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Relationships Among Middle School Students' Math Self-Efficacy, Anxiety, Math Achievement Scores, and Attitudes Toward Math

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Abstract

This study, conducted according to the correlational survey model, investigated the relationships between middle school students' mathematics achievement and their mathematics anxiety, attitudes, and self-efficacy. The study was conducted with the participation of 740 middle school students selected according to appropriate sampling procedures. The data were analyzed using correlation analysis, the independent samples t-test, and ANOVA. Effect sizes were also calculated in cases where the dependent variables differed significantly across the independent variables. The highest correlation between the scales and their dimensions was found between the general mathematics attitude scale and the interest dimension, while the lowest correlation was found between the mathematics achievement score and the general mathematics self-efficacy and anxiety scale. Negative, significant relationships were observed between math anxiety and math achievement scores, interest, anxiety, effort, necessity, self-efficacy, and the overall math attitude scale. Our research findings provide strong evidence that students' self-efficacy beliefs play a significant role in the learning-teaching process in mathematics education. Accordingly, it is recommended that teaching programs be structured to target the development of students' mathematical self-efficacy. To achieve this goal, teaching strategies and practical examples that support students' self-efficacy beliefs can be incorporated into mathematics curricula, encouraging teachers to use different teaching methods and techniques. Furthermore, to enable teachers to play an effective role in developing this skill, mathematics teachers can be supported through seminars and training as part of professional development programs focused on self-efficacy.

Keywords: Perceived mathematics self-efficacy, mathematics anxiety, attitudes towards mathematics, mathematics achievement

Introduction

Mathematics has been highly valued in all societies from the past to the present day, playing a major role in shaping the future of each country by forming the basis of scientific and technological progress as well as economic and social development. Galileo explained his idea about mathematics as understanding nature, accepting that it is written in a mathematical language, and being able to decipher this language (King, 2014). Mathematics is an infinite method of thinking that has maintained its prestige for centuries (Yıldırım, 2019). Learning and developing mathematics is considered essential for acquiring the skills necessary for an individual to sustain their daily life, such as communication, creative thinking, analysis, and generalization (Abdioğlu, 2022). Rapid changes in knowledge, information, and scientific activities, as well as social needs, have increased the demand for mathematics (MEB, 2018).

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Peker and Mirasyedioğlu (2003) determined that mathematics is an important subject that must be learned. What makes mathematics education valuable and necessitates its inclusion at every grade level is its importance in individuals' daily lives and in the advancement of science (Altun, 2005; Baykul, 2003). The mathematics teaching program, which was reorganized in 2018, aims to develop individuals who are proficient in mathematics, aware of their own learning process, and possess the characteristics of reasoning, making connections, and communicating effectively (MEB, 2018).

Mathematics education, through analytical thinking, enables individuals to find solutions to problems in their daily lives. It is encountered at every level of education throughout students' educational lives and in inter-level transition exams. The importance of mathematics and mathematical thinking skills is significant in these exams (Başar et al., 2002). Therefore, determining the factors that influence students' success in mathematics is crucial for improving the mathematics learning process, ensuring the success of mathematics education, making the right decisions regarding mathematics education, and guiding educators. Identifying these factors also makes it possible to detect and control the factors that cause failure (Koç et al., 2004).

Students' insufficient achievement in mathematics (Aktan, 2012; Yıldızlı, 2015) has led educators and researchers from different disciplines to conduct studies aimed at identifying the factors that influence achievement. Thomson et al. (2003) identified the factors affecting students' mathematics achievement as student characteristics, teacher characteristics, and school-related factors. According to Pintrich and Schunk (1996), although cognitive processes such as metacognition, use of methods and techniques, attention, coding, and retrieval are emphasized for academic achievement, this approach is limited for the student's academic achievement. In addition to cognitive variables that affect academic achievement, affective variables that enable students to continue their studies must also be examined (Pajares, 2002). Reyes (1984) stated that there are two important reasons for addressing affective factors in mathematics education: contributing to the development of methods that will make students' mathematics learning processes more effective and viewing a positive attitude, regardless of achievement level, as one of the fundamental outcomes of education. Similarly, Ekici (2008) examined the data of countries ranked at the top in the PISA and TIMSS international exams and pointed out that students' success is largely influenced by affective variables. Various studies in the literature have shown that affective variables such as anxiety, attitude, self-regulation, self-efficacy, and motivation are related to mathematics achievement. These studies by Carroll et al. (2009), House (2004), Klomegah (2007), Sezgin (2013) and Yağmur (2012) have determined that attitudes toward mathematics and self-efficacy are related to academic achievement. Bayturan (2011), Demir and Budak (2016), İspir et al. (2011) and Kurtuluş and Öztürk (2017) have found that self-efficacy levels are related to students' motivation, mathematics achievement, and overall academic achievement. Usher and Pajares (2006) and Zimmerman (1995) reported a strong relationship between students' self-efficacy levels and their attitudes toward mathematics. Shen (2009) identified math anxiety as the most important reason why students dislike math class. According to Baykul (2014), Choi and Chang (2011), students' negative attitudes toward math are the most important reason for their failure in math class. Doruk, Öztürk, and Kaplan (2016) concluded that 47% of students' perceived self-efficacy in mathematics can be explained by their anxiety and attitudes toward mathematics. Similarly, Delioğlu (2017) reported that 31% of the variation in TEOG exam performance could be explained by self-efficacy, mathematics, and test anxiety.

The individual variables described above interact with one another in the teaching-learning process. When research focuses on only a few individual variables, it may overlook their mutual influences. For example, the observed effect of anxiety may stem from a low sense of self-efficacy; if self-efficacy is not included in the scope of the research, this situation may be

interpreted in different ways. This determination forms the rationale for conducting this study, and by including many variables in the scope of the research, it provides a multifaceted perspective.

