov-Smirnov test was applied to check whether the data were normally distributed, as the sample size was greater than 50 (Büyüköztürk, 2021). In the geometry attitude, which showed a normal distribution, the Independent Group t-test was used for comparisons with dichotomous variables, and One-Way Analysis of Variance (ANOVA) was used for comparisons with variables having three or more categories. For geometry anxiety and achievement, which did not show a normal distribution, the Mann-Whitney U test and the Kruskal-Wallis Test were applied. The relationships between geometry anxiety, attitude, and achievement were determined using Spearman-Brown Rank Order Correlation Analysis.

Findings

In the research investigating the relationships between secondary school students' geometry achievement, anxiety, and attitude, the following findings were obtained based on the responses taken from the scales: The results of the Mann-Whitney U test conducted to determine whether there is a significant difference in secondary school students' geometry achievement based on gender for the first sub-problem of the research are presented in Table 2.

Table 2. Results of the Mann Whitney U Test for geometry achievement scores

Group	N	Mean Rank	Rank sum	U	Z	p
Girl	176	172,46	30353,00	14087,00	-,382	,703
Boy	164	168,40	27617,00			

According to Table 2, geometry achievement scores of the students do not create a significant difference based on gender ($U_{(Total)}$=14087, z=-0.382; p> 0.05). The Mann-Whitney U test results to determine whether there is a significant difference in secondary school students' geometry anxieties based on gender are provided in Table 3.

Table 3. Results of the Mann-Whitney U Test for geometry anxiety scores

Group	N	Mean Rank	Rank sum	U	Z	p
Girl	176	166,92	29377,50	13801,500	-,697	,486
Boy	164	174,34	28592,50			

According to Table 3, geometry anxiety scores of the students do not create a significant difference based on gender ($U_{(Total)}$=13801, z=-0.697; p> 0.05). The results of the independent samples t-test to determine whether there is a significant difference in secondary school students' attitudes toward geometry based on gender are provided in Table 4.

Table 4. Independent Group t-Test results applied to determine whether attitude scores towards geometry differ by gender

Group	N	$\bar{x}$	Sd	dF	T	p
Girl	176	78,44	19,48	336,573	0,953	0,341
Boy	164	76,56	17,00			

According to Table 4, the students' geometry attitude scores do not show a significant difference based on gender [$t_{(336.573)}$= 0.953; p > 0.05]. Despite the lack of a significant difference, the mean geometry attitude score of girls is higher than the mean geometry attitude score of boys. The results of the Kruskal-Wallis test to determine whether there is a significant difference in secondary school students' geometry achievements based on mother's education level are provided in Table 5.

Table 5. Kruskal Wallis results to determine whether geometry achievement scores differ by mother-educational status

Mother's Educational Level	N	Mean Rank	SD.	X^2	P	Difference
Illiterate (0)	8	124,69	5	70,046	,000	0-4, 0-5, 1-3,
Primary school (1)	72	132,58				1-4, 1-5, 2-3,
Secondary school (2)	80	134,81				2-4, 2-5, 3-4,
High school (3)	98	169,33				3-5
University (4)	59	241,10				
Postgraduate (5)	23	253,20				

According to Table 5, students' geometry achievements vary significantly based on mother's education level (X^2= 70; df = 5; p < 0.05). The significant differences in students' geometry achievement scores based on mother's education level are observed between illiterate and university graduate, postgraduate; primary school graduate and high school graduate, university graduate, postgraduate; secondary school graduate and high school graduate, university graduate, postgraduate; secondary school graduate and high school graduate, university graduate, postgraduate; high school graduate and university graduate, postgraduate. As a result, the geometry achievement of students whose mothers are illiterate is lower compared to those whose mothers are university and postgraduate graduates; the geometry achievement of students whose mothers are primary school graduates is lower compared to those whose mothers are high school, university, and postgraduate graduates; the geometry achievement of students whose mothers are secondary school graduates is lower compared to those whose mothers are high school, university, and postgraduate graduates; the geometry achievement of students whose mothers are high school graduates is lower compared to those whose mothers are university and postgraduate graduates. In conclusion, students whose mothers are university and postgraduate graduates are more successful in geometry. The results of the Kruskal-Wallis test to determine whether there is a significant difference in secondary school students' geometry anxieties based on mother's education level are provided in Table 6.

