






Experiences and mathematics anxiety of STEM students

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ABSTRACT

Mathematics anxiety is not a new topic in the field of education, but this construct held its significance in the field over time as it affects other constructs that also contribute to a quality mathematics education. The literature revealed that among senior high school students, mathematics anxiety was found to be prevalent. However, the literature lacked investigations with regards to the mathematics anxiety of this group of students and the factors that can affect it. To address the gap, this quantitative study examined the students' experiences on teacher interactions, pedagogical practices and mathematical content and their significant relationship to the students' level of mathematics anxiety. The respondents were 101 STEM students of Pikit National High School and the study used descriptive statistics as well as correlational analysis. The study revealed that STEM students experienced moderately positive teacher interactions, moderately student-centered teaching, moderately positive experiences on mathematical content, and obtained a moderate level of mathematics anxiety. It was further revealed that students' experiences on teacher interactions and mathematical content have negative correlation with their level of mathematics anxiety and was found to be significant.

Keywords: mathematics anxiety, mathematical content, pedagogical practices, STEM students, teacher interactions

INTRODUCTION

One of the things that established mathematics as an important area of knowledge is that it is a problem solving tool that helps to provide solutions in different real life issues (Delgado & Kassim, 2019). However, amidst the fact regarding the importance of mathematics in the field of education, the literature noted that students seem to develop fear in the subject. This is referred to as mathematics anxiety, which hinders their learning and achievement.

As what Luttenberger et al. (2018) explained, an individual has been experiencing mathematics anxiety when he feels uneasy and undergoing some physiological reactivity when dealing with mathematics. They also added that individuals felt this kind of anxiety when they solve problems regarding mathematics, when they operate on numbers, and even just being involved in a mathematics situation that requires their full attention. This obstructs an individual's capacity to handle numbers and face challenging situations regarding mathematics (O'Leary et al., 2017).

Mathematics anxiety is an important and timeless issue to discuss as it relates to other important constructs in the field of education such as mathematics achievement, learning behaviors and confidence in the subject. The study of Barroso et al. (2021) revealed that mathematics anxiety was negatively correlated to the student's mathematics achievement. It was also found in mathematically anxious students that they tend to forget math-related processes in solving mathematical tasks, tend to demonstrate procrastination, invest lower levels of effort in the subject, and avoid math-related career choices in the future (Luttenberger et al., 2018).

In the literature review made by Zhang et al. (2019), it was found that mathematics anxiety had a stronger negative link in senior high school group compared to other grade levels. The same results were reported in the study of Mohamed and Tarmizi (2010), where higher level of mathematics anxiety was found in senior students than in junior students. In the Philippines setting, specifically in the province of Sorsogon, Estonanto (2017) concluded that the low academic performance in Pre-calculus of Science, Technology, Engineering, and Mathematics (STEM) students was influenced by their mathematics anxiety. This emphasized the need to focus on senior high school students and investigate on the factors that affect their mathematics anxiety.

As a matter of fact, several studies explored the factors that affect the learners' mathematics anxiety such as gender where it was found that levels of mathematics anxiety differ between male and female learners (Delgado & Kassim, 2019). Reciprocal learning strategies and mathematical modeling were also found to significantly reduce the students' mathematics anxiety (Guita

Table 1. Students' experiences on teacher interactions

Statements	Mean	Verbal description
My math teachers were supportive in my efforts to learn mathematics.	3.76	Agree
My teachers had confidence in me as a student of mathematics.	3.46	Undecided
My teachers spent the necessary amount of time helping me to understand math concepts.	3.57	Agree
I had many competent math teachers.	3.54	Agree
My math teachers were very patient with me.	3.79	Agree
I can recall math teachers who made me feel dumb in class.*	2.96	Undecided
My teachers did not believe I was capable of learning mathematics.*	3.52	Agree
I did not feel comfortable seeking help from my math teachers outside of class.*	2.65	Undecided
Many of my math teachers were incompetent.*	3.40	Undecided
My teachers became frustrated with me.*	3.49	Undecided
Overall mean	3.41	Undecided

Note. *Scores reversed; 1.00-1.49: Strongly disagree (highly negative); 1.50-2.49: Disagree (negative); 2.50-3.49: Undecided (moderately positive); 3.50-4.49: Agree (positive); & 4.50-5.00: Strongly agree (highly positive)

& Tan, 2018; Santos et al., 2015). However, the focus of these studies was the mathematics anxiety of either elementary pupils or junior high school students.