Learning is influenced by many factors, such as the learner, the teacher, the learning environment, and the teaching program. Even just the characteristics of the learner alone can present a highly complex structure. Learners' anxiety levels, perceptions of self-efficacy, motivation levels, and attitudes can influence each other and be observed in different ways from student to student. Due to the methodological structure of educational research, evaluations are mostly based on majorities or averages, so the situation of each individual within the group cannot be taken into account, and the search for the "big picture" comes to the fore. Sometimes educators or researchers may experience confusion about which information they have acquired from the literature may be valid for their own participants or students. To overcome this problem, it is important to work with as many variables as possible, at least in terms of achieving high variance ratios in explaining the nature of variability. Based on all this, the general aim of this study is to determine the relationships between middle school students' mathematics achievement and their mathematical self-efficacy, anxiety, and attitudes. It is thought that this general aim will be further enhanced by the following sub-aims:

- Do middle school students' attitudes toward mathematics and their mathematical self-efficacy and anxiety show significant differences based on the school they attend, their grade level, their emotional state regarding mathematics classes, and the gender of their mathematics teacher?
- What is the direction and level of the relationship between middle school students' attitudes toward mathematics, their mathematical self-efficacy and anxiety, and their mathematics achievement scores?

Some studies have found that the school, grade level, feelings about math class, and gender of the math teacher considered in achieving these sub-goals may be effective in learners' success in math class. One such study, conducted by Tuncer and Yılmaz (2020), concluded that feelings toward mathematics affect mathematics achievement. The same study determined that age and teacher gender are also important in terms of mathematics achievement. Therefore, the grade level variable was linked to age and became one of the dimensions of this study. It has been reported that physical facilities and classroom environment in schools affect mathematics achievement (Dursun and Dede, 2004). Therefore, it was decided to include the schools where the participants studied in the scope of the research.

Method

This study, which examined the relationships between middle school students' math self-efficacy, anxiety, math achievement scores, and attitudes toward math, was conducted using the correlational survey model, one of the quantitative research methods. Correlational survey is a research design that aims to determine the relationship between two or more variables and to reveal whether these variables change together or the degree of change (Karasar, 2012). In the correlational survey method, the event or situation under investigation is addressed as it currently exists, and the variables affecting this situation are not determined (Kaya, Balay & Göçen, 2012). This study is correlational but cross-sectional in nature. The study's measurements are limited to the responses provided at the time of data collection; the perceptions measured may vary over time.

Population and Sample

The population of this study consists of middle school students enrolled in Elazığ province during the 2023-2024 academic year. In the research, an appropriate sampling method was chosen to save time and quickly collect data when creating a sample from the population.

Appropriate sampling is defined as a type of sampling conducted on individuals who are close to the researcher, easily accessible, and willing to participate in the research (Erkuş, 2009). Within this scope, the study was conducted by applying data collection tools to 740 middle school students in grades 5, 6, 7, and 8 attending three different public schools in the Central District of Elazığ Province during the second semester of the 2023-2024 academic year. Permissions were obtained from those who developed and adapted the scales used as data collection tools in the study.

According to the grade level variable of the middle school students participating in the study, 188 (25.4%) were in 5th grade, 217 (29.3%) were in 6th grade, 198 (26.7%) were in 7th grade, and 137 (18.5%) were in 8th grade. The distribution of students according to the variable of the school they attend is as follows: 263 (35.5%) attend Şehit Nadir İpek Middle School, 238 (32.1%) attend Vali Tevfik Gür Middle School, and 239 (32.2%) attend Şehit Middle School. Students' feelings towards mathematics lessons are distributed as follows: 405 (54.7%) "I like mathematics lessons," 227 (30.6%) "I am undecided," and 108 (14.5%) "I do not like mathematics lessons." The distribution of participants according to the gender of their math teachers is 553 (74.8%) female and 186 (25.1%) male.

Data Collection Tools

Two different scales developed by different researchers were used in the study to determine the relationship between middle school students' math self-efficacy, anxiety levels, math achievement scores, and attitudes toward math. The first of these data collection tools is the Mathematics Attitude Scale developed by Önal (2013), which consists of a total of 22 items and four dimensions. These dimensions are structured as interest, anxiety, effort, and necessity. The scale has a 5-point Likert-type rating system, and the items are answered as "Strongly Agree," "Agree," "Undecided," "Disagree," and "Strongly Disagree." In the study in which the scale was developed, the internal consistency coefficient was calculated as .90 for the general population. In this study, the alpha coefficient of the scale was found to be .857.

Another data collection tool used in the study is the Mathematics Self-Efficacy and Anxiety Scale developed by May (2009) and adapted into Turkish by Kartal, Baltacı, and Yıldız (2022), which consists of a total of 27 items and two dimensions. These dimensions are self-efficacy and mathematics anxiety. The scale uses a 5-point Likert-type rating system, and items are answered as "Strongly Agree," "Agree," "Undecided," "Disagree," and "Strongly Disagree." The internal consistency coefficient for the scale as a whole was calculated as .94. In this study, the alpha coefficient of the mathematics self-efficacy and anxiety scale was found to be .722.

Mathematics achievement in the study was determined based on the students' responses. The students were asked to write down their mathematics achievement scores.

Data Analysis

The data collected using data collection tools were analyzed, and the dimensions and overall scale were compared in terms of various variables. In this context, the Levene test was first used to check whether the distribution was homogeneous. When the distribution was homogeneous, the Independent Groups T-test or One-Way Analysis of Variance was used; when the distribution was not homogeneous, the analysis was performed according to the test for non-homogeneous variances and the Kruskall Wallis H test. The LSD test was used to determine significant differences between groups in the ANOVA analysis When there were statistically significant differences between group means, effect sizes were calculated. If the observed significant differences were detected using the Independent Groups T-test, analysis was performed according to Cohen d; if detected using One-Way ANOVA and the Kruskall Wallis H-test, analysis was performed according to Eta-squared. In interpreting Cohen's d, (0.00-0.20)

was considered a weak effect, (0.21-0.50) a small effect, (0.51-1.00) a medium effect, and >1 a large effect (Cohen, 1988; Cohen, Manion, & Morrison, 2007). In the interpretation of eta squared, values of .01 for a small effect, .06 for a moderate effect, and .14 for a large effect (Cohen, 1988) were considered. Furthermore, the relationship between variables was evaluated using correlation analysis. Correlation values were interpreted according to the ranges stated by Kalaycı (2006). These ranges are as follows: 00 - .19 indicates a very weak relationship, .20- .39 indicates a weak relationship, .40 - .69 indicates a moderate relationship, .70 - .89 indicates a strong relationship, and .90-1.00 indicates a very strong relationship.

Research Ethics and Institutional Review Board Approval Information

Permission to use the data collection tools in this study was obtained from the relevant authors. The study was conducted on a voluntary basis, and the necessary permissions were obtained from the students' parents, taking into account the age of the group from which data was collected.

