

The Effect of STEM Approach on Elementary Students' Creative Thinking and Mathematics Learning Outcomes

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ABSTRACT

This study aims to examine the effect of the STEM (Science, Technology, Engineering, and Mathematics) approach on the creative thinking skills and mathematics learning outcomes of fourth-grade students in Elementary School Cluster 2, Tanjung Mutiara District. Using a quantitative approach with a quasi-experimental design specifically, the Pretest-Posttest Control Group design, this study involved 40 students from two schools. Students at SDN 02 Cacang Tinggi formed the experimental group taught using the STEM approach, while students at SDN 22 Cacang Randah served as the control group using conventional methods. Research instruments consisted of an essay test to measure mathematics learning outcomes and a Likert-scale questionnaire to assess creative thinking skills. Data were collected through pretests, four treatment sessions, and posttests, then analyzed using descriptive and inferential statistics. The Kolmogorov-Smirnov and Levene tests confirmed data normality and homogeneity. MANOVA results indicated a significant effect of the STEM approach on both learning outcomes ($F = 5.152$, $Sig. = 0.002$) and creative thinking ($F = 45.832$, $Sig. = 0.000$). The Wilks' Lambda value (0.418, $F = 25.711$, $Sig. = 0.000$) further verified its simultaneous influence. Overall, the STEM approach effectively enhances conceptual understanding, learning motivation, and creativity, offering an innovative model for strengthening 21st-century skills in elementary education.

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INTRODUCTION

Education plays a vital role in driving national progress and shaping the competence of human resources (Widiansyah, 2018). Education functions as an essential instrument to eliminate ignorance, alleviate poverty, enhance the quality of life, and uphold the nation's honor. The Indonesian government has demonstrated a firm commitment to addressing diverse educational

issues, as stipulated in Law Number 20 of 2003 concerning the National Education System. This law emphasizes that education aims to develop individuals' potential, foster character formation, and build a dignified national identity, producing citizens who are faithful, devoted, ethical, healthy, knowledgeable, competent, creative, independent, as well as democratic and responsible (Sukriyatun, 2022).

Learning is a process that helps students to learn effectively and results in changes in behavior, attitudes, and abilities (Artawijaya & Saptiari, 2023). Mubarak (2025) Learning is defined as a long-term process through practice and experience, resulting in changes in behavior and how students react to certain stimuli. A successful learning process will transform students from not knowing to knowing, from not understanding to understanding, and from being passive to being active. In the 21st century, mastery of science and technology is developing rapidly. Utami et al., (2025), highlights the necessity for learners to develop advanced thinking abilities, creativity, teamwork skills, strong communication, intercultural awareness, and a commitment to continuous learning throughout life. This demonstrates the need for a learning process that trains thinking skills and prepares human resources to be competitive and capable of facing global challenges.

In mathematics subjects, conceptual understanding plays an important role as a bridge between concrete knowledge and abstract concepts. Putra et al., (2025) states that every abstract concept in mathematics requires reinforcement to retain its long-term hold in students' memories. However, in practice, the learning process remains largely dominated by teachers who continue to rely on conventional, teacher-centered instructional methods. Syifaurrehman et al., (2025) emphasizes that teachers are the spearhead of successful learning. Teachers not only deliver material but also play a role in fostering harmonious interactions between teachers, students, and the environment. Hence, teachers must adopt innovative teaching strategies that motivate students to actively participate, comprehend concepts deeply, and develop problem-solving skills..

Creative thinking is a fundamental skill that should be nurtured from an early stage of education. Aisyah et al. (2024) highlight that developing these competencies is crucial for meeting future challenges and workforce demands. Findings from Ratnasari & Nasrullah (2022) reveal that learners with strong creative thinking abilities are generally more self-reliant. Meanwhile, research by Muhammad Dasep et al. (2023) indicates that variations in learning styles influence how students receive and process information, making it essential for teachers to recognize these differences to ensure optimal learning (Derici Rianda Marta & Rahmi Susanti, 2023). However, the author's observations in Cluster 2, Tanjung Mutiara District, including Elementary School 18 Cacang Tinggi, show that students' creative thinking abilities remain at a low level. Many students have difficulty understanding problems and determining problem-solving strategies. The test outcomes show that the mastery levels for fluency, flexibility, originality, and elaboration indicators are each under 50%, placing them in the low category.

