Beyond Numbers: Examining Mathematics Self-Efficacy and Anxiety among Structural Engineering Students

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ABSTRACT

This study aimed to investigate the relationship between mathematics self-efficacy and anxiety among structural engineering students. This study employed a mixed-methods research approach, specifically a descriptive research design, in which quantitative data were first collected through survey questionnaires, followed by qualitative data collected through group interviews that explained the quantitative results. Using this research design, the researchers first gathered information by administering a survey to 100 structural engineering students to assess their mathematics self-efficacy and anxiety. This was followed by collecting additional data from the same participants with 10 (ten) members as they participated in a structured interview. Content analysis was used to examine the data gathered from the interview. The findings revealed that students frequently expressed confidence in applying mathematics to their future engineering careers, understanding mathematical concepts, and completing mathematics-related tasks. However, confidence was expressed less frequently during classroom participation, in mathematical identity, and in high-stakes assessment situations. Mathematics anxiety was expressed primarily in relation to examinations, grades, and classroom evaluation, while concerns about applying mathematics in future engineering practice were expressed less frequently. Correlation analysis revealed a statistically significant but weak negative relationship between mathematics self-efficacy and Mathematics 111 performance, indicating that students who reported greater confidence tended to achieve higher academic performance. In contrast, mathematics anxiety was not significantly related to performance in Mathematics 111. The study concludes that strengthening mathematics self-efficacy while creating supportive learning environments that reduce mathematics anxiety may enhance students' mathematics learning experiences. Finally, the researchers recommended that teachers create a supportive classroom environment that fosters a positive, approachable atmosphere and encourages students to freely express their thoughts and questions without fear of judgment.

Keywords: mathematics education, education, self-efficacy, anxiety

INTRODUCTION

One of the most important foundations for problem-solving in engineering education is mathematics. Proficiency in this subject matter is crucial, as it supports the computational, analytical, and modeling skills required in the field of engineering. With its undeniable significance, many engineering students still struggle with mathematics, which constitutes cognitive demands. They also have difficulty with affective factors, which influence their learning, including their self-efficacy and anxiety in mathematics.

Self-efficacy is the judgment about one's ability to plan and carry out actions to achieve a specific performance (Bandura, 1986). In mathematics, it refers to students' belief in their ability to successfully perform various

mathematical tasks. Conversely, as defined by Barroso et al. (2021), mathematics anxiety is defined as tension, anxiety, and other feelings that interfere with working with numbers and solving mathematical problems in a variety of situations and is a math-specific anxiety that is distinguished from test anxiety and general anxiety (Barroso et al., 2021). In engineering programs, these psychological constructs carry added significance. Structural engineering students frequently encounter complex mathematical concepts such as differential equations, mechanics, and structural analysis. Cognitive skills do not solely determine their success in these areas but are also shaped by how confident or anxious they feel when engaging with mathematical material.

Previous studies have extensively examined mathematics self-efficacy and anxiety across various student populations, demonstrating that these constructs play a critical role in shaping academic performance. Riboroso et al. (2018), for instance, found that elementary education students experience average self-efficacy and moderate anxiety. In a recent study by Zou (2024) among secondary school students, he found that mathematics self-efficacy had a negative role between mathematics anxiety and mathematics performance, and a completely positive role between mathematics motivation and mathematics performance. Within the context of engineering education, Morán-Soto and González-Peña' (2022) explored engineering students' math anxiety and math self-efficacy and discovered significant gender differences, with male students reporting higher self-efficacy and lower anxiety. Their findings underscore the importance of examining these constructs in STEM-related fields, where mathematical competence is essential.

Despite the growing body of literature, research focusing specifically on structural engineering students remains limited, a subgroup within engineering programs whose mathematics experiences may differ due to their curriculum's heavy quantitative demands. Existing studies have concentrated on general education students, secondary learners, or engineering populations without disaggregation by specialization. Moreover, few studies have simultaneously examined the most frequently reported indicators of mathematics self-efficacy and anxiety, particularly using mixed-methods approaches that integrate students' qualitative narratives with quantitative trends.