The necessary official permissions were obtained from the Elazığ Provincial Directorate of National Education to implement the scales in schools, and the study was evaluated by the Ethics Committee of Fırat University Social and Human Sciences Research, which granted its approval with decision no. 22389 dated 15.02.2024.

The authors declare that they have no competing interests. No financial support was received from any individual or organization for this study.

Findings

This section presents the findings obtained from the analysis of data collected from middle school students through scales for the sub-objectives of the study. The first finding in this context is the comparison of the mathematics attitude scale and its dimensions across schools, and the results are presented in Table 1.

Table 1
Comparison of the mathematics attitude scale and its dimensions by school

	n	$\bar{X}$	Sour. Var.	Sum of Suq.	df	Mean of S.	F	p	Diff.
Anxiety									
1.	262	2,92	B.G.	4,738	2	2,369	3,536	,030*	2>3
2.	236	2,99	W.G	491,074	733	,670			
3.	238	2,79	Total	495,811	735				
Total	736	2,90				Levene (F=,478 p=,620), n^2= ,010			
Effort									
1.	263	3,85	B.G.	,851	2	,426	,586	,557	-
2.	237	3,77	W.G	534,186	735	,727			
3.	238	3,81	Total	535,037	737	Levene (F=1,742 p=,176)			
Total	738	3,81							
Necessity									
1.	263	3,84	B.G.	1,264	2	,632	,524	,592	-
2.	237	3,81	W.G	886,817	736	1,205			
3.	239	3,91	Total	888,081	738	Levene (F=1,887 p=,152)			
Total	739	3,85							
Whole of Mathematics Attitude Scale									
1.	260	3,43	B.G.	,656	2	,328	,637	,529	-
2.	234	3,42	W.G	375,081	728	,515			
3.	237	3,36	Total	375,737	730	Levene (F=1,858 p=,157)			
Total	731	3,40							

1.Şehit Nadir İpek Middle School, Vali Tevfik Gür Middle School, 3. Şehit Cihan Şahin Middle School

According to the results in Table 1, since the condition of homogeneity of variance was met for the dimensions of anxiety, effort, necessity, and the overall mathematics attitude scale, the results of the ANOVA test were considered; no significant differences were observed between schools for the dimensions of effort, necessity, and the overall mathematics attitude scale (p>.05). However, a significant difference was found for the anxiety dimension (p=.030<.05). According to the post-hoc LSD test analysis for this dimension, a significant difference in the anxiety dimension was found in favor of Vali Tevfik Gür Middle School between Şehit Cihan Şahin Middle School and Vali Tevfik Gür Middle School. Based on the calculated effect size value, the effect on the anxiety dimension is "small."

According to the Levene test result, in terms of interest dimension (F=3.010, p=.050), since schools were not distributed homogeneously ($p \leq .05$), the Kruskall Wallis H test was applied. The findings obtained in this context are presented in Table 2.

Table 2
Comparison of opinions regarding interest dimension according to schools

Variable		M.Rank	X^2	Sig.	Diff.	n^2
Interest	1.	377,14	2,466	,291	-	
	2.	378,96				-
	3.	351,74				

1.Şehit Nadir İpek Middle School (n=261), Vali Tevfik Gür Middle School (n=238), 3. Şehit Cihan Şahin Middle School (n=239)

According to the results in Table 2, no significant difference was found between schools in terms of interest ($p > 0.05$).

In the comparison of the mathematics self-efficacy and anxiety scale and its dimensions across schools, the ANOVA test results were considered since the condition of homogeneity of variances was met for self-efficacy, mathematics anxiety, and the overall mathematics self-efficacy and anxiety scale. The findings are presented in Table 3.

Table 3
Comparison of the mathematics self-efficacy and anxiety scale and its dimensions across schools

	n	$\bar{X}$	Sour. Var.	Sum of Suq.	df	Mean of S.	F	Sig.	Diff.
Self-efficacy									
1	262	3,49	B.G.	1,960	2	,980			
2	236	3,42	W.G	726,010	730	,995	,985	,374	
3	235	3,36	Total	727,970	732				
Total	733	3,43				Levene(F=,121 p=,886)			
Math Anx.									
1	262	2,97	B.G.	2,213	2	1,107			
2	235	2,89	W.G	552,950	732	,755	1,465	,232	
3	238	3,02	Total	555,163	734				
Total	735	2,96				Levene(F=,786 p=,456)			
Whole of the Scale									
1	261	3,20	B.G.	,864	2	,432			
2	233	3,12	W.G	188,056	725	,259	1,666	,190	
3	234	3,17	Total	188,921	727				
Total	728	3,17				Levene (F=1,747 p=,175)			

1.Şehit Nadir İpek Middle School, Vali Tevfik Gür Middle School, 3. Şehit Cihan Şahin Middle School

According to the results in Table 3, no significant differences were observed between schools in terms of self-efficacy, math anxiety, and the overall dimensions of the math self-efficacy and anxiety scale (p>.05).

In the comparison of the mathematics attitude scale and its dimensions according to grade levels, the ANOVA test results were considered since the condition of homogeneity of variance was met for the dimensions of interest, anxiety, effort, necessity, and the overall mathematics attitude scale, and the findings are presented in Table 4.

Table 4
Comparison of the mathematics attitude scale and its dimensions by grade level

	n	$\bar{X}$	Sour. Var.	Sum of Sq.	df	Mean of S.	F	p	Diff.
Interest									
1.	188	3,71	B.G.	50,899	3	16,966	20,249	,000*	1>2,3,4
2.	217	3,46	W.G	615,012	734	,838			2>3,4
3.	198	3,19	Total	665,911	737				3>4
4.	135	2,98				Levene(F=2,274, P=,079)			
Total	738	3,36				n^2=,076			
Anxiety									
1.	184	3,02	B.G.	4,360	3	1,453	2,165	,091	
2.	217	2,90	W.G	491,452	732	,671			-
3.	198	2,86	Total	495,811	735				
4.	137	2,80				Levene(F=,517 p=,671)			
Total	736	2,90							
Effort									
1.	188	4,03	B.G.	21,082	3	7,027	10,036	,000*	1>2,3,4
2.	215	3,81	W.G	513,955	734	,700			4<2,3
3.	198	3,80	Total	535,037	737				
4.	137	3,52				Levene(F=2,139 p=,094)			
Total	738	3,81				n^2=,039			
Necessity									
1.	188	4,04	B.G.	31,669	3	10,556	9,060	,000*	1>3,4
2.	217	4,02	W.G	856,413	735	1,165			2>3,4
3.	198	3,74	Total	888,081	738				
4.	136	3,50				Levene(F=,995 p=,395)			
Total	739	3,85				n^2=,036			
Whole of Mathematics Attitude Scale									
1.	184	3,65	B.G.	26,026	3	8,675	18,035	,000*	1>2,3,4
2.	215	3,47	W.G	349,712	727	,481			2>3,4
3.	198	3,30	Total	375,737	730				3>4
4.	134	3,11				Levene(F=,910 p=,436)			
Total	731	3,40				n^2= ,069			

