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Factors Related to Mathematics Anxiety among Senior High School Students in Basic and Pre-Calculus: A Descriptive CROSS-Sectional Psychological study

Cristobal A. Rabuya, Jr.
Leyte Normal University, Tacloban City, Leyte, Philippines 6500
carabuya@lnu.edu.ph

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Abstract

Mathematics anxiety is a pervasive and often debilitating phenomenon that can hinder students' learning and achievement in mathematics. It is particularly prevalent among senior high school students, who face the challenging subjects of basic and pre-calculus. Consequently, this study assessed the factors contributing to mathematics anxiety among senior high school students. A descriptive cross-sectional research design was employed in the study because it described the detailed information of component indicators of mathematics anxiety of students at a single point in time. Thirty-six (36) Science, Technology, Engineering, and Mathematics (STEM) students were officially enrolled in a laboratory school in Tacloban City, Philippines, for the school year 2022–2023. Of these, 28 served as respondents, with a response rate of 77.78%. Data were analyzed using mean, standard deviation, mode, and t-test. Results revealed that the majority of students have moderate anxiety in mathematics. In addition, taking examinations and giving surprise quizzes in mathematics have contributed to high anxiety among them. Moreover, lack of self-confidence and pressured quizzes and tests are the prevalent factors that cause students' math anxiety. It was also found that there is no significant difference in mathematics anxiety levels between male (M=3.32, SD=.48) and female (M=3.06, SD=.48) STEM students, $t(26)=1.4$, $p=.16$

Keywords- Mathematics, School Students, Psychological study

Introduction

Mathematics anxiety is a pervasive and debilitating phenomenon that significantly impedes students' learning and achievement in mathematics. As early as middle school, students often develop certain dispositions towards mathematics (Furner & Duffy, 2022). For many, it is perceived as a challenging subject to master in the classroom (Siaw et al., 2021). A key contributing factor to students' struggles in learning mathematics is mathematics anxiety, a globally recognized phenomenon that has garnered research attention for over four decades (Mann & Walshaw, 2019). Its prevalence in K-12 classrooms, as highlighted by Dempsey and Huber (2020) and Marks (2022), poses a serious risk to students' long-term educational prospects if not adequately addressed. Mathematics anxiety encompasses feelings of unease, fear, and negative emotions towards mathematics, varying from person to person (Batashvili, Cipora & Hunt, 2022; Siaw et al., 2021). Furthermore, it is a prevalent occurrence exists that acts as an obstacle to the acquisition of knowledge and success in the realm of mathematics. (O'Hara et al., 2022). Numerous students suffer from mathematics anxiety, which has a significant impact on their ability to learn mathematics effectively (Brewster & Miller, 2022; Caviola et al., 2022). Moreover, mathematics anxiety adversely impacts an individual's physiological and mental processes, leading to diminished their academic performance in the field of mathematics (Brewster & Miller, 2020).

According to Estonanto and Dio (2019), mathematics anxiety is a multifaceted problem influenced by various factors that play a role in its formation. Agustyaningrum et al. (2021) identified three primary factors that contribute to challenges encountered in the study of mathematics, specifically in the course of abstract algebra: attitudes towards the subject, prior knowledge, and teaching materials. Another study by Pringle, Workman, and Arrastia-Chisholm (2022) explored the impact of environmental factors on mathematics anxiety, highlighting how certain factors can increase or exacerbate it. Furthermore, Garba et al. (2022) underscored the significance of peer behavior and communication within the mathematics classroom, as they have a notable impact on the magnitude of mathematics anxiety experienced by individuals. They found that negative behaviors from peers, such as

