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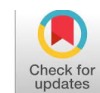
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Effectiveness of STEM-Based Learning in Reducing Students' Math Anxiety

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ABSTRACT

Mathematics is one of the core subjects in junior high school that plays a crucial role in improving students' academic performance; however, it often causes anxiety, which leads to decreased motivation and learning outcomes. This study aims to examine the effectiveness of STEM-based learning in reducing students' math anxiety. The method used in this study is a quantitative approach with a quasi-experimental design utilizing a non-equivalent control group. The sample consisted of two classes with a total of 58 students: the experimental class had 29 students, and the control class also had 29 students. STEM-based learning was implemented through a project to build miniature bridges, designed to help students understand the concept of similarity by relating it to real-life situations. Data collection utilized a mathematics anxiety questionnaire with a Likert scale administered before and after the intervention. Data analysis was performed using the N-gain test and the t-test (independent samples t-test). The results of the study indicate that STEM-based learning was able to significantly reduce students' levels of mathematical anxiety, as evidenced by the N-gain score in the experimental class of 0.78, which falls into the high category. Meanwhile, the t-test results showed a significance value of 0.000, < 0.05, indicating a significant difference between the experimental and control classes. The implications of this study are as follows: STEM-based learning can serve as an innovative alternative teaching strategy to create a more interactive learning environment, boost students' self-confidence, and provide a more comfortable learning setting so that students do not feel stressed or anxious when learning mathematics.



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Introduction

Mathematics is one of the core subjects in junior high school that plays a crucial role in students' academic development. At this level, it serves as the primary foundation for developing critical thinking, creativity, logical mathematical reasoning, and problem-solving skills—all of which are essential for a deeper understanding of mathematics (Natsir et al., 2023). However, despite the importance of mathematics education, many junior high school students face obstacles in their learning process. Many students struggle and even feel afraid when confronted with mathematics lessons. One such obstacle, mathematical anxiety, is a common phenomenon at this level, where students feel afraid or anxious when facing mathematics lessons or problems.

Mathematical anxiety is a feeling of discomfort or fear experienced by an individual when facing mathematical problems perceived as difficult, which triggers various symptoms (Reni Nuraeni & Munandar, 2023). Students experiencing math anxiety typically struggle to concentrate, lose motivation to learn, and avoid situations involving mathematics. In mathematics education, math anxiety has a negative impact on students. This can disrupt their concentration and learning outcomes, leading to low motivation and feelings of frustration (Nasution et al., 2025). Mathematics-related anxiety can be identified through several signs, such as fear when faced with math problems, tension during the learning process, a lack of confidence in solving problems, worry about making mistakes when answering questions, and a tendency to avoid activities related to mathematics. This situation makes students less active in the learning process, makes it difficult for them to concentrate, and causes them to feel insecure when expressing opinions or solving math problems. If this situation persists, it can lead to low student participation and declining mathematics learning outcomes.

Several previous studies have examined the phenomenon of math anxiety among students. For instance, a study conducted by Aisyah & Galih Adirakasiwi (2025) found that math anxiety among junior high school students arises from a lack of understanding of basic concepts and the pressure to solve problems quickly. In line with this, Fadhilah & Syarifatul (2024) stated that students with high levels of math anxiety tend to achieve lower learning outcomes and are less active in classroom learning activities. Thus, this condition demonstrates that math anxiety affects not only students' emotional aspects but also their cognitive abilities.

Social and cultural environmental factors also influence students' levels of math anxiety, in addition to internal factors. In Indonesia, many students still view mathematics as a difficult and intimidating subject, stemming from societal perceptions or past learning experiences that were not enjoyable. Teachers and parents, in this context, often unconsciously perpetuate these views, leading to math anxiety and a lack of confidence when learning mathematics. This is supported by research conducted by Putri et al. (2021), which found that students feel pressured and become increasingly reluctant to understand and develop mathematical concepts creatively due to a learning environment that tends to be authoritarian and monotonous. These conditions can result in low student motivation and achievement, as well as increased levels of mathematical anxiety.

Various other studies also confirm that students' levels of math anxiety are influenced by negative perceptions of mathematics, poor learning experiences, a lack of teacher support, and social pressure from the surrounding environment. Sha'adah et al. (2024) found that students experience difficulty in solving math problems overall due to fear and tension when facing mathematics, making it hard for them to develop their ideas. Additionally, Dinawati & Siswono (2021) found that the higher the level of students' math anxiety, the lower their creative thinking skills in solving math problems. This demonstrates that math anxiety can be a serious barrier to improving students' academic achievement.

