Al-Fikru: Jurnal Pendidikan dan Sains
5(2), 2024, 255-261
Available at: https://ejournal.unzah.ac.id/index.php/alfikru

The effect of STEM (Science, Technology, Engineering, and Mathematics) approach on critical thinking abilities of SMPN 1 Maron students

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Received: 5 December 2024; Revised: 25 December 2024; Accepted: 31 December 2024

Abstract: This study aims to analyze the impact of the STEM (Science, Technology, Engineering, and Mathematics) approach on the critical thinking skills of students at SMPN 1 Maron. STEM integrates interdisciplinary concepts into learning to enhance 21st-century skills, such as critical thinking. The study employed a quasi-experimental pre-test post-test control group design involving 53 students divided into an experimental group (27 students) and a control group (26 students). The research instruments included critical thinking essay tests and student response questionnaires. Data analysis was conducted using T-tests, ANOVA, and correlation analysis. The results revealed a significant improvement in the experimental group, with the average critical thinking scores increasing from 70.25 (pre-test) to 88.75 (post-test), while the control group showed an increase from 68.50 to 75.30. This difference indicates the effectiveness of the STEM approach in enhancing students' critical thinking skills. In conclusion, the STEM approach has proven to contribute positively to the development of critical thinking skills among junior high school students. These findings can serve as a reference for developing STEM-based curricula to improve the quality of education in Indonesia.
Keywords: STEM, critical thinking, quasi-experiment, junior high school education

How to Cite: Lestari, W., Mauliska, N., & Blouin, A. (2024). The effect of STEM (Science, Technology, Engineering, and Mathematics) approach on critical thinking abilities of SMPN 1 Maron students. *Al-Fikru: Jurnal Pendidikan dan Sains, 5*(2), 255-261. https://doi.org/10.55210/al-fikru.v5i2.1920

Introduction

Education in Indonesia faces a major challenge in preparing the younger generation to face the complexities of the era of globalization and the industrial revolution 4.0. One of the responses proposed is the integration of the STEM (Science, Technology, Engineering, and Mathematics) approach in the education curriculum, as an effort to improve students' skills and competencies in science and technology (Ardianti et al., 2020; Sukma, 2018). At SMPN 1 Maron, students' critical thinking skills are still low based on initial test results, so innovative strategies are needed to improve these abilities. Moreover, at the Junior High School (SMP) level, a critical period in the formation of mindset and cognitive skills, it is important to identify and understand the influence of the STEM approach on students' critical thinking skills.

The STEM (Science, Technology, Engineering, and Mathematics) approach integrates principles from science, technology, engineering, and mathematics into education, with a focus on practical application, problem solving, and cross-disciplinary collaboration. Previous studies have shown that STEM integration in learning can improve students' critical thinking skills, increase learning motivation, and facilitate deeper mastery of concepts (Honey et al., 2014; Rahmawati et al., 2022; Suardi, 2020). In Indonesia, the implementation of STEM is increasingly emphasized to prepare

the younger generation to face the challenges of the 21st century, as mandated in the 2013 curriculum (Krisna et al., 2019).

Critical thinking skills are an important aspect of education that enables students to analyze, evaluate, and synthesize information critically and rationally. In the context of STEM education, critical thinking skills are key to facing complex challenges that often require analytical approaches and innovative solutions. However, previous studies have shown that the implementation of STEM has not been fully optimal at the junior high school level in Indonesia, especially in relation to critical thinking skills (Thovawira et al., 2021). While previous research has shown the success of STEM approaches at the high school and college levels, there has not been much research exploring their impact at the junior high school level, particularly in Indonesia.

This study aims to investigate in depth the influence of the STEM (Science, Technology, Engineering, and Mathematics) approach on the critical thinking skills of students at SMPN 1 Maron. Different from previous studies that mostly focused on the context of high school or college level, this study focuses on the junior high school level, thus providing new insights that are relevant in the context of basic education. The novelty of this study lies in the combination of the use of quasi-experimental methods with multi-level measurements (pre-test and post-test) and advanced statistical analysis to assess the effectiveness of the STEM approach more holistically.

Considering the educational context in Indonesia, as well as the relevance and urgency of implementing the STEM approach, this study aims to make a significant contribution in strengthening the foundation of STEM education at the junior high school level, while increasing our understanding of how this approach affects students' critical thinking skills. Therefore, this study will not only provide deeper theoretical insights, but also have practical implications for curriculum development, teaching, and evaluation of education in Indonesia, especially in improving students' critical thinking skills.

STEM (Science, Technology, Engineering, and Mathematics) Approach

The STEM approach is an interdisciplinary approach to education that integrates concepts and methods from Science, Technology, Engineering, and Mathematics into holistic learning. This approach aims to integrate learning from various disciplines and encourage students to apply their knowledge and skills in real contexts (Bybee, 2013; Krisna et al., 2019).