1: 5th grade, 2:6th grade, 3:7th grade, 4:8th grade

As shown in Table 4, no significant difference was observed between grade levels in terms of anxiety (p>.05). Significant differences were found in terms of interest, effort, necessity, and overall mathematics attitude scale dimensions (p<.05). According to the LSD post-hoc test analysis results for these dimensions, there were significant differences in the interest dimension between 5th and 6th grades, 5th and 7th grades, 5th and 8th grades, 6th and 7th grades, 6th and 8th grades, and 7th and 8th grades showed a significant difference in favor of 5th graders. Based

on the effect size value, the effect of the interest dimension is “moderate.” In the work dimension, a significant difference in favor of 5th graders was found between 5th and 6th graders, 5th and 7th graders, 5th and 8th graders, 6th and 8th graders, and 7th and 8th graders. According to the effect size value, the effect of the study size is “small.” In the necessity dimension, a significant difference in favor of 5th graders was found between 5th and 7th graders, 5th and 8th graders, 6th and 7th graders, and 6th and 8th graders. According to the effect size value, the effect of the necessity dimension is “small.” According to the overall dimension of the mathematics attitude scale, there were significant differences in favor of 5th graders between 5th and 6th graders, 5th and 7th graders, 5th and 8th graders, 6th and 7th graders, 6th and 8th grades, and 7th and 8th grades. The effect size value indicates that the effect of the general dimension of the mathematics attitude scale is “moderate.”

In the comparison of the mathematics self-efficacy and anxiety scale and its dimensions according to grade levels, the ANOVA test results were considered since the condition of homogeneity of variances was met for self-efficacy, mathematics anxiety, and the overall dimensions of the mathematics self-efficacy and anxiety scale. The findings obtained are presented in Table 5.

Table 5
Comparison of the mathematics self-efficacy and anxiety scale and its dimensions according to grade level

	n	$\bar{X}$	Sour. Var.	Sum of Sq.	df	Mean of S.	F	p	Diff.
Self-efficacy									
1.	188	3,79	B.G.	54,481	3	18,160	19,657	,000*	1>2,3,4
2.	214	3,51	W.G	673,489	729	,924			2>3,4
3.	195	3,27	Total	727,970	732				3>4
4.	136	3,01			Levene(F=1,729) p=,160)				
Total	733	3,43				n^2=,075			
Math Anxiety									
1.	186	2,89	B.G.	1,741	3	,580	,767	,513	
2.	217	2,96	W.G	553,422	731	,757			-
3.	196	2,98	Total	555,163	734				
4.	136	3,04				Levene(F=,144 p=,933)			
Total	735	2,96							
Whole of Mathematics Self-Efficacy and Anxiety Scale									
1.	186	3,29	B.G.	6,481	3	2,160	8,573	,000*	1>3,4
2.	214	3,20	W.G	182,440	724	,252			2>3,4
3.	193	3,10	Total	188,921	727				
4.	135	3,03				Levene(F=1,293 p=,276)			
Total	728	3,17				n^2=,034			
1: 5th grade, 2:6th grade, 3:7th grade, 4:8th grade									

As shown in Table 5, no significant difference was observed between grade levels in terms of the mathematics anxiety dimension (p>.05). Significant differences were found according to the dimensions of self-efficacy, mathematical self-efficacy, and anxiety (p<.05). According to the results of the post-hoc LSD test analysis for these dimensions, in the self-efficacy dimension, 5th graders with 6th graders, 5th graders with 7th graders, 5th graders with 8th graders, 6th and 7th grades, 6th and 8th grades, and 7th and 8th grades. The effect size value indicates that the effect of the self-efficacy dimension is “moderate.” In the general dimension of the mathematics self-efficacy and anxiety scale, there was a significant difference in favor of 5th graders between

5th and 7th graders, 5th and 8th graders, 6th and 7th graders, and 6th and 8th graders. According to the effect size value, the effect of the general dimension of the mathematics self-efficacy and anxiety scale is "small."

Another variable in the study is the emotional state related to mathematics lessons. In this context, the findings obtained from comparing the mathematics attitude scale and its dimensions according to the emotional state related to mathematics lessons are presented in Table 6.

Table 6
Comparison of the dimensions of the mathematics attitude scale based on the emotional state toward the mathematics course

Variable	n	$\bar{X}$	Sour. Var.	Sum of Sq.	df	Mean of S.	F	p	Diff.
Interest									
1.	404	3,90	B.G.	299,150	2	149,575	299,752	,000*	1>2,3
2.	226	2,95	W.G	366,761	735	,499			2>3
3.	108	2,21	Total	665,911	737	Levene (F=2,201 p=,111)			
Total	738	3,36				n^2=,449			
Anxiety									
1.	403	3,15	B.G.	55,146	2	27,573	45,864	,000*	1>2,3
2.	225	2,62	W.G	440,666	733	,601			
3.	108	2,56	Total	495,811	735	Levene (F=2,902 p=,056)			
Total	736	2,90				n^2=,111			

1. I like, 2. I'm undecided, 3. I don't like

According to the results in Table 7, since the condition of homogeneity of variance was met for the interest and anxiety dimensions, the ANOVA test results were considered, and a significant difference was found for the interest and anxiety dimensions ($p<.05$). According to the post-hoc LSD test analysis for these dimensions, a significant difference in favor of "I like it" was found in the interest dimension between "I like it" and "I am undecided," "I like it" and "I don't like it," and "I am undecided" and "I don't like it" based on the emotional state related to the mathematics course. In the anxiety dimension, a significant difference in favor of "I like it" was found between "I like it" and "I am undecided," and between "I like it" and "I dislike it," based on the emotional state toward the mathematics course. According to the calculated effect size value, a "large" effect was observed in the interest and anxiety dimensions.

