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Factors Influencing Mathematics Anxiety Among Undergraduate Students using Regression Model

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Abstract: Mathematics anxiety remains a common issue in education today, impacting students of all ages. This phenomenon has been documented across multiple generations, but its impact on the current generation of students is particularly interesting. This study aims to determine the factors influencing mathematics anxiety among undergraduate students at Universiti Teknologi Mara Kelantan Branch. The study investigated variables such as courses, teacher related factor, spatial abilities, socio-economic factors, and parent factor and evaluated their impact on students' mathematics anxiety. The study involved the participation of 320 students, who were selected randomly and completed questionnaires using Google Form. The collected data was subjected to analysis using the multiple linear regression method. The findings highlighted that teacher related factor and spatial abilities significantly influenced mathematics anxiety among students, while courses, socio-economic factors, and parent factor played a comparatively lesser role. In addition to expanding our understanding of the mechanisms underlying mathematical anxiety, this research offers insightful information to researchers, parents, educators, and the public. The authors emphasise the importance of educational intervention and awareness strategies as they offer suggestions and recommendations for strategic guidance in managing mathematics anxiety.

Keywords: Mathematics anxiety, teacher related factor, spatial abilities, parent factor, undergraduate

1 Introduction

Mathematics anxiety can be defined as feelings of apprehension as well as elevated physiological reactivity while dealing with mathematics, such as when manipulating numbers, solving mathematical problems, or being exposed to an evaluative circumstance involving mathematics. Because academic accomplishment is highly valued in Asia, Asian students tend to experience significant levels of anxiety [1]. An unfavourable emotional response to mathematics, known as mathematics anxiety, can be quite crippling. In other words, as opposed to exam anxiety, mathematics anxiety is an anxiety that is explicitly related to mathematics. It is distinctive because other specialised subject areas, like reading, writing, or history, do not commonly experience anxiety problems.

Knowing and being good at math is important for how well we live individually and as a society. There is a widespread issue around the world where feeling anxious about math is linked to not doing well in math. The Program for International Student Assessment (PISA) shows this connection between many countries and cultures. The substantial negative correlation observed in PISA data highlights the impactful connection between mathematics anxiety and students' achievements in mathematics [2].

Mathematics challenges are a common occurrence for students in elementary, secondary, and higher education. At the higher education level, students who struggle with mathematics are more likely to ignore the course or, in the worst situation, fail it and leave school altogether. Unfortunately, students do poorly in secondary schools and colleges, especially in mathematics, even after attending Malaysian schools for more than eleven years [3]. Students must comprehend their own levels of motivation and anxiety related to mathematics in order to help them deal with this problem. A significant percentage of Malaysian students suffer from mild to moderate anxiety related to mathematics [4].

The purpose of this study is to identify the elements that lead to mathematics anxiety in undergraduate students. Mathematics anxiety is the reason for the pressure, uneasiness, or terror that students experience when faced with mathematical tasks or situations. It is detrimental to have mathematics anxiety, particularly for undergraduate students, since it can have a detrimental effect on their learning and performance in the subject. Lack of confidence in one's ability to solve mathematical problems can also make mathematics classes uncomfortable. In the new millennium, mathematics has become essential. Additionally, children who struggle with mathematics have fewer options for choosing careers and pursuing courses that will ensure a successful future job [5].

A Mathematics Anxiety

Mathematics anxiety describes a condition of stress and worry that hinders a person's capacity to manipulate numbers, carry out mathematical operations, and resolve mathematical issues in a variety of academic and real-world settings [6]. Scholars primarily studied methods and tools for measuring mathematics anxiety from the mid-1950s to the beginning of 1990s. This involves investigating the factors that contribute to mathematics anxiety among students [7].

Previous research has shown that younger students report more physical symptoms of academic anxiety than cognitive symptoms (like concern), whereas older students are affected mentally by intrusive thoughts about mathematics [8]. Prior studies have indicated a connection between mathematics anxiety and subpar performance in high school and college mathematics courses [9]. Up to 80% of community college students and 25% of four-year college students in the US say they suffer from moderate to severe arithmetic anxiety. Undergraduate students' confidence in their abilities to solve mathematical issues may influence their motivation and degree of engagement in class in addition to their fear of mathematics [10].