Table 6. Kruskal Wallis results to determine whether geometry anxiety scores differ by mother-educational status

Mother's Educational Level	N	Mean Rank	SD.	X^2	p
Illiterate (0)	8	210,31	5	3,822	,575
Primary school (1)	72	174,83			
Secondary school (2)	80	179,56			
High school (3)	98	166,48			
University (4)	59	162,80			
Postgraduate (5)	23	148,43			

According to Table 6, students' geometry anxieties do not vary based on mother's education level (X^2= 3.82; df = 5; p > 0.05). The results of the One-Way Analysis of Variance (ANOVA) test conducted to determine whether there is a significant difference in secondary school students' geometry attitudes based on mother's education level are provided in Table 7.

Table 7. Results of One-Way Analysis of Variance (ANOVA) conducted to determine whether geometry attitude scores differ by mother-educational status

N, $\overline{x}$, ss Values					**ANOVA Results**					
Point	**Group**	*N*	$\overline{x}$	*ss*	**Var.K.**	*KT*	*Sd*	*KO*	*F*	*p*
ATG	Illiterate	8	72,50	14,42	**G.B**	1990,954	5	398,191	1,189	,314
	Primary school	72	74,18	18,48	**G.I**	111891,549	334	335,005		
	Secondary school	80	77,22	18,30	**Total**	113882,503	339			
	High school	98	79,58	16,35						
	University	59	80,25	20,10						
	Postgraduate	23	75,21	21,63						

ATG: Attitudes Toward Geometry

When examining Table 7, it has been determined that there is no significant difference in students' attitudes towards geometry based on mother's education level ($F = 1.18$; $p > 0.05$). The results of the Kruskal-Wallis test conducted to determine whether there is a significant difference in secondary school students' geometry achievements based on father's education level are provided in Table 8.

Table 8. Kruskal Wallis Results to determine whether geometry achievement scores differ by father's educational status

Father's Educational Level	**N**	**Mean Rank**	**SD.**	X^2	**p**	**Difference**
Illiterate	6	72,58	5	52,177	,000	0-3, 0-4,
Primary school	47	123,50				0-5, 1-4,
Secondary school	56	138,98				1-5, 2-4,
High school	95	156,00				2-5, 3-4,
University	98	210,18				3-5
Postgraduate	38	224,46				

According to Table 8, students' geometry achievements vary based on father's education level (X^2=52.17; sd = 5; $p < 0.05$). The significant differences in students' geometry achievement scores based on father's education level are observed between illiterate and high school graduates, university graduates, and postgraduates; between primary school graduates and university graduates, postgraduates; between secondary school graduates and university graduates, postgraduates; and between secondary school graduates and university graduates, postgraduates. Consequently, it has been determined that the geometry achievements of students whose fathers are illiterate are lower compared to those whose fathers are high school, university, or postgraduate graduates; the geometry achievements of students whose fathers are primary school graduates are lower compared to those whose fathers are university or postgraduate graduates; the geometry achievements of students whose fathers are secondary school graduates are lower compared to those whose fathers are university or postgraduate graduates; and the geometry achievements of students whose fathers are high school graduates are lower compared to those whose fathers are university or postgraduate graduates. Therefore, it can be concluded that students whose fathers are university or postgraduate graduates have higher geometry achievements. The results of the Kruskal-Wallis test conducted to determine whether there is a significant difference in secondary school students' geometry anxieties based on father's education level are presented in Table 9.

Table 9. Kruskal Wallis results to determine whether geometry anxiety scores differ by father's educational status

Father's Educational Level	**N**	**Mean Rank**	**SD.**	X^2	**p**
Illiterate	6	164,83	5	1,933	,858
Primary school	47	186,20			
Secondary school	56	170,30			
High school	95	170,34			
University	98	168,67			
Postgraduate	38	157,38			

According to Table 9, students' geometry anxieties do not vary based on father's education level (X^2=1.93; sd = 5; $p>0.05$). The results of the One-Way Analysis of Variance (ANOVA) conducted to determine whether there is a significant difference in secondary school students' geometry attitudes based on father's education level are presented in Table 10.