disruptive behavior from struggling students or dominance from high-achieving students, as well as the use of frightening and discouraging statements, directly contribute to heightened their anxiety in mathematics. On the other hand, their findings also indicated that supportive speech and positive peer behaviors like peer achievement, and engaging in group discussions can help minimize students' mathematics anxiety. Thus, the findings of their study is evident that peers play a significant role in students' day-to-day interactions and their experience of mathematics anxiety. Kusmaryono, Ubaidah, and Abdul Basir (2022) emphasized the notable direct influence of mathematics anxiety on students' motivation to learn. They also observed an indirect influence stemming from the teacher's role and the nature of the mathematics content on learning motivation. Furthermore, they highlighted that students can effectively handle mathematics anxiety by experiencing positive anxiety, leveraging it as a catalyst for achievement and transforming anxiety into motivation based on their individual experiences and available resources. Yuan, Tan, and Ye (2023) provided an extensive outlook on the phenomenon of students' math anxiety and its repercussions in various economies. Their findings revealed strong negative relationships between math anxiety and student performance on standardized tests, levels of interest in mathematics, and overall mathematical knowledge across all studied economies. However, in high- and low-achieving economies, they observed reverse relations between math anxiety and student abilities, perceived importance, and self-attribution. They also found weak correlations between math anxiety and teaching methods, parents' influences, and friends' performances. This suggests that the impact of math anxiety varies depending on the specific context. Similarly, Brewster and Miller (2022) emphasized a significant relationship between students' mathematical abilities and their levels of mathematics anxiety, as measured during mid-term examinations. Their study demonstrated a strong negative relationship, indicating that students with lower mathematical abilities tend to experience higher level of anxiety in mathematics.

Crook-Smith (2022) found that mathematics self-efficacy is a significant predictor of mathematics anxiety. However, mindfulness did not have a statistically significant moderating effect on the relationship between mathematics self-efficacy and mathematics anxiety. On the other hand, Anson (2021) revealed that mathematics anxiety-related disengagement contributes to negative self-perceptions, reduced cognitive processes, and painful neurological responses. Sociodemographic factors were also found to have modest moderating effects on students' mathematics anxiety (Caviola et al., 2022). By utilizing structural equation modeling, Cribbs, Huang, and Piatek-Jimenez (2021) conducted a study that emphasized the role of mathematics identity as a complete mediator between mathematics mindset and interest in STEM careers. Furthermore, they also found mathematics identity to be a mediator between mathematics anxiety and interest in STEM careers. Lee (2009) and OECD (2013) noted that there have been consistent observations of negative associations between mathematics anxiety and academic achievement in numerous countries. These findings indicate that mathematics anxiety might be an underestimated factor in regions where mathematics achievement levels remain persistently low. Additionally, Richland et al. (2020) discovered a significant relationship wherein teachers' own levels of mathematics anxiety were predictive of their students' attitudes towards mathematics, and in certain instances, their academic achievement as well. This relationship was particularly prominent in regions with higher academic performance and more abundant educational resources.

Siaw et al. (2021) identified a weak positive relationship between students' mathematics performance in final examinations and their anxiety levels. Sari and Szczygiel (2023) suggested that an increase in the difficulty level of mathematical concepts can contribute to higher anxiety levels. Li, Cho, Cosso, and Maeda (2021) conducted a meta-analysis study, revealing a moderate negative relationship between mathematics anxiety and motivation of students to learn mathematics. Moreover, the relationship between mathematics anxiety and beliefs about competence was found to be stronger compared to the relationship with beliefs about the value of mathematics. This finding suggests that self-efficacy and self-concept play a significant role in the context of mathematics anxiety. Moreover, Brewster and Miller (2020) emphasized the detrimental consequences of low mathematics achievement, particularly for individuals pursuing careers in STEM fields that require a high level of mathematical proficiency. Gender disparities were also evident, as boys demonstrated lower anxiety level of mathematics in comparison to girls (Mann & Walshaw, 2019; Capinding, 2022). Max and Walshaw (2019) further noted that anxiety level of girls in mathematics tends to increase with school decile and is higher in single-sex girls-only schools.

To mitigate the adverse effects of mathematics anxiety on students, several strategies have been proposed. Dempsey and Huber (2020) advocate for the implementation of standards-based grading by math teachers, which can help create a supportive learning environment. Pringle, Workman, and Arrastia-Chisholm (2022) suggested that teachers should evaluate and adapt their instructional approaches to support students who are experiencing mathematics anxiety and are in need of remedial assistance. Additionally, they recommend the implementation of interventions that promote perspective-taking and empathy among educators and students to address anxiety effectively. Furthermore, it is essential for all students to feel confident in their mathematical abilities. Thus, it becomes the responsibility of schools to foster an environment where students value and feel competent in mathematics (Furner & Duffy, 2022). By instilling a positive attitude toward mathematics, schools can empower students to make informed decisions and pursue careers that may rely on mathematical skills in the future.

