International Conference on Elementary Education
Volume 8, Nomor 1

e-ISSN: 2808-8263
p-ISSN: 2829-0976

Application of STEAM Project Based Learning Model to Improve Mathematical Creativity of Sixth Grade Students at SDN Binong, Pamarayan

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Abstract. Mathematics learning in elementary schools is often still oriented towards final results and calculation skills alone, rather than the creative thinking process of students. Phenomena in the field show that most students experience difficulties when faced with contextual problems that require flexible and innovative thinking. This indicates that procedural learning has not been able to foster creativity and mathematical imagination. To address this challenge, this study aims to examine the effectiveness of project-based STEAM learning in improving the mathematical creativity of sixth-grade students at SDN Binong Elementary School in Pamarayan District. The study uses a quantitative approach with a one-group pretest-posttest design, involving 28 students. The instruments used are mathematical creativity tests and learning activity observation sheets. The results of the analysis using a paired t-test showed a significant increase in students' mathematical creativity, with a pretest average score of 60.7 and a posttest average score of 84.2 ($t = 9.03$; $p < 0.05$). The most prominent improvement occurred in the aspects of originality and flexibility of thinking. These results indicate that project-based STEAM learning is able to transform the classroom into a space for exploring ideas, fostering the courage to innovate, and developing creative thinking skills in the context of real life.

Keywords: STEAM, Project Based Learning, Mathematical Creativity, Elementary School.

INTRODUCTION

Mathematics education in elementary school plays a fundamental role in shaping students' logical, systematic, and creative thinking skills. However, in practice, mathematics education at the elementary level is still oriented towards procedural skills and final results, such as calculation accuracy and mastery of formulas, thereby failing to foster divergent and innovative thinking skills (Shan, 2024). This orientation causes students to be less accustomed to dealing with open-ended problems that require creative reasoning and flexibility in thinking. As a result, students often experience difficulties in solving contextual problems that require exploration of ideas and varied solution strategies (Manfreda Kolar and Hodnik, 2021).

Mathematical creativity is one of the important competencies of the 21st century that needs to be developed from elementary education. Silver (2024) states that creativity in mathematics includes the ability to produce original, flexible, fluid, and mathematically valuable ideas. Thus, mathematics learning should not only emphasize the final result but also the students' thinking process in finding various possible solutions. Recent research shows that the development of mathematical creativity is closely related to higher-order thinking skills, problem solving, and mathematical literacy (Genç et al., 2025; Muttaqin and Tohir, 2021; Sulistyaningsih et al., 2025). Therefore, a learning model is needed that can activate the role of students as a whole in exploring concepts, experimenting, and collaborating.

One relevant model for developing mathematical creativity is Project-Based Learning (PjBL). The PjBL model places students as active subjects who are directly involved in the process of designing and completing real projects. Omelianenko (2024) asserts that project-based learning encourages students to learn through authentic experiences that are challenging, meaningful, and contextual. In line with this, several studies show that the application of PjBL can increase student engagement, critical thinking skills, and mathematical creativity (Rehman et al., 2024; Rusmana et al., 2025; Sholeh et al., 2024). However, in order for project-based learning to not be merely product-oriented, this approach needs to be enriched with the Science, Technology, Engineering, Art, and Mathematics (STEAM) framework, which emphasizes the integration of various disciplines.

Students can think across disciplines, relate abstract mathematical ideas to practical applications, and communicate ideas via creative creativity according to the STEAM method (Wannapiroon and Pimdee, 2022). Through design exercises, experiments, and project presentations, PjBL and STEAM integration enhances students' emotional and psychomotor as well as cognitive elements (Fadhilah et al., 2025). According to a number of recent research, using STEAM-based learning can help primary school kids become more creative, collaborative, and adept at solving problems (Rosyida et al., 2025; Wahyudi et al., 2024). Therefore, it is anticipated that the use of the STEAM-based PjBL paradigm in mathematics education would change the classroom into a place for idea exploration, encouraging the bravery to create, and cultivating contextual mathematical creative thinking abilities.

In addition, current national education policies that promote the strengthening of the Pancasila Student Profile through project-based learning are in line with the implementation of STEAM-based PjBL models (Devega, 2024). The deep learning curriculum mandates that students demonstrate critical, creative, and collaborative thinking skills as a form of preparation for the challenges of the 21st century. In this regard, STEAM Project-Based Learning (PjBL) emphasizes students' scientific and creative thought processes during learning activities in addition to the completion of the final output.