The ANOVA test results were considered since the condition of homogeneity of variance was met for the self-efficacy and math anxiety dimensions of the math self-efficacy and anxiety scale when comparing these dimensions according to the emotional state related to the math course. The findings obtained are presented in Table 7.

Table 7
Comparison of the dimensions of the mathematics self-efficacy and anxiety scale according to the emotional state related to mathematics lessons

Variable	n	$\bar{X}$	Sour. Var.	Sum of Sq.	df	Mean of S.	F	p	Diff.
Self-Efficacy									
1.	401	3,93	B.G.	259,609	2	129,804	202,316	,000*	1>2,3
2.	225	3,05	W.G	468,362	730	,642			2>3
3.	107	2,34	Total	727,970	732	Levene(F=2,511 p=,082)			
Total	733	3,43				n^2=,357			

Table 7
Continued

Variable	n	$\bar{X}$	Sour. Var.	Sum of Sq.	df	Mean of S.	F	p	Diff.
Math Anxiety									
1.	402	2,75	B.G.	40,529	2	20,264	28,823	,000*	1<2,3
2.	226	3,23	W.G	514,634	732	,703			2>3
3.	107	3,20	Total	555,163	734	Levene(F=2,491 p=,084)			
Total	735	2,96				n^2=,073			

I like, 2. I'm undecided, 3. I don't like

According to the results in Table 7, a significant difference was found for the dimensions of self-efficacy and math anxiety (p<.05). The post-hoc LSD test analysis for these dimensions revealed a significant difference in favor of "I like it" versus "I am undecided," "I like it" versus "I dislike it," and "I am undecided" versus "I dislike it" in the self-efficacy dimension based on feelings toward math class. In the math anxiety dimension, a significant difference was found in favor of "I am undecided" versus "I like it" and "I am undecided" versus "I dislike it" based on feelings toward math class. According to the calculated effect size value, a "large" effect was observed in the self-efficacy dimension and a "medium" effect in the mathematics anxiety dimension.

According to the Levene test result, the overall mathematics self-efficacy and anxiety scale (F=4.273, p=.014), the overall mathematics attitude scale (F=4.660, p=.010), and the work (F=5.412, p=.005) and necessity (F=5.240, p=.005) dimensions of the mathematics attitude scale were not distributed homogeneously according to the emotional state related to the mathematics course (p<.05), the Kruskall Wallis H test was applied. The findings obtained in this context are presented in Table 8.

Table 8
Comparison of opinions regarding scale and size according to emotional states

Variable		Mean Rank	X^2	p	Diff.	n^2
Whole of Math sel-efficacy and Anxiety	1.I like (n=398) 2.I'm undecided (n=224) 3. I don't like (n=106)	404,26 353,10 239,31	52,490	,000*	1>2,3 2>3	,093
Effort	1.I like (n=398) 2.I'm undecided (n=224) 3. I don't like (n=106)	438,39 330,71 193,99	123,945	,000*		,178
Necessity	1.I like (n=398) 2.I'm undecided (n=224) 3. I don't like (n=106)	447,69 313,00 196,87	144,527	,000*		,198
Whole of Math Attitude Scale	1.I like (n=398) 2.I'm undecided (n=224) 3. I don't like (n=106)	487,32 264,80 124,33	323,739	,000*		,448

Shown in Table 8, the overall mathematics self-efficacy and anxiety scale, the overall work, necessity, and mathematics attitude scale dimensions differed significantly according to the emotional state related to mathematics lessons (p<.05). In these significant differences, the overall mathematics self-efficacy and anxiety scale, the overall work, necessity, and mathematics attitude scale dimensions showed significant differences in favor of liking between liking and being undecided, liking and disliking, and being undecided and disliking, according to the emotional state related to mathematics lessons. According to the effect size value, the overall

mathematics self-efficacy and anxiety scale, the overall mathematics attitude scale, and the overall mathematics attitude scale dimensions are at a "large" effect level.

Another variable in the study is the gender of the math teacher. Findings from comparing the scales and dimensions according to the gender of the math teacher are presented in Table 9.

Table 9

Comparison of opinions regarding scale and size according to the gender of the mathematics teacher

Variable		$\bar{X}$	sd	F	Levene p	t	df	p	Cohen d
Interest	Female	3,28	,954	1,774	,183	-3,865	735	,000*	0,33
	Male	3,59	,896						
Anxiety	Female	2,86	,799	3,149	,076	-2,624	733	,009*	0,33
	Male	3,04	,873						
Effort	Female	3,77	,853	,506	,477	-1,882	735	,060	-
	Male	3,91	,844						
Necessity	Female	3,82	1,102	,446	,504	-1,303	736	,193	-
	Male	3,94	1,079						
Self-efficacy	Female	3,35	,994	,440	,507	-3,685	730	,000*	0,31
	Male	3,65	,968						
Math anxiety	Female	3,00	,850	,901	,343	2,264	732	,024*	0,19
	Male	2,84	,918						
Whole of math sel-e. and anxiety scale	Female	3,15	,498	4,866	,028*	-,994	291,833	,321	-
	Male	3,20	,542						
Whole of math attitude scale	Female	3,35	,717	,523	,470	-3,802	728	,000*	0,22
	Male	3,58	,689						

As shown in Table 9, the dimensions of interest, anxiety, effort, necessity, self-efficacy, math anxiety, and the overall math attitude scale are distributed homogeneously according to the gender of the math teacher ($p > 0.05$); however, they are distributed non-homogeneously in terms of the overall math self-efficacy and anxiety scale ($p < 0.05$). Therefore, the Independent Groups T-test was used for interest, anxiety, effort, necessity, self-efficacy, math anxiety, and the overall math attitude scale; while the t-test for non-homogeneous variances was used for the overall math self-efficacy and anxiety scale. According to the analysis results in Table 10, interest (t(735)= -3.865; p=.000*<.05), anxiety (t(733)= -2.624; p=.009*<.05), the overall mathematics attitude scale (t(728)= -3.802; p=.000*<.05), self-efficacy (t(730)= -3.685; p=.000*<.05), and math anxiety (t(732)= 2.264; p=.024*<.05) differed significantly based on the teacher's gender; work (t(735)= -1.882; p=.060>0.05), necessity (t(736)= -1.303; p=.193>0.05), mathematical self-efficacy and anxiety scale overall (t(291.833= -,994; p=,321>,05). According to the effect size value, the effect of the interest, anxiety, self-efficacy, and overall mathematics attitude scale dimensions is "small," while the effect of the mathematics anxiety dimension is "weak."