The STEM approach facilitates students to develop 21st century skills, including critical thinking, creativity, communication, and collaboration.(English, 2016; Sumaji, 2019). STEM-based learning has been shown to increase student motivation to learn and provide real-world relevant learning experiences, especially in the fields of science and technology (Hiğde & Aktamış, 2022; Rusminati & Juniarso, 2023)

Table 1. Components of STEM (Science, Technology, Engineering, and Mathematics)

Science	Technology	Engineering	Mathematics
Students are invited to observe, ask questions, formulate hypotheses, conduct experiments, and draw conclusions.	Students are introduced to modern technology and how to use technology to collect data, analyze information, and communicate.	Students are encouraged to design a product or system, consider limitations and needs, and test and refine the solutions they create.	Students learn to apply mathematical concepts in practical contexts, such as measuring, calculating, and predicting outcomes.

In the STEM approach, learning is not limited to one discipline, but integrates concepts and skills from various disciplines. Students are encouraged to collaborate, think critically, and solve

problems creatively. This approach creates a learning environment that is relevant to the real world, preparing students for future challenges in the era of technology and innovation.(Moore et al., 2020).

Critical Thinking Skills

Critical thinking skills are skills that enable a person to evaluate, analyze, and synthesize information wisely and logically (Facione, 2015). It involves complex mental processes, including the ability to break down information into smaller parts, assess the reliability and relevance of information, integrate multiple perspectives to form a comprehensive understanding (Abrami et al., 2015), and ask in-depth questions about the information presented.

In education, critical thinking is a major focus because of its crucial role in informed decision making, effective problem solving, and efficient communication.(Ardianti et al., 2020). Research shows that students who are trained to think critically perform better academically and are better able to deal with challenges in real-life contexts (Alsaleh, 2020; Suripto et al., 2023).

Critical thinking skills also help students develop productive collaboration and innovation skills to address complex challenges in the workplace and everyday life. Therefore, developing critical thinking skills is a priority in education, especially through learning approaches such as STEM, which integrate these skills into everyday learning activities (Adhelacahya et al., 2023; Johnson & Johnson, 2021).

Method

This study uses a quantitative approach with a pre-test post-test control group experimental design. The population of this study includes all students of SMPN 1 Maron in the academic year 2024. The subjects of the study consisted of 53 students of SMPN 1 Maron who were divided into two groups: 27 students in the experimental group who received learning with the STEM (Science, Technology, Engineering, and Mathematics) approach, and 26 students in the control group who received conventional learning.

The data collection instruments used were creative thinking ability tests and student response questionnaires. The validity and reliability of the tests and questionnaires were confirmed through expert judgment and pilot testing. The tests used consisted of a series of essay questions designed to measure analysis, evaluation, and synthesis of information. The data collection procedures were carried out sequentially, namely pre-test, intervention, post-test, and filling out the questionnaire.

Critical thinking ability data will be analyzed using SPSS statistical software. The statistical analysis to be conducted includes: (1) T-test: To compare the average critical thinking ability score between the experimental group and the control group before and after the intervention; (2) ANOVA test: To identify significant differences between the experimental group and the control group on critical thinking ability scores after the intervention; (3) Correlation: To evaluate the relationship between critical thinking ability scores and student satisfaction with learning with the STEM approach. Before conducting T-tests and ANOVA, normality and homogeneity tests were performed to ensure the data met statistical assumptions.

Results and Discussion

The following bar chart illustrates the average pre-test and post-test scores for the experimental and control classes. From the chart, it can be seen that the average post-test score, both in the experimental and control classes, is higher than the average pre-test score. This indicates an increase in scores after the treatment. The experimental class showed a higher average post-test score than the control class, which reflects the effectiveness of the treatment given. This difference is an initial

indicator before further analysis is carried out regarding the influence of the STEM approach on students' critical thinking skills.

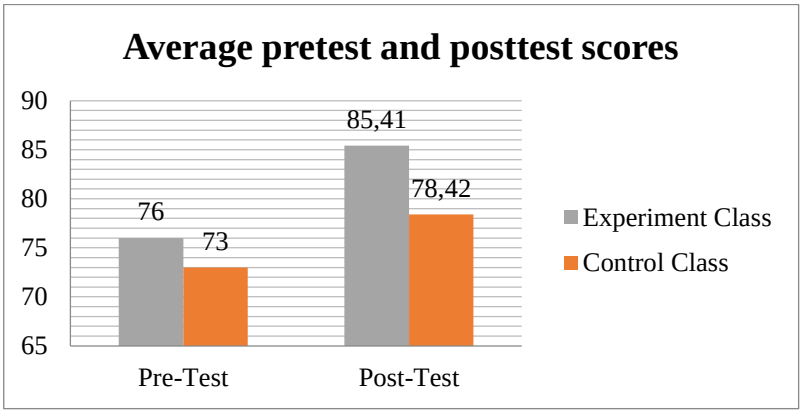

Figure 1. Diagram of average pretest and posttest scores

Based on the results of statistical analysis using SPSS software, significant findings in the study on the influence of the STEM approach(Science, Technology, Engineering, and Mathematics)on the critical thinking skills of SMPN 1 Maron students can be further described. The test results can be seen in Table 2.normalityshows that the data generally approaches a normal distribution, with a significance value greater than alpha ($\alpha = 0.05$) for all variables, indicating no violation of the normality assumption. This indicates that the data used in this study can be considered eligible for further statistical analysis.

