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The Effect of STEM Learning Approach on Students' Mathematical Problem-Solving Ability

Hidayati Rais[1*], Ramadhani[2], Abdulnassir Yassin[3]
Universitas Merangin, Jambi, Indonesia[1]
Politeknik Negeri Padang, Padang, Indonesia[2]
Islamic University in Uganda, Uganda[3]
*Correspondence E-mail: hidayatirais14@gmail.com

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Abstract
This study aims to describe mathematical problem-solving skills before and after being taught using the STEM learning approach better than Conventional learning. Using a quantitative approach, quasi-experimental method with posttest-only control design. The population of this study was class VIII students with 7 classes totalling 151 students, through simple random sampling to provide equal opportunities to be selected as samples, 27 students from class VIII E experimental group and 22 students from class VIII A control group. Data collection techniques using mathematical problem-solving ability essay test. Data analysis was carried out normality test using Kolmogorov-Smirnov formula and homogeneity test using F test. The results of data analysis obtained normal distribution data and homogeneous variants, then the hypothesis test using t-test obtained t_{count}= 2.3921 greater than t_{table}= 1.6779 at the significance level α= 0.05. It is concluded that the ability to solve mathematical problems taught using the STEM learning approach is better than using Conventional learning for class VIII students of SMP Negeri 12 Merangin in the 2024/2025 academic year. This study implies that the STEM approach can be an effective strategy to improve students' mathematical problem-solving skills.

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Introduction

Students' mathematical problem-solving ability is one of the essential abilities that must be possessed by students in the learning process of mathematics. This ability is not only important for understanding mathematical concepts, but also for applying them in everyday life. However, the results of international studies such as PISA show that students' mathematics skills in Indonesia are still relatively low [1]. PISA 2019 ranked Indonesia 74th out of 79 countries, indicating that Indonesian students' maths and science skills are in a concerning position, being ranked 6th lowest of other countries. Meanwhile, the PISA 2022 results show that Indonesian students' literacy, numeracy and science skills are still low [1].

Observations at SMPN 12 Merangin show that many students have difficulty in solving problems that require problem solving skills, especially problems that require in-depth analysis. Students are generally only able to solve routine problems that are procedural in nature. Traditional learning methods that do not actively involve students are also an inhibiting factor, resulting in low understanding of the material, learning motivation, confidence, and student learning outcomes, especially in mathematical problem-solving skills. Therefore, a more interesting

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and interactive learning approach is needed to increase students' interest in mathematics, so that they do not consider mathematics as a difficult subject, but instead, as something fun [2].

Learning motivation is an important factor in the educational process, significantly influencing student engagement and achievement. For junior secondary education, cultivating a high level of motivation is essential to foster lifelong interest in learning and academic success. Students' scientific thinking, environmental awareness and technological literacy are strongly influenced by maths & science subjects [3]. Students who have self-confidence tend to be more motivated and enjoy learning mathematics, which in turn improves their mathematical achievement. One's belief in a student's ability to improve performance and influence students' daily lives is known as self-confidence. Self-confidence is the key to student success in mathematics. This means that students with a high self-confidence index tend to have good mathematics learning outcomes. Therefore, it is important to develop students' self-confidence in learning mathematics [4].

Interviews with some students at SMPN 12 Merangin indicated that they felt less interested in mathematics because of the monotonous teaching methods. One student said, ‘We often feel bored with learning methods that only listen to the teacher's explanation and do the problems in the book.’ This statement shows that innovation in learning approaches is needed to increase students' interest and mathematical problem-solving skills. Teachers have not optimally provided mathematical problem solving skills, so an innovative and fun learning approach is needed [2].

The initial test of mathematical problem-solving ability conducted on 28 October 2024 showed low results. The initial test used two description questions with four indicators in the question score interval 1-32 with an ideal score of 4 and a maximum indicator score of 80 and the criteria for problematic indicators on average for each indicator ≤ 50% then 50% × 4 = 2 of the average ideal score for each indicator. From the results of the analysis of the initial test answer sheets from 20 students, there are two problematic indicators, namely, question no. 1, where students have not been able to achieve the indicator of identifying strategies that can be taken. In question number 2, students have not been able to achieve the indicator of checking the correctness of the solution [2]. The results of the two initial test questions obtained an average score of 14.70, this shows that students' mathematical abilities are below the learning completeness criteria score.