Given these gaps, the present study seeks to examine the relationship between mathematics self-efficacy and mathematics anxiety among structural engineering students. By employing a mixed-methods approach, this study provides a deeper understanding of how students perceive their mathematical abilities and how anxiety manifests in their learning experiences. Through survey responses and qualitative insights from structured interviews, the study aims to uncover the patterns, challenges, and emotional landscapes that shape students' engagement with mathematics.

Understanding the dynamics of mathematics self-efficacy and anxiety provides valuable insights into the learning environment. It can potentially guide educational strategies to enhance students' confidence and alleviate anxiety, fostering a more effective and supportive educational journey for structural engineering students.

Statement of the Problem

The study aimed to examine the mathematics self-efficacy and anxiety of structural engineering students in a private higher education institution in Marawi City. Hence, this study sought to answer the following research questions:

1. How frequently do structural engineering students express mathematics self-efficacy and mathematics anxiety?
2. Are mathematics self-efficacy and mathematics anxiety significantly related to students' Mathematics 111 performance?

METHODOLOGY

This study employed a mixed-methods research approach, specifically a descriptive research design in which quantitative data were first collected through survey questionnaires, followed by qualitative data collected through interviews, specifically focus group discussions, which explained the quantitative results. Using this research design, the researchers collected data by administering a survey to 100 randomly selected structural

engineering students at a private higher education institution in Marawi City to determine their levels of mathematics self-efficacy and anxiety. This was followed by collecting additional information from the ten (10) respondents, who participated in structured interviews. The researchers chose structural engineering students as respondents for the study because they constituted the largest group reporting experiences of mathematics anxiety.

In this study, the researchers adapted a survey questionnaire and guide questions for structured interviews. The questionnaire was adapted from May (2009). Although originally administered as a single instrument assessing mathematics-related beliefs and emotions, the questionnaire comprises two theoretically distinct constructs. For the present study, the instrument was operationalized into two subscales based on the original framework: Mathematics Self-Efficacy (Items 1–14; $\alpha = 0.93$) and Mathematics Anxiety (Items 15–29; $\alpha = 0.93$). The self-efficacy subscale measures students' perceived capability to perform mathematics-related tasks, whereas the anxiety subscale assesses emotional reactions and apprehension toward mathematics. Each item was rated using a five-point Likert scale ranging from 1 (Never) to 5 (Usually). Thus, high scores indicate a high degree of mathematics self-efficacy and mathematics anxiety, and low scores indicate a low rate of mathematics self-efficacy and mathematics anxiety.

The data collected from the survey questionnaire were analyzed using appropriate statistical methods. Mean and standard deviation were employed to examine the distribution and prevalence of mathematics self-efficacy and anxiety factors. Meanwhile, the qualitative data obtained from the Focus Group Discussion (FGD) and in-depth interviews were transcribed and subjected to thematic analysis using Braun and Clarke's (2006) six-phase thematic analysis. The researchers (1) familiarized themselves with the transcripts through repeated reading, (2) generated initial codes, (3) searched for recurring themes, (4) reviewed and refined candidate themes, (5) defined and named each theme, and (6) produced the final thematic report. Coding was conducted independently by two researchers, and discrepancies were resolved through discussion to enhance trustworthiness. Representative quotations were selected to illustrate each theme.

In this study, ethical standards were established for conducting research involving human respondents. Permission was obtained from the institution, and all respondents were informed of the procedures and purpose of this study. They were assured that their participation was voluntary. No personal identifiable information was included to protect the respondents' privacy and confidentiality.

RESULTS AND DISCUSSIONS

I. How frequently do structural engineering students express mathematics self-efficacy and mathematics anxiety?

This section presents the frequently expressed indicators of mathematics self-efficacy and anxiety among respondents. The table below illustrates respondents' self-efficacy in Mathematics. Mathematics self-efficacy refers to an individual's belief in their ability to perform and successfully complete tasks in specific situations. It involves a student's confidence in their ability to understand and excel at mathematical tasks. This belief in one's capabilities significantly shapes academic performance, motivation, and resilience in the face of challenges.

