



Creative Problem-Solving Skills in Learning with STEM Approach

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ABSTRACT

This study aims to determine the improvement of students' creative mathematical problem-solving skills in learning with the STEM approach. The population in this study were all VIII grade students of SMP Negeri 1 Bandar Lampung in the 2024/2025 academic year, and as many as 352 students were distributed in eleven classes. The samples of this study were classes VIII.7 and VIII.9, which were selected using a purposive sampling technique, and the research design used was a non-equivalent control group design. The data in this study are quantitative data obtained through tests to measure mathematical creative problem-solving skills. The data on the improvement score (N-Gain) in the experimental class was not normally distributed, so the data analysis in this study used the Mann-Whitney U test and the proportion test. Based on the results of the Mann-Whitney U test analysis, it was found that the increase in the mathematical creative problem-solving skills of students with the STEM approach was higher than the increase in the mathematical creative problem-solving skills of students in the conventional learning and the proportion of students who had well categorized mathematical creative problem-solving skills was more than 60% of the number of students with the STEM approach. Thus, the application of learning with the STEM approach is practical regarding the creative mathematical problem-solving skills of class VIII students at SMP Negeri 1 Bandar Lampung.

Keywords: creative mathematical problem-solving skills; effectiveness; STEM approach

INTRODUCTION

In the 21st century, technological development is taking place rapidly (Halim, 2022). (Megahantara, 2017; Rukmana et al., 2023) State's that technology has a significant influence, one of which is in the field of education, which offers benefits and opportunities for students and educators by creating an interactive learning environment that can increase understanding and retention of information. In addition, technology allows teachers to develop a curriculum tailored to each student's needs and provides a more effective learning experience (Fricticarani et al., 2023). Based on this description, technology has a substantial role in education, facilitating individual development significantly.

Mathematics is one of the fields of science that has a vital role in technological advances taught at all levels of education (Nahdi, 2019). According to Juanda et al. (2014), mathematics is a basic science that supports the development of modern technology, has a vital role in various other fields of science, and contributes to improving thinking skills. This is in line with the opinion of Sari et al. (2019), who also revealed that mathematics has a vital role in various fields of science and can improve thinking skills. Thus, based on the above description, it can be concluded that mathematics has a fundamental role in

developing technology and various other disciplines and serves as a tool for improving thinking skills.

Improving the quality of mathematics learning at all levels of primary and secondary education in Indonesia requires developing thinking and 21st-century skills. The 21st-century skills in question are the ability of each individual to master the 4Cs, which are the keys to achieving success in community life in the 21st century (Arnyana, 2019). Furthermore, according to the US-based Partnership for 21st Century Skills (P21), four skills are needed in 21st-century learning: critical thinking and problem-solving, communication, collaboration, creativity, and innovation (Zubaidah, 2018). Creative problem-solving (CPS) is one of the skills that hone the problem-solving skills and creativity of thinking of students.

Teffinger et al. suggested that creative problem-solving skills are an ability that encourages a person to create various ideas and think creatively based on a strong theoretical and research foundation to adapt the use in situations that can be applied effectively in everyday life according to the context (Saenboonsong & Poonsawad, 2024). In line with this opinion, Amran (2019) revealed that creative problem-solving is a problem-solving ability that requires the ability to use the mind to explore appropriate, creative ideas and alternative ways to overcome shortcomings or obstacles in achieving the desired goals. Thus, creative problem-solving is a person's ability to find innovative solutions and enable creative ideas to solve problems by applying different contexts in learning.

Creative problem-solving skills in mathematics are essential for students to possess, but in fact, the creative problem-solving skills of Indonesian students are still relatively low. The Organization for Economic Cooperation and Development (OECD) announced the results of PISA 2022, where Indonesia ranked 70th out of 81 participating countries. One indication of this phenomenon is that the PISA 2022 results show an average score of 366, which has decreased compared to 2018, with an average score of 379. In 2022, Indonesia's average math score is equivalent to the score in 2000, which was 367.

Meanwhile, conditions in the field show that students' creative mathematical problem-solving skills are still relatively low. This is based on the preliminary test results of students at SMP Negeri 1 Bandar Lampung. The question was tested on a group of students in class 9.8 of SMP Negeri 1 Bandar Lampung to measure students' mathematical creative problem-solving skills in the field, with 21 students taking the test. Based on the test results, about 9.52% (2 out of 21 students) could answer the question with one correct answer, while about 90.48% could not provide correct and complete answers. In these students' answers, students only provide one idea or answer based on their understanding. However, the method given by students is limited to one point of view that is generally taught at school, without considering other variations of ways to solve the problem. This condition shows a low indicator of developing unusual or uncommon plans. This also results in low indicators of planning problems in more than one way and being able to change approaches or ways of thinking. Based on the description above, the creative mathematical problem-solving skills of SMP Negeri 1 Bandar Lampung students are still low. The Students' low mathematical and creative problem-solving skills of students are caused by several factors, one of which is the ineffective learning process. In addition, the

lack of technology integration, where technology can be a potent tool to improve creative mathematical problem solving, but the lack of technology integration in mathematics learning can reduce students' opportunities to develop these skills. This is the opinion of Milah et al. (2022), who said that technology helps train mathematical skills by guiding learners through structured steps in solving mathematical problems.