The STEM (science, technology, engineering, and mathematics) oriented learning approach is thought to be one of the possible ways to address these issues. The STEM (Science, Technology, Engineering, and Mathematics) approach to education integrates information and skills from multiple fields simultaneously. Math, science, technology, and engineering are all included in STEM education. To guarantee that the potential of various viewpoints from each discipline may be unveiled, it is crucial to extrapolate each of these disciplines. STEM-based education places a strong emphasis on student participation in the teaching and learning process and offers practical experiences that shape students' attitudes, knowledge, and abilities. It is anticipated that this STEM-based education will give pupils a range of problem-solving experiences [5].The purpose of the STEM

(Science, Technology, Engineering, and Mathematics) approach is to increase student creativity, especially in the fields of mathematics and natural science. This approach emphasises the learning process of solving problems in the real world.

The STEM approach is an approach that integrates science, technology, and mathematics education techniques that are focused on solving problems in everyday life. There are four STEM (Science, Technology, Engineering, and Mathematics) disciplines that can improve problem solving skills as follows [6]: (1) Science contributes to the development of interest and understanding related to the life world, collaboration skills, materials, research, physics, critical enquiry, and experimentation.(2). Technology enables engagement in the application of knowledge, skills, thinking, and problem-solving using algorithms (computing) that will later be used to expand capabilities and assist in all human needs and desires. (3). Engineering is the application of knowledge and abilities to solve practical issues through the design and construction of machinery or equipment. (4). Mathematical knowledge and skills help with information interpretation and analysis, risk assessment, problem simplification and even resolution, and decision-making.

This research brings new changes to the world of education, especially in creating effective learning approaches to improve students' mathematical problem-solving skills and implementing innovative STEM approaches in junior high schools to strengthen students' mathematical competencies. This study aims to describe the mathematical problem-solving ability before and after being taught using the STEM learning approach of grade VIII students of SMPN 12 Merangin in the odd semester of the 2024/2025 academic year. The implications of this research will provide insights and real evidence on how the STEM approach is effective in learning mathematics. It may encourage wider application of the learning approach in various educational contexts to improve the quality of learning and student achievement.

Research Methods

This kind of study uses a quasi-experimental methodology and is quantitative in nature. In quantitative research known as quasi-experimental research, one or more independent variables are manipulated while other factors that are pertinent to the study also referred to as the dependent variable are controlled. Another way to think of experimenting is as testing, specifically testing that doesn't require a reason or that can be characterized as direct experimentation or manipulation. Finding out if the independent variable's causal relationship with two or more variables is good is the aim of quasi-experimental research[7]

A. Research Design

This study's research design is a posttest-only control design. There are two groups, each chosen at random, for the posttest alone control design [8] [8]. The experimental group is the first to receive treatment, and the control group is the one that does not receive any treatment. The first group given treatment is called the experimental group, and the untreated group is called the control group. The research design carried out on the experimental group and control in Figure 1.

R	X	O_1
R	-	O_2

Figure 1. Research design

Description:
R : Randomisation
X : STEM learning approach treatment in experimental class
O1 : Test of mathematical problem-solving ability
- : Conventional learning treatment in control class.
O2 : Mathematical problem-solving ability test

B. Participants

The population of this study were all class VIII students with 7 classes of SMPN 12 Merangin totalling 151 people. The sampling technique used Simple Random Sampling, which is to provide equal opportunities for each member of the population to be selected as a sample. The selected samples were VIII E class of 27 students as an experimental class using the STEM learning approach and VIII A class of 22 students as a control class using Conventional learning.