Table 10. Results of One-Way Analysis of Variance (ANOVA) conducted to determine whether geometry attitude scores differ by father-education status

N, $\overline{x}$, ss Values					**ANOVA Results**					
Point	**Group**	*N*	$\overline{x}$	*Ss*	**Var.K.**	*KT*	*Sd*	*KO*	*F*	*p*
ATG	Illiterate	6	83,1667	17,82	**G.B.**	794,198	5	158,840	,469	,799
	Primary school	47	75,0213	16,97	**G.I**	113088,305	334	338,588		
	Secondary school	56	76,3214	17,13	**Total**	113882,503	339			
	High school	95	78,9789	18,75						
	University	98	77,9184	17,94						
	Postgraduate	38	76,9737	21,92						

ATG: Attitudes Toward Geometry

Upon examining Table 10, it has been determined that students' attitudes towards geometry do not show a significant difference based on father's education level (F=0.469; p > 0.05).

Table 11. Results of the Mann-Whitney U Test for geometry achievement scores

Group	**N**	**Mean Rank**	**Rank Sum**	**U**	**Z**	**p**
7th grade	174	162,92	28348,50	13123,500	-1,459	,145
8th grade	166	178,44	29621,50			

When examining Table 11, students' geometry achievement scores do not create a significant difference based on grade level ($U_{(Total)}$=13123, z=-1.459; p>0.05).

Table 12. Results of the Mann-Whitney U Test for Geometry Anxiety Scores

Group	**N**	**Mean Rank**	**Rank Sum**	**U**	**Z**	**p**
7th grade	174	167,72	29182,50	13957,50	-,535	,593
8th grade	166	173,42	28787,50			

According to Table 12, students' geometry anxiety scores do not create a significant difference based on grade level ($U_{(Total)}$=13957, z=-0.535; p>0.05).

Table 13. Independent Group t-Test results applied to determine whether attitude scores towards geometry differ by grade level

Group	**N**	$\overline{x}$	**Sd**	**dF**	**T**	**p**
7th grade	174	79,52	16,34	318,494	2,044	0,42
8th grade	166	75,45	20,04			

According to Table 13, there is no significant difference in geometry attitudes between 7th grade and 8th grade students ($t_{(318.494)}$ = 2.044; p > 0.05).

Table 14. Mann-Whitney U Test results conducted to determine whether geometry achievement scores differ by school type

Group	N	Mean Rank	Rank Sum	U	Z	P
Privacy School	64	276,80	17715,50	2028,50	-9,624	,000
Public School	276	145,85	40254,50			

According to Table 14, students' geometry achievements vary significantly in favor of private schools based on school type ($U_{(Total)}$=2028, z=-9.624; p<0.05).

Table 15. Mann-Whitney U Test results conducted to determine whether geometry anxiety scores differ by school type

Group	N	Mean Rank	Rank Sum	U	Z	P
Privacy School	64	149,41	9562,50	7482,500	-1,906	,057
Public School	276	175,39	48407,50			

According to Table 15, students' geometry anxieties do not vary based on school type ($U_{(Total)}$=7482, z=-1.906; p > 0.05).

Table 16. Results of One-Way Analysis of Variance (ANOVA) conducted to determine whether geometry attitude scores differ by the school attended

Group	N	$\overline{x}$	Sd	dF	T	P
Privacy School	64	79,26	19,17	338	,836	,809
Public School	276	77,13	18,13			

Upon examining Table 16, it was determined that students' attitudes towards geometry did not show a significant difference based on school type ($t_{(338)} = 0.836$; $p > 0.05$). Since the variables did not follow a normal distribution, Spearman's Correlation Analysis was conducted to determine the level of relationship between secondary school students' geometry anxieties and their achievements (Büyüköztürk, 2021, p. 31).