Table 1 Respondents' Mathematics Self-Efficacy

Indicators (Mathematics Self-Efficacy)	Mean	SD	Interpretation
1 I feel confident enough to ask questions in my mathematics class.	3.39	0.92	Sometimes
2 I believe I can do well on a mathematics test.	3.37	0.98	Sometimes
3 I believe I can complete all of the assignments in a mathematics course.	3.86	1.04	Usually
4 I believe I am the kind of person who is good at mathematics.	3.24	1.05	Sometimes
5 I believe I will be able to use mathematics in my future career when need.	4.07	1.11	Often
6 I believe I can understand the content in a mathematics course.	3.78	0.94	Often

7 I believe I can get an "A" when I am in a mathematics course.	3.26	1.01	Sometimes
8 I believe I can learn well in a mathematics course.	3.77	0.92	Often
9 I feel confident when taking a mathematics test.	3.50	1.04	Often
10 I believe I am the type of person who can do mathematics.	3.54	0.99	Often
11 I feel that I will be able to do well in future mathematics courses.	3.62	0.95	Often
12 I believe I can do the mathematics in a mathematics course.	3.64	0.94	Often
13 I feel confident when using mathematics outside of school.	3.45	1.00	Often
14 I believe I can think like a mathematician	2.99	1.11	Sometimes

Legend: 1"Never", 2 "Seldom", 3 "Sometimes", 4 "Often", 5 "Usually"

Based on the data above, the findings indicate that respondents often expressed confidence in several mathematics-related competencies, particularly those associated with the practical application of mathematics, learning mathematical concepts, and completing academic tasks. Conversely, confidence was expressed sometimes for indicators related to mathematical identity, classroom participation, and achieving high examination performance.

Among the indicators, the statement "I believe I will be able to use mathematics in my future career when needed" obtained the highest mean (M = 4.07, SD = 1.11). In contrast, the indicator "I believe I can think like a mathematician" (M = 2.99, SD = 1.11) has the lowest mean.

These findings suggest that respondents frequently perceived themselves as capable of understanding and applying mathematics, particularly when they recognized its relevance to their future profession. As structural engineering relies heavily on mathematical reasoning for structural analysis, mechanics, and design, students may naturally associate mathematical competence with future professional success, thereby reinforcing their confidence in learning and applying mathematical concepts. The responses suggest that although respondents frequently believed they could learn and apply mathematics, they were comparatively less confident when evaluating their mathematical identity, participating in classroom discussions, or performing in formal assessment situations.

This distinction highlights the context-specific nature of mathematics self-efficacy. According to Bandura (1997), efficacy beliefs are not fixed personality traits but vary depending on the task and the learning environment.

In a deeper analysis of interview data, structural engineering students consistently associated understanding, clarity of instruction, and task familiarity with greater confidence in their abilities. As one participant shared:

"… when I really understand the discussion that our instructor discusses that will be the time I'll be confident na masasagutan ko yong (I can answer that) math problems. Second, I'm good at analyze a problem or equation easily". (Respondent 6)

Another respondent explained that comprehension directly boosts confidence during assessments:

"The qualities that I've so far was I understand easily the topic and a little bit confidence in every recitation that we have in class to possess that confident in you must…" (Respondent 2)

These insights align with Bandura's (1997) assertion that mastery experiences—patterns of successful understanding or problem-solving—significantly enhance self-efficacy beliefs.

However, some areas of self-efficacy appeared less robust. Indicators such as confidence in asking questions, feeling confident during tests, or identifying oneself as "good at mathematics" were mostly answered as "Sometimes". This implies that though they believe that they have the ability to complete tasks, they remain

less confident in evaluative or self-perception-related situations. These findings align with Bandura's (1997) concept of domain-specific self-efficacy, wherein individuals may exhibit confidence in certain tasks but not necessarily in performance-based or identity-related situations.

Yet, the interviews reveal a more nuanced picture. Many students described positive feelings when asking questions in class, emphasizing its role in building confidence:

"It can boost our confidence when asking and it help ourself to be not shy and… also it can help out confidence in public when talking or answering questions". (Respondent 3)

"It will enhance my self-esteem, and it will make me feel ease when asking questions…". (Respondent 4)

"When I ask questions, I feel like I really understand the topic and yes it can contribute to my confidence." (Respondent 10)

These responses reveal that respondents value questioning as an empowering experience, suggesting that efficacy depends on context and that self-efficacy is stronger when students feel they have a supportive learning environment.