C. Intervention

The implementation of the STEM learning approach in the experimental class was conducted for 4 meetings lasting for two weeks. The STEM approach is designed to integrate concepts from science, technology, engineering and mathematics in interactive and project-based learning activities. During the intervention, students in the experimental class were involved in various activities that encouraged them to think critically, creatively and solve problems independently. This approach is expected to improve students' mathematical problem-solving ability compared to conventional learning in the control class.

D. Data Collection

The data collection technique used a 5-item mathematical problem solving ability description test. In this study, the instruments used were esay questions about problem solving ability. The questions were given to the two sample classes after treatment. As for the stages carried out in the preparation of the instrument, the following is a description of the test instrument. The flowchart of instrument testing is presented in Figure 2.

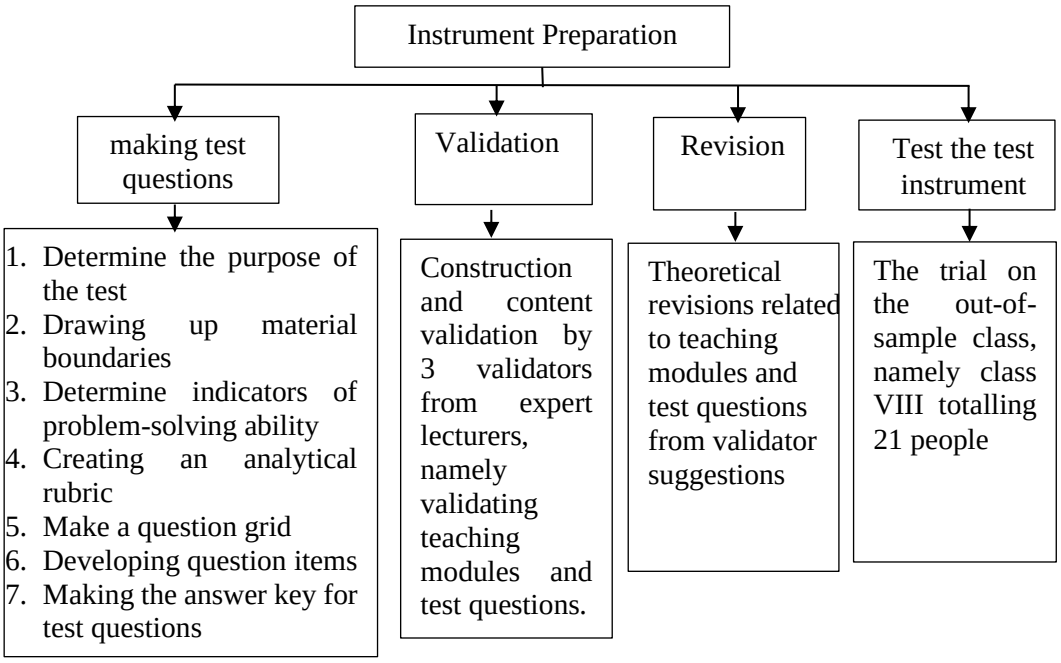

Figure 2. Flow chart of Test instrument

The rubric used by researchers is an analytical rubric because each stage of problem solving can be given an assessment weight. There are four indications of problem-solving skill that are used, specifically (1). recognizing data that is sufficient for issue resolution, data that is known, and data that is dubious. (2). Identify strategies that can be pursued. (3). Put the plan into action. (4). Check the correctness of the solution [2]. Based on the results of the initial test, two problematic indicators were obtained from four indicators, namely indicator number 2 and number 4. The following is given an overview of the research instrument lattice can be seen in table 1.