B Mathematics Anxiety Level Assessment

There are a few tools used for assessing mathematics anxiety. One of the first and best-known instruments for measuring mathematics anxiety is the 98-item Mathematics Anxiety Rating Scale (MARS) [11]. The MARS is commonly used to measure mathematics anxiety in adults [1]. The MARS is one of the most widely used tools for assessing the idea of mathematics anxiety because of its high validity and reliability. Given the current availability of a variety of scales to assess mathematics anxiety, researchers may find it useful to comprehend how each scale varies in its correlations to mathematical competence when selecting their study measures. [12].

The Math Anxiety Questionnaire for Adults (MAQA) is a shorter version of MARS, where it implies a unidimensional test with 19 simple mathematical problems. Using this tool, participants rated their degree of mathematics anxiety on a four-point scale. The questions were chosen based on the theory of mathematics anxiety from previous research. Anxiety related to mathematics is gauged by the overall average score; the greater the score, the more severe the anxiety [12].

C Factors Influencing Mathematics Anxiety

i. Teacher Related Factor

Various instructor behaviours were found to be associated with increased math anxiety in Sokoto State's secondary schools. These subcategories include rushing through the lesson, taking too many notes, giving too many exercises, acting irritably, punishing too much, using insufficient teaching aids,

packing the math class too full, and ignoring the needs of slow learners. These elements are consistent with earlier research findings that emphasise how students' apprehension about mathematics is influenced by the learning environment and the unfavourable behaviour of teachers. Teaching methods and math teachers themselves are the root causes of math anxiety. As a result, a teacher's demeanour and manner of instruction greatly influence students' anxiety of the subject [13].

Other elements have also surfaced in the Nigerian setting, such as the widespread application of harsh punishment in math classes. Students reported receiving a variety of punishments, including caning and kneeling in front of their peers as forms of corporal discipline. The practice of giving out too many arithmetic notes in class is another element that respondents brought up. This method often results in a dull lecture that is too focused on the instructors [13].

Teachers or educators are partly to blame for arithmetic anxiety. They believe that in order to address mathematics anxiety, teachers must take a significant role. To assist students who suffer from mathematics anxiety, math teachers can refrain from drawing comparisons based on gender and show equal interest in each student's questions. They discovered that based on mathematical curiosity, the disparities in mathematics anxiety might not be possible. However, the research findings emphasised that mathematics anxiety was a hereditary condition rather than a learnable one and that the methods used for teaching exacerbated the condition [14].

ii. Spatial Ability

Spatial ability is commonly refers to the ability to mentally represent and transform two-dimensional and three-dimensional images. Numerous studies have demonstrated that men perform better than women on tasks requiring spatial awareness, particularly those requiring mental rotation. It has been hypothesised that mathematics and spatial skills are closely related. Even when mathematical and verbal talents are considered, people with greater spatial ability typically perform better in mathematics and sciences in general [15].

Mathematical anxiety and spatial anxiety are positively correlated, although mental rotation task performance is negatively correlated. People with high mathematics anxiety experienced more spatial anxiety than people with low mathematics anxiety [16].

iii. Parent factor

Parents have an important influence in the development of mathematics anxiety since they are the primary socialisers and role models for their children. A parent who has a preference for a certain academic subject, for example, is probably going to enjoy teaching their kids that subject the best. They added that parents frequently give their children skewed knowledge, and that this also applies to morals. As a result, parents have an impact on their children's learning and academic growth in addition to influencing their own thoughts for the future. A more authoritarian parenting style was associated with higher levels of mathematics anxiety among the participants. Math anxiety was higher among participants who described an authoritarian parenting style [17].

The key result in this research is that there is a positive correlation between mathematics anxiety and an authoritarian parenting style, which means that people are more likely to suffer mathematics anxiety when their parents are strict and controlling. However, there is a negative correlation between self-efficacy and mathematics anxiety, suggesting that lower levels of mathematics anxiety are associated with greater confidence in one's mathematical skills. In conclusion, having extremely authoritarian parents is linked to higher levels of mathematics anxiety, whereas having a strong belief in one's mathematical abilities can assist in lessening mathematics anxiety [17].

It is proven that parents do contribute to the condition of mathematics anxiety, and their findings supported those of other studies that reached the same conclusion [5]. The attitude of the parents, their own arithmetic worry, and the way they communicated with them all had a substantial impact on the children's capacity to develop math anxiety. Children's mathematics anxiety may be influenced by their

parents' mathematics anxiety and manifest in their mathematics performance, including self-efficacy, grade point average, behavioural goals, attitudes toward math, and math evaluation. Parental mathematics anxiety is more noticeable in parent and child connection. When neither parents nor children show signs of mathematics anxiety, the child will do well in the subject. On the other hand, the child will do poorly in math if both the parents and the child have a higher level of mathematics anxiety [18].