Furthermore, the table below presents the distribution of respondents' anxiety levels in mathematics. Mathematics anxiety is tension and apprehension that interferes with mathematics performance ability, the manipulation of numbers, and the solving of mathematical problems in a wide variety of ordinary life and academic situations.

Table 2 Respondents' Mathematics Anxiety

Indicators (Mathematics Anxiety)	Mode	SD	Interpretation
15 I get tense when I prepare for a mathematics test.	3.44	1.09	Often
16 I get nervous when I have to use mathematics outside of school.	3.24	1.16	Sometimes
17 I worry that I will not be able to use mathematics in my future career when needed.	2.87	1.14	Sometimes
18 I worry that I will not be able to get a good grade in my mathematics course.	3.26	1.33	Sometimes
19 I worry that I will not be able to do well on mathematics tests.	3.31	1.23	Sometimes
20 I feel stressed when listening to mathematics instructors in class.	2.91	1.21	Sometimes
21 I get nervous when asking questions in class.	3.04	1.11	Sometimes
22 Working on mathematics homework is stressful for me.	3.01	1.14	Sometimes
23 I worry that I do not know enough mathematics to do well in future mathematics courses.	3.15	1.16	Sometimes
24I worry that I will not be able to complete every assignment in a mathematics course	3.01	1.20	Sometimes
25 I worry I will not be able to understand mathematics.	2.99	1.08	Sometimes
26 I worry that I will not be able to get an "A" in my mathematics course.	3.12	1.04	Sometimes
27 I worry that I will not be able to learn well in my mathematics course.	3.03	1.07	Sometimes
28 I get nervous when taking a mathematics test.	3.20	1.31	Sometimes
29 I am afraid to give an incorrect answer during my mathematics class.	3.30	1.31	Sometimes

Legend: 1"Never", 2 "Seldom", 3 "Sometimes", 4 "Often", 5 "Usually"

The data reveal that respondents "sometimes" to "often" experience mathematics anxiety in indicators, which suggests that they moderately have anxiety in mathematics. Mathematics anxiety was expressed most frequently in contexts involving examinations and academic evaluation, whereas concerns related to the future application of mathematics in engineering were expressed less frequently.

Among the indicators, "I get tense when I prepare for a mathematics test" obtained the highest mean (M = 3.44, SD = 1.09), indicating that respondents often experienced anxiety during examination preparation. Conversely, the least frequently expressed indicator was "I worry that I will not be able to use mathematics in my future career when needed" (M = 2.87, SD = 1.14).

These findings suggest that mathematics anxiety among structural engineering students is primarily associated with situations in which their mathematical competence is evaluated through examinations, classroom participation, and academic performance. These findings also indicate that respondents were relatively less concerned about the long-term application of mathematics in their future engineering careers and more concerned about immediate academic demands, particularly those involving assessment and performance expectations.

From a neurocognitive perspective, mathematics anxiety may interfere with mathematical performance by consuming working-memory resources that are essential for reasoning and problem solving. According to Ashcraft and Krause (2007), anxious thoughts compete with cognitive processes required to manipulate numerical information, reducing learners' capacity to solve mathematical problems effectively.

The indicator on anxiety about not achieving high grades and not learning well in their mathematics courses suggests that students' emotional responses to mathematics are shaped by academic performance pressure. This is, in fact, consistent with the previous study of Ramirez et al. (2018), which indicates that fear of failure and high academic expectations intensify anxiety levels.

During the interview, respondents described emotional challenges when facing assessments or situations where they were not prepared:

*"*May be being very nervous and very tense and feeling like risks I can't answer questions, and getting wrong answer." (Respondent 3)

Performance pressure was also repeatedly mentioned:

"Fear and feeling pressured…. Majority of the aim for pass grades and not for high grades." (Respondent 7)

"I felt bad when I get low score because I know that I did my best during math test but I don't have choice because that's the only ability I give in math test." (Respondent 5)

"There are times I felt bad when I get low score in our quizzes/exams." (Respondent 9)

These narratives above confirm that students experience anxiety when they are being evaluated during tests, quizzes, grades, and even expectations from instructors. This aligns with the research, which shows that the test-related anxiety is one of the most dominant forms of mathematics anxiety among college learners (Ashcraft & Krause, 2007; Ramirez et al., 2018).