Table 1. Research Instrument Lattice

Basic Competence	Indicators	Problem solving ability indicators
Calculate the surface area and volume of cubes and blocks	1. Determine the formula for blocks' and cubes' surface areas. 2. Determine the blocks' and cubes' surface areas. 3. Determine the formula for blocks' and cubes' volumes. 4. Determine the blocks' and cubes' volumes.	1. Identify strategies that can be pursued. 2. Check the correctness of the solution

E. Data Analysis

The purpose of data analysis is to test the hypothesis. The normality and homogeneity tests are the first prerequisites for analysis that are performed before the data is analyzed. The purpose of the normality test is to determine whether or not the sample data is regularly distributed. Kolmogorov-Smirnov is the normalcy test that is employed. To find out if the two sample groups are homogeneous that is, have the same variance a homogeneity test is

performed. The Hartly Test or F Test was employed for homogeneity testing in this investigation. The purpose of hypothesis testing is to demonstrate the acceptability of the hypothesis. Additionally, the hypothesis must be testable by statistical methods or reasoning and the force of justification. The Independent Sample T-test, also known as the t-test, is the formula utilized because the data is homogeneous and normality distributed.

Results and Discussion

During the research, both experimental and control classes were given a problem solving ability test on cube and beam material. After the test, an assessment of the results of mathematical problem solving skills was carried out, from the data on the results of student answers. The number of students (N), average ($\bar{X}$), standard deviation (S), as well as the highest score (Xmax) and the lowest score (Xmin) are known. Data on student mathematical ability test results in table 2

Table 2. Mathematical Problem Solving Ability Test Results

Class	N	Final Test Score			
		$\bar{X}$	S	X_{max}	X_{min}
Experiment	27	33,41	5,859	40	16
Control	22	28,86	7,460	40	14

Table 2 shows that the experimental class, which employed the STEM learning approach, had a higher average final test score than the control class, which employed the traditional learning model. This suggests that students' ability to solve mathematical problems is enhanced more effectively by the STEM learning approach. An indication of the variation in students' scores can be seen in the standard deviation difference between the two courses. When compared to the control class, the experimental class's lower standard deviation suggests that students' results are more uniform and less scattered. On the other hand, the control class's higher standard deviation suggests that there is greater variety in this class's capacity for problem-solving. The experimental class's minimum score of 16 was higher than the control class's, which had a score of 14, even though the maximum score for both classes was 40. This demonstrates that while some students excelled in both classrooms, the experimental class's lower basic ability level outperformed the control class. This implies that, as compared to traditional education, the STEM approach not only improved students' average mathematical problem-solving skills but also yielded more notable and equitable results for every student.

Description of data comparison of mathematical problem-solving ability of experimental class and control class can be seen in the following figure 3.

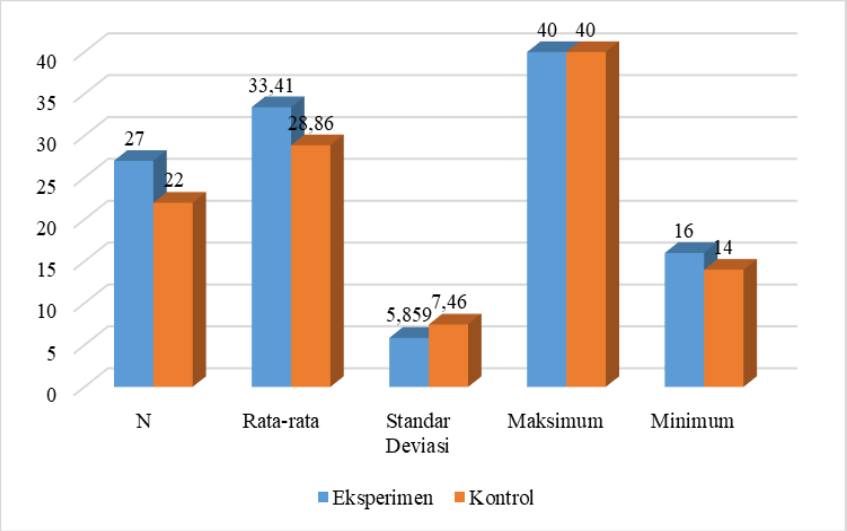

Figure 3. Data Description of Experimental and Control Classes

According to Figure 3, the experimental class taught using the STEM learning technique scored an average of 33.41 on the test of mathematical problem solving, higher than the control class taught using traditional learning, which scored an average of 28.86. Thus, it may be said that students in the experimental class performed better on tests of their ability to solve mathematical problems than students in the control class.