2 Methodology

This study used an online cross-sectional design and was conducted at a public institution in Kelantan. All UiTM Kota Bharu campus students, particularly those enrolled in the Faculty of Business Management and the Faculty of Computer Sciences and Mathematics, were the study's target group. In this study, stratified random sampling was used to collect samples for each stratum. A stratified random sample was chosen because it can most accurately reflect the total population and has the least amount of bias. Each of the six strata in this study corresponds to a distinct course at UiTM Kota Bharu campus.

The population consists of 1020 students, and samples were selected proportionately from each stratum using the produced random number. The anticipated sample size for this study was calculated using the formula provided by Krejcie and Morgan [19]. The sample size of 308 pupils from the entire population was established using a 95 percent confidence level and a suggested error range of 5 percent. The number of samples chosen from each stratum is displayed in Table 1 below.

Table 1 : The Number of Samples from Each Strata

Course	Population size	Sample size
Marketing	200	(308/1020) × 200 = 60
Finance	292	(308/1020) × 292 = 88
Islamic Banking	173	(308/1020) × 173 = 52
Business Economics	140	(308/1020) × 140 = 42
Statistics	198	(308/1020) × 198 = 60
Statistics and Entrepreneurship	17	(308/1020) × 17 = 6
TOTAL	**1020**	**308**

Primary data was collected from students at UiTM Kota Bharu campus using online surveys. The questionnaires were created using Google Form, and the link to the form was sent to the selected sample via instant messaging. The data in this study were analysed using SPSS version 25.0, which is the statistical tool for the social sciences. Finally, the statistical techniques used in this study were Pearson's correlation and multiple linear regression.

A Theoretical framework

A theoretical framework that describes the logical meaning of the link between the independent variable and the dependent variable is assumed in order to examine the relationship between the factors that influence mathematics anxiety among university students. The three independent variables that are thought to have an impact on health literacy are teacher related factor, spatial abilities, and parent factor. In Figure 1, the theoretical framework is shown.

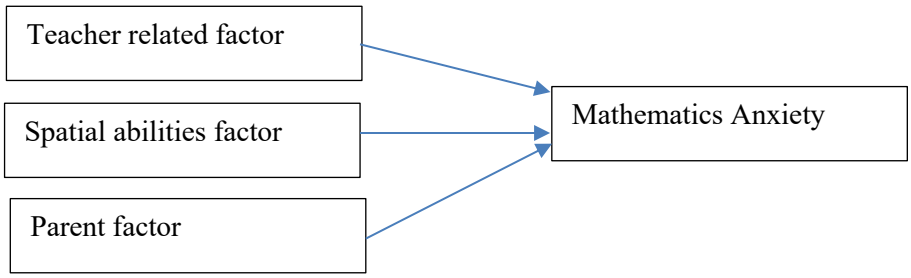

Figure 1 : The Theoretical Framework of the Study

B Measuring Instrument

This study employed structured questionnaires. There were five sections in the questionnaires: Part A: Demographic Profile; Part B: Mathematics Anxiety Level; Part C: The Role of the Teachers; Part D: The Role of Spatial Abilities; and Part E: The Role of Parents.

In Part A, the respondents were asked questions about their fundamental traits. The purpose of these questions was to collect data that would aid researchers in comprehending the backgrounds and traits of the participants. The Math Anxiety Questionnaire for Adults (MAQA) was used in Part B to gauge the respondents' level of mathematics anxiety. They answered on a Likert scale with a score ranging from 1 to 4, which indicates how definitely no to definitely yes they are. The respondents were given a Likert scale score ranging from 1 to 5 in sections C and E. The ranking was determined by how strongly one agrees or disagrees with the assertions. Seven items on a 5-point Likert scale (1 being extremely difficult to 5 being very simple) made up the scale for Part D. On a scale of 1 to 5, the respondents were asked to honestly rate their feelings on the given statement. The table below contains a summary of the questionnaires.

Table 2 : The Measuring Instrument

Part	Construct	Number of items	Sources
A	Demographic profiles	6	
B	MAQA	19	[12]
C	Teacher related factor	6	[13]
D	Spatial abilities factor	7	[20]
E	Parent factor	6	[21]

C Pearsons's Correlation

This method was used to identify whether there is the existence of a significant relationship between mathematics anxiety and the independent variables.

