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The Effect of Mathematics Anxiety on Students' Learning Achievement: An Ex Post Facto Study

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Abstract. *Mathematics anxiety can reduce students' ability to understand and solve mathematical problems, thus affecting their overall attitude towards mathematics. Mathematics anxiety, a psychological factor that can affect students' learning achievement in mathematics learning in high school, makes it the most challenging subject in school. This study aimed to identify the effect of mathematics anxiety on students' learning achievement at the high school level and to analyze strategic factors that can help reduce mathematics anxiety for students. This study used a quantitative method with an ex post facto research type with a correlational design. The population was grade X high school students in South Tangerang, with a sample size of 84. The side technique used cluster random sampling. Data collection used an instrument in the form of a mathematics anxiety and learning achievement questionnaire. Data analysis was carried out through partial correlation and multiple correlation with a significance level of 0.05, and the prerequisite test analysis used normality, linearity, and multicollinearity tests. The results showed that mathematics anxiety influenced by self-efficacy factors, classroom climate, and academic support from parents and peers significantly affected students' learning achievement in high school. Schools can facilitate a more conducive learning environment to minimize mathematics anxiety and improve learning outcomes. Implementing a learning program that is psychologically responsive and adaptive to students' needs is expected to improve students' mathematics achievement significantly..*

Keywords: *Anxiety, Mathematics, Achievement, Learning Outcomes, Learning.*

1. INTRODUCTION

Mathematics anxiety is one of the psychological challenges often faced by students in high school, which can indirectly affect their learning achievement. Factors such as self-efficacy, classroom climate, and academic support from parents and peers play an important role in shaping students' mathematics learning experiences (Barroso et al., 2021). A deeper exploration of these factors can provide a better understanding of how mathematics anxiety affects learning achievement (Li et al., 2021).

Self-efficacy, or students' belief in their ability to complete mathematical tasks or challenges, strongly influences their approach to solving mathematics problems. Students with high self-efficacy tend to have better resilience to mathematics anxiety and can achieve higher learning outcomes (Zakariya, 2022). On the other hand, students who feel unable to overcome mathematical challenges may experience increased anxiety that can hinder their learning process (Özcan & Kültür, 2021).

Classroom climate also plays a crucial role in supporting or worsening mathematics anxiety. A supportive classroom environment, where mistakes are seen as

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part of the learning process and where there is collaboration and positive interactions between students, can reduce mathematics anxiety and improve learning achievement (M.-T. Wang et al., 2020). Conversely, a competitive or unsupportive classroom climate can increase mathematics anxiety and interfere with student's ability to learn effectively (Barksdale et al., 2021).

Academic support from parents and peers is another important aspect. This support not only provides practical assistance in understanding mathematical concepts but also provides emotional support that helps students feel more secure and confident in facing academic challenges (Demirtaş & Uygun-Eryurt, 2022). Parents and peers who provide encouragement and understand the difficulties faced by students can help reduce mathematics anxiety and encourage positive attitudes towards mathematics learning (Passolunghi et al., 2020).

Previous research (Gabriel et al., 2020; Süren & Kandemir, 2020; Zanabazar et al., 2023) provides a deep understanding that various factors, such as self-efficacy, classroom climate, and academic support, including support from parents, can influence mathematics anxiety in students. These factors play an important role in creating conditions that support student learning achievement, especially in mathematics. This research has excellent potential to be further developed and modified, focusing on efforts that can encourage students to reduce mathematics anxiety and improve achievement. With a more targeted approach, this research is expected to provide new insights into designing more effective educational strategies, which not only support students' academic achievement but also help create a more positive and productive learning environment, especially in mathematics learning.

This study aims to explore how the combination of self-efficacy factors, classroom climate, and academic support from parents and peers can be utilized to reduce mathematics anxiety and, ultimately, improve high school students' learning achievement. The results of this study are expected to be the basis for the development of effective intervention strategies that educators and parents can implement in an effort to optimize the mathematics learning process in schools.

2. LITERATURE REVIEW

Anxiety

Anxiety, in a psychological context, is an emotional state characterized by feelings of worry, apprehension, and fear that are often accompanied by physical symptoms such as rapid heartbeat, sweating, and muscle tension. According to Khasawneh et al., (2021), anxiety can be divided into two types: state anxiety, which is a temporary response to a particular situation, and trait anxiety, which is a long-term personality characteristic. Research in education often focuses on state anxiety because of its direct relationship to learning and testing situations. Mathematics anxiety is a feeling of tension and anxiety that interferes with the effective manipulation of numbers and solving mathematical problems in a variety of everyday life and academic situations (Lau et al., 2022). Mathematics anxiety not only decreases math test performance but can also affect a person's career choices, indicating the long-term impact of this problem (Szczygieł & Pieronkiewicz, 2022).

