

An Analytical Exploration of Mathematical Stress and Anxiety Among Engineering Students: Challenges and Insights

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Abstract:

This paper aims to investigate the effects of maths stress and anxiety on engineering students, with special regard to their results and psychological state. Due to the competitive academic environment of engineering and the critical role mathematics has, this study is to explore the correlation of mathematical stress and anxiety, and a variety of demographic variables such as gender, place of living, birth order, intermediate group, and residential status. The research design adopted in the study incorporated both quantitative and qualitative research methods in order to collect a myriad of information. The target population was engineering students; 300 participants were included in the sample, and data were collected from a self-administered questionnaire on the mathematical stress and anxiety of students. To analyze the data collected the following statistical analysis techniques were employed: descriptive statistics, correlation analysis and regression analysis. The results presented also suggest that there is no straightforward association between mathematical stress and anxiety and: demographic variables, although some of these relationships bear a mild relationship. In the regression analysis it was established that both mathematical stress and anxiety affect the academic performance, but this relationship is complex and depends on various factors. The authors note that mathematical anxiety does not have a one-size-fits-all solution; the study's results indicate that it should be treated individually. This calls for several techniques to be formulated and implemented in colleges to address the problems and various student's background are considered. Therefore, this study seeks to support the existing initiatives by examining the complex antecedents of students and hence boost academic performance and well-being. Future studies should build on these relations and identify more variables to enhance support initiatives and methods.

Keywords: Stress, Anxiety, Academic Challenges, and Educational Support.

1. Introduction

Mathematics stress and math anxiety are the common problems among engineering students, greatly influencing their academic achievement and psychological health. The present introduction of mathematical stress and anxiety as significant concerns for engineering students creates the context for further analysis of the specific problems and the necessity of addressing them. This includes the pressure of comprehending and implementing mathematical concepts as well as the ability to work under time constraints and academic stress Luttenberger et al. (2018). The research carried out in the recent past has paid a lot of attention to the effects of mathematical stress and anxiety among students in as much as they impact on their learning abilities and overall health Mammarella et al. (2019). In this way, educators and policymakers will be able to provide recommendations for engineering students to cope with stress and anxiety, thus, improving their academic experience and mental health, Zhang et al. (2019). Mathematical stress on the other hand can be defined as the challenges students face or the pressures they encounter while solving mathematical problems Lewis (2020). Stressors arising from engineering education might be worsened by the quantitative reasoning and problem-solving approaches used, therefore, it is crucial to understand the effects of stressors on the students' experience and achievements Ayuso et al. (2020). Engineering courses which are usually associated with complex curricula and significant application of mathematics usually compound these difficulties Gabriel et al. (2020). Knowledge of the association between mathematical stress and anxiety is important in designing coping and intercessions structures Jensen & Cross (2021). The expectations to comprehend difficult problems in mathematics, perform well academically, and solve challenging problems can cause a lot of stress and anxiety to learners, thus limiting their performance Herman et al. (2023).

The purpose of this anxiety study can be defined as the feelings and mental processes elicited by the perceived challenge of mathematical problems and the threat of success/failure. These are aspects that can take the attention of students, impede their thinking, and affect their performance.

1.1 Background of the Study

Mathematics is one of the most significant components of engineering education as it serves as the basis for the analysis of numerous engineering concepts and the solution of numerous intricate issues. The academic programs of engineering entail high level of mathematical knowledge and skills that the students need to achieve in order to excel academically and professionally. It is beneficial to note that due to this emphasis on mathematics, stress and anxiety is experienced from students who are faced with complex coursework and expectations.

1.2 Nature and Consequences of Stress in Mathematics

Mathematical stress is defined as the challenges and pressures experienced by the students while solving mathematical problems. These can be such as stress arising out of the attempt to grasp the various theories, solving problems and meeting set timelines. The students feel much pressure to perform well in mathematics which increases tension in students and results to poor performance and even poor health. It is crucial to comprehend some essential aspects of stress concerning mathematics in order to define how it influences students and to be able to create efficient strategies of assistance Wang et al. (2020).