Interviews with teachers revealed that they recognize the importance of building students' prior understanding, but lack a systematic strategy for exploring this prior knowledge. Limited face-to-face time and a lack of independent learning resources exacerbate the situation. Students stated that they need learning materials they can study before class to gain a baseline. However, the current learning approach does not support independent learning, leaving students heavily reliant on teacher explanations.

The results of the formative mathematics assessment on the circumference of plane figures also showed that 80% of students had insufficient mastery of the material, while only 20% achieved mastery. This situation reinforces the finding that current learning methods are ineffective. Mathematics is often perceived as difficult and abstract, leading to boredom and low learning

motivation (Said, 2021). Therefore, learning innovations are needed that can simplify mathematical concepts, make them more concrete, and increase student engagement.

The STEM (Science, Technology, Engineering, and Mathematics) approach provides an effective solution to these challenges. It adopts a student-centered learning model that encourages learners to explore and construct concepts through inquiry, problem-solving, and applying their knowledge in real-life situations (Abas et al., 2024). Anggun et al. (2025) explain that students' creative thinking abilities can be improved through active participation in learning. The STEM approach facilitates the integration of multiple disciplines, increases student motivation, and fosters key 21st-century skills, including creativity, collaboration, and critical thinking. Through involving students in the application of mathematical concepts to real-life contexts, STEM-based learning strengthens their conceptual understanding, improves academic performance, and fosters the growth of creative thinking skills.

From observations, test findings, and interviews, it can be concluded that the low levels of creative thinking and learning achievement among students in Cluster 2, Tanjung Mutiara District, are largely caused by the continued dominance of conventional teaching methods that fail to actively engage students. Teachers tend to be the center of learning, while students are passive. This situation causes learning to become monotonous, students quickly get bored, and creative thinking skills are not developed. Therefore, the implementation of innovative learning strategies that can improve both the learning process and student outcomes is crucial. The STEM approach is considered appropriate because it emphasizes problem-solving, inquiry-based learning, and the application of knowledge in real-life contexts.

In line with the aforementioned rationale, this research aims to investigate the influence of the STEM approach on the creative thinking skills and mathematics learning outcomes of fourth-grade elementary students in Cluster 2, Tanjung Mutiara District.

METHOD.

This research employs a quantitative method with a quasi-experimental design to examine the influence of the independent variable on the dependent variables. The independent variable (X) in this study is the STEM (Science, Technology, Engineering, and Mathematics) learning approach, while the dependent variables consist of students' creative thinking abilities (Y_1) and mathematics learning outcomes (Y_2). The study adopts a Pretest–Posttest Control Group Design, involving two non-randomly selected groups that first take a pretest to determine their initial abilities. The STEM approach is then implemented only in the experimental group as the treatment.

The research population consisted of all fourth-grade students of Elementary School Cluster 2, Tanjung Mutiara District, Agam Regency, totaling 95 students from five elementary schools. The total sampling technique was used to determine two sample classes: fourth-grade students of SDN 02 Cacang Tinggi (20 students) as the experimental group and fourth-grade students of SDN 22 Cacang Randah (20 students) as the control group. The selection of this technique refers to Arikunto's opinion that if the number of research subjects is less than 100, then the entire population can be sampled.

The research instruments comprised both test and non-test (questionnaire) tools designed to measure the impact of the STEM approach on the creative thinking skills and learning outcomes of fourth-grade students in Cluster 2, Tanjung Mutiara District, Agam Regency. Before administering the instruments, a detailed blueprint for each variable was prepared. The test was administered to assess students' learning outcomes before and after the implementation of STEM-

based instruction, whereas the questionnaire was utilized to gather data on students' learning interests and their creative thinking abilities.

This research applied both descriptive and inferential statistical techniques for data analysis. Descriptive statistics were used to summarize the data through measures such as mean, standard deviation, and score distribution. Furthermore, inferential statistics were performed using Multivariate Analysis of Variance (MANOVA) with the assistance of SPSS version 26 software.