The description of the average score of each question of mathematical problem-solving ability of the two sample classes can be seen in Figure 4 below:

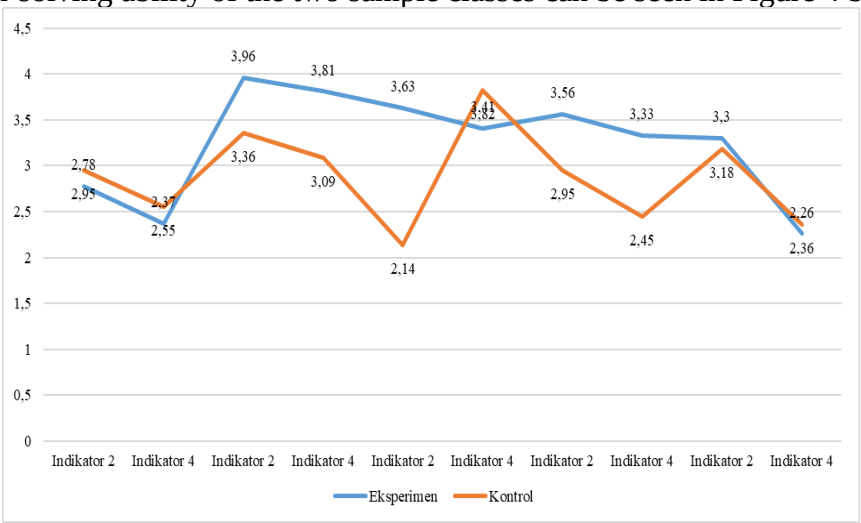

Figure 4. Description of class average score Sample

The overall average score of the indicators from the final test results of the experimental class was 3.24, or 81% of the total, according to Figure 4, which illustrates students' ability to solve mathematical problems. This shows that the ability to solve mathematical problems is at a very high criterion.

The recapitulation of the level of mastery according to the indicators of mathematical problem-solving ability and the number of students can be seen from table 3.

Table 3. Recapitulation of Average Mastery Level of Mathematical Problem-Solving Ability of Experimental Classes

Indicators	Mastery			Number of students per-qualification				
	$\bar{x}_{max}$	$\bar{x}_{indikator}$	%	Very High	High	Medium	Low	Very Low
2	4	3,81	99	26	1	0	0	0
4	4	3,63	95,25	25	1	0	0	1
Overall		3,72	97,13					

Based on table 3. overall, the data shows that most students in the experimental class have a very good level of mastery of mathematical problem-solving skills. Furthermore, the average mastery of the control class per indicator qualification can be seen in the table below:

Table 4. Recapitulation of Average Mastery Level of Mathematical Problem-Solving Ability of Control Class

Indikator	Mastery			Number of students per-qualification				
	$\bar{x}_{max}$	$\bar{x}_{indikator}$	%	Very High	High	Medium	Low	Very Low
2	4	3,82	95,5	21	0	0	0	1
4	4	3,36	84	15	0	7	0	0
Overall		3,59	89,75					

Based on table 4, the overall data shows that most students taught with conventional learning have mastered mathematical problem-solving skills well. The purpose of the normality test is to ascertain whether the sample class results' data are regularly distributed.

Table 5. Results of the normalcy test computation.

No	Class	N	D_{max}	$D_{(\propto,n)}$	Description
1	Experiment	27	0,139	0,254	Normally Distributed
2	control	22	0,208	0,281	Normally Distributed

The experimental and control classes' data are both normally distributed, as indicated by Table 5's value of $D_{max} \leq D_{(\alpha,n)}$. The purpose of the homogeneity test is to ascertain whether the variances of the two-sample data are homogeneous. The F test can be used to do a homogeneity test. The following table displays the findings of the homogeneity test computation:

Table 6. Recapitulation of Sample Homogeneity Test

Class	F_{count}	F_{table}	Description
Experiment	1,6212	1,9776	Homogeneous
control			

Based on Table 6, the results of the calculation of the experimental class obtained variants slightly spread compared to the variants of the control class which are more spread out, this shows that there is a lot of variation in mathematical problem-solving ability, so the two samples with $F_{count} > F_{table}$ have homogeneous variances.

