# Structured Approach in Critical Thinking Skills and Mathematics Anxiety of Grade 12 Stem Students of Isulan National High School

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## ABSTRACT

This study investigated the impact of a structured teaching approach on reducing mathematics anxiety and improving critical thinking skills among Grade 12 STEM students at Isulan National High School during their Basic Calculus curriculum. Utilizing a pre-experimental one-group pretest-posttest design, 30 students identified with high levels of math anxiety participated in a focused 20-day intervention, consisting of daily two-hour sessions that emphasized real-world applications of calculus, guided discussions, and scaffolded problem-solving strategies. Assessment tools, including the Suinn-Winston Mathematics Anxiety Scale and a validated critical thinking test, were administered before and after the intervention. Statistical analysis revealed significant reductions in mathematics anxiety and notable gains in critical thinking, demonstrating the effectiveness of structured teaching methods. These findings highlight the value of incorporating structured instructional strategies to address both the emotional and cognitive demands of advanced mathematics, fostering greater student confidence, engagement, and higher-order thinking.

## INTRODUCTION

Education is a cornerstone for fostering skills essential for personal and societal development, particularly in an era driven by innovation and technology. Among the most critical skills in this context is critical thinking, which empowers individuals to evaluate, analyze, and synthesize information effectively. Critical thinking is especially crucial for students in the Science, Technology, Engineering, and Mathematics (STEM) strand, as their curriculum demands logical reasoning, problem-solving, and analytical skills to address complex challenges (Paul & Elder, 2019).

However, mathematics anxiety presents a significant impediment to student learning and performance in STEM-related fields. An individual has been experiencing mathematics anxiety when they feel uneasy and experience some physiological reactivity when interacting with mathematics, as explained by Luttenberger et al. (2018). Additionally, they stated that individuals experienced this type of apprehension when they were tasked with resolving mathematical problems, manipulating numbers, or simply engaging in a mathematical situation that necessitated their undivided attention. According to O'Leary et al. (2017), this hinders an individual's ability to manage numbers and confront difficult mathematical scenarios.

The senior high school group exhibited a more pronounced negative correlation with mathematics apprehension than other grade levels, as indicated by the literature review conducted by Zhang et al. (2019). The same findings were reported in the study conducted by Mohamed and Tarmizi (2010), which revealed that senior students were more susceptible to mathematics anxiety than their junior counterparts.

In Philippine education, intervention materials are highly regarded as tools for remediating learners' low academic performance. In its ongoing effort to improve the quality of education in the nation, the Department of Education (DepEd) consistently introduces innovations in various fields of Science and Mathematics teaching.

Accordingly, the study of Domondon et al. (2023) on the analysis of student's difficulties in learning calculus revealed that STEM students struggled to solve Basic Calculus. Several challenges include limited and difficulty in understanding the concepts, improper application of knowledge, and complex formulas and procedures.

In response to these challenges, there is a growing interest in exploring evidence-based strategies to address mathematics anxiety and improve student performance. Research suggests that a structured teaching approach can mitigate mathematics anxiety and promote critical thinking skills (Schunk & Zimmerman, 2014). Structured approaches provide students with systematic, step-by-step methods for understanding and solving mathematical problems, fostering a supportive learning environment that reduces anxiety and builds confidence. Techniques such as guided inquiry, collaborative learning, and scaffolded instruction have been found to enhance students' cognitive engagement and performance (Vygotsky, 1978). However, despite these promising findings, there is limited research that specifically explores the combined effects of structured approaches on both critical thinking skills and mathematics anxiety, particularly among STEM students in the Philippine context.

This study aims to address this research gap by investigating the relationship between structured approaches, critical thinking skills, and mathematics anxiety among Grade 12 STEM students of Isulan National High School.

# METHODOLOGY

## Research Design

This study employed a quantitative research method using a pre-experimental research design, specifically the one-group pretest-posttest design, to evaluate the effects of a structured teaching approach on critical thinking skills and mathematics anxiety among Grade 12 STEM students. The one-group pretest-posttest design is commonly used to assess the outcomes of interventions by comparing measurements taken before and after the intervention within the same group of participants (Creswell & Creswell, 2018).

This design allows researchers to assess changes by comparing the results of measurements taken before and after the intervention. According to Campbell and Stanley (1963), this design is suitable for examining the immediate effects of a treatment when a control group is not feasible.

This design is appropriate for classroom-based research where all participants receive the same intervention due to logistical or ethical constraints (Fraenkel & Wallen, 2006). It provides a practical approach for determining the immediate impact of the integrated structured approach within the given educational setting.

