

P-ISSN: 2338-8617

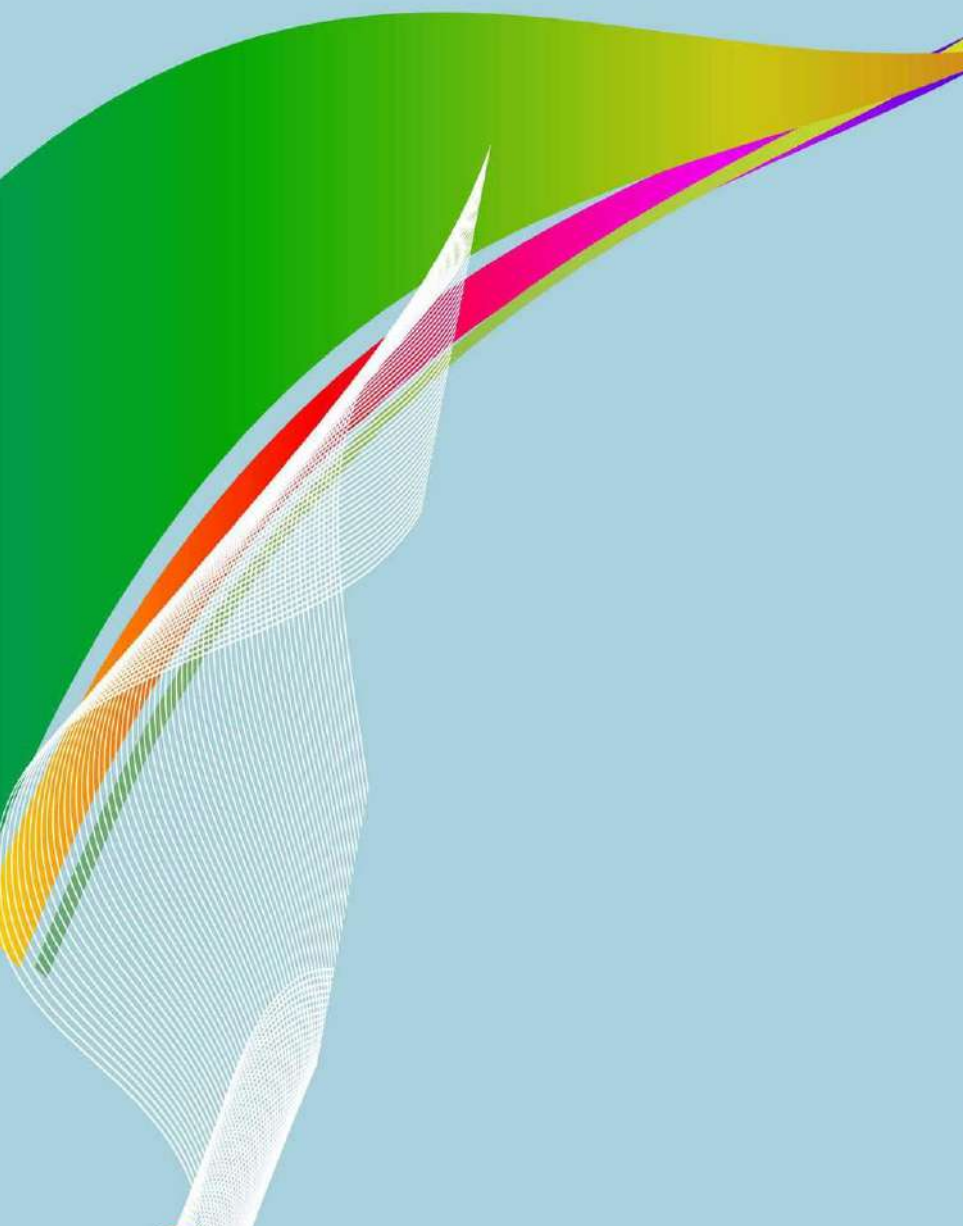
E-ISSN: 2443-2067

*Jurnal Ilmiah*

# PEURADEUN



Vol. 11, No. 1, January 2023



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Indonesian Journal of the Social Sciences