The STEM (science, technology, engineering, and mathematics) approach can be applied to make math learning more interesting and effective in improving students' creative problem-solving skills in the 21st century. STEM is an approach that integrates science, technology, engineering, and mathematics thoroughly into problem-based learning, where knowledge and skills are used together to solve specific situations or problems (Mulyani, 2019). STEM is a means for students to generate ideas based on science and technology through exploratory activities in thinking and solving problems based on four integrated disciplines (Indarwati, 2021). According to Suryani et al. (2023), the four STEM disciplines are science, technology, engineering, and mathematics as follows:

1. Science fosters students' curiosity and understanding of the living, material, and physical world and the development of teamwork, research, critical thinking, and experimentation skills.
2. Technology, a multitude of disciplines covering a wide range of fields, is the application of computational knowledge, skills, and thinking to enhance human capabilities and help fulfill needs and wants.
3. Engineering is the skills and knowledge to design and create practical machines, equipment, and procedures to solve real-world problems.
4. Mathematics equips the skills to interpret information, simplify, streamline problems, and help fulfill human needs and desires.

In line with the demands of 21st-century education, STEM aims for students to have science and technology literacy obtained from reading, writing, observing, and doing science so that when students enter society, they can develop and apply the competencies they have to deal with problems in everyday life related to the STEM field of science (Mu'minah & Aripin, 2019). Therefore, the STEM approach helps explore students' potential by utilizing skills and learning processes in science, technology, engineering, and mathematics to stimulate creative thinking in solving problems. So based on that, this research was conducted to determine the extent to which the STEM approach affects students' creative problem-solving skills in learning.

RESEARCH METHODS

The research was conducted at SMP Negeri 1 Bandar Lampung with a population of all grade VIII students in the odd semester of the 2024/2025 academic year distributed in 11 classes, namely classes VIII.1 to VIII.11. Each class consists of 32 students with a total of 352 students. Sampling was carried out using the purposive sampling technique, which is a sampling technique with specific considerations. Sampling in this study was based on the existence of two teachers who teach grade 8. With this technique, two classes will be taken from 5 classes taught by the same mathematics teacher with almost identical average end-of-semester assessment scores. The classes selected as research samples were

class VIII.9, previously class VII.10 as the experimental class, and class VIII.7, previously class VII.2 as the control class. Using a non-equivalent control group design in the experimental class, learning with the STEM approach and conventional learning in the control class. After the treatment, a posttest was conducted to determine the improvement of creative problem-solving skills in both classes.

A total of 2 questions related to SPLDV were used to collect data on students' mathematical creative problem-solving skills before and after being treated with different learning applications. The determination of scores is based on nine indicators of creative mathematical problem-solving ability used, which are 1) identifying the most relevant information (I1), 2) planning problems in more than one way (I2), 3) being able to change approaches or ways of thinking (I3), 4) developing unusual or uncommon plans (I4), 5) solving problems with more than one answer (I5), 6) solving problems in various ways (I6), 7) solving problems that are different (unique) from usual (I7), 8) solving problems in detail (I8), and 9) checking back (I9). Before all test questions are used to collect data on students' creative mathematical problem-solving skills, test the item's validity, reliability, differentiating power, and difficulty level of the items. Based on the results of the trials that have been carried out, the test questions used are valid and reliable with a reliability coefficient of 0.70, differentiating power on sufficient and reasonable criteria, as well as moderate and easy difficulty levels. So that all test questions fit the specified criteria and are suitable for use.

RESULTS AND DISCUSSION

Table 1 describes the pretest and posttest results for students' mathematical creative problem-solving skills.

Table 1. Descriptive Analysis of Students' Initial and Final Mathematical CPS skills

Class	Students' Mathematical CPS Initial Skills				Students' Final CPS Mathematical Skills			
	\bar{x}	High score	Low score	S	\bar{x}	High score	Low score	S
	Experiment	7.97	22	3	6,05	46.25	54	34
Control	7.63	22	2	5,71	31.59	47	12	7.94

Based on Table 1, it was found that the treatment with different learning in both classes affected students' final mathematical CPS ability. The STEM approach to learning is more effective in improving students' CPS skills than conventional learning, with a considerable difference in scores. In addition, based on the data of students' initial and final mathematical abilities, it is known that the difference in the increase in the achievement of indicators in the two classes is presented in Figure 1.