1.3 The Psychological Factor in Mathematics Anxiety

Mathematical anxiety therefore can be defined as the emotional and psychological reactions towards mathematics learning by students Caviola et al. (2022). These anxieties can be in form of fear of failure, examination stress and general mathematics stress. This kind of anxiety hampers concentration, efficiency,

and yields little satisfaction in the course of learning among students. The implications of mathematical anxiety are psychological, which may affect the students' academic and career prospects in the future.

1.4 Incidence and Significance of the Problem

It is important to know the degree of mathematical stress and anxiety and how they influence students to be able to resolve these problems Zhou et al. (2020). Previous research has pointed out to the increasing incidence of mathematical stress and math anxiety among engineering students Nochaiwong et al. (2021). These studies show that these problems are present, and they significantly affect student performance and well-being. These challenges are however worsened by the rigors of engineering education, where problem solving, and quantitative abilities are emphasized.

1.5 Need for Effective Support and Interventions

Because of the effects of mathematical stress and anxiety on engineering students, there is the need for adequate support in place or intervention. Understanding the origins of such difficulties as well as outcomes resulting from them will enable educators and policymakers to come up with specific interventions intended for reducing stress and anxiety among students Luchenski et al. (2018). It is in this context that the present research intends to shed light on these matters, providing recommendations on the measures that educational organisations can take to improve learners' learning and quality of life.

2. Objectives

- The purpose of this research will be to assess the levels of mathematical stress and anxiety among first year engineering students along with the influence of demographic factors on the two.
- To determine the coping options and the support networks to be used in the reduction of stress and anxiety in mathematics among the students.

2.1 Literature Review

Morán-soto and benson (2018) used a mixed method approach to analyse the impact of mathematics preparation and mathematics self-efficacy on students' decisions to select and persist in an engineering major. The present research compared the level of mathematics self-efficiency with the performance, conduct, and perceptions of engineering students in their first years of college mathematics. The study involved 408 participants who filled the mathematics self-efficacy survey and 11 participants who were interviewed in detail. The behaviours and attitudes of the participants in mathematics courses, self-efficacy beliefs and the match between the self-efficacy beliefs and the actual mathematics abilities were studied by the researchers in this study adopting the Grounded theory approach. The research indicated that while interview participants claimed high mathematics self-efficacy, most of them had incongruity between their perceived self-efficacy and actual capacity. In terms of self-regulation, participants whose self-efficacy and competence were relatively equal spent more time on the mathematics skills and on seeking assistance. Estonanto and Dio (2019) observed that mathematics anxiety affected learners in many ways such as; academic achievement, learning competencies, skills, and career development. In their study, they sought to establish the causes of mathematics anxiety in Calculus among senior high school students. To establish factors that cause anxiety, the study used qualitative research, while to determine the level of anxiety among students, a descriptive research design was used. This research was carried out in five SHS' in a province of Southern Luzon, Philippines that offered STEM strand. Out of these, sixty-nine participants filled the Mathematics Anxiety Inventory (MAI) prepared by Plake and Parker. The findings showed that close to all respondents displayed

either high or moderate mathematics anxiety. Finally, the study found out that the content knowledge, particularly the difficulty level of Calculus, the personality of the teacher, and the students' inability to understand and dissect the concepts taught were the main causes of mathematics anxiety among the participants. Brown et al. (2020) described that mathematics was one of the most important components in the training of engineering students because their ability to reason mathematically would be crucial for solving various problems at workplaces for the rest of their lives. The purpose of the research was to figure out how many differences there are between engineering students from two universities in terms of math anxiety and math evaluation anxiety where the two universities are different in cultural context. The participants were 20 engineering students from the southeast of the United States and 88 engineering students from Colombia. Data were collected through the administration of the English and Spanish versions of the AMAS which had nine items and two subscales. Two-way factorial ANOVAs were used to analyse the data with cultural background, gender, and the interaction between cultural background and gender on math anxiety. The study further showed that there was a significant difference between the two cultures in learning math anxiety.