The study sought to determine the direction and level of relationship between the variables. To this end, a correlation analysis was performed, and the results are presented in Table 10.

Table 10

Correlation analysis between the mathematics attitude scale, mathematics self-efficacy and anxiety scale and its sub dimensions, and mathematics achievement scores

Correlation	N	r	p
MAS * Interest	738	,341**	,000
MAS * Anxiety	736	,303**	,000
MAS * Effort	738	,349**	,000
MAS * Necessity	739	,269**	,000
MAS * Math Attitude	731	,416**	,000

MAS * self-efficacy	733	,431**	,000

Table 10
Continued

Correlation	N	r	p
MAS * Math anxiety	735	-,314**	,000
MAS * Math self-efficacy and anxiety	728	,075*	,042
Interest * Anxiety	734	,349**	,000
Interest * Effort	736	,535**	,000
Interest * Necessity	737	,538**	,000
Interest * Math attitude	731	,922**	,000
Interest * Self-efficacy	732	,761**	,000
Interest * Math anxiety	733	-,311**	,000
Interest * Math self-efficacy and anxiety	727	,369**	,000
Anxiety * Effort	734	,152**	,000
Anxiety * Necessity	735	,344**	,000
Anxiety * Math attitude	731	,576**	,000
Anxiety * Self-efficacy	729	,338**	,000
Anxiety * Math anxiety	732	-,558**	,000
Anxiety * Math self-efficacy and anxiety	725	-,236**	,000
Effort * Necessity	737	,426**	,000
Effort * Math attitude	731	,666**	,000
Effort * self-efficacy	731	,587**	,000
Effort * Math anxiety	733	-,120**	,001
Effort * Math self-efficacy and anxiety	726	,398**	,000
Necessity * MTÖ	731	,715**	,000
Necessity * self-efficacy	732	,481**	,000
Necessity * Math anxiety	734	-,348**	,000
Necessity * Math self-efficacy and anxiety	727	,085*	,022
Math attitude * Self-efficacy	725	,773**	,000
Math attitude * Math anxiety	727	-,432**	,000
Math attitude * Math self-efficacy and anxiety	721	,264**	,000
Self-efficacy * Math anxiety	728	-,398**	,000
Self-efficacy * Math self-efficacy and anxiety	728	,493**	,000
Math anxiety * Math self-efficacy and anxiety	728	,602**	,000

**.01 level of significance (MAS: Mathematics Achievement Score)

As shown in Table 11, positive and negative significant correlations were observed between the mathematics attitude scale and the mathematics self-efficacy and anxiety scale and their dimensions ($p<.05$). The highest correlation between the scales and their dimensions was found between the general mathematics attitude scale and the interest dimension (r=.922**, p=.000), while the lowest correlation was found between the mathematics achievement score and the general mathematics self-efficacy and anxiety scale (r=.075*, p=.042). Negative, significant relationships were observed between math anxiety and math achievement scores, interest, anxiety, effort, necessity, self-efficacy, and the overall math attitude scale.

Results, Discussion, and Recommendations

Only a significant difference was found in the anxiety dimension between the interest, anxiety, effort, and necessity dimensions of the mathematics attitude scale and the self-efficacy and mathematics anxiety dimensions of the mathematics self-efficacy and anxiety scale, according to the school variable of the students participating in the study. Sevgi, Sarı, and Işık (2021) found that middle school students' math anxiety did not differ significantly based on the school variable, which supports our research. The findings of Aydın and Keskin (2017) that students' math anxiety differed significantly according to the school they attended and Sevgi and Yakışıklı (2020) that students' attitudes toward math differed significantly according to the

school they attended contradict our study. The reason for the lack of significant differences in the scales overall and in other dimensions is thought to be that the schools where the research was conducted had similar social environments, academic achievements, and student profiles. The significant difference in the anxiety dimension may stem from the school environment. Teaching approaches aimed at reducing anxiety can be adopted in schools.

When the dimensions of the mathematics attitude scale and the mathematics self-efficacy and anxiety scale were examined according to the class level variable, significant differences were observed in all dimensions except for anxiety and mathematics anxiety. Looking at the averages, the averages of 5th graders were found to be higher than those of 6th, 7th, and 8th graders in the interest, effort, necessity, and self-efficacy dimensions and in the scales in general. The findings of Kurtuluş and Öztürk (2017) and Yılmaz (2011) that students' self-efficacy beliefs decrease as grade level increases, and the findings of Şimşek, Şahinkaya, and Aytekin (2017; Tan, 2015; Taşdemir, 2008) that students' mathematics attitude scores decrease as grade level increases. Some studies (Alkan et al., 2004; Kurbanoğlu and Takunyacı, 2012; Sezgin, 2013) have found that students' mathematics attitude scores increase as the grade level increases, which contradicts our finding that Sevgi and Yakışıklı (2020) found no significant difference between middle school students' mathematics self-efficacy and grade level. It is thought that the decline in students' mathematics attitude and self-efficacy scores as grade level increases stems from the difficulties of preparing for the central exam that 8th-grade students face when transitioning to the next level of education.

The study found significant differences in favor of 5th graders between grade level and interest, effort, necessity, self-efficacy, overall mathematics attitude scale, overall mathematics self-efficacy, and overall mathematics anxiety scale. This finding may indicate that students' beliefs about their mathematical self-efficacy are higher in the early years of middle school, and that as the grade level increases, mathematical topics become increasingly difficult, abstract, and complex. Furthermore, it can be considered that 5th grade students have more confidence in mathematical activities, have a higher interest and love for mathematics compared to upper grade levels, and relate mathematics more to daily life and career choices. In addition, younger students may be more eager to learn new information and develop their skills, which may have led them to display more positive attitudes towards the subject.