In order to bridge the gap that existed in the literature, the students' mathematics anxiety was investigated, particularly the senior high school students who were enrolled to STEM strand. Significantly, this study acknowledged the importance of past experiences as factors affecting the students' mathematics anxiety. In this regards, this study examined the factors that affect the mathematics anxiety of STEM students of Pikit National High School. Specifically, this study determined the respondents' experiences on teacher interactions, pedagogical practices and mathematical content; determined the respondents' level of mathematics anxiety; and determined the significant relationship between the respondents' experiences and their level of mathematics anxiety.

This study will be beneficial to educational researchers with the information it will contribute to the literature especially when it comes to understanding the anxiety of senior high school students when it comes to mathematics. It will also help mathematics teachers in order to assess their way of teaching and how they interact with their students as these can influence mathematics anxiety. Moreover, this study will allow the students to revisit their perceptions and attitudes towards mathematics concepts and build more positive emotions towards it in order to have a stronger foundation in learning the subject.

MATERIALS AND METHODS

This study is a quantitative research that used a descriptive statistics to determine the students' experiences on teacher interactions, pedagogical practices, mathematical content as well as their level of mathematics anxiety. It also utilized correlational design to determine the significant relationship between the respondents' experiences and their level of mathematics anxiety.

The study adopted the research instruments of Allen (2001). Experiences on teacher interactions were measured with the teacher experience scale (TES). Experiences on pedagogical practices were measured with the pedagogy experience scale (PES). Experiences on mathematical content were measured with the content experience scale (CES). The level of mathematics anxiety was measured with the revised mathematics anxiety scale (RMAS). All of the scales consisted of 10 items and the respondents answered the instrument utilizing a Likert scale in five points ranging from (1) "strongly disagree" to (5) "strongly agree".

With complete enumeration, the respondents of the study were all the STEM students (n=101) of Pikit National High School enrolled in the school year 2021-2022. Before conducting the data collection, the researchers gained the permission from the university to conduct the study. The researchers then obtained the permission from the school principal of the Pikit National High School as well as from the Head of the Senior High School Department of the school. After the researchers obtained the list of all STEM students at the school, they made a group chat from an online platform to communicate with all the respondents. They administered both the informed consent form and research instrument through Google Forms and the data were completely gathered after two weeks of data collection.

RESULTS

Results showed that the highest mean among the statements is 3.79, which means that the respondents agree that their teachers were very patient (**Table 1**). However, it was found from the lowest mean (2.65) that the respondents felt that reaching out to their mathematics teachers outside of class was uncomfortable. The overall mean of the respondents' experiences on teacher interactions (3.41) showed that it was moderately positive.

The results revealed the highest mean of 3.97, which means that the respondents agreed that they learned most effectively when teachers connect the new lesson to their previous knowledge (**Table 2**). However, with the lowest mean of 2.17 revealed that the respondents disagreed that their teachers expected them to actively participate. The overall mean of the respondents' experiences on pedagogical practices (3.08) further revealed that they have experienced a moderately student-centered approach in learning mathematics.

Table 2. Students' experiences on pedagogical practices of their teachers

Statements	Mean	Verbal description
My teachers used math games to reinforce my understanding of concepts.	2.98	Undecided
My teachers often applied their math lessons to real world situations.	3.85	Agree
I learned best when my teachers took time to connect new concepts to that which I had already learned.	3.97	Agree
My teachers emphasized understanding and not just memorization.	3.86	Agree
My teachers used a combination of manipulatives, visual aids, and cooperative learning.	3.62	Agree
My teachers frequently used a lecture format.*	2.43	Disagree
My teachers relied on overhead projectors or chalkboards as tools to present information.*	2.79	Undecided
My teachers assigned several homework problems each night.*	2.42	Disagree
During my math classes I was expected to sit quietly and listen.*	2.17	Disagree
My teachers focused mainly on memorization facts and procedures.*	2.70	Undecided
Overall mean	3.08	Undecided

Note. *Scores reversed; 1.00-1.49: Strongly disagree (highly teacher-centered); 1.50-2.49: Disagree (teacher-centered); 2.50-3.49: Undecided (moderately student-centered); 3.50-4.49: Agree (student-centered); & 4.50-5.00: Strongly agree (highly student-centered)