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**JIP**  
The Indonesian Journal of the Social Sciences  
[www.journal.scadindependent.org](http://www.journal.scadindependent.org)  
DOI Prefix Number: 10.26811



ACCREDITED "Sinta 2" by Decree No. 164/E/KPT/2021  
Valid Until the January 2026 Edition

**The Relationship between Mathematics Anxiety and Mathematical Performance among Undergraduate Students**

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**Article in Jurnal Ilmiah Peuradeun**

Available at : <https://journal.scadindependent.org/index.php/jipeuradeun/article/view/780>

DOI : <https://doi.org/10.26811/peuradeun.v11i1.780>

**How to Cite this Article**

APA : Zanabazar, A., Deleg, A., Ravdan, M., & Erdene, E.T. (2023). The Relationship between Mathematics Anxiety and Mathematical Performance among Undergraduate Students. *Jurnal Ilmiah Peuradeun*, 11(1), 309-322. <https://doi.org/10.26811/peuradeun.v11i1.780>

Others Visit : <https://journal.scadindependent.org/index.php/jipeuradeun>

Jurnal Ilmiah Peuradeun (JIP), *the Indonesian Journal of the Social Sciences*, is a leading peer-reviewed and open-access journal, which publishes scholarly works, and specializes in the Social Sciences that emphasize contemporary Asian issues with interdisciplinary and multidisciplinary approaches. JIP is published by SCAD Independent and published 3 times of year (January, May, and September) with p-ISSN: 2338-8617 and e-ISSN: 2443-2067. Jurnal Ilmiah Peuradeun has become a CrossRef Member. Therefore, all articles published will have a unique DOI number. JIP has been accredited by the Ministry of Education, Culture, Research, and Technology, the Republic of Indonesia through the Decree of the Director-General of Higher Education, Research and Technology No. 164/E/KPT/2021, date December 27, 2021. This accreditation is valid until the January 2026 edition.

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## THE RELATIONSHIP BETWEEN MATHEMATICS ANXIETY AND MATHEMATICAL PERFORMANCE AMONG UNDERGRADUATE STUDENTS

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Received: March 22, 2022	Accepted: November 15, 2022	Published: January 30, 2023
Article Url: <a href="https://journal.scadindependent.org/index.php/jipeuradeun/article/view/780">https://journal.scadindependent.org/index.php/jipeuradeun/article/view/780</a>		

### Abstract

Mathematics has become imperative for citizens of the new millennium, as it has become crucial for self-managed life activities. Still, the perception that "mathematics is a difficult subject" hinders students from handling the subject seriously. This type of phobia limits the students' opportunity to select professions and study in prospective fields to guarantee a smooth career in the future. The purpose of this study was to determine how student mathematics anxiety affects student mathematics achievement. The sample for the survey was selected randomly. We proposed the hypothesis that "the levels of mathematical anxiety have a negative impact on mathematical performance". Consequently, descriptive, correlation, and regression analyses have been carried out to prove our hypothesis. We used the Mathematics Anxiety Rating Scale questionnaire (A-MARS) developed by Richardson and Suinn (1972) for assessing mathematics anxiety and the General Entrance Exam (GEE) results in mathematics are considered the achievement criteria. The study's results illustrated the negative linear correlation ( $r = -0.479$ ,  $p < 0.05$ ) between mathematics anxiety and mathematical performance. In another world, the results show that mathematics anxiety negatively affects students' mathematical performance.

**Keywords:** Mathematics Anxiety; Mathematical Performance; Undergraduate Students.



## A. Introduction

Mathematics is an essential skill that shapes one's mental ability and encourages logical reasoning and mental rigor. Hence, the inclusion of the discipline in primary and secondary education plays a crucial role for people worldwide in obtaining fundamental knowledge and skills (Aseidu-Addo & Yidana, 2004). Heavy reliance on technology has created a demand for professionals with high mathematical skills and the ability to understand complex concepts to solve problems in science and other disciplines (Shaikh, 2013).

Still, the "mathematics is a difficult subject" perception hinders students from handling mathematics seriously. Recent researchers are increasingly focusing on the fact that mathematics anxiety negatively affects students' mathematical performance, achievement, and well-being (Dowker, Sarkar, & Looi, 2016; Ramirez, Shaw, & Maloney, 2018).