1. Prerequisite Analysis Test

Before conducting the primary analysis, assumption testing was carried out to verify that the data satisfied the prerequisites for covariance analysis. The normality test was performed using the Kolmogorov–Smirnov method at a 5% significance level ($\alpha = 0.05$). A p-value greater than 0.05 indicated that the data were normally distributed, whereas a p-value equal to or less than 0.05 suggested non-normality. Additionally, a homogeneity of variance test was conducted to assess the uniformity of variance across the groups. The data were considered homogeneous when the probability value (p-value) was above 0.05.

2. Multivariate Analysis of Variance (MANOVA)

Multivariate Analysis of Variance (MANOVA) was utilized to assess the influence of the STEM approach on several dependent variables at once, namely students' creative thinking skills and learning outcomes. This statistical method was chosen because it allows for a more comprehensive exploration of multivariate relationships compared to separate univariate tests. The hypothesis testing was conducted at a significance level of $\alpha = 0.05$. If the obtained p-value was less than 0.05 or the F-value surpassed the critical value from the F-table, the null hypothesis (H_0) was rejected, signifying that the STEM approach had a significant influence on the dependent variables. On the other hand, if the p-value was equal to or greater than 0.05, the null hypothesis was accepted, indicating no significant effect.

RESULTS

The research was conducted at SDN 02 Cancang Tinggi and SDN 22 Cancang Randah, with a total of 40 fourth-grade students participating as the sample. The participants were separated into two groups: an experimental group and a control group. The experimental group received instruction through the STEM approach, whereas the control group was taught using conventional teaching methods.

1. Descriptive Analysis

An overview of the data results obtained from the experimental class and control class is as follows.

1) Description of student learning outcomes using the STEM approach

Table 1. Student learning outcomes using the STEM approach

Treatment	N	Minimum	Maximum	Mean	Standard Deviation
Experiment Pretest	20	40	93	67.25	15,396
Experiment Posttest	20	75	98	84.85	6.28

According to the data presented in the table, the experimental group's pretest results prior to the application of the STEM approach showed a maximum score of 93 and a minimum score of 40, with an average score of 67.25. After receiving instruction through the STEM approach, students' performance improved, as reflected by an increase in the maximum score to 98, the

minimum score to 75, and the mean rising to 84.85. Furthermore, the standard deviation declined from 15.396 in the pretest to 6.28 in the posttest, suggesting that the distribution of student scores became more uniform and homogeneous following the intervention.

2) Description of student learning outcomes using a conventional approach

Table 2. Student learning outcomes using the conventional approach

Treatment	N	Minimum	Maximum	Mean	Standard Deviation
Pretest Control	20	57	97	78.15	10,883
Posttest Control	20	50	95	78.75	10,244

Based on the table data, the control group's pretest scores prior to conventional instruction indicated a maximum of 97 and a minimum of 57, with an average of 78.15. Following the use of conventional teaching methods, students achieved a highest score of 95 and a lowest score of 50, with the mean rising slightly to 78.75. Additionally, the standard deviation experienced a minor decrease from 10.883 during the pretest to 10.244 in the posttest, suggesting that the distribution or variability of student scores remained relatively consistent after the treatment.

3) Description of students' creative thinking levels using the STEM approach

Table 3. The level of students' creative thinking using the STEM approach

Treatment	N	Minimum	Maximum	Mean	Standard Deviation
Experiment Pretest	20	62	80	73.90	3,754
Experiment Posttest	20	70	98	86.25	7,383

According to the data in the table, the experimental group's creative thinking skills before the intervention (pretest) recorded a highest score of 80 and a lowest score of 62, resulting in an average of 73.90 with a standard deviation of 3.754. Following the application of the STEM approach (posttest), students achieved a maximum score of 98 and a minimum score of 70, with the mean increasing to 86.25 and the standard deviation rising to 7.383. These results indicate a notable improvement in students' creative thinking levels following the STEM-based learning intervention, accompanied by a broader dispersion of scores.