Furthermore, the STEAM approach applies an integrated, cross-disciplinary framework that connects mathematical concepts with science, technology, engineering, and the arts. This integration allows students to understand mathematical concepts in a contextual and meaningful way. Through project activities, students have the opportunity to develop ideas, design solutions, and present their findings. This leads to intrinsic motivation and a sense of responsibility for the learning process (Orsini et al., 2016).

e-ISSN: 2808-8263
p-ISSN: 2829-0976

Selain dari sisi akademik, model ini juga relevan dalam konteks pembentukan karakter siswa di sekolah dasar. Proyek yang dirancang secara kolaboratif menumbuhkan keterampilan sosial, empati, dan komunikasi antarpeserta didik. Menurut Mahmudah et al., (Mahmudah et al., 2024), The integration of art into mathematics learning can encourage students to express mathematical ideas visually and creatively, making learning more enjoyable and meaningful. Therefore, this study has an important urgency to examine the effectiveness of implementing the STEAM-PjBL model as a learning innovation that can meet the needs of developing the mathematical creativity of elementary school students in the digital age.

According to the description given above, the purpose of this study is to determine how well sixth-grade students at SDN Binong Elementary School in Pamarayan District can develop their mathematical creativity through the use of the STEAM-based Project Based Learning paradigm. It is anticipated that this study would potentially aid in the creation of an integrative and useful mathematics learning model for primary school teachers in order to create engaging, innovative learning experiences that meet the objectives of 21st-century learning.

METHODOLOGY

This study employed a one-group pretest–posttest design, a quantitative technique, and a quasi-experimental methodology. Because it may be used to measure changes in ability in the same group before and after therapy, this design was selected (Creswell and Creswell, 2017). In this design, the study participants were administered a pretest to ascertain their baseline mathematical creativity abilities, followed by treatment in the form of the implementation of a STEAM-based Project Based Learning (PjBL) model, and a posttest to assess the improvement in these abilities.

Research Subject and Location

The research was conducted at SDN Binong Elementary School, Pamarayan District, Serang Regency, Banten Province, in the even semester of the 2025/2026 academic year. The research subjects consisted of 28 sixth-grade students, comprising 14 male students and 14 female students. The subjects were selected using purposive sampling, which involved selecting classes that were considered to have characteristics suitable for the research needs, such as heterogeneous academic abilities and sufficient learning time for project implementation.

Research Procedures

The planning, implementation, and assessment phases comprised the three primary phases of this study's execution. In the preparation stage, the researcher developed learning tools that included a Lesson Plan (RPP), STEAM-based project worksheets, and mathematical creativity assessment instruments. In addition, coordination was carried out with classroom teachers to determine the implementation schedule and project context relevant to the sixth-grade mathematics learning theme.

The implementation stage began with a pretest to measure students' initial mathematical creativity skills. Next, students participated in the learning process using a STEAM-based Project-Based Learning (PjBL) model for four meetings or eight lessons. In this process, students worked in small groups to design, create, and present project products that integrated mathematical concepts with elements of science, technology, engineering, and art. Teachers acted as facilitators who provided guidance, feedback, and facilitated reflection on the students' learning process.

The final stage is the evaluation stage, which is conducted after all learning activities have been completed. At this stage, students are given a posttest to determine the increase in mathematical creativity after the application of the learning model. In addition, researchers also observe student learning activities during the learning process to assess the level of engagement and creativity that emerges in the implementation of the project.

Research Instruments

The research instruments used consisted of two types, namely mathematical creativity tests and learning activity observation sheets (Kadir and Satriawati, 2017). The mathematical creativity test took the form of a description developed based on four indicators of creativity according to Silver (2024), namely fluency as the ability to generate many ideas in solving problems; flexibility as the ability to use various solution strategies; originality as the ability to express unique ideas or solutions; and elaboration as the ability to develop or expand ideas in detail. This test was validated through expert judgment by three mathematics education lecturers and experienced elementary school teachers. The reliability of the instrument was calculated using the Cronbach's Alpha formula with a coefficient of 0.87, which indicates a high level of reliability (Sugiyono, 2021).

In addition, a learning activity observation sheet was used to monitor student participation during the implementation of STEAM-based projects. The aspects observed included active involvement, group cooperation, idea exploration, and creative problem-solving skills.

e-ISSN: 2808-8263
p-ISSN: 2829-0976

Data Analysis Techniques

The pretest and posttest data were analyzed using a paired sample t-test to determine the significance of the difference in means before and after treatment. This test was conducted after the data met the assumption of normality, which was tested using the Shapiro–Wilk test. The increase in mathematical creativity was also calculated using the N-Gain Score, with interpretation criteria according to Hake (1998): low ($g < 0.3$), moderate ($0.3 \leq g < 0.7$), and high ($g \geq 0.7$). Data analysis was performed using SPSS version 25.0.