Table 17. Results of Spearman Correlation Analysis Performed to Determine the Relationships Between Geometry Anxiety and Geometry Achievement

Variables	**N**	**r**	**p**
GAn-GAc	340	-,299	,000

GAn: Geometry Anxiety **GAc**: Geometry Achievement

As seen in Table 17, the results of the Spearman Correlation Analysis conducted to determine the relationship between secondary school students' geometry anxiety scores and geometry achievement scores revealed a significant, negative, and low-level relationship between the variables ($r = -0.299$; $p < 0.05$). In other words, it can be said that as geometry achievement increases, geometry anxiety decreases, and as geometry anxiety increases, geometry achievement decreases.

Table 18. Results of Spearman correlation analysis conducted to determine the relationships between attitude towards geometry and geometry achievement

Variables	**N**	**r**	**p**
ATG-GAc	340	,108	,046

ATG: Attitudes Toward Geometry **GAc**:Geometry Achievement

As observed in Table 18, the results of the Spearman Correlation Analysis conducted to determine the relationship between secondary school students' geometry attitude scores and geometry achievement scores revealed a significant, positive, and low-level relationship between the variables ($r = 0.108$; $p > 0.05$). Thus, it can be said that as geometry achievement increases, the attitude towards geometry also increases. The results of the Spearman Correlation Analysis conducted to determine the level of relationship between secondary school students' geometry attitudes and their anxieties are provided in Table 19.

Table 19. Results of Spearman correlation analysis conducted to determine the relationships between attitude towards geometry and geometry anxiety

Variables	**N**	**r**	**p**
ATG-GA	340	-,519	,000

ATG: Attitudes Toward Geometry **GA**:Geometry Attitude

As shown in Table 19, the results of the Spearman Correlation Analysis conducted to determine the relationship between secondary school students' geometry attitude scores and geometry anxiety scores revealed a significant, negative, and moderate-level relationship between the variables ($r = -0.519$; $p < 0.05$). Thus, it can be concluded that as geometry anxiety increases, the attitude towards geometry decreases.

Conclusion and Discussion

Examination of Geometry Achievement, Anxiety, and Attitude According to Gender Variable: Results and Discussion

When examining students' geometry achievements, it was concluded that there was no significant difference between geometry achievements and gender. This situation may stem from the similarity of the social environments of the children studied, the parallelism of the education they received, and the similarity of the support received for education. TIMSS 2011, 2015, and 2019 data also show that the gender factor does not significantly differentiate mathematics achievement at the 8th grade level, and the mathematics averages of female and male students are close (MEB, 2020).

Parallel to the study, there are studies indicating that there is no connection between students' geometry achievement and gender (Özkan and Yıldırım, 2013; Erkek and Işıksal-Bostan, 2015; Özkan and Yıldırım, 2013; Şahin and Keşan, 2022). Similar results were also found in studies by Dursun and Dede (2004) and Taşdemir (2015) that mathematical achievement did not change depending on gender.

It was concluded that there was no significant difference between students' geometry anxiety and the gender variable. Factors causing geometry anxiety in students, regardless of gender, may include reflections of parents' math anxiety on the student, and teacher attitudes and behaviors. The behaviors of mathematics teachers that cause anxiety in students, such as ignoring the questions asked by students, being indifferent, appearing angry and frowning, and making disdainful comments, prevent students from focusing on the lesson (Bekdemir et al., 2004). Although mathematics anxiety and geometry anxiety are considered different concepts in the literature, studies examining whether there is a significant difference between mathematics anxiety and the gender variable have been reviewed since geometry is a branch of mathematics. In this regard, the studies by Cooper and Robinson (1991), Bindak and Dursun (2011), and Sapma (2013) have concluded that there is no significant difference between mathematics anxiety and gender, which is consistent with the result of the current study. In addition, Erktin et al. (2006) found in their study that girls' math anxiety was higher than that of male students. Akarca (2019) found a significant relationship between gender and geometry anxiety in the scale development study and determined that girls' geometry anxiety was higher compared to boys. There are studies in the literature that are consistent with this result (Doruk and Kaplan, 2016; Kartal et al., 2022). The higher level of anxiety in girls may have different reasons. According to Akarca (2019), the social environment, experiences, and the different roles and responsibilities assigned to women and men in society have led to girls being anxious. From this perspective, it can be said that parents and society's biases on this issue may cause anxiety in female students.