This study aims at studying the relationships between mathematics anxiety and mathematical performance among Mongolian NUM and MSUE undergraduate students who successfully passed the math test of the GEE.

Lazarus (1974) described mathematics anxiety as an irrational and impeditive dread of mathematics. Tobias and Weissbrod defined it as the panic, helplessness, paralysis, and mental disorganization that arises among some people when they face solving a mathematical problem (Bahr & DeGarcia, 2008).

Mathematics anxiety can be understood as a particular condition encountered due to several factors, including personal causes, low self-confidence and avoidance of asking questions, environmental causes akin to a negative experience in mathematics, negative attitude of parents and teachers, and cognitive.

Mathematics competence and mathematics anxiety have a reverse correlation. The ones with math competence tend to be invulnerable to mathematics anxiety, while incompetent ones are more exposed to it. The one who suffers from a high mathematics anxiety level tends to struggle with a lack of quality decision-making regarding personal finance and health care.

From the mid-1950s till the beginning of the 1990s, researchers mainly explored methods and tools measuring mathematics anxiety. Some researchers attempted to explain failure in mathematics in contrast to the achievements in other subjects. Mathematics anxiety measurement tool-MARS (mathematical anxiety rating scale) with 98 questions was developed by Richardson and Suinn (1972) and became the most used tool in empirical studies.

From the 1990s to 2010, the studies recognized four main factors that influenced mathematics anxiety: students' personalities, teachers, families, and schools (Landerl, 2019). Negative impacts of mathematics anxiety on mathematical performance were brought to light from the meta-analysis conducted by Sara and Caviola (Caviola, Toffalini, Giofrè, & Ruiz, 2022).

From 2010 up to the present, diagnostics of mathematics anxiety with the use of information technology and estimation of the relationships between cognition and affective factors research era started.

Dreger and Aiken initially assessed the relationship between mathematics anxiety and its impact on performance in 1957. They revealed that mathematics anxiety declines performance or decreases individuals' ability (Ashcraft & Moore, 2009).

Ashcraft and Kirk (2001) considered that a high level of mathematics anxiety among the students made feeling fear and stress contribute to missing the content of the subject and decreasing performance and changes in attitude.

Mathematics anxiety is an intense psychological reaction expressed as panic, fear, impatience, and mental blockage that hinders students' daily routine disabling mathematical solving problems and fully immobilizes handling any activities related to computation (Villamizar, Araujo Arenas, & Trujillo Calderón, 2020). Macher., et al. (2012)'s study conducted in the Netherlands noted the crucial role of mathematics anxiety in mathematical performance. Negative perceptions towards mathematics lesson students' calculation ability persist even at mature ages and prevent the ones handling the computation. The anxiety negatively impacts memory, attention to



multiple activities, and problem-solving (Syokwaa, Aloka, & Ndunge, 2014). The students concerned with mathematics avoid handling math assignments, and these students tend to be incompetent or have low skills in mathematics (Plaisance, 2009). Mathematical competence and mathematics anxiety have a reverse correlation the one with mathematical competence tends to be invulnerable to mathematics anxiety while incompetent ones are more exposed to it (Amartuvshin, 2016). Students with mathematics anxiety tend to avoid math courses (Buckley, Reid, Goos, Lipp, & Thomson, 2016). It affects their capability to handle math problems and negatively impacts academic achievement (Cates & Rhymer, 2003; Ma & Jiangmin, 2004; Miller & Bichsel, 2004; Buckley, Reid, Goos, Lipp, & Thomson, 2016; Villamizar, Araujo Arenas, & Trujillo Calderón, 2020; Casty, Ciriaka, & Peter, 2021).

Based on the results of the previous research, we proposed the hypothesis that “the levels of mathematics anxiety harm the mathematical performance” for the current study.

## **B. Method**

The current research examines the relationships between mathematics anxiety and mathematical performance among mathematics majors. The survey was conducted among the students who entered NUM and MSUE upon qualifying for the GEE. A random sampling method was applied to select the sample for the study. We proposed the hypothesis that 'the levels of mathematics anxiety harm mathematical performance. Consequently, descriptive, correlation and regression analyses have been carried out to prove our hypothesis.