Various efforts have been made to reduce students' math anxiety, one of which is through the implementation of various innovative learning models, such as project-based learning (Andini Ritonga, 2023), the constructivist-based discovery learning model (Umayah, 2019), the CPA (concrete-pictorial-abstract) approach (Wahyudy et al., 2019), and Problem-Based Learning (PBL) can reduce math anxiety (Setiani, 2016). Various studies indicate that these instructional models can help reduce levels of math anxiety while simultaneously improving student learning outcomes. Based on these findings, it can be concluded that selecting the appropriate instructional model plays a crucial role in mitigating students' math anxiety. One approach with these characteristics is STEM-based learning, as it connects learning to real-life contexts and actively engages students.

Based on the results of initial observations at SMPN 1 BatuLayar obtained from interviews in October 2025 with seventh-grade mathematics teachers, it was found that some students exhibited fear, hesitation, and anxiety when studying mathematics, particularly with material requiring analytical skills and creative thinking. Ms. M also noted that the most prominent math anxiety occurs among seventh-grade students because they are still adapting to more complex teaching methods and still struggle to understand foundational material.

Observations during the learning process also revealed that some students appeared passive while the teacher explained mathematical concepts. Some students also tended to hesitate to ask questions or provide answers to the teacher's inquiries. Additionally, certain students exhibited signs of low self-confidence, such as fear of coming to the front of the class, worry about giving the wrong answer, and avoiding solving math problems deemed difficult. This situation reflects the presence of high levels of math anxiety among seventh-grade students at SMPN 1 BatuLayar. This condition indicates that learning that fails to provide active learning experiences can result in low student engagement during the learning process. Therefore, a learning approach is needed that can create an active, enjoyable learning environment relevant to real-life contexts. One approach considered capable of addressing this issue is STEM-based learning. The STEM approach integrates science, technology, engineering, and mathematics by emphasizing problem-solving activities, group collaboration, and the application of concepts in real-world and interactive situations (Syarifuddin et al., 2025).

The STEM-based learning approach is also aimed at developing critical and creative thinking skills, as well as problem-solving abilities through engaging activities relevant to real life. Through this approach, students can build self-confidence, thereby reducing anxiety regarding mathematics learning (Kusyanto et al., 2022). Additionally, STEM learning provides a more meaningful learning experience because students are directly involved in exploration and problem-solving activities (Yusuf et al., 2022). This active engagement encourages students to become more confident, active in the learning process, and less likely to feel afraid when facing mathematics, thereby reducing mathematical anxiety.

STEM-based learning is considered effective in reducing math anxiety because learning activities do not solely emphasize achieving results but also provide students with opportunities to explore, discuss, and solve problems collaboratively. Through this process, students can gradually grasp mathematical concepts, thereby reducing their fear of mathematics. Additionally, learning that is connected to real-life situations helps students realize that mathematics has practical applications and is not merely abstract. This fosters greater confidence and makes students feel more comfortable during mathematics lessons.

Although numerous studies have demonstrated that STEM-based learning approaches can enhance learning outcomes, critical thinking skills, creativity, and problem-solving abilities in students, research specifically examining the impact of STEM on students' math anxiety remains limited, particularly at the junior high school level. Most previous studies have focused

on students' cognitive aspects, while affective aspects such as math anxiety have not been thoroughly explored. In fact, math anxiety is one of the factors that can influence students' motivation, self-confidence, and success in learning mathematics. Therefore, this study is important to examine the effectiveness of STEM-based learning in reducing middle school students' math anxiety levels while strengthening research on the role of affective aspects.

Method

Type and Participants

This study employs a quantitative approach using a *quasi-experimental* design. A *quasi-experimental design* is a research method aimed at determining the effect of a treatment on specific conditions without exercising full control over the research variables (Wahjusaputri & Purwanto, 2022). The study population comprised all 86 seventh-grade students at SMPN 1 BatuLayar and was conducted during the second semester of the 2025/2026 academic year. The sample was selected purposively, considering the equivalence of students' initial abilities and levels of math anxiety based on the results of the initial observation, namely Grade 7B as the experimental group and Grade 7C as the control group. The experimental class implemented STEM-based learning, while conventional learning was applied in the control class. The independent variable in this study is STEM-based learning, while the dependent variable is students' levels of math anxiety. The demographic data of the study are presented in Table 1.