It was concluded that there was no significant positive or negative difference between students' attitudes towards geometry and gender. Students' attitudes towards geometry may vary depending on whether the student likes the teacher and the course, whether the teacher teaches the lesson at the student's level and actively involves the student and the methods and techniques used by the teacher. In terms of teaching methods and techniques, it has been determined that dynamic geometry software used in the lesson (Akyüz and Türk, 2016), drama-based teaching (Duatepe-Paksu and Ubuz, 2009), lessons where metacognitive strategies are used (Şahin and Kendir, 2013), and project-based teaching where students create their models and encounter daily life problems (Özdemir, 2006) increase students' attitude towards geometry. Similar results are also seen in studies in the literature that have similar results in the relationship between attitude toward geometry and gender (Anıkaydın, 2017; Sevgi and Gürtaş, 2020; Avcı et al., 2014; Poçan et al., 2020). On the other hand, Kaba et al. (2016) found in their study that there was a significant difference between secondary school students' attitudes toward geometry and gender. It can be said that the higher attitudes of female students towards geometry than male students are due to the positive relationship between success and attitude (Kaba et al., 2016). Moreover, considering that students' attitudes will be positive when they are willing to learn geometry (Günhan and Başer, 2007), it can be said that the girls in the sample of the mentioned study are more interested and willing to learn geometry.

Examination of Geometry Achievement, Anxiety, and Attitude According to Mother's Education Level: Results and Discussion

When examining students' geometry achievements, it was found that there is a significant difference between geometry achievements and the mother's education level. According to pairwise comparisons, students whose mothers are university and postgraduate graduates have significantly higher geometry achievement compared to those with lower levels of education. The main reason for this could be that mothers with higher education levels are more advantageous in providing both economic and academic support to their children's education. As the mother's education level increases, her positive contribution to her child's mental and physical support will also increase (Aslanargun et al., 2016). This situation may be because in Turkish society, mothers have a lot of responsibilities in all stages of development from the birth of the baby, and the awareness of an educated mother leads to a greater focus on the child's success (Gelbal,

2008). Considering that mothers guide their children in their lessons and homework like a teacher (Hortaçsu, 1995), having a particularly high level of education, especially at the university and higher level, means that the mother will be more conscious about researching how the child learns better and following the student's development, thus increasing the student's math achievement. Parallel to the increase in the student's mother's education level, the student's opportunities may increase as a result of the mother having a higher-paying profession. Çınar and Ural (2016) also found that as the mother's education level increases, providing a more prosperous environment for the child will increase success. The result of the current study that "Geometry achievement increases as students' mother's education level increases" is parallel to the study by Geçici and Aydın (2019), which found that students with higher levels of mother's education were more successful in geometry activities, and the study by Çanakçı and Özdemir (2015), which found that those whose mothers are university graduates are more successful in mathematics compared to those with primary education. On the other hand, Çınar and Ural (2016) concluded that mathematics achievement did not significantly differ according to the mother's education level.

When examining students' geometry anxiety, it was found that there is no significant difference between geometry anxiety and the mother's education level. The influence of the school and the teacher who conducts the teaching may have a greater effect on the formation of anxiety. Kutluca et al. (2015) stated in their study, "Math anxiety is not a congenital condition but a trait acquired after starting school and can increase," which can be associated with the fact that the student is mostly exposed to geometry at school and by the mathematics teacher. Ashcraft et al. (2005) suggested that the student's anxiety about mathematics is entirely acquired at school. In addition, individuals experiencing math anxiety attribute this to the mathematics teacher who taught them when they were children (Perry, 2004). The idea that anxiety arises in students due to teachers' demeaning or prejudiced behaviors supports this notion (Furner and Duffy, 2002). Similar results were obtained regarding math anxiety (Kutluca et al., 2015; Tuncer and Yılmaz, 2016). Studies such as Akarca (2019) found that geometry anxiety decreases as the mother's education level increases, and studies such as Özbey and Yenilmez (2006), Sapma (2013), and Bozkurt (2012) found that math anxiety decreases as the mother's education level increases, reached a different conclusion from the current study.