Three factors determine mathematics anxiety (Ashcraft et al., 2021; Tomasetto et al., 2021). Namely, first, self-efficacy is a person's belief in their ability to succeed in a particular situation or achieve a particular task. Second, classroom climate reflects students' perceptions of their learning environment, including aspects such as teacher support, interaction between students, and acceptance of mistakes as part of the learning process. Third, academic support from parents and peers is a significant external factor in influencing students' academic achievement and math anxiety. The combined support from parents and peers creates a more holistic and supportive learning environment, which can reduce math anxiety and improve academic achievement.

Mathematics Learning

Mathematics learning is a teaching and learning process that focuses on the field of mathematics, covering various concepts, theories, and practical applications. This process aims to equip students with the skills needed to understand mathematical logic, problem-solving, quantitative analysis, and critical thinking (McMinn et al., 2021). Mathematics learning at the Senior High School level in Indonesia covers various topics and concepts that are important for the development of students' analytical and logical abilities (Lin, 2023; Vale & Barbosa, 2023).

Mathematics learning at the Senior High School level distinguishes itself from previous levels because of the uniqueness of the age and intellectual development of

students. On average, high school students are between 15 and 19 years old, in the middle adolescence phase (Clements & Sarama, 2020; Niss & Blum, 2020). According to Piaget's cognitive development theory, high school students are at the formal operational stage (Maghfiroh et al., 2023). At this stage, they are able to process concrete operations into more complex thought structures, formulate hypotheses, integrate various possible ideas and propositions, and reflect, which includes thinking about their thought processes—an ability known as metacognition.

Student Learning Achievement

Learning achievement is an indicator of a student's learning success or capacity to participate in their learning activities, which is reflected in the grades achieved. This achievement not only shows how well students receive, assess, and process information during the teaching and learning process but also reflects their level of success in understanding the subject matter (Bryan et al., 2011). Learning achievement is usually measured through grades or report cards given in each field of study (Ihsan et al., 2019). Evaluations carried out on students allow us to know their level of learning achievement, which is shown through evaluation results that reflect their high or low achievement in learning (G. Li et al., 2022).

Mathematics learning achievement describes the level of student mastery of mathematics subject matter as measured by the results of learning tests (Yang et al., 2021). The scores obtained in the test reflect students' ability to understand mathematical concepts, apply formulas, solve problems, and use mathematical logic effectively. This achievement not only shows how well students understand the material being taught but also their ability to integrate that knowledge in different situations. This evaluation of mathematics learning achievement is important to identify strengths and areas that need improvement, as well as to adjust teaching methods to be more effective in supporting students' academic success.

3. METHODS

This study uses a quantitative method with an ex post facto design model to find potential causes of changes in behaviour, symptoms, or phenomena that occur due to an event (Johnson & Christensen, 2022; Teo, 2013). It also uses a correlational design to determine the extent of the relationship between two or more variables. The data collected include four variables: self-efficacy (X1), classroom climate (X2), academic support from parents and peers (X3), and learning achievement (Y).

The study population included students of state Senior High School 12 South Tangerang City and state Senior High School 3 South Tangerang City, with a sample of 84 class X students. The sampling technique used was cluster random sampling, where the population is divided into several separate groups (clusters) before being selected randomly. Data collection was carried out using a questionnaire to measure math anxiety, self-efficacy, classroom climate, academic support from parents and peers, and learning achievement. This questionnaire uses a Likert scale with five alternative answers consisting of positive and negative statements.

Validity testing was carried out through content and construct validity. Experts assessed content validity to ensure that the indicators measured were in accordance with the objectives. Construct validity was calculated using the biserial correlation coefficient, with the results of Self-efficacy (X1) 15 valid statements with a correlation score >0.512 and 2 invalid statements. Class climate (X2) 15 valid statements with a correlation score >0.449 and 3 invalid statements. Academic support (X3) 13 valid statements with a correlation score >0.492 and 3 invalid statements. Learning achievement (Y) 11 valid statements with a correlation score >0.410 and 1 invalid statement. Reliability testing was carried out using the KR-20 formula (Heale & Twycross, 2015). The instrument is considered reliable if the reliability coefficient is >0.6. The results showed that all instruments (X1, X2, X3, and Y) had a reliability coefficient >0.6, so they were declared reliable and could be used in the analysis and hypothesis testing stages.