Spearman's correlation assumes that the data is at least ordinal and that there is a monotonic relationship between the scores of the two variables. Because the questionnaire is in Likert scale form, Spearman rank correlation was utilised to determine the correlation between the variables. Intervals or ratios will be used to quantify the degree of linear connection between the variables. Table 3 [22] provides a general guideline for understanding the Guilford's law correlation size.

Table 3 : Rule of Thumb for Interpreting the Size of Correlation (Guilford's Law)

Size of Correlation	Interpretation
0.90 ≥ r > 1.00	Very high positive correlation
0.70 ≥ r > 0.90	High positive correlation
0.50 ≥ r > 0.70	Moderate positive correlation
0.30 ≥ r > 0.50	Low positive correlation
0.00 ≥ r > 0.30	Negligible correlation
-0.90 ≥ r > -1.00	Very high negative correlation
-0.70 ≥ r > -0.90	High negative correlation
-0.50 ≥ r > -0.70	Moderate negative correlation
-0.30 ≥ r > -0.50	Low negative correlation
0.00 ≥ r > -0.30	Negligible correlation

D Multiple Linear Regression

Multiple regression analysis allows researchers to assess the strength of the relationship between the dependent variable and several independent variables as well as the importance of each of the independent variables to the relationship, often with the effect of other independent variables being statistically eliminated. The multiple regression model is as shown in Eq. (1).

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_\iota \quad \text{Eq. (1)}$$

Where;

Y is the student's mathematics anxiety level

$\beta_0, \beta_1, \beta_2, \beta_3$ are the regression coefficients

X_1, X_2, X_3 are the independent variables (X_1 is Teacher Related Factor, X_2 is Spatial Abilities Factor and X_3 is Parent Factor).

ε_ι is the error term

The data was first tested for the assumption of normality, the assumption of homoscedasticity, the assumption of independence, and the assumption of linearity and multicollinearity before the multiple regression analysis can be done.

3 Results and Discussion

A Students' Mathematics Anxiety Level

There were 320 total respondents that participated in the survey through the Google Form questionnaires. This means that the 320 total respondents was more than the estimated sample size that was calculated, which was 280 respondents. A larger sample size indicates a more accurate average value.

The findings below demonstrate the respondents' level of mathematical anxiety. It can be inferred that 31.6% of the students suffer from mathematics anxiety while 68.4% of the students do not.

Table 4 : Students' Mathematics Anxiety Level

Mathematics Anxiety Level	Number of students	Percentages
Definitely do not feel anxiety	115	35.94%
Generally do not feel anxiety	104	32.50%
Feel some anxiety	58	18.13%
Definitely feel anxiety	43	13.44%
Total	320	100.00%

B Spearman's Rank Correlation Analysis

The correlation matrix was used to determine the patterns of relationships. The strength and direction of a linear relationship were determined using the Spearman's rank correlation coefficient and ensuring that the independent variables, as well as the mathematics anxiety, were present in the study. This preliminary study was conducted before multiple regression analysis to ensure that the regression model did not represent a serious violation.

Table 5 : Result of Spearman's Correlation

Variables	Correlation coefficient	*p*-value
Mathematics Anxiety level with Teacher Related Factor	-0.565	0.000
Mathematics Anxiety level with Spatial Abilities Factor	0.924	0.000
Mathematics Anxiety level with Parent Factor	0.410	0.000

Table 6 above shows the Spearman's rank correlation coefficient for all variables. The result shows that all three independent variables were correlated to Mathematics Anxiety. The p-value was less than 0.05, indicating that there is a significant relationship between the two variables.

C Multiple Linear Regression

i. Checking the Assumptions

Figure 2 shows that the normal P-P plot of the points was scattered along the straight line on the Mathematics Anxiety. Therefore, the normality assumption was satisfied.