When examining students' attitudes towards geometry, it was found that there is no significant difference between attitude towards geometry and the mother's education level. Students' attitudes towards geometry may vary depending on teaching methods and materials or the student's ability to think geometrically. The methods and strategies that make geometry attitude positive are dynamic geometry software, drama-based teaching, metacognitive strategies, and project-based teaching and concrete models, while traditional methods lead to a negative attitude in students (Bayram, 2004; Özdemir, 2006; Duatepe-Paksu and Ubuz, 2009; Şahin and Kendir, 2013; Akyüz and Türk, 2016). Another study also shows that there is a positive and low correlation between Van Hiele's geometric thinking levels and geometry attitude (Uzun, 2019). As secondary school students' attitude toward geometry increases, there is also a moderate positive relationship in their geometric thinking levels (Günhan et al., 2022). In the literature, it is shown that the attitude towards mathematics does not differ according to the mother's education level, which is parallel to the results of studies by Özabacı and Yenilmez (2003), Kaba and Özdişci (2018), Kara (2021), Kaba et al. (2016), Tuncer and Yılmaz (2016), and Tan (2015). On the other hand, in the study by İlhan et al. (2021), it was found that the attitude towards mathematics increases as the mother's education level increases, forming a more positive attitude.

Examination of Geometry Achievement, Anxiety, and Attitude According to Father's Education Level: Results and Discussion

When examining students' geometry achievements, it was found that there is a significant difference between geometry achievements and the father's education level. According to pairwise comparisons, students whose fathers are university and postgraduate graduates have significantly higher geometry achievement compared to others. As the father's education level increases, except for exceptional cases, the financial support for education is likely to increase due to the higher income level of the family. Therefore, the father's education level may create a difference in the student's geometry achievement. Özkan and Yıldırım (2013) suggested in their study that as the father's education level increases, the contribution of an educated father to the student's academic life and self-confidence is greater. Moreover, in affluent

families, parents have the opportunity to be more involved in their children's education and development, which can lead to more success for children both in school and in life (Aslanargun et al., 2016).

When examining students' geometry anxiety, it was found that there is no significant difference between geometry anxiety and the father's education level. This result may be because fathers generally have less influence on students' emotional characteristics such as anxiety in Turkish society, and mothers are usually observed to be more emotional towards their children. In parallel, Özabacı and Yenilmez (2003) encountered a result that the mother's education level significantly differentiated students' math anxiety, while the father's education level did not bring about any change. However, studies with opposite results can be found in the literature. Akarca (2019) found in their study that there is a negative and significant relationship between the father's education level and geometry anxiety. There are also studies showing that math anxiety in students differs significantly according to the father's education level (Özbey and Yenilmez, 2006; Bozkurt, 2012; Sapma, 2013; Tuncer and Yılmaz, 2016).

When examining students' attitudes towards geometry, it was found that there is no significant difference between attitude towards geometry and the father's education level. Attitude towards geometry is related to the student's liking for the lesson, how time passes in the lesson according to him, and what technology-supported or different method-based geometry lesson means to him. In this regard, the items of the geometry attitude scale developed by Katrancı and Şengül (2019) support this. Similar results have been encountered in the literature regarding math attitude (Özabacı and Yenilmez (2003); Tuncer and Yılmaz, 2016). The result of the current study contradicts the result of the study by Kaba et al. (2016) and Kaba and Özdişci (2018). In the study by Kaba et al. (2016), it was found that especially fathers with a master's degree have much more positive attitudes towards geometry compared to those with lower graduation degrees. In this context, it can be said that fathers also closely involve themselves in their children's lessons and homework, and as their education levels increase, they can provide more appropriate guidance to them.