We assumed the confidence level of our survey at 95% with a confidence level of 5%. The estimated sample size for the survey was 379, considered fully capable of representing the population. We considered that the data used in the study fully satisfies the quality of requirements as we used data from 916 respondents. The survey was conducted online between April 26 to June 21, 2021, and collected data from 916 respondents.



The questionnaire consisted of two parts with 26 questions on mathematics anxiety and mathematical performance.

We used the adopted version of Richardson, Suinn’s (1972) mathematics anxiety rating scale instrument (A-MARS) measuring responses with a 5-point Likert scale. For assessing mathematical performance, General Entrance Exam (GEE) results in mathematics are taken comparatively against anxiety. The General Entrance Exam (GEE) is an annual examination held in Mongolia to admit graduates of the current year and previous years to universities and colleges.

### C. Result and Discussion

SPSS 23.0 software is used for data processing, and numerous statistical techniques such as descriptive, correlation, and linear regression are applied to produce the results. The questionnaire included a part that collected background information on the respondents to understand their social and demographic status better.

#### 1. Result

Demographic characteristics such as age, gender, institutional affiliation, and levels of the study are cautiously examined in the study.

Table 1. Background information on the survey respondents

Gender		Age Segment		Institutional affiliation		Year of Study		Grade Point Average	
Sex	%	Age	%	Affiliation	%	Year	%	GPA	%
Male	13.2	17-18	9.6	NUM	46.9	1 <sup>st</sup> year	29.4	1.0-1.4	0.1
		19-20	51.3			2 <sup>nd</sup> year	16.5	1.5-1.9	1.2
		21-22	33.6			3 <sup>rd</sup> year	29.5	2.0-2.3	3.4
Female	86.8	23-24	3.9	MUSE	53.1	4 <sup>th</sup> year	23.9	2.4-2.7	12.0
								2.8-3.1	30.7
		25 +	1.5			5 <sup>th</sup> year	0.8	3.2-3.6	42.2
								3.7-4.0	9.7
						4.0 and above	0.7		

Source: Researcher’s estimate



The above table shows that by gender, 13.2% of the respondents were male, while the majority of the respondents, 86.8% of them, were female. By age, the majority of respondents who participated in the survey were 19-20-year-old students (51.3%), following 21-22-year-old respondents (33.6%), and the minority were 23-24-year-old participants (3.9%), and those who were 25 and older than respondents (1.5%).

By affiliation, 53.1% of respondents studied in MSUE, and the remaining ones, or 46.9%, were students of NUM. By levels of study, 29.4% of respondents were in their first year, 16.5% enrolled in their second year, 29.5% studied in their third year, and only 0.8 % of them studied in their fifth year.

#### *a. Descriptive analysis*

The output of the descriptive analysis is summarized in the below tables (tables 2-3).

*Table 2. The mathematics anxiety level of the respondents*

<b>Descriptive Statistics - Mathematics Anxiety</b>				
	<b>N</b>	<b>Mean</b>	<b>Std. Deviation</b>	<b>Variance</b>
MA1 (Studying for a math test)	916	2.27	1.078	1.163
MA2 (Taking math section of the college entrance exam)	916	3.01	1.228	1.507
MA3 (Taking an exam (quiz) in a math course)	916	2.55	1.150	1.323
MA4 (Taking an exam (final) in a math course)	916	2.88	1.241	1.540
MA5 (Picking up math textbook to begin working on a homework assignment)	916	2.05	1.161	1.349
MA6 (Being given homework assignments of many complex problems that are due at the next class meeting)	916	2.51	1.202	1.444
MA7 (Thinking about an upcoming math test 1 week before)	916	2.54	1.196	1.431
MA8 (Thinking about an upcoming math test 1 day before)	916	2.78	1.253	1.570
MA9 (Thinking about an upcoming math test 1 hour before)	916	2.99	1.319	1.740
MA10 (Realizing you have to take a certain number of math classes to fulfill requirements)	916	2.69	1.254	1.572
MA11 (Picking up math textbook to begin a difficult reading assignment)	916	2.46	1.166	1.359
MA12 (Receiving your final math grade in the mail)	916	2.60	1.257	1.581