Table 1. Demographic Data of The Study

| Variable | Category | Frequency | Percentage |
|-----------------------|----------------------------|-----------|------------|
| Total population | Grade VII A | 28 | 32,6% |
| | Grade VII B | 29 | 33,7% |
| | Class VII C | 29 | 33,7% |
| | Total | 86 | 100% |
| Research group | Experimental (kelas B) | 29 | 50% |
| | Control (kelas C) | 29 | 50% |
| Initial ability level | Equivalent initial ability | 58 | 100% |

Instruments

The instrument used in this study was a student mathematical anxiety questionnaire in the form of a closed-ended questionnaire using a *Likert* scale with four response options. The questionnaire contained 27 statements and was developed by adapting a research instrument created by Joni Pranata in 2020. This instrument was previously adapted by Joni Pranata from a mathematics anxiety questionnaire compiled by Husnul Qausarina in 2016, which had undergone an expert validation process, as evidenced by the validation sheet in the appendix of her thesis; however, it was not accompanied by statistical validity or reliability tests (Pranata, 2020). The statements of the mathematical anxiety instrument are presented in Table 2.

Table 2. Students Mathematical Anxiety Instrument

| No | Statements | No | Statements |
|-----|--|-----|--|
| 1. | When I'm in class, I understand the math material, but after a while I tend to forget it.. | 15. | I don't feel anxious when facing a math quiz. |
| 2. | I have trouble understanding the math material being taught. | 16. | I feel happy when taking a math test. |
| 3. | The teacher's explanations help me understand the math material well. | 17. | I'm confident I can solve math problems well. |
| 4. | I tend to stay quiet and don't feel confident expressing my opinions during math class. | 18. | I have trouble speaking fluently when the teacher asks questions orally. |
| 5. | The sheer volume of math material makes it hard for me to grasp it all. | 19. | My heart beats faster during a math exam compared to other subjects. |
| 6. | I'm worried because I haven't found the right study strategy to tackle math exams. | 20. | My appetite decreases before a math exam. |
| 7. | During exams, I often forget the material I've studied beforehand. | 21. | I see math as a difficult and stressful subject. |
| 8. | I'm afraid to raise my hand and answer the teacher's questions during math class. | 22. | My appetite increases when I think about an upcoming math exam. |
| 9. | I feel embarrassed to show my math test results to my friends. | 23. | I feel happy when asked to solve a problem in front of the class. |
| 10. | Math lessons often make me feel stressed. | 24. | I feel a knot in my stomach when I'm called on to solve a problem in front of the class. |
| 11. | I can concentrate when studying math in class | 25. | My hands get cold when my math work is criticized by my classmates. |
| 12. | I don't feel embarrassed to show my math test results to my friends. | 26. | I feel weak when I remember that the math exam is coming up soon. |
| 13. | In my opinion, math is abstract, so it's hard to stay focused while studying. | 27. | My face feels pale when I'm asked to do an assignment in front of the class. |
| 14. | I feel anxious when thinking about a math test. | | |

Research Design

This study employed a nonequivalent control group pretest-posttest design, in which the experimental class received instruction in the form of STEM-based learning using a project-based learning model on the topic of similarity over two sessions. Students created miniature bridge projects using popsicle sticks to understand the concept of similarity through discussion, problem-solving, project design, and contextual analysis. The STEM learning activities were carried out through five stages, namely: reflection (science), investigation (science and technology), discovery (mathematics), application (engineering and mathematics), and communication (mathematics and engineering). Meanwhile, the control class followed conventional learning conducted over two sessions. Both groups were given pre- and post-tests to measure changes in students' levels of math anxiety before and after the intervention. An overview of the research design is presented in Table 3.

Table 3. Research Design

| Group | Pre-test | Treatment | Posttest |
|-------|----------|-----------|----------|
| E | O_1 | X | O_2 |
| K | O_3 | - | O_4 |

Notes:

O_1 and O_3 : Pretest results for the experimental and control groups

O_2 and O_4 : Posttest results after the intervention was administered.