Examination of Geometry Achievement, Anxiety, and Attitude Variables in terms of Grade Level: Results and Discussion

When examining students' geometry achievement, it was found that there is no significant difference between geometry achievements and grade levels. In secondary school, the foundations of geometry are laid in the 5th and 6th grade grades, and with the development of abstract thinking in the 7th and 8th grades, new information is added on top of the previously established foundation, which may explain why there is no difference in geometry achievement across grade levels. The abstract concept of equations, as mentioned by Altıntaş et al. (2021), is challenging for students to learn. Formulating equations in the problems they encounter helps students solve those problems more systematically and coherently (Köroğlu et al., 2004). Equations come before geometry topics in the mathematics curriculum. Thus, being able to formulate equations in subsequent geometry topics can facilitate problem-solving. A student who has grasped equations will be successful in geometry regardless of their class level. In contrast to the current study, Bozkurt (2012) found in their study that the math achievement of 7th grade students is significantly higher than that of 8th grade students, suggesting that the accumulation of learning deficits may be the reason for this difference in a cumulative subject like mathematics.

When examining students' geometry anxiety, it was found that there is no significant difference between geometry anxiety and grade levels. This might be because geometry anxiety is related to the psychological state of the student regarding geometry. In this context, expressions such as "I feel anxious, worried, afraid, nervous, dislike, hate" in the scale developed by Sağlam et al. (2011) and in Akarca's (2019) scale indicate that geometry anxiety is associated with the student's emotional state. In contrast to the findings of this research, Akarca (2019) found that the geometry anxiety of 7th and 8th grade students is significantly higher than that of 6th grade students, while Bindak and Dursun (2011) found that the math anxiety of 8th graders is significantly higher than that of 6th and 7th graders. The presence of an exam (LGS) at the end of the year that determines the high school they will attend could be a reason why math and geometry anxiety in 8th grades are significantly higher than in other grades. The results of studies on the relationship between math anxiety and class level in the literature do not align with the results of this study (Özbey and Yenilmez, 2006; Sapma, 2013; Bozkurt, 2012).

When examining students' attitudes towards geometry, it was found that there is no significant difference between attitudes towards geometry and grade levels. This may be because attitudes take a long time to form, and students' attitudes towards geometry may not change after a year. Attitudes are the result of decisions reached through life experience and are not easily changed (Uysal, 2022). As indicated by expressions such as "Time never passes in geometry classes, it's like solving a puzzle and fun, the use of technology in geometry classes provides an advantage" in the scale developed by Katrancı and Özdişci (2019), making these decisions requires a process. In the literature, while there is no difference found in the studies of Cansız-Aktaş and Aktaş (2012) and Avcı et al. (2014); Dede (2012) covering secondary and high school students, Kaba et al. (2016), Kaba and Özdişci (2018) focusing solely on secondary school students; and Sevgi and Yakışıklı (2020) showed opposite results. Katrancı and Şengül (2019) found that as the class level increases, math attitude also increases. There are both overlapping and non-overlapping results in the literature.

Examination of Geometry Achievement, Anxiety, and Attitude Variables in terms of School Type: Results and Discussion

When examining students' geometry achievement based on school type, it was found that there is a significant difference favoring private schools. This result can be interpreted as "Geometry achievement in private schools is higher than that in public schools." This finding aligns with the conclusion of Savaş et al. (2010) that "Students attending private schools perform better in mathematics than those in public schools." The reasons for this may include the better physical and social environment provided by private schools, as well as more advanced student assessment systems and guidance services. The smaller class sizes in private schools allow teachers to devote more attention to individual students, and students can benefit from technology and counseling services, leading to a higher quality education. Additionally, grades given to students in private schools tend to be more lenient (Gürler, 2020), which may contribute to the higher geometry achievement observed in private schools in this study. Considering the financial adequacy of students attending private schools, there are studies indicating a positive relationship between family income and math achievement (Ainley et al., 1995; Zabulionis, 1997).