Understanding the factors associated with mathematics anxiety in education context particularly in senior high school program is crucial for educators and policymakers in devising effective strategies to alleviate students' anxiety and promote positive learning experiences. Hence, this study identifies the prevalent factors that contribute to mathematics anxiety among senior high school students in Tacloban City, Leyte, Philippines in the subjects of basic and pre-calculus. By examining these factors, the researcher can gain insights into the underlying causes of mathematics anxiety and develop targeted interventions to mitigate its negative effects. Moreover, the researcher aspires to pave the way for evidence-based interventions that will foster a love for mathematics among the next generation of learners. Through this study, the researcher hopes to contribute to the growing body of knowledge on mathematics anxiety, specifically in the context of senior high school students studying basic and pre-calculus.

Statement of the Problem

This study mainly described the prevalent factors and mathematics anxiety level of Science, Technology, Engineering, and Mathematics (STEM) students in Basic and Pre-Calculus subjects in a laboratory school in Tacloban City, Leyte, Philippines during the school year 2022-2023. Specifically, this study sought to answer the following questions:

1. What is the level of mathematics anxiety of STEM students in Basic and Pre-Calculus?
2. What are the prevalent factors related to mathematics anxiety of STEM students?
3. Is there a significant difference in mathematics anxiety levels between male and female STEM students?

Methodology

Research Design

This study utilized a descriptive cross-sectional design to describe the prevalent related factors and mathematics anxiety levels among STEM students in a laboratory school during the school year 2022-2023. According to Wang and Cheng (2020), a descriptive cross-sectional study primarily aims to characterize the prevalence of one or multiple outcomes within a specific population. Additionally, Kesmodel (2018) emphasized that this type of study involves gathering relevant information at a particular point in time. Therefore, the researcher deemed the descriptive cross-sectional design appropriate, as it aligns with the study's main objective of describing the related factors and anxiety levels among STEM students in which data were collected and gathered from May 1, 2023 to May 13, 2023.

Respondents and Sampling Strategy

A total of 36 Science, Technology, Engineering, and Mathematics (STEM) students were officially enrolled in a laboratory school located in Tacloban City, Philippines, for the academic year 2022–2023. Each of these students was provided with an informed consent form along with a survey questionnaire. Out of the 36 students, 28 willingly participated in the study by responding to both the informed consent and the survey questionnaire, resulting in a commendable response rate of 77.78%. Moreover, only STEM students were considered as respondents of the study because they were the ones who had basic and pre-calculus subjects.

Research Locale

The research was carried out at a laboratory school situated in Tacloban City, Leyte, Philippines. The school operated a senior high school program in 2020, offering two academic strands: Humanities and Social Science (HUMSS) and Science, Technology, Engineering, and Mathematics (STEM). As part of the enrollment process, all applicants underwent written and oral examinations to ensure their eligibility as students of the school. Due to the laboratory school's specific nature, the number of students enrolled in both HUMSS and STEM strands was regulated and carefully controlled.

Research Instrument and Statistical Treatment of Data

The study utilized the Mathematics Anxiety Inventory (MAI), a widely recognized and validated assessment tool originally developed by Plake and Parker (1982). This instrument consisted of 24 items, each rated on a scale from "very low anxiety" (1) to "very high anxiety" (5), providing a comprehensive assessment of individuals' mathematics anxiety levels. To interpret the weighted mean scores of the respondents on the MAI, a specific range of anxiety scores was used: "1.00-1.80 =*Very Low Anxiety*", "1.81-2.60=*Low Anxiety*", "2.61-3.40=*Moderate Anxiety*", "3.41-4.20=*High Anxiety*", and "4.21-5.00=*Very High Anxiety*". Additionally, the study incorporated the eight thematic areas identified by Estonanto and Dio (2019) as emerging themes in the study of factors related to mathematics anxiety among STEM students.

To analyze and describe the level of mathematics anxiety among STEM students, statistical measures namely the frequency count, percentages, mean and standard deviation were utilized. These measures allowed for a quantitative representation of the overall anxiety levels experienced by the respondents. Furthermore, the mode was employed to identify the prevalent factors related to mathematics anxiety among STEM students, highlighting the most frequently reported sources of anxiety within the sample.

In order to explore potential gender differences in mathematics anxiety levels among STEM students, a t-test for independent samples was employed. This statistical test enabled the identification of any significant variations in anxiety levels between male and female students within the STEM strand. By analyzing the data through this lens, the study aimed to uncover potential disparities in mathematics anxiety experiences based on gender.