Descriptive Statistics - Mathematics Anxiety				
	N	Mean	Std. Deviation	Variance
MA13 (Opening a math or stat book and seeing a page full of problems)	916	2.63	1.225	1.500
MA14 (Getting ready to study for a math test)	916	2.32	1.153	1.329
MA15 (Being given a "pop" quiz in a math class)	916	2.97	1.302	1.694
MA16 (Reading a cash register receipt after your purchase)	916	2.06	1.140	1.300
MA17 (Being given a set of numerical problems involving addition to solve on paper)	916	1.82	1.110	1.231
MA18 (Being given a set of subtraction problems to solve)	916	1.78	1.109	1.229
MA19 (Being given a set of multiplication problems to solve)	916	1.84	1.123	1.262
MA20 (Being given a set of division problems to solven)	916	1.82	1.092	1.193
MA21 (Buying a math textbook)	916	1.82	1.099	1.209
MA22 (Watching a teacher work on an algebraic equation on the blackboard)	916	1.95	1.148	1.319
MA23 (Signing up for a math course)	916	1.90	1.089	1.185
MA24 (Listening to another student explain a math formula)	916	1.98	1.178	1.387
MA25 (Walking into a math class)	916	2.03	1.204	1.450
<b>Grand Mean</b>		<b>2.33</b>		

Source: Researcher's estimate

The mathematics anxiety level of the respondents is 2.33, or presented as the average level. According to the survey results, the students expressed that they suffer intensely from mathematics anxiety when they have thoughts of the coming exam and the expected results of the past exam. Respondents feel fear or anxiety when they have to enroll in math-related courses or open textbooks on mathematics and statistics full of problems. However, they feel less fear or anxiety when they solve problems and make basic calculations. There was no significant discrepancy in mathematics anxiety among female (=2.3345) and male (=2.3035) students.

Table 3. Mathematics anxiety and mathematical performance levels

Math score of GEE	Math anxiety level	N	Std. Deviation	Variance
Below 500	2.6364	99	.77681	.603
501-550	2.5726	133	.78750	.620
551-600	2.5535	193	.93261	.870
601-650	2.3876	178	.84450	.713



Math score of GEE	Math anxiety level	N	Std. Deviation	Variance
651-700	2.0869	180	.84107	.707
701-750	1.8425	97	.88998	.792
751-800	1.7178	36	.78796	.621

Source: Researcher's estimate

The analysis revealed that the less mathematics anxiety felt by the respondents, the higher they achieved their mathematical performance.

**b. Correlation analysis**

Is conducted to test relationships between the factors, and the following results are summarized in table 4.

Table 4: Results of correlation analysis

Correlations		MA	MP
Mathematics Anxiety- MA	Pearson Correlation	1	
	Sig. (2-tailed)		
	N	916	
Mathematics Performance - MP	Pearson Correlation	-.479**	1
	Sig. (2-tailed)	.000	
	N	916	916

\*\* . Correlation is significant at the 0.01 level (2-tailed).

Source: Researcher's estimate

According to the correlation analysis, a negative linear correlation prevailed between mathematical performance and mathematics anxiety ( $r = -0.479$ ,  $p < 0.05$ ).

**c. Regression analysis**

We conducted a regression analysis to test the study's hypothesis, summarized in Table 5.

Table 5. Results of regression analysis

Model	R	R Square	Model Summary	
			Adjusted R Square	Std. The error in the Estimate
1	.479 <sup>a</sup>	.478	.477	.85833

a. Predictors: (Constant), MP



ANOVA					
Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	56.729	1	56.729	77.000	.000 <sup>b</sup>
Residual	673.378	914	.737		
Total	730.107	915			

a. Dependent Variable: MA  
b. Predictors: (Constant), MP

Coefficients <sup>a</sup>						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.896	.070		41.111	.000
	MP	-.453	.017	-.479	-8.775	.000

a. Dependent Variable: MA

The analysis results demonstrated that mathematics anxiety harms mathematical performance ( $\beta = -.479$ ,  $p < 0.01$ ), a one-point increase in mathematics anxiety level decreases mathematical performance by 0.479 beta point. The determination coefficient of (R square) 0.479 clarifies that these factors or capable of explaining the proposed relationships by 47.9%. However, the remaining parts are explained by other factors not included in the equation.