After carrying out the normality test, both data in the experimental class and control class were normally distributed and continued the homogeneity test on the sample class obtained homogeneous variance data. Because both sample class data are normally distributed and homogeneous variance, to answer the hypothesis using

the t-test formula. The test results obtained $t_{count} = 2{,}3921$ compared to t_{table} and $dk = n_1 + n_2 - 2 = 27 + 22 - 2 = 47$with α = 0.05 obtained t_{table} = 1.6779 in accordance with the decision criteria for right party testing if $t_{hitung} \geq t_{tabel}$ or $2{,}3921 \geq 1{,}6779$ then H_1 is accepted and H_0 is rejected, meaning that the ability to solve mathematical problems taught using the STEM learning approach is better than those taught with conventional learning for class VIII students of SMPN 12 Merangin in the 2024/2025 academic year.

Based on the results of data analysis with normal distribution and homogeneous variants, it means that mathematical problem-solving skills towards the STEM learning approach are better than conventional learning for class VIII students of SMPN 12 Merangin in the 2024/2025 academic year. This illustrates that the STEM learning approach has a positive effect on student motivation and confidence. Motivation to learn mathematics is a key factor for students for their future, because it is a predictor in determining motivation in pursuing careers in STEM fields [9].The findings of this study are in line with the results of research (Astuti et al, 2021) [10], stating the results of research based on the keywords used in the search are STEM, problem solving and physics. Based on the analysis carried out, it can be concluded that learning through the STEM approach can improve students' problem-solving skills. Furthermore, research conducted (Istiana, et al, 2023) the results of hypothesis testing show that the t-count> t_{table} value, which indicates a significant effect of STEM learning on students' problem solving skills on the topic of environmental change [11].

Conclusion

The study aimed to describe the mathematical problem-solving ability of grade VIII students of SMPN 12 Merangin before and after being taught through the STEM learning approach in the 2024/2025 academic year. The results showed that the STEM approach significantly improved the mathematical problem-solving ability of experimental class students obtained an average score of 33.41, while control class students obtained an average score of 28.86. Based on hypothesis testing using the t-test formula, it shows that the STEM learning approach is significant, because $t_{count} \geq t_{table}$ or $2.3921 \geq 1.6779$. This means that the ability to solve mathematical problems taught using the STEM learning approach is better than conventional learning for students in class VIII SMP Negeri 12 Merangin in the 2024/2025 academic year. The positive impact of the STEM learning approach can increase students' involvement in active and collaborative learning and help them connect mathematical concepts with real applications. However, this study has limitations in population coverage and posttest-only design which may not reflect long-term changes. Therefore, future research is expected to expand the coverage and use a longitudinal design for more comprehensive results. The implication of this research for the development of education is that the STEM approach can be an effective learning approach to improve mathematical problem-solving skills, which can improve the quality of mathematics education in secondary schools. Suggestions for mathematics teachers to adopt the STEM learning approach in the teaching process. This approach can encourage more active student involvement, cooperation in groups, and better critical thinking skills. For the school, it is expected to provide adequate training and resources for teachers to

effectively implement this approach. Further research is also recommended to explore the implementation of the STEM approach in other subjects and in different educational contexts to strengthen the validity of these findings.

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Author Contributions

Hidayati Rais: conducted primary research including data collection and preliminary analyses. Wrote the introduction and research methodology sections and reviewed and edited the final manuscript. Ramadhani: analysed the data and contributed to the interpretation of the results. Wrote the results and discussion sections of the study and coordinated with the first author on the overall structure and coherence of the manuscript. Abdulnassir Yassin: formal analysis; data curation; methodology; writing- review and editing.

Availability of data and materials

The authors have made all the data available.

Competing interests

No conflicting interests are disclosed by the writers.

Additional information

No additional information from the authors.

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