The experimentation began in the third quarter of the school year in January 2025 and ended on the first week of February 2025.

## Research Locale

This study was conducted at Isulan National High School (INHS). The school is in the municipality of Isulan in the province of Sultan Kudarat. It is a public secondary high school that caters Junior and Senior high school curricula from Grade 7 to Grade 12. There were 17 Math teachers in Junior High School and 5 Mathematics teachers in Senior High School assigned to teach in different strands. While many teachers have attended seminar workshops on teaching methodologies, the demands of their workload and limited time for planning often make it challenging to implement new strategies in the classroom. Moreover, one of the strands offered by Isulan National High School in the senior high school curriculum is the STEM strand and the researcher was assigned to teach in STEM curriculum.

In previous academic years, the School-Based Management (SBM) report from the mathematics department head highlighted consistently low academic performance in the specific areas of Basic Calculus. This decline was attributed to the disruptive impact of the pandemic. Notably, some grade 12 STEM students, despite demonstrating strong academic abilities, experienced failures in the subject. Consequently, the selected locale

for the research was appropriate to ensure the study's relevance and the convenience of the assigned teacher, who was also the researcher.

**Research Participants**

The study involved 30 Grade 12 STEM students from Isulan National High School who had been identified as experiencing mathematics anxiety during their Grade 11 year. These students were selected based on their performance in mathematics and their self-reported challenges with math-related tasks, particularly those involving calculus.

The respondents participated in a twenty-day intervention aimed at enhancing their critical thinking skills and reducing mathematics anxiety. Focused on basic calculus topics for the third quarter, the intervention involved daily two-hour sessions. These students were selected based on their high mathematics anxiety records from the Senior High School Guidance Counselor, as well as their prior difficulties with mathematics, making them well-suited for the study's goal of addressing math anxiety and fostering critical thinking in mathematics.

**Research Instrument**

This study employed a combination of surveys and pre-and post-tests to gather data on mathematics anxiety levels and critical thinking skills among Grade 12 STEM students at Isulan National High School, specifically in the context of Basic Calculus.

A researcher-made 40-item test questionnaire was validated by three different experts in the field of Mathematics teaching and Education Program Supervisor in Mathematics of Sultan Kudarat Division, the Senior High School Mathematics Subject Head of Isulan National High School, Special Science Teacher 1, and Mathematics Master teacher I of Isulan National High School. The test questionnaire was subjected to pilot testing, also used for the pretest and post-test. Moreover, in determining the validity of the test questionnaire, the content and face validity of the test item from the expert was first conducted, followed by an item analysis after conducting the pilot testing. Results from the experts' content validity of test questions revealed that out of 60 questions, 50 items have a content validity ratio of 0.75 and above, indicating that the questions are considered essential. Further, 40 questions out of 50 items passed the item analysis test and formed part of the final test questions.

Meanwhile, Cronbach alpha was used to determine the internal reliability of the test questionnaire, and the obtained alpha value was 0.88, indicating that the test questionnaire was good to use as a classroom-level assessment tool.

Furthermore, to evaluate the student's level of critical thinking skills, the study adopted the description and formula DEPED SF9 Learner's Progress Report Card grade rating scale.

Lastly, to measure the students' anxiety levels related to Basic Calculus, the study utilized the revised standardized survey known as the Mathematics Anxiety Rating Scale (MARS). Suinn and Winston (2003) created a 30-item scale that was derived from the MARS in order to create a valid, condensed version that could be administered in a variety of contexts. This survey was administered both before and after the intervention, which involved the integration of a structured approach, to assess any changes in anxiety levels.

**Data Gathering Procedure**

The researcher developed a structured intervention to reduce mathematics anxiety and increase critical thinking in Grade 12 STEM students at Isulan National High School. Four math specialists created and verified instructional activities and assessment tools, including a pretest and post-test. A pilot test with 30 students was followed by item analysis to establish item validity and reliability using difficulty and discrimination indices.

After receiving clearance from the Graduate School Dean, Schools Division Superintendent, and School Principal, the intervention was deployed during Basic Calculus instruction for 20 days. For baseline data, students took the Suinn-Winston Mathematics Anxiety Scale and a problem-solving pretest (Suinn & Winston,

2003). The intervention included explicit instruction, scaffolding, incremental responsibility release, and confidence-building tactics in daily lessons.