In their study titled as "Anxiety and motivation as predictors of students' mathematics achievement: The magnitude of the effect" published in 2020, Süren and Kandemir aimed to investigate the effects of anxiety and motivation on mathematics achievement at the end of middle school and the beginning of high school. The research included assessment of anxiety and motivation connected to such factors as gender, pre-school education, support and training courses, private tutoring and others. The participants of the study were 777 students of the eighth grade in a province of the Aegean region in Turkey. Jamieson et al. (2021) noted that mathematics anxiety was a factor that hampers the success in mathematics and science. Surendra et al. focused on the study of different regression model to estimate the future. Navya et al. (2021) made a study on impact of sleep on usage of mobile phone at a bedtime. Srilekha et al. (2024) used the generalized regression models to study the dependent and influenced variables. Despite the progress that has been done in the psychological explanations of mathematics anxiety and the intervention programs, the connection between mathematics anxiety, affective and biological reactions, and performance under stress conditions is still not well researched. To fill this gap, the researchers carried out a study involving 478 students from community college, 30 mathematics classrooms, focusing on the correlations between mathematics anxiety, stress appraisals, neuroendocrine reactivity (cortisol and testosterone) and test performance. The study revealed that higher maths anxiety was predicted by student's perceived academic demands and available coping resources during the exam, lower testosterone levels during an exam than at baseline, and poor performance on the exam. Moreover, stress appraisals partially mediated between mathematics anxiety, neuroendocrine reactivity and performance. The study's findings have important implications for student achievement, well-being, and the development of interventions aimed at reducing mathematics anxiety. On the other hand, the participants who had a match while completing the task were more likely to procrastinate and put little effort into improving their abilities so as to gain mastery of the task, and in so doing, they would tend to blame their failure and frustrations on external factors. These dissimilarities in behaviour and attitude are yet, however, tempered with the fact that all the participants affirmed their willingness to persevere with the necessary mathematics courses for their major even if they fail their first college mathematics course.

Questionnaires included the Mathematical Motivation Scale (MMS) and the Mathematics Anxiety Scale for Elementary School Students (MASESS) in addition to a researchers developed personal information form which was used to obtain participants' demographics. Descriptive statistics, independent samples t-tests, correlation analysis and structural equation Modeling were used in the analysis. It was established that the students had moderate to severe Mathematics anxiety and moderate Mathematics motivation with the two

variables being positively and moderately correlated. Also, anxiety was considered as a significant predictor of mathematics achievement than motivation, hence, its importance in the students' performance in mathematics.

3. Methods

3.1 Research Design

The research methodology of this study is based on the quantitative approach to assess mathematical stress and anxiety among the first-year engineering students. The research will use structured questionnaires to measure levels of stress and anxiety among the students and to analyze the relationships between these levels and such demographic indicators as gender, age, class, etc. This makes it possible to engage in the systematic collection and analysis of numerical data which can help in the establishment of patterns and relationships between mathematical stress, mathematical anxiety and the students' demographic factors.

3.2 Sample and Population

The target population for the present study include first year engineering students from various engineering colleges. To accomplish the goal of the study, a total of 300 students will be included in the study with the help of stratified random sampling technique so as to have a good representation of the population with reference to different demographic variables. The sample will be divided on the basis of gender, area of domicile, birth order, intergroup (MPC/MC group and other groups), and types of school (day scholar and hostler). This technique of sampling effectively makes sure that the study will embrace a wide range of experiences and generalization of the study will not be compromised as well as analysis of how various demographic factors affect mathematical stress and anxiety.

3.3 Variables

In the study, the following variables of interest are of interest. Mathematical stress was established as the amount of stress claimed by the students concerning their mathematics classes using a Likert scale. The level of anxiety that students have before or during mathematics examination is also measured using Likert-scale items, to define the case of mathematical anxiety. Gender, locality of living, birth order, intermediate group, residential status are some of the demographic variables. All these variables are measured in a way that can offer information about the effect they may have on mathematical stress and anxiety so as to establish possible factors and interactions.

3.4 Data Collection Methods

The data will be collected by means of a structured electronic questionnaire that will be sent to the 300 students in the sample. The questionnaire is to obtain basic demographic data as well as specific data about the stress and anxiety toward mathematics. It consists of questions about the experiences of stress and anxiety, how often and how much, and regarding the efficiency of coping strategies, and academic resources. The use of electronic format in completing the questionnaire makes it easier in administration of the questionnaires and collection of data since the responses are well coordinated.