X : The intervention consisted of STEM-based learning

Analysis

The data in this study were analyzed using statistical methods with the aid of SPSS software. The analysis was conducted to determine differences in students' levels of math anxiety before and after the STEM-based instruction intervention in the experimental and control classes. The analysis stages included prerequisite tests and hypothesis testing.

Prerequisite Test and Hypothesis Test

The data analysis in this study includes prerequisite tests and hypothesis testing. The prerequisite testing phase consists of normality and homogeneity tests. The normality test was conducted using the *Shapiro–Wilk* method to determine whether the students' pretest and posttest data on math anxiety were normally distributed. The data are considered normally distributed if the *p-value* is $> \alpha$; conversely, if the *p-value* is $\leq \alpha$, the data are not normally distributed (Ningsih & Astuti, 2024). Next, the homogeneity test was performed using *Levene's* test to determine the equality of variances between the experimental and control groups. The data is considered homogeneous if the *sig value* $> \alpha$; conversely, if the *sig value* $\leq \alpha$, the variances of the two groups are not homogeneous (Astuti, 2016).

After the prerequisite tests were met, a hypothesis test was conducted using the *N-Gain* test to determine the extent of the reduction in students' math anxiety levels following instruction. The calculation was based on the difference between pretest and posttest scores normalized against the minimum ideal score. The higher the *N-Gain* value obtained, the greater the reduction in students' math anxiety. The *N-Gain* formula is shown in Equation.

$$N - Gain(G) = \frac{\text{skor pre test} - \text{skor post}}{\text{skor pre test} - \text{skor ideal}}$$

The *N-Gain* (*G*) criteria are presented in Table 4.

Table 4. *N-Gain* Level Criteria

| Average | Criteria |
|-----------------------|----------|
| $G > 0.7$ | High |
| $0.3 \leq G \leq 0.7$ | Medium |
| $0 < G < 0.3$ | Low |
| $G \leq 0$ | Failed |

This study also used a *t-test* to determine whether there was a significant difference between the mean levels of math anxiety in the experimental and control groups. The test used was an *independent samples t-test*, since the two groups were independent of each other—that is, they were not paired. The formula for the *t-test* is shown in Equation

$$t_{\text{hit}} = \frac{M_1 - M_2}{\sqrt{\frac{SS_1 + SS_2}{n_1 + n_2 - 2} \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}}$$

Where M_1, M_2 are the group means, SS_1, SS_2 are the group sums of squares, and denote n_1, n_2 the sample sizes. The hypotheses used in this study are: $H_0 : \mu_1 = \mu_2$ which means there is no significant difference between the experimental and control groups, and $H_1 : \mu_1 \neq \mu_2$ which indicates a significant difference between the two groups. Decision-making is based

on a $p\text{-value} \leq \alpha$; if the $p\text{-value}$ is $\leq \alpha$, the null hypothesis (H_0) is rejected, and if the $p\text{-value} > \alpha$, H_0 is not rejected.

Research Findings

Description of the Implementation of Instruction

The teaching and learning activities in this study were conducted at SMPN 1 BatuLayar during the second semester of the 2025/2026 academic year over four sessions, with two sessions each in the experimental and control classes, allotted 2 x 40 minutes per session. In the experimental class, STEM-based learning was implemented using a project-based learning model on the topic of similarity. The lesson began with the presentation of a contextual problem via a PowerPoint presentation on the shapes and structures of miniature bridges. Next, students were divided into 5 groups to observe the geometric shapes in the bridge framework, discuss two-dimensional figures with similar shapes, and identify relationships of similarity between figures through the stages of reflection, investigation, and discovery.

The application stage took place during the second session, where students designed and constructed miniature bridges using popsicle sticks in groups based on the concept of similarity previously learned. After the project was completed, students analyzed the similar figures in the miniatures, calculated side ratios, and presented their group discussion results in front of the class through the communication stage. The researcher acted as a facilitator guiding the students throughout the learning process. Meanwhile, the control class used conventional learning methods, including lectures, question-and-answer sessions, and problem-solving exercises, and utilized PowerPoint (PPT) presentations to deliver the material on similarity, but without the application of the STEM approach.

Pretest Results

A description of students' mathematical anxiety at the initial stage in the experimental and control classes was obtained from the pretest results. A summary of the *pretest* results is presented in Figure 1.