Table 3. Students' experiences on mathematical content

Statements	Mean	Verbal description
New math content has usually been easy for me to understand.	3.10	Undecided
I usually comprehended math content well and seldom got lost.	3.28	Undecided
I have generally considered math as a related, sequential, progression of ideas.	3.60	Agree
When confronted with a difficult concept, I generally worked until I understood the concept.	3.79	Agree
I cannot recall many mathematical concepts that were hard for me to understand.	3.38	Undecided
I did not like being introduced to new mathematical content.*	3.07	Undecided
I was frequently lost and had trouble keeping up in my math classes.*	2.64	Undecided
I generally have had difficulty relating new mathematical concepts to those I had previously learned.*	2.67	Undecided
When I had trouble with a concept I usually gave up and quit trying.*	3.56	Agree
I struggled with many concepts in mathematics.*	2.46	Disagree
Overall mean	3.16	Undecided

Note. *Scores reversed; 1.00-1.49: Strongly disagree (highly negative); 1.50-2.49: Disagree (negative); 2.50-3.49: Undecided (moderately positive); 3.50-4.49: Agree (positive); & 4.50-5.00: Strongly agree (highly positive)

Table 4. Students' level of mathematics anxiety

Statements	Mean	Verbal description
It would not bother me at all to take more math courses.*	3.08	Undecided
I have usually been at ease during math tests.*	3.05	Undecided
I have usually been at ease during math courses.*	2.82	Undecided
I usually do not worry about my ability to solve math problems.*	3.37	Undecided
I almost never get uptight while taking math tests.*	3.11	Undecided
I get really uptight during math tests.	3.18	Undecided
I get a sinking feeling when I think of trying hard math problems.	3.43	Undecided
My mind goes blank, and I am unable to think clearly when doing mathematics.	3.15	Undecided
Mathematics makes me feel uncomfortable and nervous.	3.12	Undecided
Mathematics makes me feel uneasy and confused.	3.32	Undecided
Overall mean	3.16	Undecided

Note. *Scores reversed; 1.00-1.49: Strongly disagree (very low math anxiety); 1.50-2.49: Disagree (low math anxiety); 2.50-3.49: Undecided (moderate math anxiety); 3.50-4.49: Agree (high math anxiety); & 4.50-5.00: Strongly agree (very high math anxiety)

Results showed that the highest mean among the statements is 3.79, which means that when the respondents are confronted with a difficult concept, the respondents work hard until they understood the concept (**Table 3**). It was also found from the lowest mean (2.46) that the respondents struggled with many concepts in mathematics. The overall mean of the respondents' experiences on mathematical content (3.16) showed that it was moderately positive.

Among all of the statements that assessed the respondents' level of mathematics anxiety, getting a sinking feeling when thinking of trying hard math problems got the highest weighted mean (3.43) while being not at ease during math subjects had the lowest weighted mean (2.82). The respondents' level of mathematics anxiety had an overall mean of 3.16, which implies that the respondents have a moderate mathematics anxiety (**Table 4**).

Respondents' experiences on teacher interactions and mathematical content were found to be significantly correlated with their level of mathematics anxiety at 0.01 level (**Table 5**). Experiences on teacher interactions were negatively correlated with mathematics anxiety ($r_s = -0.469$) as well as experiences on mathematical content and mathematics anxiety ($r_s = -0.637$). Respondents' experiences on pedagogical practices of their mathematics teachers was negatively correlated with mathematics anxiety ($r_s = -0.088$); however, it was not statistically significant.

Table 5. Relationship between students' experiences and their level of mathematics anxiety

Students' experiences	Spearman's rho correlation coefficient (r_s)	p-value
Teacher interactions	-0.469**	0.000
Pedagogical practices	-0.088	0.381
Mathematical content	-0.637**	0.000

Note. **Correlation is significant at the 0.01 level (2-tailed); 0.90-1.00 (-0.90--1.00): Very strong correlation; 0.70-0.89 (-0.70--0.89): Strong correlation; 0.40-0.69 (-0.40--0.69): Moderate correlation; 0.20-0.39 (-0.20--0.39): Weak correlation; 0.00-0.19 (0.00--0.19): Very weak correlation

DISCUSSIONS

It was shown that the respondents experienced moderately positive experiences on teacher interactions (**Table 1**). They have patient teachers, and this further implies that they are likely to be active learners since researchers cited in the study of Prewett et al. (2019) that when learners believed that their teachers care about them, they are more likely to do well in class and be more engaged in school. However, a separation existed between them and their teachers since they do not feel seeking assistance from their teachers when class hours are over. The separation between mathematics teachers and students can be traced from teachers' misconduct (Lin et al., 2017).