3.5 Questionnaire Design

The questionnaire is comprised of two large sections. The first section is demographic information of gender, locality of living, birth order, intermediate group and residential status. The following data is important for the purpose of sample classification and to examine the impact of these variables on mathematical stress and anxiety. The second section is on stress and anxiety in mathematics: Students are asked the extent of their

agreement with Likert-scale questions about their global stress, the frequency of anxiety, its influence on performance, obstacles encountered in assignments, self-confidence in solving problems, preparing for exams and the efficacy of coping strategies. This structure makes certain that the questionnaire captures all aspects of the study goals and gives a good understanding of students' experience.

3.6 Data Analysis

Descriptive and inferential statistics shall be used in the analysis of the collected data. On the descriptive part, mean, standard deviation, and frequencies of the students' stress and anxiety will be presented in form of bar graphs. Descriptive statistics will determine the extent of mathematical stress and anxiety among students as well as the relationship between demographic factors and stress and anxiety. Multiple regression analysis will be used to determine the extent to which demographic characteristics can predict stress and anxiety. The program for these analyses is R programming, which will allow for a deeper exploration of the data and a check of the hypotheses of the study.

4. Results and Analysis

4.1 Descriptive analysis

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Gender:	300	1.00	2.00	1.4067	.49203
Locality of Living:	300	1.00	2.00	1.4367	.49680
Birth Order:	300	1.00	3.00	1.9733	.79250
Intermediate Group:	300	1.00	4.00	2.5833	1.15506
Residential Status:	300	1.00	2.00	1.5400	.49923
Mathematical Stress and Anxiety	300	1.00	5.00	3.2133	1.36407
Valid N (listwise)	300				

Descriptive analysis of the study is important in that it offers a background of the sample and the general distribution of the variables. The sample comprised 300 engineering students, and the analysis focused on several variables: gender, where they live, birth order, the intermediate group, their residential status, and maths stress and anxiety.

In the gender variable, the mean was 1.41 and a standard deviation of 0.49, and therefore the ratio of boys to girls was almost equal, but there were slightly more boys than girls. This implies that the sample had a slightly more of one gender than the other gender in the sample.

The locality of living variable which distinguished between urban and rural backgrounds had a mean of 1.44 and a standard deviation of 0.50. This means that the sample had almost half of the students from urban areas and the other half from rural areas though slightly inclined to one locality.

As for birth order, the mean was 1.97 with SD of 0.79, implying a random distribution among first born, second born, third born (and so on) students. The variation in this variable is therefore an indication of the possible range of family situations and how they may influence mathematical stress and anxiety.

The intermediate group, which sorts students according to the previous educational concentration (MPC and other groups), had a mean of 2.58 and the standard deviation of 1.16. This variability suggests that the

students are more spread out in terms of their education level, and this may be useful when explaining their mathematical stress and anxiety.

For residential status—varying between day scholars and hostellers—the mean was 1. 54 with a standard deviation of 0. 50. This implies that the distribution of the two groups is equal with slightly more inclined towards the students who live in the hostels.

4.2 Correlation Analysis

Correlations							
		Gender:	Locality of Living:	Birth Order:	Intermediate Group:	Residential Status:	Mathematical Stress and Anxiety
Gender:	Pearson Correlation	1	.653**	-.032	.476**	.328**	.109
	Sig. (2-tailed)		.000	.579	.000	.000	.058
	N	300	300	300	300	300	300
Locality of Living:	Pearson Correlation	.653**	1	-.021	.441**	.192**	-.010
	Sig. (2-tailed)	.000		.713	.000	.001	.868
	N	300	300	300	300	300	300
Birth Order:	Pearson Correlation	-.032	-.021	1	.057	-.006	.123*
	Sig. (2-tailed)	.579	.713		.323	.921	.033
	N	300	300	300	300	300	300
Intermediate Group:	Pearson Correlation	.476**	.441**	.057	1	.229**	.207**
	Sig. (2-tailed)	.000	.000	.323		.000	.000
	N	300	300	300	300	300	300
Residential Status:	Pearson Correlation	.328**	.192**	-.006	.229**	1	-.013
	Sig. (2-tailed)	.000	.001	.921	.000		.828
	N	300	300	300	300	300	300
Mathematical Stress and Anxiety	Pearson Correlation	.109	-.010	.123*	.207**	-.013	1
	Sig. (2-tailed)	.058	.868	.033	.000	.828	
	N	300	300	300	300	300	300

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

* . Correlation is significant at the 0.05 level (2-tailed).