The study found significant differences between grade level and self-efficacy, the overall mathematics attitude scale, and the overall mathematics self-efficacy and anxiety scale. A review of the literature (İlhan, Gemcioğlu, & Poçan, 2021; Filiz & Gür, 2020) shows that previous studies support our findings, indicating a significant difference between mathematics attitude and grade level. Another finding of our study is that no significant relationship was found between grade level and math anxiety. Previous studies in the literature (Sevgi, Sarı and Işık, 2021; Kandal and Baş, 2021) also support this finding. Kandal and Baş (2021) stated that there was no significant relationship between middle school students' grade level and their math anxiety, while Sevgi, Sarı, and Işık (2021) stated that middle school students' math anxiety did not differ significantly according to grade level. Other than that, previous studies (Adal and Yavuz, 2017; Dursun and Bindak, 2011; Tuncer and Yılmaz, 2016) contradict our findings. Adal and Yavuz (2017) concluded that middle school students' levels of math anxiety differed significantly according to their grade level. Dursun and Bindak (2011) stated that the average mathematics anxiety scores of 8th-grade middle school students were significantly higher than those of students in lower grades. Tuncer and Yılmaz (2016) found that mathematics anxiety did not differ significantly in terms of grade level.

When the dimensions of the mathematics attitude scale and the mathematics self-efficacy and anxiety scale were examined according to students' emotional state towards mathematics

lessons, significant differences were observed across all scales and dimensions. The averages of students whose feelings towards math class were "I like it" in terms of interest, anxiety, effort, necessity, self-efficacy, and overall scale were higher than those who felt "I'm undecided" or "I don't like it." In the mathematics anxiety dimension, the averages of students whose feelings towards mathematics lessons were "I am undecided" were higher than those who felt "I like it" and "I dislike it." Reviewing the literature, Tuncer and Yılmaz (2016) stated that when comparing students who like math and students who like other subjects, there is a significant difference in favor of students who like math in terms of attitude scores and in favor of students who like other subjects in terms of anxiety scores. Peker and Şentürk (2012) emphasized that students who stated they liked mathematics had significantly lower mathematics anxiety levels compared to students who stated they did not like mathematics. Şahin (2008) found that feelings toward mathematics lessons were a determining factor in the mathematics anxiety levels of 4th and 5th grade elementary school students; students who stated that they liked mathematics lessons had statistically significantly lower mathematics anxiety levels than students who stated that they did not like the lessons. Sırmacı (2007) stated that mathematics attitude scores were significantly higher in favor of students who liked mathematics more than other subjects. He also noted that students who like math class the least have significantly higher math anxiety than students who like other subjects the least. Tuncer and Yılmaz (2020) stated that students who choose math as their favorite subject have less anxiety about math, more positive attitudes, and higher academic achievement. Tekin et al. (2023) concluded that students' attitudes toward mathematics showed significant differences based on their level of liking for the subject. Reyes (2019) concluded that mathematics anxiety was related to emotional feelings and participants' past academic performance. Omar, Aris, and Hoon (2022) revealed that the emotion factor is not a statistically significant predictor of mathematics achievement. However, they stated that the emotion factor is an important predictor of mathematics anxiety for a high-performing student group.

When the dimensions of the mathematics attitude scale and the mathematics self-efficacy and anxiety scale were examined according to the gender of mathematics teachers, significant differences were observed in the dimensions of interest, anxiety, self-efficacy, mathematics anxiety, and the mathematics attitude scale in general. Furthermore, when looking at the interest, anxiety, and self-efficacy dimensions and the overall mathematics attitude scale, male teachers' averages were higher than female teachers' averages, while female teachers' averages were higher in the mathematics anxiety dimension. In this case, students with female math teachers had higher math anxiety, while students with male math teachers had higher interest, anxiety, self-efficacy, and math attitudes. Previous studies in the literature (Tuncer and Yılmaz, 2020; Tekin et al., 2023) support our findings. Karakaya et al. (2023) stated that students' attitudes toward mathematics lessons showed significant differences according to the teacher's gender, while Tuncer and Yılmaz (2020) stated that male teachers had higher averages in terms of attitude. However, Yaşar's (2016) finding that the teacher's gender does not significantly differentiate attitudes toward mathematics contradicts our research. Furthermore, Yenilmez and Duman (2008) found that mathematics achievement differs significantly according to the teacher's gender, with students whose teachers are female having higher mathematics achievement, regardless of the teaching method used and the teacher's

When examining the correlation between the mathematics attitude scale, the mathematics self-efficacy and anxiety scale, and mathematics achievement scores, a positive and significant relationship was found between mathematics achievement scores and interest, anxiety, effort, necessity, self-efficacy, the overall mathematics attitude scale, and the overall mathematics self-efficacy and anxiety scale, while a negative significant relationship was observed between mathematics achievement scores and mathematics anxiety. Reviewing the literature (Chen et al.,

2018; Erden and Akgül, 2010; Harari, Vukovic, and Bailey, 2013; Ma and Xu, 2004; Mutegi et al., 2021; Dursun and Bindak, 2011; Peker and Şentürk, 2012; Şahin, 2008; Yenilmez and Özabacı, 2003; Živkovic et al., 2023) support our findings that there is a negative and significant relationship between math anxiety and math achievement. Perez-Fuentes et al. (2020) found that mathematical self-efficacy is a strong predictor of mathematical achievement, while Hiller et al. (2022) that both math anxiety and mathematical self-efficacy show a meaningful relationship with math achievement, Zhang and Wang (2020) that interest in math has a direct and positive effect on students' math achievement, Altakhyneh (2020) that moderate anxiety has a positive effect on achievement, while no difference in achievement was observed for low and high levels of math anxiety, Desai and Richards (1998) found a significant relationship between mathematics anxiety level and achievement. The findings of Tuncer and Yılmaz (2020) that achievement in mathematics is positively related to attitude toward mathematics and negatively related to anxiety toward mathematics are consistent with our study.

Desai and Richards (1998) reported in their research that there is a relationship between math anxiety and performance, emphasizing that anxiety should be considered as a variable in the process of improving students' performance. Accordingly, the level of anxiety must be taken into account in the process of improving learners' performance. Chen et al. (2018) stated that after considering math success, many cognitive and affective factors predict math success, suggesting that attitude toward math is one of the most important variables in math education. This finding, which reflects mathematics achievement in relation to attitude, is consistent with Aksu and Bikos' (2002) view that "Negative attitudes towards the subject cause high levels of anxiety in students, and this negatively affects academic performance." As a result of this research, educators must absolutely consider attitude in terms of math achievement. It can be argued that if activities aimed at fostering positive attitudes in students are planned while also taking into account students' anxiety levels in the teaching process, math achievement will be positively affected. Furthermore, looking at our findings regarding math achievement scores, it can be argued that students' positive emotional state, development of positive attitudes toward math, and high self-efficacy perceptions increase their math achievement.