Table 2. Data Normality Test Results

Tests of Normality

		Kolmogorov-Smirnova			Shapiro Wilk		
	Category	Statistics	df	Sig.	Statistics	df	Sig.
Student Grades	Experimental Class Pre-Test	.106	27	.200*	.945	27	.158
	Post-Test of Experimental Class	.104	27	.200*	.955	27	.287
	Pre-Test Control Class	.120	26	.200*	.943	26	.155
	Post-Test Control Class	.147	26	.158	.930	26	.077

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Furthermore, the homogeneity of variance test shows that the variance between groups as a whole is quite homogeneous, with a significance value greater than α, namely . This indicates that the groups have similar variability, thus strengthening the reliability of the analysis results. The results of the homogeneity test can be seen in Table 3 below.$0.246 > 0.05$.

Table 3. Results of Data Homogeneity Test

Test of Homogeneity of Variances

Student Grades			
Levene Statistics	df1	df2	Sig.
1.405	3	102	.246

The analysis of the paired samples T-test in Table 4 shows a significant difference between students' scores before and after the intervention in both groups (experimental group and control

group), with a significance value of 0.000 <0.05. This shows that the intervention carried out, both using the STEM approach and conventional methods, has a significant effect on improving students' critical thinking skills. However, the greatest change occurred in the experimental class usinglearning with a STEM (Science, Technology, Engineering, and Mathematics) approach.

Table 4. Paired Sample T-Test Results

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Student Grades - Category	59,802	15,995	1,554	56,721	62,882	38,493	105	.000

In addition, the results of the ANOVA analysis showed a significant difference between the experimental group and the control group in terms of students' critical thinking skills, with a significance value of 0.000 < 0.05. This indicates that there is a real difference between the effectiveness of the STEM approach (Science, Technology, Engineering, and Mathematics)and conventional methods in improving students' critical thinking skills. The results of the ANOVA test can be seen in Table 5 below.

Table 5. ANOVA Test Results

ANOVA

Student Grades

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	23075.477	3	7691.826	196,238	.000
Within Groups	3998.033	102	39,196		
Total	27073.509	105			

There is also a strong and significant correlation between student grades and learning categories, with a Pearson correlation coefficient of -0.808 <0.01 as seen in Table 6. This shows that the higher the student grades, the lower the learning categories applied. This means that learning with the STEM approach(Science, Technology, Engineering, and Mathematics) tends to result in improved student grades and higher critical thinking skills.

Table 6. Correlation Results Using SPSS

Correlations

		Mark	Category
Mark	Pearson Correlation	1	-.808**
	Sig. (2-tailed)		.000
	N	53	53
Category	Pearson Correlation	-.808**	1
	Sig. (2-tailed)	.000	
	N	53	53

**. Correlation is significant at the 0.01 level (2-tailed).

The results of this study show significant evidence of the effectiveness of the STEM (Science, Technology, Engineering, and Mathematics) approach in improving students' critical thinking skills at SMPN 1 Maron. Statistical analysis revealed a significant difference between students' scores before

and after the intervention, both in the experimental group receiving learning with the STEM approach and the control group using conventional methods. These findings provide strong evidence that the STEM approach is able to make a positive contribution to improving students' critical thinking skills.

Furthermore, the results of the ANOVA analysis confirmed a significant difference between the experimental group and the control group in terms of students' critical thinking skills. This shows that learning with the STEM approach has a greater impact on improving students' critical thinking skills compared to conventional methods. The strong correlation between student grades and learning categories also confirms that learning with the STEM approach tends to result in increased student grades and higher critical thinking skills.

Therefore, these findings have important implications in the context of education, as they support the need to integrate the STEM (Science, Technology, Engineering, and Mathematics) approach into the educational curriculum. The implementation of the STEM approach can provide a more holistic and relevant learning experience for students, as well as prepare them to face complex challenges in the era of technology and innovation. Thus, this study provides a valuable contribution in supporting the development of quality education that is relevant to future demands.

Conclusion

This study shows that the STEM (Science, Technology, Engineering, and Mathematics) approach has a significant influence in improving critical thinking skills of students at SMPN 1 Maron. The average score of students in the experimental group increased from 70.25 (pre-test) to 88.75 (post-test), while in the control group there was an increase from 68.50 (pre-test) to 75.30 (post-test). Statistical analysis revealed a significant difference between students' scores before and after the intervention, both in the experimental and control groups. These results emphasize the importance of implementing the STEM (Science, Technology, Engineering, and Mathematics) approach in improving the quality of learning and student learning outcomes in secondary schools.

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