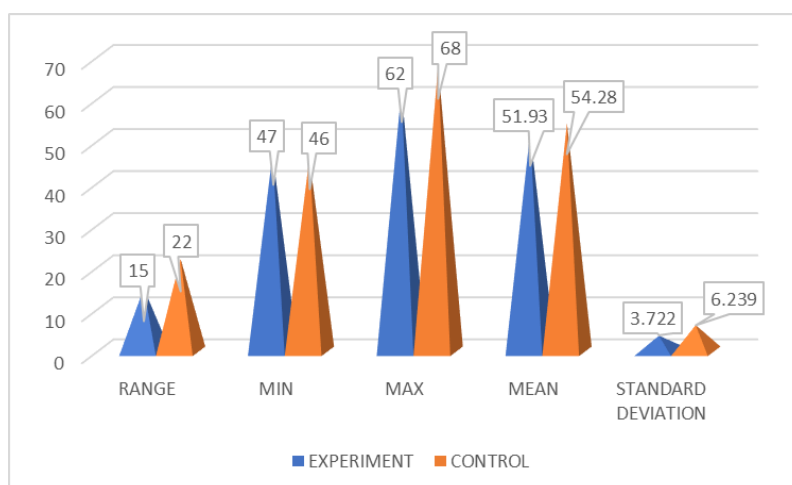


Figure 1. Full Pyramid of Descriptive Statistics For Pretest Data of the Experimental and Control Classes

Figure 1 shows that the initial ability of students in the experimental class (29 students) had a minimum score of 47, a maximum of 62, a range of 15, a mean of 51.93, and a standard

deviation of 3.722. Meanwhile, the control class (29 students) had a minimum score of 46, a maximum of 68, a range of 22, a mean of 54.28, and a standard deviation of 6.239. These data indicate that the mean *pretest* score for the control class was higher than that of the experimental class, and the data spread in the control class was greater, suggesting that the variation in students' initial abilities in the control class was more diverse compared to the experimental class.

Posttest Results

The description of students' math anxiety data in the experimental and control classes after the intervention was obtained from the results of the *posttest* that was administered. A summary of the *posttest* data is presented in Figure 2.

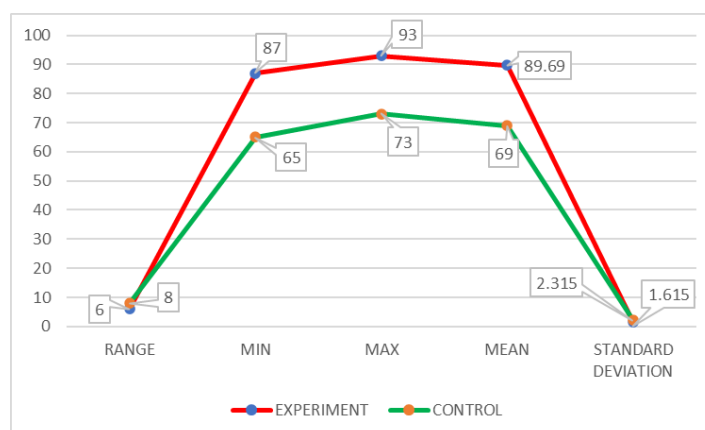


Figure 2. 2D-Line Descriptive Statistics of *Posttest* Data for the Experimental and Control Classes

Figure 2 shows the final results of students' math anxiety in the experimental and control groups. In the experimental group, the lowest score was 87 and the highest was 93, with a difference of 6 points. The mean score in this group was 89.69 with a standard deviation of 1.615. Meanwhile, in the control group, the lowest score was 65 and the highest was 73, with a range of 8. The mean score in the control group was 69 with a standard deviation of 2.315. These data indicate that the *posttest* mean for the experimental class was higher than that of the control class, and the data dispersion in the control class was greater, as evidenced by the higher standard deviation.

Prerequisite Test

Normality Test

The data normality test was conducted using the *Shapiro-Wilk test* with the assistance of the IBM SPSS software. The results of the data normality test obtained from the SPSS output are presented in Table 5.

Table 5. Results of the Normality Test

| Class | Shapiro-Wilk | |
|-------------------------------|--------------|----------|
| | Statistic | P- value |
| Eksperimental <i>Pretest</i> | 0,938 | 0,091 |
| Eksperimental <i>Posttest</i> | 0,953 | 0,220 |
| Control <i>Pretest</i> | 0,934 | 0,071 |
| Control <i>Posttest</i> | 0,962 | 0,372 |

Based on the results of the *Shapiro-Wilk* normality test in Table 5, the significance values for the pretest and posttest of the experimental class were 0.091 and 0.220, respectively, while those for the control class were 0.071 and 0.372; all of these significance values were greater than 0.05 ($sig. > 0.05$). Therefore, it can be concluded that the research data are normally distributed and meet the requirements for further analysis.