Results and Discussion

Table 1.
Distribution of STEM Students in terms of their Mathematics Anxiety Level

Mathematics Anxiety Level	Frequency (f)	Percentage (%)
High	9	32.14
Moderate	15	53.57
Low	4	14.29
Total	**28**	**100**

Table 1 shows that majority of STEM students in the laboratory school experienced a moderate level of mathematics anxiety, particularly in Basic and Pre-calculus subjects. Out of the total sample, 9 STEM students, accounting for 32.14%, exhibited a high level of mathematics anxiety. On the other hand, 4 (14.29%) students demonstrated a low level of mathematics anxiety.

Table 2.
Mathematics Anxiety Inventory Results of STEM Students

Indicators	Mean	Standard Deviation	Description
"Being given a surprise quiz in mathematics"	4.79	0.50	Very High
"Taking a final exam in mathematics"	4.61	0.69	Very High

"Taking a major exam in mathematics"	4.36	0.83	Very High
"Thinking about an upcoming mathematics test one day before"	4.32	0.98	Very High
"Being given homework of many difficult problems"	4.18	0.90	High
"Waiting for the result of a mathematics test returned in which you are expected to do well"	4.14	0.97	High
"Getting ready to study for a mathematics test"	3.46	0.96	High
"Walking around campus and thinking about a mathematics class"	3.39	1.03	Moderate
"Being told to work a problem in quadratic equation"	3.29	1.12	Moderate
"Reading and interpreting graphs and charts"	3.21	0.99	Moderate
"Enrolling a course in mathematics"	3.18	1.31	Moderate
"Solving square root problems"	3.07	1.15	Moderate
"Working on mathematical problem"	3.04	1.00	Moderate
"Reading a formula in mathematics"	3.00	0.94	Moderate
"Starting a new chapter in mathematics book"	2.93	1.12	Moderate
"Entering a mathematics classroom"	2.79	1.32	Moderate
"Looking through pages in mathematics textbook"	2.79	1.03	Moderate
"Picking up a mathematics textbook to begin working a homework"	2.64	1.19	Moderate
"Listening to lecture in a mathematics class"	2.64	0.91	Moderate
"Having to use the table at the back of a mathematics book"	2.39	1.07	Low
"Watching a teacher working an equation on the board"	2.14	0.93	Low
"Listening to a student explain a mathematics formula"	2.07	0.77	Low
"Reading the word mathematics"	2.07	1.09	Low
"Buying a mathematics book"	1.75	0.93	Very low

Table 2 presents a comprehensive overview of the indicators contributing to mathematics anxiety among STEM students in a laboratory school in Tacloban City. The results indicate that several situations evoke a very high level of mathematics anxiety among students. Specifically, "being given a surprise quiz in mathematics" (M=4.79, SD=0.50), "taking a final exam in mathematics" (M=4.61, SD=0.69), "taking a major exam in mathematics" (M=4.36, SD=0.83), and "thinking about an upcoming mathematics test" (M=4.32, SD=0.98) were the primary contributors to heightened anxiety. Additionally, three other indicators were found to elicit a high level of mathematics anxiety. These included "being given homework with numerous difficult problems" (M=4.18, SD=0.90), "Waiting for the result of a mathematics test returned in which you are expected to do well" (M=4.14, SD=0.97), and "getting ready to study for a mathematical test" (M=3.46, SD=0.96). In contrast, certain scenarios were associated with a low level of mathematics anxiety among students. These included "having to use the table located at the back of a mathematics book" (M=2.39, SD=1.07), "watching a teacher work out an equation on the board" (M=2.14, SD=0.93), "listening to a student explain a mathematics formula" (M=2.07, SD=0.77), "reading the word "mathematics" (M=2.07, SD=1.09), and "buying a mathematics book" (M=1.75, SD=0.93).

These findings offer valuable insights for educators and curriculum developers in terms of understanding the specific situations that evoke anxiety among STEM students. By identifying these triggers, appropriate strategies and support mechanisms can be implemented to alleviate anxiety and create a more conducive learning environment. For instance, teachers can employ techniques that reduce test-related anxiety, provide additional guidance for challenging homework assignments, and offer proactive support during exam preparation and result anticipation. Furthermore, educators can leverage the identified low-anxiety scenarios to foster positive associations with mathematics, encouraging students to engage more confidently with the subject matter. Finally, these interventions can help mitigate mathematics anxiety and promote students' academic success and well-being in STEM education.

Table 3.