Post-tests of the same instruments assessed mathematics anxiety and critical thinking skills after the intervention. To assess the importance of pretest-posttest changes, the data were analysed statistically. The findings showed that the organised method reduced mathematics anxiety and improved calculus problem-solving in senior high school students.

### Ethical Considerations

In conducting this study, the researcher ensured that ethical principles were strictly followed to protect the rights, well-being, and confidentiality of the participants. Before the study commenced, informed consent was obtained from both the students and their parents or guardians after they were provided with a clear explanation of the research objectives, procedures, potential benefits, and any associated risks. Participation was entirely voluntary, and students were assured that they had the right to withdraw at any point without any academic or personal consequences.

## RESULTS AND DISCUSSION

### Level of Mathematics Anxiety

Table 1 presents the level of Mathematics anxiety of Grade 12 STEM students before and after the integration of structured approach in learning Basic Calculus.

| Testing | Mean Score | SD | Description |
|---|---|---|---|
| Pre-test | 117.87 | 0.55 | Moderately Anxious |
| Post-test | 80.47 | 0.45 | Somewhat Anxious |

The results revealed that, prior to the intervention, Grade 12 STEM students exhibited a substantial level of mathematics anxiety (M=117.87, SD=0.55) that falls within the moderately anxious category, indicating that majority of students experience noticeable anxiety in math-related situations, which may affect their confidence and performance. Meanwhile, after implementing the structured approach, the Grade 12 STEM students' mean anxiety score decreased substantially (M=80.47, SD=0.45), which falls under the somewhat anxious category, indicating that students feel slightly uneasy about math-related situations, but it does not significantly impact the performance. The result implies that the structured approach appears to have effectively decreased mathematics anxiety, with the majority of students experiencing a noticeable reduction in their anxiety levels.

This indicates that a majority of students experienced noticeable anxiety in math-related situations, potentially affecting their confidence and performance. This aligns with previous research suggesting that high levels of math anxiety can impair working memory and critical thinking efficiency (Ashcraft & Ridley, 2005).

This finding is supported by Hembree (1990), who found that structured and scaffolded instruction reduces mathematics anxiety by increasing student confidence and comprehension.

### Level of Critical Thinking Skills

Table 2 shows the level of critical thinking skills of Grade 12 STEM students before and after integrating the structured approach in learning Basic Calculus.

| Testing | Mean Score | SD | MPS | Description |
|---|---|---|---|---|
| Pre-test | 17.67 | 3.69 | 77.67 | Fairly Satisfactory |
| Post-test | 26.83 | 3.83 | 86.83 | Very Satisfactory |

Based on the result, during the pre-test the students obtained a mean score of 17.67 (SD=3.69) and equivalent to an MPS of 77.67 which translates to a fairly satisfactory level of critical thinking skills in the topics of Basic Calculus. This means that, while the students had a reasonable understanding of the concepts, there was still room for improvement of their critical thinking. On the other hand, during the post-test and after the integration of structured approach, the students obtained a mean score of 26.83 (SD=3.83) or equivalent to an MPS of 86.83 and translate to a very satisfactory level of critical thinking skills of the concepts of Basic Calculus. Furthermore, the result implies that the increase in mean score from 17.67 to 26.83 and MPS from 77.67 to 86.83 indicates a significant enhancement in the students' ability to engage in critical thinking of the concepts of Basic Calculus through structured approach.

This improvement aligns with existing studies that emphasize how structured teaching methods—such as guided instruction, problem-based learning, and scaffolding—enhance critical thinking by encouraging students to approach problems systematically (Brookfield, 2017).

Furthermore, these findings support the argument that structured learning environments foster deeper cognitive engagement, allowing students to develop analytical skills essential for higher-level mathematics (Vygotsky, 1978; Rosenshine, 2015). The results demonstrate that providing structured guidance, clear learning objectives, and reflective activities enables students to process and apply mathematical concepts more effectively, thereby strengthening their critical thinking skills.

**Paired Sample T-test**

Table 3 reveals the conducted paired sample t-test to determine the significant difference between the mathematics anxiety level of Grade 12 STEM students before and after integrating the structure approach in learning Basic Calculus.

| Source | N | Mean | SD | df | p-value |
|---|---|---|---|---|---|
| Pre-test | 30 | 117.87 | 0.55 | 29 | 0.00 |
| Post-test | 30 | 80.47 | 0.45 | | |
| Mean Difference | | **37.40** | | | |

*Significant at 0.05 level of significance

Based on the analyzed result, there is a significant difference between the mathematics anxiety level of the students before (M=117.87, SD=0.55) and after (M=80.47, SD=0.45) integrating the structured approach, t (29) =43.36, $p<0.05$. This implies that the mathematics anxiety level of the students decrease significantly after integrating the structured approach as reflected on the mean score of 117.87 in the pretest to 80.47 in the post-test with a mean difference of 37.40 points. The result further implies that structured approach in learning is effective to alleviate the mathematics anxiety of Grade 12 STEM students.