Moreover, students also recognized anxiety coming from fear of being judged or committing mistakes during class interactions:

"I feel nervous when I did not listen to the instructor but the emotion, I experience during math class is normal right now…" (Respondent 10)

Although the quantitative data point to moderate anxiety, the qualitative data reveal that for many structural engineering students, mathematics anxiety is experienced as a mix of nervousness, pressure, disappointment, and fear of failure. Their reflections illustrate the everyday emotional burdens students carry in mathematics-related tasks, particularly in formal assessment environments.

II. Are mathematics self-efficacy and mathematics anxiety significantly related to students' Mathematics 111 performance?

Table 3 Relationship of Math 111 Grade to Mathematics Self-Efficacy and Anxiety

Relationship		Correlation coefficient (r_{rho})	*p*-value	Remark
Math 111 Grade	Mathematics Self-Efficacy	-.197	.050*	Significant
	Mathematics Anxiety	.186	.064	Not Significant

Legend: *means significant at 0.05 level of significance

Table 3 presents the correlation between the respondents' Math 111 grade and their levels of mathematics self-efficacy and mathematics anxiety. The data above reveal a significant negative relationship between Math 111 grade and mathematics self-efficacy (rρ = –.197, p = .050). In the Philippine grading system, a lower numerical grade indicates better performance, so the expected negative correlation is theoretically sound. As students' mathematics self-efficacy increases, their Math 111 grades tend to improve. This finding aligns with Bandura's self-efficacy theory, which posits that individuals who believe in their capabilities are more persistent, confident, and effective when performing academic tasks.

This finding supports Bandura's (1997) Social Cognitive Theory, which posits that individuals' beliefs in their capabilities influence their academic engagement, persistence, and performance. Students with stronger mathematics self-efficacy are more likely to approach challenging mathematical tasks with confidence, persist despite difficulties, and employ effective problem-solving strategies. In engineering education, where mathematical reasoning is fundamental to subjects such as structural analysis, mechanics, and design, confidence in one's mathematical ability may encourage sustained engagement with complex quantitative tasks, thereby contributing to improved academic performance.

In contrast, the correlation between mathematics anxiety and Math 111 grade was not statistically significant (rρ = .186, p = .064). Although the coefficient suggests a moderate positive tendency—where higher anxiety may be associated with slightly poorer grades—the relationship is not strong enough to conclude that anxiety meaningfully affects academic performance for this group.

This implies that despite experiencing tension, nervousness, or fear related to mathematics, many students were still able to perform adequately in Math 111. Thus, while anxiety is emotionally impactful, it did not significantly hinder Math 111 performance among the respondents.

CONCLUSIONS

The study aimed to examine the mathematics self-efficacy and anxiety of 2nd and 3rd year structural engineering students in a private higher education institution in Marawi City during the first and second trimesters of the academic year 2023-2024. The study emphasizes that students' belief about their abilities significantly impacts their academic performance and emotional well-being.

The findings revealed that respondents frequently expressed confidence in mathematics, particularly regarding its usefulness in their future engineering careers, their ability to complete mathematics-related tasks, and their understanding of mathematical concepts. However, confidence was expressed less frequently in situations involving mathematical identity, classroom participation, and high-stakes assessments.

With respect to mathematics anxiety, respondents most frequently reported feelings of tension during mathematics test preparation and concerns related to examinations, grades, and classroom evaluation. In contrast, anxiety about using mathematics in their future careers was expressed less frequently, suggesting that students generally recognized the importance of mathematics for their profession while experiencing apprehension primarily in academic evaluative contexts.

The qualitative findings further demonstrated that mathematics self-efficacy developed through conceptual understanding, repeated practice, and successful learning experiences, whereas mathematics anxiety was largely associated with fear of failure, classroom evaluation, and examination pressure.

Furthermore, the study found a statistically significant, albeit weak, relationship between mathematics self-efficacy and Mathematics 111 performance, indicating that students who more frequently expressed confidence in their mathematical abilities tended to achieve better academic performance. In contrast, mathematics anxiety was not significantly related to Mathematics 111 performance, suggesting that although respondents experienced anxiety in mathematics-related situations, these feelings did not necessarily translate into poorer academic outcomes.

Further research and exploration of tailored approaches to address these specific concerns may offer valuable insights for educators and educational psychologists.

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