The data also have shown that the respondents' experiences on pedagogical practices of their teachers were moderately student-centered (**Table 2**). Furthermore, it was revealed that teachers connect new learning concepts from the students' previous knowledge. However, it was also noted that their mathematics teachers do not expect much from them. According to Sinay and Nahornick (2016), mathematical memorization is insufficient for acquiring complex understanding. Teachers must provide real-world applications of the subject or provide an inquiry environment where complex components of the subject are seen to be connected. They also added that in a mathematics classroom, creativity and collaboration allow the creation of a supportive and engaging learning environment.

Additionally, the respondents' experiences on mathematical content were moderately positive (**Table 3**). They possessed determination in learning challenging new concepts in mathematics. It was also revealed that even though they have the determination to learn, they still struggled with many concepts in mathematics. According to the curriculum guide in mathematics as provided by the Department of Education, mathematics is focused on its twin goals of developing the learners' critical thinking and problem solving (Balagtas et al., 2019). According to Mazana et al. (2019), students are more likely to engage in problem-solving when they enjoy mathematics in the first place, which in turn improves their learning and performance in the subject but there are still some students who reported that real-world questions in mathematics are too challenging.

It was also revealed that the respondents have moderate mathematics anxiety (**Table 4**). Some respondents were anxious just by trying to think of mathematics problems while some felt at ease during math subjects. The result agrees to the body of literature that most students feel a moderate level of mathematics anxiety (Anugrah et al., 2019; Jolejole-Caube et al., 2019). However, moderate mathematics anxiety is still not a good thing to celebrate. This means that the respondents still felt uncomfortable with the subject. As manifestations of mathematics anxiety, the respondents felt unusual change of feelings and emotions when introduced to things related to mathematics (Luttenberger et al., 2018). The respondents still have mathematics anxiety that may hinder their future career choices and academic endeavors (O'Leary et al., 2017).

It was shown that the respondents' experiences on their interactions with their mathematics teachers were found to have a significant and negative correlation with their level of mathematics anxiety (**Table 5**). This means that if a student feels positive student-teacher relationships, it reduces their level of mathematics anxiety. Moreover, any negative attitude of their math teacher increases their mathematics anxiety. The result was the same to the study of Semeraro et al. (2020) and acknowledged that teachers' role is not only limited to facilitator of learning but transcends into the affective dimension. It was also stated in the previous study that students' attachment to their teachers provides a secure refuge in which moderates students' bad emotions while at school. Moreover, Beilock and Willingham (2014) suggested that mathematics anxiety can be lessen if the teacher acknowledges that the student is having a hard time, no more sweet words but a mere conviction from the teacher that the student is capable of doing the task.

The data also revealed a negative correlation between the respondents' experiences on the pedagogical practices of their mathematics teachers and their level of mathematics anxiety (**Table 5**). However, the relationship was weak, and the data gathered were not enough to tell that the negative correlation was significant. This further implies that there is no relationship exists between the respondents' experiences on pedagogical practices and their level of mathematics anxiety. But according to Blazer (2011), teachers can make the subject important to students' lives by making connections to common applications, involving them in investigation, thinking, practicing and applying to help them see mathematics as a valuable tool. It was further added that those teachers who used the subject as a punishment for an inappropriate behavior tend to contribute to the students' mathematics anxiety.

Furthermore, the data showed a significant and negative correlation between the respondents' experiences on mathematical content and their level of mathematics anxiety (**Table 5**). This means that the mathematics anxiety perceived by the respondents can be inferred from their perceptions and attitudes towards mathematical content. The more they felt positive in learning new concepts in mathematics, the greater the chance in reducing their mathematics anxiety. However, if the respondent perceived the new concepts to be hard and immediately quit when faced with challenging math problems, it follows that the respondent's mathematics anxiety will increase. The results conform to the body of literature that the complexities of math problem and avoidance of the subject when sensing failure induces mathematics anxiety (Caviola et al., 2017; Skagerlund et al., 2019).

CONCLUSIONS

This study concluded that STEM students at senior high school experienced moderately positive teacher interactions, moderately student-centered teaching in mathematics subjects and moderately positive experiences on mathematical content. STEM students also obtained a moderate level of mathematics anxiety. Students' experiences on teacher interactions and mathematical content have moderate negative correlation with their level of mathematics anxiety and were found to be statistically significant. However, their experiences on pedagogical practices were found to have no significant relationship with their mathematics anxiety. The researchers recommend that mathematics teachers must nurture positive and healthy student-teacher relationships and help students build and maintain positive attitudes towards the subject in order to combat the prevalence and the detrimental effects of mathematics anxiety among learners.

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