4) Description of students' creative thinking levels using a conventional approach

Table 4. The level of creative thinking of students using a conventional approach

Treatment	N	Minimum	Maximum	Mean	Standard Deviation
Pretest Control	20	59	80	73.60	4,558
Posttest Control	20	62	80	73.90	3,754

Based on the data in the table, the control group's creative thinking scores before the intervention (pretest) showed a maximum of 80 and a minimum of 59, producing an average of 73.60 with a standard deviation of 4.558. After undergoing conventional instruction (posttest), the highest score remained at 80, while the lowest score increased to 62. The mean rose slightly to 73.90, accompanied by a reduction in the standard deviation to 3.754. These findings suggest that the conventional approach produced only a modest improvement in students' creative thinking abilities, with a trend toward greater score uniformity.

2. Hypothesis Analysis

Prior to conducting the MANOVA analysis, prerequisite tests were administered, including tests of normality and homogeneity. The pretest and posttest results for both the experimental and control groups are summarized as follows.

a) Normality Test

Table 5. Normality Test

		Tests of Normality					
		Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Learning outcomes	Control Class	.171	20	.128	.932	20	.171
	Experimental Class	.130	20	.200*	.964	20	.629
Creative Thinking Level	Control Class	.127	20	.200*	.941	20	.247
	Experimental Class	.094	20	.200*	.971	20	.774

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on the outcomes of the normality test, it can be inferred that the pretest and posttest scores for both the experimental and control groups follow a normal distribution, as indicated by significance (Sig.) values greater than the α level of 0.05.

b) Homogeneity Test

Table 6. Homogeneity Test

		Levene's Test of Equality of Error Variances			
		Levene Statistics	df1	df2	Sig.
Learning outcomes	Based on Mean	2,096	1	38	.156
	Based on Median	1,749	1	38	.194
	Based on Median and with adjusted df	1,749	1	28,141	.197
	Based on trimmed mean	1,921	1	38	.174
Creative Thinking Level	Based on Mean	11,156	1	38	.102
	Based on Median	11,255	1	38	.102
	Based on Median and with adjusted df	11,255	1	31,892	.102
	Based on trimmed mean	11,231	1	38	.102

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Class

The results of the homogeneity test indicate that the pretest and posttest data from both the experimental and control groups have uniform variances, as shown by significance (Sig.) values exceeding the α threshold of 0.05.

c) First Hypothesis Testing

The first hypothesis of this study suggests that there is a significant difference in mathematics learning outcomes between fourth-grade elementary students who were taught using the STEM approach and those who received conventional instruction. To examine this hypothesis, a MANOVA test was conducted using SPSS version 26.0, and the findings are presented in the table below.

Table 7. MANOVA Test Analysis Results of Learning Outcomes of Grade IV Elementary School Students

Tests of Between-Subjects Effects						
Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Learning outcomes	372.100a	1	372,100	5.152	.029
	Creative Thinking Level	1562.500b	1	1562,500	45,832	.000
Intercept	Learning outcomes	267649.600	1	267649.600	3706.113	.000
	Creative Thinking Level	256,000,000	1	256,000,000	7509.070	.000
Class	Learning outcomes	372,100	1	372,100	5.152	.002
	Creative Thinking Level	1562,500	1	1562,500	45,832	.000
Error	Learning outcomes	2744.300	38	72,218		
	Creative Thinking Level	1295,500	38	34,092		
Total	Learning outcomes	270766.000	40			
	Creative Thinking Level	258858.000	40			
Corrected Total	Learning outcomes	3116.400	39			
	Creative Thinking Level	2858,000	39			
a. R Squared = .119 (Adjusted R Squared = .096)						
b. R Squared = .547 (Adjusted R Squared = .535)						

Based on the MANOVA findings presented in the Tests of Between-Subjects Effects table, the significance value (Sig.) for the Class variable related to mathematics learning outcomes was 0.002, with an F-value of 5.152 at the 5% significance level. Because the Sig. value is less than $\alpha = 0.05$ ($0.002 < 0.05$), the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This finding indicates a statistically significant difference in mathematics learning outcomes between fourth-grade students who learned through the STEM approach and those who were taught using traditional instructional methods.

d) Second Hypothesis Testing

The second hypothesis of this research asserts that a significant difference exists in the creative thinking abilities of fourth-grade elementary students who learn through the STEM approach compared to those who undergo conventional instruction. To evaluate this hypothesis, a MANOVA analysis was carried out using SPSS version 26.0, and the results are outlined in the following table.