Homogeneity Test

The homogeneity test in this study was conducted using *Levene's* test with the aid of IBM SPSS software. The results of the homogeneity test based on the SPSS output are presented in Table 6.

Table 6. Homogeneity Test Results

| | <i>Levene Statistic</i> | <i>df1</i> | <i>df2</i> | <i>Sig.</i> |
|----------------------|-------------------------|------------|------------|-------------|
| <i>Based on mean</i> | 3,276 | 1 | 56 | 0,076 |

Based on the results of the homogeneity test presented in Table 6, the significance value *based on the mean* was 0.076. This value is greater than the significance level of 0.05, so the data can be considered homogeneous. Thus, the data meet the requirements for analysis in the next stage.

Hypothesis Testing

N-Gain Test Results

In this study, data analysis was conducted using the IBM SPSS software for each group. The results of the *N-Gain* test for the experimental group are presented in Table 7.

Table 7. *N-Gain* Test Results for the Experimental Class

| | <i>Descriptive Statistic</i> | | | |
|---------------|------------------------------|------------|-------------|-----------------------|
| <i>N-Gain</i> | <i>Min</i> | <i>Max</i> | <i>Mean</i> | <i>Std. Deviation</i> |
| <i>Score</i> | 0,72 | 0,83 | 0,78 | 0,02 |

Table 7 shows that in the experimental class, the *N-Gain* scores ranged from a minimum of 0.72 to a maximum of 0.83, with an average of 0.78 (78%) and a standard deviation of 0.0297 (2%). These values fall into the high category based on Hake's criteria ($G > 0.7$), indicating the effectiveness of STEM-based learning in reducing students' math anxiety levels. As for the control class, the *N-Gain* test results are presented in Table 8.

Table 8. *N-Gain* Test Results of the Control Class

| | <i>Descriptive Statistic</i> | | | |
|---------------|------------------------------|------------|-------------|----------------------|
| <i>N-Gain</i> | <i>Min</i> | <i>Max</i> | <i>Mean</i> | <i>Std.Deviation</i> |
| <i>Score</i> | 0,06 | 0,48 | 0,30 | 0,12 |

In the control class (29 students), the *N-Gain* scores ranged from a minimum of 0.06 to a maximum of 0.48, with an average of 0.30 (30%) and a standard deviation of 0.12 (12%). These values fall into the moderate category according to Hake's criteria ($0.3 \leq G \leq 0.7$), indicating a lower reduction in students' math anxiety compared to the experimental class using conventional instruction. Thus, it can be concluded that the STEM-based learning model is more effective in reducing math anxiety than the conventional learning model.

Results of the *t*-Test

The results of the *independent sample t-test* are presented in [Table 9](#).

Tabel 9. Results of the *t*-Test

| | <i>df</i> | Estimasi | Standard-Error | <i>t</i> -stat | Sig. 2- tailed |
|--------------------------------|-----------|----------|----------------|----------------|----------------|
| <i>Equal variances assumed</i> | 56 | 20,586 | 0,524 | 39,280 | 0,000 |

The test results show a t_{hitung} of 39.280 with 56 degrees of freedom (*df*). The significance value (*two-tailed*) obtained is 0.000, which is less than 0.05. Therefore, H_0 is rejected. Furthermore, the estimated value of 20.586 indicates a difference in the mean between the experimental and control groups. Based on these results, it can be concluded that there is a significant difference between the two classes, thus indicating H_0 that STEM-based learning is effective in reducing students' anxiety levels.

Discussion

Based on the research findings, STEM-based learning has been shown to be effective in reducing students' math anxiety. This indicates that learning that connects mathematical concepts to real-world contexts and actively engages students can create a more meaningful learning experience ([Jannah et al., 2024](#)). This approach ensures that students do not merely passively receive material but are actively involved in the process of exploration and problem-solving, thereby reducing their fear and anxiety regarding mathematics. The reduction in math anxiety is evident in several aspects, such as a decrease in students' fear when facing math problems, reduced anxiety when asked to answer questions or solve problems in front of the class, and increased student confidence during the learning process.