Data analysis used parametric statistical methods to test the hypothesis by considering population parameters. Data processing was carried out with the help of the IBM SPSS Statistics program version 26, using partial and simultaneous correlation tests. The analysis aims to measure the influence of self-efficacy (X1), classroom climate (X2), and academic support (X3) on learning achievement (Y). Before testing the hypothesis, data description tests and prerequisite tests were conducted, including normality, linearity, and multicollinearity tests, to ensure that the data met the analysis requirements.

4. RESULTS

The determination of categories for each variable is based on the assumption that the population scores are normally distributed according to the standard normal curve. The results of the analysis show that the self-efficacy of most respondents, 84 people (52.2%), is in the moderate category with an average value of 9.44. The Classroom Climate of most respondents, namely 54 people (46.1%), is in the good category with an average value of 11.3. The Academic support of most respondents, namely 60 people (43.3%), is in the moderate category with an average value of 10.1. The learning achievement of 39 respondents (37.9%) is in the moderate category, with an average value of 9.71.

This study conducted a prerequisite test analysis with the aim of ensuring that the data meets the assumptions required before conducting further analysis. The prerequisite tests carried out include the Normality Test, which tests whether the data is normally distributed, which is the main requirement for regression analysis. The Linearity Test is used to ensure that the relationship between the independent and dependent variables is linear. A multicollinearity test is used to test whether there is a high correlation between independent variables that can affect the accuracy of the regression model. After the prerequisite test is met, the analysis is continued with Hypothesis Testing to test the relationship between the variables that have been studied. The results of the normality test analysis using the Shapiro-Wilk model show that the significance value for each variable is as follows: self-efficacy of 0.621, classroom climate of 0.456, academic support of 0.555, and learning achievement of 0.430. All significance values are greater than 0.05 ($\alpha > 0.05$) so that the data for each variable is declared normally distributed. More detailed information is presented in the following table.

Table 1. Normality Test Results

Tests of Normality							
Variable	**Kolmogorov-Smirnov[a]**			**Shapiro-Wilk**			**Explanation**
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**	
X1	.079	84	.244	.922	84	.621	Normal
X2	.119	84	.592	.709	84	.456	Normal
X3	.146	84	.328	.866	84	.555	Normal
Y	.181	84	.267	.982	84	.430	Normal

The results of the linearity test listed in Table 2 show that the Sig. Deviation from Linearity value for the self-efficacy variable is 0.728, for classroom climate is 0.719, and for academic support is 0.792. These values are greater than 0.05, which means that there is a linear relationship between the independent variable and the dependent variable. For more details, see the following table.

Table 2. Linearity Test Results

Variable	F - Linearity	Sig.	Criteria	Explanation
X1	1.771	0.728	P> 0.05	Linear
X2	1.869	0.719	P> 0.05	Linear
X3	1.922	0,792	P> 0.05	Linear

The results of the multicollinearity test presented in Table 3 show that the variables of self-efficacy, classroom climate, and academic support have a tolerance value of 0.964 (tolerance > 0.10) and a VIF value of 1.037 (VIF < 10), which indicates that there is no multicollinearity between the variables. A more detailed explanation can be seen in the following table.

Table 3. Multicollinearity Test Results

Variable	Tolerance	VIF	Explanation
X1	.871	1.229	No multicollinearity
X2	.871	1.229	No multicollinearity
X3	.871	1.229	No multicollinearity

The results of the hypothesis test in Table 4 using partial correlation show a positive influence between self-efficacy (X1) and learning achievement (Y) with a partial value of 0.411 and a significance of 0.001. In addition, class climate (X2) has a positive influence on learning achievement (Y), with a partial value of 0.429 and a significance of 0.003. Academic support (X3) also shows a positive influence on learning achievement (Y) with a partial value of 0.476 and a significance of 0.002. All of these significance values are below p <0.05, which means that self-efficacy (X1), class climate (X2), and academic support (X3) have a positive and significant influence on learning achievement (Y). Further details can be seen in the following table.

Table 4. Partial Test Results

Variable	Partial	Sig.	Criteria	Explanation
X1 -> Y	.411	.001	p<0.05	Significant
X2 -> Y	.429	.003	p<0.05	Significant
X3 -> Y	.476	.002	p<0.05	

The results of the simultaneous multiple regression test presented in Table 5 show that self-efficacy (X1), classroom climate (X2), and academic support (X3) simultaneously influence learning achievement (Y) in mathematics learning—the Sig. F Change value of 0.000, which is smaller than 0.05 (p <0.05), and the R-value of 0.601 indicates that the influence of the independent variables on the dependent variable is included in the strong category. Further explanation of the results can be seen in the following table.