Prevalent Factors Related to Mathematics Anxiety of STEM Students

Factors	Frequency	Percent	Rank
"Lack of Self-Confidence"	24	85.71	1.5
"Pressured Quizzes and Tests"	24	85.71	1.5
"Fear of Failure"	23	82.14	3
"Poor Skills in Analysis"	19	67.86	4.5
"Abstract Math Concepts"	19	67.86	4.5
"Interest and Study Habits"	17	60.71	6
"Pressure from Parents and Peers"	11	39.29	7
"Teacher Factor"	9	32.14	8

Table 3 identifies several prevalent factors related to mathematics anxiety among STEM students, shedding light on the key contributors to this phenomenon. The most frequently reported factors were a lack of self-confidence and the presence of pressured quizzes and tests. These elements played a significant role in generating anxiety among the STEM students. Fear of failure emerged as the next prominent factor, amplifying the anxiety experienced by the students. Furthermore, the study highlighted that "poor skills in analysis" and "abstract mathematical concepts" were significant factors contributing to mathematics anxiety. Students who struggled with these aspects of mathematics experienced heightened anxiety in their studies. Additionally, the students' level of interest in mathematics and their study habits emerged as influential factors. Those with less interest in the subject or poor study habits were more prone to experiencing mathematics anxiety. The pressure exerted by parents and peers also played a role in the students' anxiety levels. The expectations and demands from these external sources contributed to the students' apprehension and unease regarding mathematics. Lastly, the influence of teachers on students' anxiety levels was also noted. The teaching methods, communication style, and classroom environment created by teachers could impact students' confidence and anxiety levels in mathematics.

Table 4.

Difference in Mathematics Anxiety Levels between Male and Female STEM Students

Sex	N	Mean	S.D.	*t*	*df*	*p-value*
Male	13	3.32	0.484	1.440	26	.162
Female	15	3.06	0.477			

The results presented in Table 4 indicate that there is no statistically significant difference in mathematics anxiety levels between male (M=3.32, SD=.48) and female (M=3.06, SD=.48) STEM students, as demonstrated by the t-test analysis ($t(26)=1.4$, $p=.16$). These findings suggest that, within the studied sample, gender does not appear to be a significant factor in influencing mathematics anxiety levels among STEM students. Both male and female students exhibited similar levels of anxiety when it comes to mathematics. Furthermore, these results imply that the absence of a gender-based difference in mathematics anxiety indicates that interventions aimed at reducing mathematics anxiety can be applicable to both male and female students. Strategies such as promoting an inclusive and positive mathematics learning environment, providing support and resources for anxious students, and implementing effective teaching methods can benefit all students regardless of their gender.

Conclusion and Recommendation

The findings of the study indicate that a significant portion of STEM students in the laboratory school in Tacloban City experience a moderate level of mathematics anxiety, particularly in Basic and Pre-calculus subjects. The research further identifies specific situations that trigger high levels of anxiety, including upcoming mathematics tests, major exams, surprise quizzes, and final exams.

The study highlights that students' lack of self-confidence and the presence of pressured quizzes and tests are the most frequently reported factors contributing to mathematics anxiety. These findings suggest the importance of addressing students' self-perception and providing a supportive learning environment that minimizes anxiety-inducing assessment practices.

Interestingly, the study reveals that gender does not appear to have a significant influence on mathematics anxiety levels among STEM students. This suggests that strategies to reduce mathematics anxiety should be applicable to students of all genders, emphasizing the need for inclusive approaches.

Based on these findings, several recommendations can be made. Firstly, educators should focus on building students' self-confidence in mathematics through targeted interventions and supportive feedback. Implementing formative assessments and reducing high-pressure testing situations can also alleviate mathematics anxiety among students. Providing opportunities for practice, offering extra support, and creating an open dialogue about mathematics anxiety can foster a positive learning environment.

Additionally, educators and school administrators should consider implementing stress-reduction techniques, such as mindfulness exercises, to help students manage anxiety during challenging mathematics tasks. Collaborative learning activities, peer support, and fostering a growth mindset can also contribute to reducing mathematics anxiety and promoting a sense of community among STEM students.

It is essential for future research to delve deeper into the underlying causes of mathematics anxiety and investigate effective interventions tailored to the unique needs of STEM students in the laboratory school in Tacloban City. By addressing mathematics anxiety effectively, educators can enhance students' mathematical performance, promote positive attitudes toward the subject, and ultimately support their success in STEM education and future careers.

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