Table 8. Results of MANOVA Test Analysis of Creative Thinking Levels of Fourth Grade Elementary School Students

Tests of Between-Subjects Effects						
Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Learning outcomes	372.100a	1	372,100	5.152	.029
	Creative Thinking Level	1562.500b	1	1562,500	45,832	.000
Intercept	Learning outcomes	267649.600	1	267649.600	3706.113	.000
	Creative Thinking Level	256,000,000	1	256,000,000	7509.070	.000
Class	Learning outcomes	372,100	1	372,100	5.152	.002
	Creative Thinking Level	1562,500	1	1562,500	45,832	.000
Error	Learning outcomes	2744.300	38	72,218		
	Creative Thinking Level	1295,500	38	34,092		
Total	Learning outcomes	270766.000	40			
	Creative Thinking Level	258858.000	40			
Corrected Total	Learning outcomes	3116.400	39			
	Creative Thinking Level	2858,000	39			

a. R Squared = .119 (Adjusted R Squared = .096)
b. R Squared = .547 (Adjusted R Squared = .535)

According to the MANOVA results shown in the Tests of Between-Subjects Effects table, the significance value (Sig.) for the Class variable related to creative thinking skills was 0.000, with an F-value of 45.832 at the 5% significance level. Since the Sig. value is less than $\alpha = 0.05$ ($0.000 < 0.05$), the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This result shows a notable difference in creative thinking skills between students who were taught through the STEM approach and those who underwent conventional learning. Hence, it can be concluded that the STEM approach is more effective in enhancing students' creative thinking abilities compared to traditional instructional methods.

e) Third Hypothesis Testing

The third hypothesis in this study suggests that significant differences exist in both creative thinking abilities and mathematics learning outcomes between fourth-grade elementary students who are taught using the STEM approach and those who receive conventional instruction. To test this hypothesis, a MANOVA analysis was performed with the aid of SPSS version 26, and the results are displayed in the table below:

Table 9. MANOVA Test Analysis Results of Learning Outcomes and Creative Thinking Levels of Fourth Grade Elementary School Students

Multivariate Tests					
Effect	Value	F	Hypothesis df	Error df	Sig.

Intercept	Pillai's Trace	.997	5756.262b	2,000	37,000	.000
	Wilks' Lambda	.003	5756.262b	2,000	37,000	.000
	Hotelling's Trace	311,149	5756.262b	2,000	37,000	.000
	Roy's Largest Root	311,149	5756.262b	2,000	37,000	.000
Class	Pillai's Trace	.582	25.711b	2,000	37,000	.000
	Wilks' Lambda	.418	25.711b	2,000	37,000	.000
	Hotelling's Trace	1,390	25.711b	2,000	37,000	.000
	Roy's Largest Root	1,390	25.711b	2,000	37,000	.000

a. Design: Intercept + Class

b. Exact statistics

The MANOVA results displayed in the Multivariate Tests table indicate that the Wilks' Lambda value is 0.418, accompanied by an F-value of 25.711 and a significance level (Sig.) of 0.000. Since this significance value is less than $\alpha = 0.05$ ($0.000 < 0.05$), the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is accepted. This indicates that there are significant simultaneous differences in creative thinking abilities and mathematics learning outcomes between students who were taught through the STEM approach and those who followed conventional learning methods. These findings affirm that the STEM approach exerts a significant influence on both dependent variables, thereby supporting its effectiveness in enhancing students' creative thinking abilities and overall learning quality.

DISCUSSION

The findings of this research demonstrate that the integration of the STEM (Science, Technology, Engineering, and Mathematics) approach in mathematics instruction for fourth-grade students in Cluster 2, Tanjung Mutiara District, significantly enhances both students' learning outcomes and their creative thinking abilities. The prerequisite tests confirmed that the data met the assumptions for MANOVA analysis, as the results indicated normal distribution (Sig. > 0.05) and homogeneous variance (Sig. > 0.05). This finding strengthens the reliability of the statistical analysis procedure used and ensures that the differences found are not due to the unfairness of the data distribution, but rather the effect of the treatment given.