When examining students' geometry anxiety based on school type, it was found that there is no significant difference. This finding may be attributed to the idea that geometry anxiety, like math anxiety, is a learned type of anxiety over time, as suggested by Kutluca et al. (2015). Parents may contribute negatively to students' geometry anxiety, as parents' math anxiety can be passed on to students and lower their achievement (Soni & Kumari, 2017). The pressure parents put on students regarding math achievement increases their stress and anxiety (Cangüven et al., 2022). The result that math anxiety does not differ based on school type aligns with the conclusion of the study by Özbey and Yenilmez (2006).

When examining students' attitudes towards geometry based on school type, it was found that there is no significant difference. Regardless of whether it is a private or public school, if the learning environment is suitable for students, they feel comfortable and are not hesitant to ask questions, and their attitude toward geometry can be positive. The social-psychological climate of the classroom affects the attitude toward mathematics (Haladyna et al., 1983). Therefore, students' attitude toward geometry is influenced by the classroom atmosphere.

Geometry Achievement, Anxiety, and Attitude: Results and Discussion of Their Relationships

An examination of the relationship between attitude towards geometry and geometry anxiety revealed a significant, moderate negative correlation. As attitude towards geometry increases, geometry anxiety decreases. According to Neale (1969), a student's attitude towards a subject is related to whether they like the subject or not. In line with this, Peker and Şentürk (2012) found that students who enjoy mathematics have lower math anxiety, while Akarca (2019) found that those who love mathematics have lower geometry anxiety. The presence of anxiety as one of the sub-dimensions in Bulut et al.'s (2002) geometry attitude scale also supports the relationship found between these two variables. Studies in the literature have also shown a negative correlation between math attitude and math anxiety (Özabacı and Yenilmez, 2003; Şentürk, 2010; Karadağ and Karadeniz, 2014; Tuncer and Yılmaz, 2016; Adal and Yavuz, 2017; Doruk et al., 2016; Ergin, 2022).

A significant, low positive correlation was found between attitude towards geometry and geometry achievement. Similar results have been in the studies of Ünlü (2014), Özkeleş-Çağlayan (2010), and Poçan et al. (2020), where a high,

positive correlation between geometry attitude and math achievement was identified. Studies also show that as math attitude increases, math achievement increases (Burrus and Moore, 2016; Ekici and Sarı, 2018; Kara, 2021; İlhan et al., 2021).

Lastly, a significant, low negative correlation was found between geometry anxiety and geometry achievement. This result is supported by Akarca (2019). Similar findings exist in the literature, including studies showing a significant relationship between math anxiety and math achievement (Ma and Xu, 2004; Özbey and Yenilmez, 2006; Sapma, 2013) as well as studies showing a negative, moderate correlation between math anxiety and math achievement (Bindak and Dursun, 2011).

Recommendations

In this study, where geometry achievement, anxiety, and attitude are examined, it has been concluded that geometry achievement varies according to father's education level, and geometry attitude, anxiety, and achievement differ according to the type of school attended. It has also been found that there is a negative relationship between geometry anxiety and attitude and achievement, while there is a positive and significant relationship between geometry attitude and achievement. In light of these results, some opinions and recommendations are provided below:

- This research was conducted with 7th and 8th grade students in Kars. A more comprehensive study including students from different cities and grades, such as 5th and 6th grades, can be conducted.
- It has been observed that students attending private schools are more successful in geometry. Therefore, the physical conditions, class sizes, student monitoring, and teaching materials of public schools can be improved and enhanced.
- Since the methods and techniques used in mathematics lessons increase mathematics attitudes, teachers can use different methods and approaches in geometry teaching to increase students' positive attitudes.
- Since the scope of the current study does not cover the reasons behind geometry anxiety, attitude, and achievement, a qualitative study can be conducted to investigate these variables.
- It has been found that there is a significant but low negative relationship between geometry anxiety and success. This result may serve as a basis for further research on the level of anxiety.
- By asking students about the departments their parents studied in university, meaningful differences in terms of geometry anxiety, achievement, and attitude between departments containing geometry and those that do not can be explored.

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