To ensure the reliability of research results, data quality control measures are carried out systematically (Andespa, 2020). Instrument validation involved not only mathematics education experts, but also elementary school practitioners who understood the characteristics of the students. Each item was tested for readability and relevance to indicators of mathematical creative thinking skills. In addition, limited trials were conducted in other classes to ensure that the level of difficulty and discriminating power of the instrument were within the acceptable range.

Researchers also sought to minimize bias that could affect the results by applying consistent learning procedures between sessions. Classroom teachers were involved as research partners through brief training on the application of the STEAM-based PjBL model. Observations were conducted by two independent observers using standardized observation sheets to maintain objectivity in assessing student activities during learning.

To reinforce the quantitative results, observational data was analyzed descriptively and qualitatively in order to illustrate changes in student behavior and engagement levels. With this approach, the findings not only showed an increase in numerical scores, but also provided a clear picture of the learning process that took place in the classroom. Triangulation analysis of data from test results, observations, and documentation was conducted to gain a comprehensive understanding of the effectiveness of the STEAM-PjBL model in developing students' mathematical creativity.

RESULTS AND DISCUSSION

The purpose of this study is to ascertain how well sixth-grade students at SDN Binong Elementary School in the Pamarayan District can develop their mathematical creativity by using the STEAM-based Project Based Learning paradigm. Data came from the pretest and posttest outcomes of students' mathematical creative skills, which were given both before and after the learning was put into practice.

The pretest and posttest scores for mathematical creativity were analyzed descriptively to see the difference in students' ability levels before and after the learning model was implemented.

Table 1. Descriptive Statistics of Students' Mathematical Creativity Scores

Statistic	Pretest	Posttest	Difference
Number of Students (n)	28	28	–
Highest Score	78	96	–
Lowest Score	42	70	–
Mean	60.7	84.2	23.5
Standard Deviation	8.9	7.4	–

The table above shows that there was an increase in the average mathematical creativity score of 23.5 points after the implementation of the STEAM-based PjBL model. In addition, the score distribution shows that most students experienced an increase in the four creativity indicators, with the highest increase in the aspects of originality and flexibility of thinking.

To determine the significance of the difference in abilities before and after the treatment, a paired sample t-test was conducted.

Table 2. Paired Sample t-Test Result for Mathematical Creativity

Variable	Mean Difference	t-value	df	Sig. (2-tailed)
Posttest – Pretest	23.50	9.03	27	0.000

A t-value of 9.03 with $p < 0.05$ was found based on the analytical findings in Table 2. This suggests that the pretest and posttest results differ significantly. Therefore, it can be said that using the STEAM-based Project Based Learning paradigm significantly enhances students' mathematical creativity.

In addition to the t-test, the increase in learning effectiveness was calculated using the N-Gain score.

Table 3. N-Gain Calculation Results for Mathematical Creativity

Improvement Category	N-Gain Range	Number of Students	Percentage (%)
High	$g \geq 0.7$	17	60.7
Medium	$0.3 \leq g < 0.7$	11	39.3
Low	$g < 0.3$	0	0

e-ISSN: 2808-8263
p-ISSN: 2829-0976

Table 3 presents the results of the N-Gain analysis used to assess the improvement in students' mathematical creativity. The data reveal that a majority of students achieved a high level of improvement, with 17 learners (60.7%) reaching an N-Gain score of $g \geq 0.7$. Meanwhile, 11 students (39.3%) fell into the medium improvement category, obtaining N-Gain values ranging from $0.3 \leq g < 0.7$. Notably, none of the students recorded an N-Gain score below 0.3, indicating the absence of participants in the low improvement category. Overall, the distribution suggests that the learning intervention was effective in enhancing students' mathematical creativity, as evidenced by the predominance of high and medium N-Gain classifications.

The results of the study show that the application of the STEAM-based Project Based Learning model significantly increases students' mathematical creativity. This improvement covers the aspects of fluency, flexibility, originality, and elaboration of ideas. These findings reinforce previous research results which state that project-based learning provides authentic and contextual learning experiences, so that students can develop creative and collaborative thinking skills (Williamson, 2023).

The highest improvement was found in the aspects of originality and flexibility of thinking, indicating that the STEAM approach provides space for students to express unique ideas and try various problem-solving strategies. This is in line with the opinion of Wannapiroon et al., (2022) that the integration of art and technology in mathematics learning can enrich the creative thinking process because students do not only focus on the results but also on the process of exploring ideas.

In addition, the characteristics of Project Based Learning, which emphasizes collaboration and real-world problem solving, make students more motivated to participate actively. For example, STEAM-based project activities in the sixth grade at SDN Binong require students to design simple building models using geometric concepts, measure scale, and calculate surface area. This process requires the application of mathematical concepts, design creativity, and effective teamwork. Such activities encourage the integration of cross-disciplinary knowledge as stated by Wibawa (2024).