A positive and significant relationship was observed between the interest dimension and anxiety, effort, necessity, self-efficacy, the overall mathematics attitude scale, and the overall mathematics self-efficacy and anxiety scale. A negative and significant relationship was observed between the interest dimension and mathematics anxiety. In this case, it can be said that as students' interest in mathematics increases, their willingness to work, their belief in the necessity of the course will increase, their self-efficacy will develop, they will have more positive attitudes towards mathematics, and at the same time, their mathematics anxiety will decrease.

A positive and significant relationship was found between the anxiety dimension and the overall mathematics attitude scale, necessity, self-efficacy, and mathematics attitude scale. A negative and significant relationship was found between the anxiety dimension and the overall mathematics anxiety and mathematics self-efficacy and anxiety scales. In this case, it was concluded that there is a positive relationship between anxiety and attitude towards mathematics. However, a review of the literature reveals many studies that contradict this result. Tuncer and Yılmaz (2020) and Srivastava, Imam, and Singh (2016) concluded that there is a negative and significant relationship between anxiety and attitude toward mathematics. Peker and Şentürk (2012) emphasized that there is a statistically significant, negative, and moderate relationship between the mathematics anxiety levels of 5th-grade middle school students and their attitudes toward mathematics lessons. Yenilmez and Özabacı (2003) stated that there is a high-level, negative, and significant relationship between high school students' math anxiety and their attitudes toward math class. Peker and Mirasyedioğlu (2003) determined that there is a negative

relationship between math anxiety and attitudes toward math. Tuncer and Yılmaz (2016) concluded that there is a strong negative relationship between middle school students' attitudes and anxiety towards mathematics. Another result of our study was that there is a positive relationship between anxiety and self-efficacy. Ducay and Alave (2021) also found a positive relationship between self-efficacy and anxiety.

A positive and significant relationship was observed between the work dimension and necessity, self-efficacy, the overall mathematics attitude scale, and the overall mathematics self-efficacy and anxiety scale, while a negative and significant relationship was observed between the work dimension and mathematics anxiety. Based on this result, students who study regularly better understand that mathematics is necessary and important, and develop their feelings of self-efficacy by practicing the topics more. This contributes to the positive shaping of their general attitudes toward mathematics. In addition, students who study mathematics regularly understand the topics better and compensate for their deficiencies more easily. In this case, it can be said that it will reduce math anxiety by eliminating stress and fear of failure.

A positive and significant relationship was observed between the necessity dimension and self-efficacy, the overall mathematics attitude scale, and the overall mathematics self-efficacy and anxiety scale, while a negative and significant relationship was observed between the necessity dimension and mathematics anxiety. Based on this result, students who believe that mathematics is necessary take the course more seriously, put in more effort, and develop their self-efficacy perceptions positively by experiencing success during this process. Believing in the necessity of the course facilitates the development of a positive attitude towards the course. Furthermore, as belief in the necessity of mathematics increases, the student's negative emotional responses to the subject decrease, which leads to a reduction in mathematics anxiety levels. Therefore, in mathematics education, students should be made aware of the connection between the subject and daily life, professions, and individual goals; thus, both their motivation will increase and their mathematics anxiety will decrease.

A positive and significant relationship was observed between the overall mathematics attitude scale and self-efficacy, mathematics self-efficacy, and anxiety scale, while a negative and significant relationship was observed between the overall mathematics attitude scale and mathematics anxiety. A review of the literature reveals that Mutegi et al. (2021) found a positive and significant relationship between math anxiety and math attitude, which contradicts our findings. Another finding of our study is that there is a positive and significant relationship between self-efficacy and mathematical attitude. Reviewing the literature, other studies indicate that there is a positive and significant relationship between students' attitudes toward mathematics and their academic self-efficacy (Adal and Yavuz, 2017; Çavdar, 2019; Durmaz, 2019; Hackett and Betz, 1989; Sezgin, 2013; Yağmur, 2012; Yamaç, 2011; Yılmaz, 2011; Yürekli, 2008). In line with this finding of our study, it can be concluded that students who perceive themselves as mathematically competent tend to develop more positive feelings towards this subject. Furthermore, it can be concluded that students with positive attitudes toward mathematics perceive themselves as more competent in mathematics.

There is a positive and significant relationship between the self-efficacy dimension and the overall mathematics self-efficacy and anxiety scale, and a negative and significant relationship between the self-efficacy dimension and mathematics anxiety. Based on this result, a student with high self-efficacy in mathematics believes that they can solve difficult problems, understand the topics, and be successful. In this case, the individual trusts their own capacity, and their fear of failure decreases. When the fear of failure decreases, math anxiety also decreases. Finally, there is a positive and significant relationship between the math anxiety dimension and the overall math self-efficacy and anxiety scale.

Based on all these findings, the following recommendations can be made:

- The findings of our research provide strong evidence that students' self-efficacy beliefs play a major role in the learning-teaching process in mathematics education. Accordingly, it is recommended that teaching programs be structured to target the development of students' mathematical self-efficacy. To achieve this goal, teaching strategies and practical examples that support students' self-efficacy beliefs can be included in mathematics teaching programs, encouraging teachers to use different teaching methods and techniques. Furthermore, to enable teachers to play an effective role in developing this skill, mathematics teachers can be supported through seminars and training as part of professional development programs focused on self-efficacy.
- Since the formation and change of students' mathematics anxiety, mathematics self-efficacy, and attitudes toward mathematics require a long process, longitudinal studies can be conducted to enable the tracking of these variables from elementary school through higher levels of education.
- In order to help students develop their self-efficacy beliefs, reduce their math anxiety, and develop positive attitudes toward mathematics, it may be beneficial to include activities aimed at these goals in the guidance programs run by school counseling services.
- Considering the significant role of middle school students' math anxiety, math self-efficacy, and math attitudes in math education, these variables could be addressed more comprehensively in the math curriculum and textbooks.
- This study addressed students' attitudes, anxiety, and self-efficacy toward mathematics, but did not examine the issues that may cause these variables. It is recommended to identify the issues that may be most influential in the development of students' attitudes, anxiety, and self-efficacy toward mathematics and to conduct in-depth research on the factors causing this situation.

Declarations

Acknowledgements:This study has certain limitations. These limitations include the sampling method, the cross-sectional measurement approach, and the fact that the data collection instruments were self-reported. In addition, the mathematics achievement scores included in the study were also obtained through participant self-report.

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