The results of the correlation analysis show the interconnection of the variables in the study and give an understanding of the connection between demographic characteristics and educational experience with mathematical stress and anxiety.

Beginning with gender, it is positively related to the nature of living place ($r = .653, p < .01$) which means that gender has a direct relation to whether the student is from an urban or rural area. Furthermore, gender has a moderate relationship with the intermediate group ($r = .476, p < .01$) and residential status ($r = .328, p < .01$), which means that gender affects the students' previous educational specialization and their accommodation while learning. But gender has a less significant relationship with mathematical stress and anxiety as the coefficient of determination is equal to .109 and p – value is equal to .058, therefore, indicating that there is almost no direct relationship of gender with anxiety in mathematics.

The locality of living is also significantly related to the intermediate group ($r = .441, p < .01$) and residential status ($r = .192, p < .01$), meaning that students' backgrounds (urban or rural) are connected with their educational priorities and their living status – whether they live in a dormitory or commute. The results of the study also show that there is a very weak and non-significant relationship between the variable of locality and the variable of mathematical stress and anxiety ($r = -.010, p = .868$) which means that where a student is coming from has no significant impact on the level of anxiety he or she has in mathematics.

Birth order has a small but positive and statistically significant relationship with mathematical stress and anxiety, ($r = .123, p < .05$) which suggests that students' position in the family may have a small effect on their anxiety in mathematics. The interaction effects of birth order with other factors like gender and locality are also insignificant and close to zero.

Intermediate group variable has moderate positive correlation with mathematical stress and anxiety ($r = .207, p < .01$) which shows that students previous educational focus has moderate relationship with their anxiety level in mathematics. Further, the intermediate group has a significant positive relationship with the residential status ($r = .229, p < .01$) which indicates that the type of residential status is also dependent on the type of education that the student is pursuing.

Residential status has a very low negative correlation with mathematical stress and anxiety which is not significant at all ($r = -.013, p = .828$) which means that whether or not a student resides in the campus or travels to school does not affect his/her anxiety in mathematics.

4.3 Regression Analysis

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.109 ^a	.012	.009	.48989
a. Predictors: (Constant), Mathematical Stress and Anxiety				

The regression analysis brings out a model summary whereby mathematical stress and anxiety are the predictors of the outcome variable. The analysis reveals very low positive relationship ($R = 0.109$) between mathematical stress and anxiety and the outcome variable with the R Square value of 0.012, meaning that only 1% of the total population in the country. Mathematical stress and anxiety accounts for two percent of the variance in the outcome variable. The adjusted R Square that considers the number of predictors in the model slightly reduces to 0.009, which again highlights the fact that the predictor has very limited variability in predicting the outcomes. The standard error of the estimate is 0.48989, which indicates that there is certain amount of inconsistency in the model.

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.868	1	.868	3.616	.058 ^b
	Residual	71.519	298	.240		
	Total	72.387	299			
a. Dependent Variable: Gender:						
b. Predictors: (Constant), Mathematical Stress and Anxiety						

The analysis of variance of the regression model shows that the predictor, the mathematical stress and anxiety, contains a sum of squares of .868 with 1 degree of freedom and came up with a mean square of .868. This gives an F-value of 3. Thus the null hypothesis is rejected and is replaced with an F ratio of 3.616, while the significance level was .058. Despite the fact that the F-value indicates the regression model might be nearing significance, the p-value of .058 is somewhat higher than the standard of .05 level of significance it can be concluded that there is no relationship between mathematical stress and anxiety and the dependent variable which is gender. The residual sum of squares is 71.519 with 298 degrees of freedom and total sum of squares is 72.387, which is generally in line with the variability of the model.