The result adheres to the study of Ramirez, G. et al (2013) on math anxiety. This study highlights the role of structured learning in reducing math anxiety by providing a supportive environment that strengthens students' mathematical skills and reduces fear of failure.

Moreover, Maloney and Beilock (2012) argue that structured teaching strategies, such as step-by-step instruction and guided practice, can significantly reduce math anxiety by making mathematical concepts more approachable.

**Wilcoxon Signed Rank Test**

Table 4 reveals the conducted wilcoxon signed rank test to determine the significant difference between the pre-test and post-test of critical thinking scores of the students.

| c | N | Median | SD | p-value |
|---|---|---|---|---|
| Pre-test | 30 | 17.70 | 3.69 | |

| | | | | |
|---|---|---|---|---|
| Post-test | 30 | 27.50 | 3.83 | 0.00 |
| Median Difference | | **9.80** | | |

*Significant at 0.05 level of significance

The conducted Wilcoxon signed rank test revealed a significant difference between the pre-test and post-test critical thinking scores of the students indicating that the post-test scores (Mdn=27.50) was significantly higher than their pre-test scores (Mdn=17.70), $p<0.05$. This implies that the critical thinking skills of the students increase significantly after integrating the structured approach. The result further implies that the structured approach to learning Basic Calculus significantly enhanced the Grade 12 STEM students' critical thinking skills, with majority of students showing a strong improvement in their performance.

The findings align with Facione, (2011) as the structured teaching approach provided a clear framework that fostered deeper reasoning and problem-solving abilities. He emphasizes that structured and scaffolded learning approaches enhance students' ability to analyze, evaluate, and apply information effectively, leading to significant improvements in critical thinking skills.

Similarly, Paul and Elder (2019) argued that structured approaches, including step-by-step problem-solving and reflective exercises, significantly contribute to students' ability to think critically and independently.

**Spearman Rank Correlation Analysis**

Table 5 reveals the conducted spearman rho correlations to evaluate the relationship between the mean gained scores of critical thinking skills and the math anxiety of Grade 12 STEM students.

| Variables | $\rho$ coefficient | p-value | Description | Interpretation | Decision |
|---|---|---|---|---|---|
| Critical Thinking Scores*<br><br>Math Anxiety | -0.02 | 0.94 | Very weak negative correlation | Not Significant | Failed to reject $H_0$ |

Based on the analyzed results, no significant negative correlation was found between the two variables, [$\rho(28) = -0.02$, $p = 0.94$]. This means that mathematics anxiety did not significantly influence the increase in critical thinking skills among Grade 12 STEM students, which further implies that other factors might have contributed to the improvement of the students' critical thinking skills.

This outcome aligns with previous research indicating that the relationship between mathematics anxiety and cognitive performance is complex. For instance, a study by Mammarella et al. (2014) found that while mathematics anxiety negatively impacts performance on mathematical tasks, its influence on broader cognitive functions, such as critical thinking, is not straightforward.

Additionally, the study of Morsayni et al. (2014) highlighted that other factor, such as instructional methods and individual student characteristics, play a significant role in developing critical thinking skills independent of anxiety levels.

# CONCLUSION

According to this study, structured instruction reduces mathematical anxiety and improves critical thinking in Grade 12 STEM students learning Basic Calculus. The large reduction in mathematics anxiety implies that specific instruction, scaffolding, gradual responsibility release, and reinforcement create a supportive environment that reduces stress and enhances mathematical confidence. A significant improvement in critical thinking skills shows that the structured method improves problem-solving and analysis.

Moreover, the Spearman's rho correlation analysis revealed no significant relationship between the reduction in mathematics anxiety and the improvement in critical thinking skills. This suggests that while both areas showed positive growth, the decrease in anxiety did not directly influence the enhancement of critical thinking, implying that other factors, such as the quality of instructional delivery and student engagement, may contribute to the development of critical thinking skills.

Overall, the study confirms that a structured teaching approach is a powerful tool for addressing both the emotional and cognitive challenges in mathematics, providing an effective framework for improving student learning outcomes.

**Conflict of Interests**

The authors declared no conflict of interest.

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