The increase in mathematical creativity can also be explained through constructivism theory, in which knowledge is constructed through experience and reflection Piaget in (Sugiyono, 2021). Through STEAM projects, students not only learn mathematical concepts passively but also construct meaning through exploration and direct application. Thus, learning activities become more meaningful and oriented toward developing students' creative potential.

Overall, the results of this study indicate that the application of the STEAM-based Project Based Learning model is effective in improving the mathematical creativity of elementary school students. These findings have important implications for teachers and primary education practitioners to integrate cross-disciplinary projects that encourage innovation, critical thinking, and collaboration as part of mathematics learning.

In addition to quantitative findings that show a significant increase in mathematical creativity, the results of observations also indicate a noticeable change in student learning behavior. In the experimental class, students appeared more enthusiastic, actively engaged in discussions, and showed a high level of curiosity about the project assignments given. They not only completed the teacher's instructions, but also took the initiative to develop new ideas in designing solutions to the problems they faced. This phenomenon shows that the STEAM-based PjBL approach is able to foster intrinsic motivation, which plays an important role in learning success.

Based on Vygotsky's social constructivism theory, interaction between students in the collaboration process is the key to creativity and new knowledge (Salsabila and Muqowim, 2024). When students work in project groups, they learn to negotiate ideas, present arguments, and combine different perspectives into a single integrated solution. This is also in line with research conducted by Lestari (2023), which found that the application of the STEAM-PjBL model improves students' divergent thinking skills because it provides space for experimentation and reflective evaluation of their own work.

In terms of implementation, teachers act as facilitators who help guide the students' exploration process without dominating the learning. Teachers provide formative feedback during the project process so that students can correct conceptual errors and develop ideas gradually. In this context, learning emphasizes not only the achievement of the final product, but also the scientific and creative thinking processes that students go through during the project. The adaptive and reflective role of teachers is an important element in ensuring that the implementation of STEAM-PjBL truly supports the development of mathematical creativity.

In addition, the results of this study show that integrating the arts into STEAM has a significant impact on students' flexibility of thinking. Activities such as drawing diagrams, designing models, and visualizing mathematical concepts in creative forms help students understand the relationship between abstract ideas and concrete representations. This is in line with the views of Shophian et al., (2023), who emphasize that aesthetic elements in learning can strengthen conceptual memory and increase students' emotional engagement with the

e-ISSN: 2808-8263
p-ISSN: 2829-0976

material. Thus, art is not just a complement to the STEAM approach, but an integral component that broadens the way students think and express their mathematical ideas.

Other findings show that STEAM-integrated project-based learning encourages students to take intellectual risks. They tend to be more willing to try new approaches to solving problems without fear of making mistakes. This is important in the context of creativity development because mistakes are considered part of a productive learning process. The safe and supportive learning environment built through the STEAM-PjBL model allows students to reflect on their own work and that of their peers.

Overall, these results reinforce the view that the STEAM-PjBL model not only affects academic achievement, but also shapes the creative, collaborative, and adaptive mindsets needed in 21st-century learning. By implementing this model continuously, elementary schools can create a more innovative learning culture, where students not only learn mathematics as a set of formulas, but as a means of thinking, creating, and solving contextual problems in everyday life.

CONCLUSION

The use of the STEAM-based Project Based Learning approach greatly enhances the mathematical creativity of sixth-grade students at SDN Binong Elementary School in Pamarayan District, according to the research findings and discussion. The average score increased from 60.7 on the pretest to 84.2 on the posttest, and the paired t-test findings demonstrated a significant difference ($t = 9.03$; $p < 0.05$). The areas of originality and thinking flexibility showed the biggest improvement, suggesting that integrating science, technology, engineering, art, and mathematics through contextual projects can enhance students' ability to develop concepts and find innovative solutions to mathematical problems.

These findings indicate that mathematics learning that integrates a project-based interdisciplinary approach not only improves conceptual understanding but also fosters the courage to innovate and think divergently. The STEAM-PjBL model turns the classroom into a space for exploring ideas and collaborating in ways that are relevant to students' real-life contexts. Therefore, elementary school mathematics teachers are advised to systematically implement this approach through structured project design, emphasizing exploration, experimentation, and reflection.

Practically speaking, the results of this study reinforce empirical evidence that STEAM-PjBL can be a strategic alternative in efforts to improve mathematical creativity in elementary schools. Meanwhile, theoretically, these findings contribute to the development of a 21st-century learning model that emphasizes cross-disciplinary integration and project-based learning. Further research is recommended to explore the impact of implementing STEAM-PjBL on other variables such as problem-solving skills, critical thinking, and learning motivation at different educational levels with a broader experimental design.

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