Coefficients ^a					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	1.280	.072		17.655	.000
Mathematical Stress and Anxiety	.039	.021	.109	1.902	.058

a. Dependent Variable: Gender:

Co-efficients table gives a clear picture about the influence of the independent variables namely mathematical stress and anxiety on the dependent variable namely gender. The intercept term in the model is 1.280 with a standard error of .072 which is statistically significant with the t value of 17.655 and a p value of .000 suggesting that the intercept is significantly different from zero. The unstandardized coefficient for mathematical stress and anxiety is .039 with a standard error of .021, indicating a positive yet very small effect on gender. For mathematical stress and anxiety, the standardized coefficient (Beta) is: .109, thus indicating that the effect size of the treatment is small. The t-value of this predictor is 1.902, and the p value is .058, which is slightly above the conventional significance threshold of .05. This result shows that although mathematical stress and anxiety and the outcome variable are positively correlated, gender was found to have no significant effect at the 0.05 level. This implies that the effects of mathematical stress and anxiety are invariant with gender and that possibly other factors may be influential in determining the outcome variable.

5. Discussion

Therefore, the purpose of this study was to establish the effect of mathematical stress and anxiety in engineering students and their career with the selected demographic and academic factors. The descriptive analysis showed that engineering students have moderate amount of mathematical stress and anxiety with mean score of 3.2133 on a scale of 5, which means that they showed a relatively high level of concern associated with their math classes. This finding tallies with the first aim of the study, which was designed to assess the level of mathematical stress and anxiety among these students. It was also found from the correlation analysis that there are low but significant relationships between mathematical stress/ anxiety and some demographic factors. More precisely, there was a moderate positive correlation with the intermediate group, which means that students of different educational tracks can be affected by stress differently. But the gender and residential status had a poor relationship with the mathematical stress and anxiety, which means that these factors do not largely influence the stress.

The regression analysis then extended the study of the relationship between mathematical stress and anxiety and different variables including gender. The R Square value was .012 revealed that mathematical stress and anxiety only account for a very small portion of gender that is why it is very weak. The ANOVA results show a value of 3 for F which is greater than the F crit. 616 and a significance level of .058, which pointed to the

fact that gender's significance in the model was marginal but not conclusive. These findings contribute to the second aim by comparing the mathematical stress and anxiety with demographic and academic factors which offers insights on the general impact of the constructs. The study, thus, is an affirmation of the fact that mathematical stress and anxiety are real among the engineering students, and they impact one or the other factor to some extent though the observed relationships were not as high as hypothesized. Future studies should aim at identifying other variables that may contribute to mathematical stress and on how better help students deal with these issues.

5.1 Conclusion

The information presented in this work is beneficial to reveal the impact of mathematical stress and anxiety on engineering students and correlate its consequences with academic achievement and students' well-being. It is for this reason that this paper sought to examine the correlation between mathematical stress, mathematical anxiety and gender, place of residence, birth order, intermediate group, and residential status. Through the study, it was clear that both mathematical stress and anxiety are prevalent in students across the various backgrounds, but the extent of the effects depends on some factors. The study shows that although mathematical stress and anxiety is evident among the engineering students, the relationship is moderate with gender and residential status. This means that although these factors have some influence over the degree of stress experience, it does not fully explain the phenomenon of mathematical stress and anxiety. The regression analysis and ANOVA that have been done in this study also support the same idea that the impact of mathematical stress on academic performance quantitatively exists, although, there are moderating factors involved. Such interconnections require an understanding of the different aspects that make up the entire system of students' experiences. The study underlines the importance of efforts in identifying and providing coping strategies for students experiencing mathematical stress and anxiety. From the understanding of the characteristics and causes of stress in engineering students, we can see that generalized treatments may not work; interventions should be based on the background and problem of engineering students. Teachers and politicians should pay attention not only to the methods that will help learners overcome the difficulties connected with maths but also to the methods that will help a child cope with stress and nervousness. The study therefore recommends that future research should investigate further on the various causes of mathematical stress and anxiety taking into account more variables and their moderating effects. A finer-grained analysis might yield additional information on how various domains in students' lives are linked to their experience of mathematical stress. By building on these findings, future research can contribute to more effective strategies and support systems designed to enhance students' academic success and overall mental health.

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