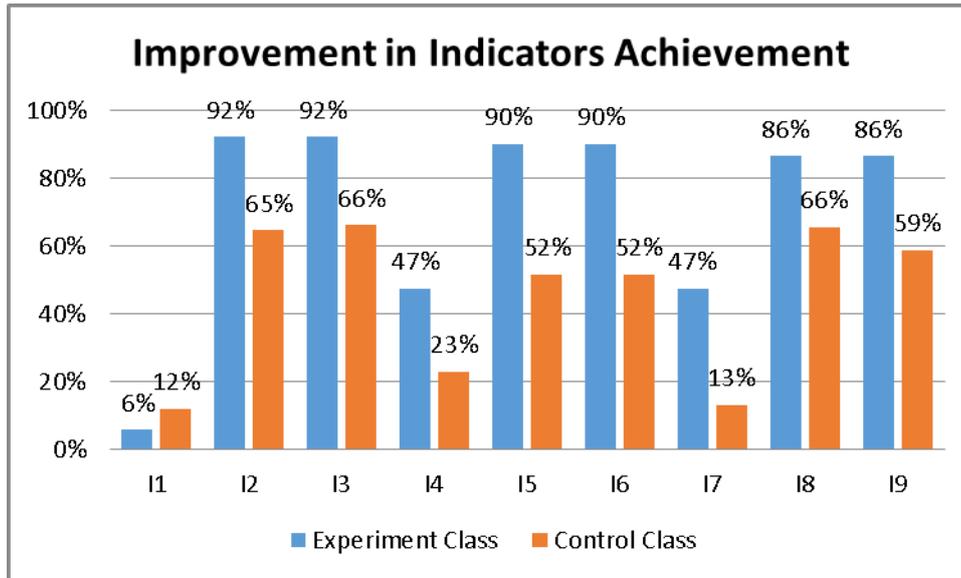


Figure 1. Improvement in Indicators Achievement

Furthermore, Table 2 lists how the improvement score (gain) is calculated, and Table 3 lists the prerequisite tests in both classes with the results.

Table 2. The Results of The Calculation of Score Improvement (N-gain)

Class	\bar{x}	N-Gain Lowest	N-Gain Highest
Experiment	0.83	0.52	1.00
Control	0.51	0.13	0.83

Table 3. Gain data prerequisite test results

Class	Prerequisite Test		
	Normality		Test Decision
	χ^2_{count}	χ^2_{table}	
Experiment	17.757	7,81452	H_0 rejected
Control	2.681		H_0 Retrieved

Based on Table 3, the test criteria with a significant level $\alpha = 0.05$ is to accept H_0 if $\chi^2_{count} \geq \chi^2_{table} = \chi^2_{(1-\alpha)(k-3)}$ (Sudjana, 2005). That shows that the test decision for the experimental class is H_0 rejected, which means that the experimental class gain data comes from a population that is not normally distributed, while the test decision for the control class is H_0 accepted, which means that the control class gain data comes from a normally distributed population. Therefore, the first hypothesis was tested using the Mann Whitney-U test presented in Table 4.

Table 4. First Hypothesis Test Results

Mann Whitney-U Test			
Z_{count}	Z_{table}	α	Test Decision
5,77	1,96	0,05	H_0 rejected

Based on Table 4, the criteria for hypothesis testing is to accept H_0 if $|Z_{count}| < Z_{table}$ with a significant level of $\alpha = 0,05$. That shows that the test decision is rejected,

which means that the median gain score of students' mathematical creative problem-solving skills with the STEM approach significantly differs from that of students' mathematical creative problem-solving skills in conventional learning. Furthermore, further analysis is carried out according to (Sheskin, 2000) by comparing the average sample data with higher values. Furthermore, in Table 1, the average increase (gain) in the mathematical creative problem-solving skills of students who follow learning with the STEM approach is significantly higher than the average increase (gain) in the mathematical creative problem-solving ability of students who follow conventional learning.

The following hypothesis test is the proportion test. The proportion test was conducted to determine the proportion of students with *creative mathematical problem-solving* skills categorized as good in the experimental class, which was more than 60% of the total students. In this study, the determination of the category of students' *creative problem-solving* skills is based on the opinion of Azwar (2006), which reveals that the grouping of student scores can be divided into three parts determined using student posttest scores (X), average (\bar{x}), and standard deviation (s) with criteria: (1) high criteria if $X \geq \bar{x} + s$, (2) medium criteria if $\bar{x} - s \leq X < \bar{x} + s$, and (3) low criteria if $X < \bar{x} - s$.