Table 5. Simultaneous Multiple Regression Test Results

Variable	R	R Square	Sig. F Change	Criteria	Explanation
X1, X2, X3, -> Y	.601	.543	.000	p<0.05	Significance

5. DISCUSSION

Math anxiety is one of the main challenges faced by many students, especially in high school. When students feel anxious or afraid of math, it can hinder them from understanding the material and working on problems well, which ultimately impacts their academic achievement (Ablian & Parangat, 2022; Yang et al., 2021). However, math anxiety is not a stand-alone factor but is influenced by several elements, such as self-efficacy, classroom climate, and academic support from parents and friends (Özben & Kilicoglu, 2021).

Self-efficacy, or students' belief in their ability to solve math problems, has a major influence on their anxiety levels. Students with low levels of self-efficacy tend to feel incapable of facing math challenges, which then increases their anxiety (C. Wang et al., 2023). Conversely, students who are confident in their abilities are more likely to overcome feelings of anxiety and take on challenges in learning (Herawati et al., 2021). Therefore, developing positive self-efficacy is very important to reduce math anxiety so that students can focus more on the learning process and achieve optimal achievement (Du et al., 2021).

The classroom climate or learning atmosphere at school also affects students' math anxiety. Classes that are dominated by a pressuring approach, lack of support from teachers, or unhealthy competition can increase students' anxiety in math lessons. In contrast, a supportive classroom climate—where teachers pay enough attention, provide space for questions, and create a conducive atmosphere—can help students feel more comfortable and confident (Kaskens et al., 2020; Zhou et al., 2020). When students feel accepted and valued in the classroom, they are more likely to overcome anxiety and improve their math performance.

Support from parents and peers also plays an important role in reducing math anxiety. Parents who provide positive reinforcement and motivation and create a comfortable learning environment at home can help students feel calmer and more confident in learning math (Bergqvist et al., 2020). In addition, supportive peers, whether in the form of group work or simply encouragement, can make students feel less alone in facing academic challenges (Hiller et al., 2022). This social support can reduce the pressure felt by students so that their anxiety is reduced and they are better able to focus on the material being taught.

High math anxiety can negatively impact student achievement. When students experience anxiety, they tend to have difficulty thinking clearly, remembering concepts they have learned, and facing math tests or assignments without feeling frustrated (Karakose et al., 2023). This condition often leads to a decline in their academic performance. However, this anxiety can be minimized by increasing self-efficacy, creating a supportive classroom climate, and providing strong academic support. Through this approach, students can learn more effectively, feel more confident, and significantly improve their learning outcomes (Schaeffer et al., 2021).

Zuo et al., (2024) research revealed that math anxiety can affect students' achievement in high school. This is emphasized by Pérez-Fuentes et al., (2020), who stated that math anxiety is a crucial factor in learning that impacts student achievement. However, anxiety can serve as an encouragement for students to focus more. This study also highlights that factors such as self-efficacy, classroom climate, and academic support from parents and friends greatly influence achievement. Hence, students need to stay focused and continue to try to learn.

Math anxiety, which is influenced by factors such as self-efficacy, classroom climate, and academic support from parents and friends, significantly influences student

achievement in high school (Fadli et al., 2021, 2022). Therefore, schools, teachers, parents, and friends need to work together to create a supportive environment that can reduce students' anxiety about mathematics and motivate them to achieve better performance (Özcan & Kültür, 2021). With a holistic and in-depth approach, students will be better able to face mathematics challenges and improve their overall learning outcomes.

6. CONCLUSION

Various factors, including self-efficacy, classroom climate, and academic support from parents and peers, can influence mathematics anxiety experienced by high school students. These factors, if managed well, have great potential to reduce students' anxiety and, in turn, improve their learning achievement in mathematics. The results of this study emphasize the importance of a holistic approach in addressing mathematics anxiety, where collaboration between students, educators, and parents is essential. With this understanding, this study is expected to be the basis for the development of more effective intervention strategies, which educators and parents can implement. The main goal is to create a supportive learning environment, increase student motivation, and optimize their achievement in mathematics learning, both in and out of class.

7. LIMITATION

The limitations of this study lie in the scope of the area, which only focuses on one area, namely Tangerang, Indonesia, so the results cannot be generalized to other areas with different characteristics. In addition, the relatively limited number of samples can affect the representativeness of the research results to the overall high school student population. This study also has not explored in depth other factors beyond self-efficacy, classroom climate, and academic support that may also influence math anxiety, such as teacher teaching methods, curriculum, or students' socio-economic backgrounds. Therefore, further research is needed with a wider scope, a larger number of samples, and a more comprehensive approach to obtain a more in-depth picture.

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