The reduction in students' math anxiety can be explained by the characteristics of STEM-based learning, which encourage collaboration, discussion, and active student engagement in problem-solving, these conditions make students feel more confident and less pressured when facing math lessons ([Agfiyah & Fuada, 2024](#)). Additionally, learning that connects the material to real-life situations helps students understand the relevance of mathematics, thereby reducing the perception that mathematics is an abstract and intimidating subject. The effectiveness of STEM-based learning is also influenced by a learning process that emphasizes the stages of thinking and problem-solving, rather than just the final outcome. Students are given the opportunity to try, make mistakes, and gradually improve their understanding. Such a learning environment creates a more comfortable and less stressful atmosphere, thereby reducing anxiety and boosting students' confidence in learning mathematics.

The results of this study align with research conducted by [Yusuf et al. \(2022\)](#), which states that STEM-based learning can enhance student engagement and motivation. However, this study offers a novel perspective by emphasizing that STEM-based learning impacts not only cognitive aspects but also affective aspects, particularly in reducing students' math anxiety. These findings reinforce that contextual and student-centered learning can create a more positive learning environment, enabling students to approach math learning with greater calmness and confidence. These findings are also supported by [Subayani's \(2022\)](#) research, which states that active and problem-based learning approaches can reduce academic pressure and enhance students' emotional engagement in mathematics learning. STEM-based learning provides space for students to participate directly, so they do not feel burdened by rigid academic demands. This indicates that an interactive and collaborative learning environment

plays a crucial role in reducing students' math anxiety. Furthermore, the implementation of STEM-based learning also contributes to enhancing students' self-confidence and positive attitudes toward mathematics. Research by Jannah et al. (2024) shows that students engaged in STEM-based learning tend to have more positive attitudes and are better able to overcome their fear of mathematics. This is because students are trained to solve problems systematically and creatively through activities relevant to real life, making them feel more capable of facing learning challenges.

The implications of this study suggest that teachers should consider implementing STEM-based learning as an alternative teaching strategy that not only focuses on achieving learning outcomes but also takes into account students' emotional well-being, particularly in reducing levels of math anxiety. Learning activities that involve collaboration, problem-solving, and the application of concepts in real life can help students feel more relaxed and confident when learning mathematics. Consequently, mathematics instruction is expected to be more effective and enjoyable, fostering a comfortable learning environment where students do not feel pressured, thereby reducing their levels of math anxiety.

Conclusion

Based on the research findings and discussion outlined above, the conclusion is that STEM-based learning is effective in reducing students' math anxiety. This is supported by the *N-Gain* analysis, which shows an average score of 0.78 a relatively high value. This indicates a significant reduction in students' math anxiety following the implementation of STEM-based learning. The *t-test* results also show a significant difference between the experimental and control groups. Students who participated in STEM-based learning exhibited lower levels of math anxiety compared to those who received conventional instruction. Thus, STEM-based learning is more effective than conventional methods in reducing students' math anxiety. Furthermore, STEM-based learning not only impacts cognitive aspects but also affective aspects of students, particularly in boosting self-confidence and reducing fear of mathematics. This indicates that the STEM approach can create a more meaningful and enjoyable learning experience for students. Despite these positive impacts, this study still has several limitations, such as being conducted on only one learning subject and using an instrument consisting solely of a mathematics anxiety questionnaire without accompanying measurements of student learning outcomes. Therefore, future researchers are advised to expand this study to cover a broader range of subject matter, use a more diverse set of instruments, include different educational levels, or examine other variables such as learning motivation, self-efficacy, and learning outcomes.

Conflict of Interest

The authors declare that there is no conflict of interest.

Auhor Contributions

Author R.P. contributed to the development of instruments, research design, understanding of theoretical foundations, data collection and processing, data analysis, presentation of results and discussion, revision, and ensuring the consistency of the entire article. Author A.M.A. contributed to the development of theoretical studies and approved the final manuscript. Author P.A. contributed to the development of the theory and approved the final version of the article.

The total percentage of author contributions to the conceptualization, drafting, and correction of this article is: R.P.: 40%, A.M.A.: 30%, and P.A.: 30%.

Data Availability Statement




The authors declare that the data supporting the findings of this study will be made available by the corresponding author, [R.P.], upon reasonable request.

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