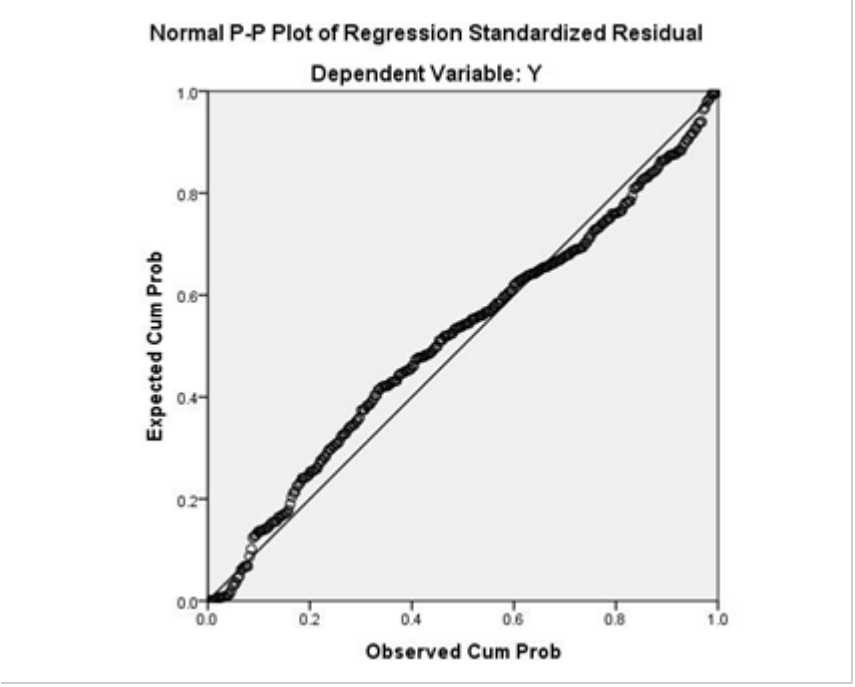

Figure 2 : The Normality Distribution Test Using P-P Plot

Figure 3 shows that the scatter plot of the points was scattered around randomly. Therefore, the homoscedasticity assumption was satisfied.

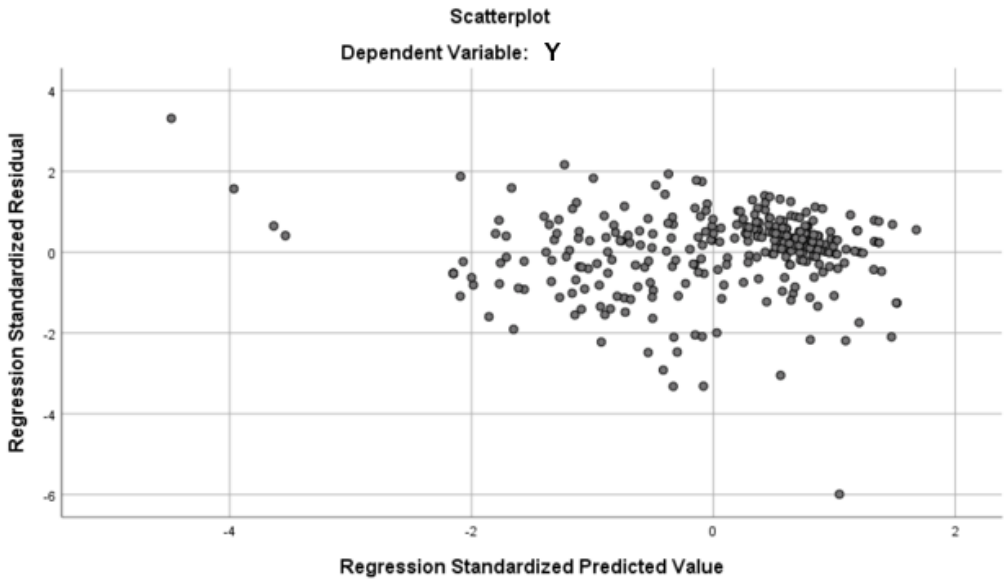

Figure 3 : Scatter Plot of Health Literacy

ii. Multicollinearity

Table 6 shows that all the tolerance values exceeded 0.1 and the VIF values were less than 10. Therefore, it can be concluded that there was no multicollinearity among independent variables. Thus, the independent variables of the study had no relationship with each other and were not dependent on each other.

Table 6 : Multicollinearity among variables

Variable	Tolerance	VIF	Findings
Teacher Related Factor	0.695	1.439	No multicollinearity
Spatial Abilities Factor	0.580	1.725	No multicollinearity
Parent Factor	0.804	1.244	No multicollinearity

iii. Goodness of Fit

Table 7 shows the measure of coefficient of determination. The value of *R* square is 0.861 this indicates that 86.1% of the variation in student's health literacy can be explained by a list of independent variables (teacher related factor and spatial abilities factor) while 13.9% can be explained by other factors.