## 2. Discussion

Although an increase in dependency on technology worldwide boosts the demand for professionals with mathematical science backgrounds and logical thoughts, however, there is a growing tendency where students have become avoidant studying mathematics. The current inclination is related to the common perception of math as a complex discipline and mathematics anxiety phenomena. Various researchers have researched the new trend prevalent among students and revealed that it prevents them from achieving good mathematical performance and a good learning opportunity for a prospective professional career.

The students of NUM and MSUE who have taken GEE were involved in the sample survey. We proposed the hypothesis that 'the levels of mathematics anxiety harm mathematical performance'. The results were produced upon conducting numerous statistical tests like descriptive analysis, correlation analysis, and regression analyses.



We used the adopted version of Richardson, Suinn's (1972) mathematics anxiety rating scale instrument (A-MARS) measuring responses with a 5-point Likert scale. For assessing mathematical performance, General Entrance Exam (GEE) results in mathematics are taken comparatively against anxiety.

The mathematics anxiety level of the respondents is 2.33, or presented as the average level. According to the survey results, the students expressed that they suffer intensely from mathematics anxiety when they have thoughts of the coming exam and the expected results of the past exam. Respondents feel fear or anxiety when they have to enroll in math-related courses or open textbooks on mathematics and statistics full of problems. However, they feel less fear or anxiety when they solve problems and make basic calculations. There was no significant discrepancy in mathematics anxiety among female ( $=2.3345$ ) and male ( $=2.3035$ ) students. According to the respondents, experiencing low levels of mathematics anxiety resulted in high mathematical performance.

Moreover, the results revealed a negative linear correlation between mathematical performance and mathematics anxiety ( $r = -0.479$ ,  $p < 0.05$ ). The results of the current study are consistent with the results of earlier studies, including Cates & Rhymer (2003), Ma & Jiangmin (2004), Miller & Bichsel (2004), Buckley & et al. (2016), Villamizar & et al. (2020) and Casty & et al. (2021) who proved by their studies that mathematics anxiety leads to the students avoiding mathematics courses which often negatively impacts on the high performance or academic achievements.

As mathematics anxiety is an emerging challenge for many students, it is significant for parents and educators to understand the genuine cause of the phenomena and to provide support in overcoming the problem. Furthermore, educators and parents need to obtain and learn simple methods revealing students' mathematics anxiety, improve their ability to use them in actual practice, and implement various teaching methods and solutions to remedy the challenge. Educators can learn more about the consequences of mathematics anxiety by reading relevant research papers and participating in training and seminars on this topic.

## **D. Conclusion**

Mathematics anxiety makes the students feel fear, stress, and pain disables them from understanding the course content, and negatively impacts their attitude toward mathematics and mathematical performance. The likelihood of choosing the non-mathematical knowledge disciplines or avoidance of mathematics may have a link with mathematics anxiety that contributes to a negative perception of math and low self-competence, which consequently impacts the student's academic achievements (Palacios, Hidalgo, Maroto, & Ortega, 2013). Some studies suggested that students affected with mathematics anxiety often lead them suffering from panic and stress that, resulted in a decrease in their mathematical performance and academic achievements (Bekdemir, 2010; Núñez-Peña, Suárez-Pellicioni, & Bono, 2013). Due to its adverse impacts, it is essential to detect in earlier stages to conduct preventive and remedying measures to support the students in making the proper decision in selecting the courses.

We need to acknowledge the limitation of the current study as it only relied on the GEE score of the students to assess the relationship between mathematics anxiety and mathematical performance.

In further studies, it is recommended not only to limit accessing the relationships between mathematics anxiety and mathematical performance but also to various factors impacting mathematics anxiety. It will have more practical significance and a realistic understanding of the phenomena from different perspectives.

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