The MANOVA analysis results revealed significant differences between the experimental and control groups across both dependent variables. Regarding mathematics learning outcomes, the analysis yielded an F-value of 5.152 with a significance level of 0.002 ($p < 0.05$). This finding suggests that students who were taught using the STEM approach attained better learning outcomes than those who received conventional instruction. Descriptively, the experimental group's mean posttest score exceeded that of the control group, indicating that integrating scientific, technological, engineering, and mathematical elements into real-world problem-solving activities enhances students' conceptual understanding and their ability to apply mathematical knowledge effectively in practical contexts. This result aligns with the view of Elvistoni & Ardiansyah (2024), who argue that a STEM-based learning model enhances active student engagement and deepens comprehension because mathematical concepts are contextualized within everyday life.

Support for these findings is also seen from a systematic literature review conducted by Azizah & Angelina, (2025), which concluded that STEM learning effectively develops higher-order thinking skills while improving conceptual understanding. Syarifuddin et al., (2025) added that the project-based STEM approach significantly improved understanding of mathematical concepts. Pedagogically, the higher learning outcomes in the experimental group can be explained

by active learning mechanisms, where students not only learn procedures but also relate mathematical concepts to everyday experiences.

For the creative thinking variable, the analysis produced an F-value of 45.832 with a significance level (Sig.) of 0.000 ($p < 0.05$) and an R^2 value of 0.547 (Adjusted $R^2 = 0.535$). This result implies that 54.7% of the variance in students' creative thinking abilities can be attributed to the model incorporating the STEM approach. These results indicate that the STEM approach contributes substantially to developing students' creative thinking skills. STEM learning provides rich learning experiences, encourages students to generate original ideas, and strengthens divergent thinking skills. These findings are in line with the view Rahim, (2024), which emphasizes that an interdisciplinary approach demands the use of higher-order thinking skills, including creativity and innovation.

Simultaneously, the multivariate test yielded Wilks' Lambda = 0.418 with $F = 25.711$ and Sig. = 0.000 ($p < 0.05$). These results confirm that the STEM approach not only impacts each variable separately but also simultaneously influences learning outcomes and creativity. This finding is in line with research Rudiana et al., (2025) which states that the integration of various disciplines in STEM strengthens knowledge transfer and increases student engagement. Furthermore, the findings related to the significant relationship between initial creativity and final creativity support this opinion Ananda et al., (2023) that creativity can be developed gradually through challenging and relevant learning experiences.

STEM-based learning environments typically utilize projects, experiments, and exploration of real-world problems to foster cognitive flexibility and creative thinking skills. Research Dewi et al., (2023), supports this finding by showing that students who participate in STEM learning are more creative than students in conventional learning. From the perspective of Vygotsky's (1978) social constructivism theory, this finding can be explained through the concept of the zone of proximal development (ZPD), where social interactions and teacher scaffolding help students achieve higher levels of cognitive development (L. Dewi & Fauziati, 2021). In the STEM context, teachers act as facilitators who guide discussions, direct exploration of concepts, and provide guidance when students encounter challenges.

Pedagogically, the success of the STEM approach is explained through the principle of active learning, where students actively design experiments, utilize technology, and apply mathematical and scientific concepts in relevant situations. Rochmawati et al., (2025) and Inayah, (2024), confirms that activity-based and collaborative learning strategies have a positive correlation with the development of student creativity. By creating an interactive, adaptive, and enjoyable learning environment, STEM supports balanced cognitive and affective development.

CONCLUSION

The application of the STEM (Science, Technology, Engineering, and Mathematics) approach in mathematics instruction for fourth-grade students in Cluster 2, Tanjung Mutiara District, has shown a notable influence on enhancing both creative thinking skills and learning achievement. The enhancement in creativity is reflected in improvements across indicators such as fluency, flexibility, originality, and idea elaboration, while mathematics achievement also shows a notable increase compared to instruction delivered through conventional methods. The MANOVA test shows a significant F value ($p < 0.05$) with a more dominant contribution to creativity, indicating the effectiveness of STEM in developing higher-order thinking skills. The implication of this study is that teachers are advised to integrate STEM in learning to increase students' motivation, creativity, and conceptual understanding.

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