Table 7 : Model Summary

R	***R* Square**
0.928	0.861

iv. General Fitness Model

Table 8 Table 8 presents the general fitness model for this study. The *F* statistic was 465.431, and the significant value was <0.001. As the *p*-value was less than the significance level (0.05), this demonstrated that the data utilised was consistent with the model. As a result, it can be concluded that the overall model was significant, and testing on the regression coefficient can be done where at least one of the independent variables is significant.

Table 8 : Multiple Linear Regression ANOVA Results

Variables	*F*-test	*p*-value
Health Literacy	465.431	0.000

v. Test of Regression Coefficient

Table 9 shows the summary result of the regression analysis. From the result, it was found that only attitude towards healthy lifestyle was significant towards health literacy.

Table 9 : Regression Coefficient Summary

Variable	Coefficient Value	*p*-value	Finding
Constant	-1.477	0.000	
Teacher Related Factor	-0.103	0.000	Significant
Spatial Abilities Factor	0.854	0.000	Significant
Parent Factor	0.036	0.132	Not Significant

vi. Model Estimation

A multiple regression model was used to describe the relationship between the dependent variable of the study. Since Parent Factor is not significant, the backward elimination has been used to get the best model. The table below represents the coefficient of the best model.

Table 10 : The Regression Using The Backward Elimination Method

Variable	Coefficient Value	*p*-value	Finding
Constant	-1.495	0.000	
Teacher Related Factor	-0.195	0.000	Significant
Spatial Abilities Factor	0.873	0.000	Significant

Let:

Y = Mathematics Anxiety

X_1 = Teacher Related Factor

X_2 = Spatial Abilities Factor

General model, Eq.(2):

$$Y = \beta 0 + \beta_1 X_1 + \beta_2 X_2 \quad \text{Eq. (2)}$$

$$Y = -1.495 - 0.195\, X1 + 0.873\, X2$$

The interpretation for each beta coefficient is presented in Table 11.

Table 11 : Interpretation of Beta Coefficient

$\beta 0$= -1.495	This indicates that there is no change in the independent variables which are Teacher Related Factor and Spatial Abilities, the mean of Mathematic Anxiety level will remain 1.495 unit.
β 1 = -0.195	When Teacher Related Factor increases by 1 unit, the mean of the Mathematic Anxiety level among students at UiTM Kota Bharu campus will also decrease by 0.195 unit, while the other variable remains constant.
β 2 = 0.873	When Spatial Abilities increases by 1 unit, the mean of Mathematics Anxiety level among students of UiTM Kota Bharu campus will also increase by 0.873 unit, while the other variable remains constant.

4 Conclusion

When Spatial Abilities increased by 1 unit, the mean of the Mathematics Anxiety level among students at UiTM Kota Bharu campus also increased by 0.873 unit, while the other variable remains constant..

Teachers play a critical role in influencing students' anxiety related to mathematics. The attitudes, ideas, and experiences that students have with mathematics are greatly influenced by their teachers. Students who have positive relationships with their teachers can feel comfortable sharing their worries about mathematics and learn in an atmosphere that is secure. Students can feel more comfortable and less nervous about the subject if their teachers are personable, empathetic, and eager to lend extra support. Teachers are frequently the first to notice symptoms of mathematics anxiety in their students. Therefore, teachers must play a big role in the prevention of anxiety escalation by an early detection of struggling students and prompt provision of help.

Since spatial abilities is one of the factors that significantly affect mathematics anxiety, for the benefit of all students, it is therefore crucial that educators concentrate on helping students improve their spatial skills as well as on helping them use spatial thinking to solve problems in a variety of mathematical areas [15]. Students who are proficient in spatial thinking are better able to understand and evaluate visual information, which facilitates decision-making and problem-solving. Furthermore, spatial abilities have an impact on students' mathematics performance. In the end, inability to comprehend mathematics well can lead to misunderstandings and irritation, which may increase mathematics anxiety.

Thus, the results of the study indicated that in order to address students' anxiety related to mathematics, attention should be paid to the teachers' role as well as students' spatial skills.

When examining students' anxiety in mathematics, future research is encouraged to consider a few more independent variables, such as the students' socioeconomic level and enthusiasm for learning. A similar idea can be used in a different context in a future study to investigate the factors that affect students' fear in mathematics.

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Conflict of Interest Statement

The authors agree that this research was conducted in the absence of any self-benefits, commercial or financial conflicts and declare the absence of conflicting interests with the funders.

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