Table 5. Second Hypothesis Test Results

Proportion Test			
Z_{count}	Z_{table}	α	Test Decision
2,45	1,64	0,05	H_0 rejected

Based on Table 5, the test criteria used are accept H_0 if $Z_{count} < Z_{0.5-\alpha}$ and reject H_0 for other things. The test decision is H_0 rejected, meaning that the proportion of students with good creative mathematical problem-solving skills is more than 60% of the students learning with the STEM approach.

The STEM approach with a guided inquiry model improves students' creative mathematical problem-solving skills better than conventional learning. This approach gives students more opportunities to explore, ask questions, investigate, and collaborate with teacher guidance as a facilitator. In line with Hulu et al. (2023), guided inquiry encourages students' active involvement in understanding concepts and conducting experiments. Nasir et al. (2022) also stated that STEM-integrated guided inquiry learning helps students build concepts, elaborate, and solve complex problems.

The initial stage of STEM-integrated guided inquiry is problem orientation, where the teacher divides students into heterogeneous groups (5-6 people) and provides daily problems through LKPD at each meeting. Students read technology-related science problems and then discuss them to identify information and solutions actively. The teacher guides them in connecting mathematical ideas and creative thinking. At this stage, students understand the problem, write the information correctly, and understand the expected solution. By Fitriansyah et al. (2021), the STEM approach in guided inquiry improves students' scientific attitudes and work. This stage also trains the creative problem-solving indicator, namely identifying relevant information.

The next stage is collecting data and information (exploration). The exploration stage involves discussion and investigation of problems with technology. Students

enthusiastically use GeoGebra, the internet, digital scales, and rulers to gather information and discuss solution strategies. In line with Rahmawati and Juandi (2022), STEM learning utilizes technology-based teaching materials. Students' responses varied; some were already skilled in using technology, while others needed guidance. Students who mastered the technology contributed more actively and showed good initial understanding. This stage hones creative problem-solving, especially in planning solutions in various ways, changing approaches, and developing unusual strategies.

The next stage is interpreting and integrating information (reasoning). The reasoning stage directs students to interpret and incorporate new knowledge. They analyze data, compare it with previous understanding, and connect concepts to build solutions. Students enthusiastically compose arguments, evaluate solutions, and conclude. By Yuniarti et al. (2023), guided inquiry with a STEM approach encourages exploration, design, discussion, and creating fun learning. This stage trains students to change their thinking approach and develop unusual plans.

The next stage is to create and develop a product solution to the problem (creating). In the creating stage, each group applies knowledge to create innovative solutions. Students design, develop, and present products using technology according to the problems in the LKPD. In the second meeting, they made tempeh (yeast and soybeans); in the fourth meeting, they made ice cream (dragon fruit and yogurt); and in the sixth meeting, they made saline solution (water and salt). According to Mulyani (2019), the STEM approach encourages students to design, utilize technology, and hone cognitive and affective. This stage trains students to solve problems and more detailed solutions.

The last stage is presenting, analyzing, and evaluating problem-solving products (communicating). Students discuss, analyze, and assess problem-solving products with the teacher's guidance. One group is appointed to present the results, while other students ask questions and give opinions. They also evaluate the process and conclude. According to Mulyani (2019), STEM learning trains students to apply knowledge to design technology-based solutions. This stage helps students double-check and solve problems in various, more detailed ways.

Conventional learning also improves creative mathematical problem-solving skills, but not as well as guided inquiry integrated with STEM. In conventional learning, students only rely on textbooks that are limited in presenting concepts practically. In contrast, STEM learning emphasizes direct application through experiments, projects, and real problem-solving, making it more effective in preparing students to face real-world challenges. Both classes improved, but some indicators in the control class were not significant. Developing unusual plans increased from 8% to 31%, while the indicator of solving different problems than usual rose from 8% to 21%, which did not reach half the increase.

Based on the explanation above, conventional learning is less effective in improving students' creative mathematical problem-solving because it focuses more on theory and memorization without involving students in creative problem-solving. Students only remember information from books without applying it in real situations. In contrast, STEM learning improves students' creative mathematical problem-solving, providing more opportunities through hands-on experiences, experiments, and innovative challenges.

CONCLUSION

Based on the research and discussion results, it can be concluded that the application of learning with the STEM approach is practical terms of mathematical creative problem-solving skills of students in class VIII.9 in related schools. That can be seen from the proportion test, where the proportion of students with well-categorized mathematical creative problem-solving skills is more than sixty percent of the number of students with the STEM approach.

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