

Integration of STEAM Approach in Mathematics Learning to Enhance Creativity of Elementary School Students

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ABSTRACT

Creativity constitutes a fundamental competency for meeting the complex demands of the 21st century and should be cultivated from an early age, particularly within the context of mathematics education. This study aims to analyze the integration of the STEAM approach in mathematics learning as an effort to enhance the creativity of elementary school students. The study was conducted using a descriptive qualitative method through a literature review by analyzing eight relevant national and international articles related to the research topic. The results indicate that the STEAM approach is effective in developing three creativity indicators: fluency (the ability to generate many ideas), flexibility (the ability to think from various perspectives), and novelty (originality in ideas and solutions). Students become more active, able to solve problems innovatively, and relate mathematical concepts to real-life situations through project-based activities. The implementation of the STEAM approach also faces several challenges, including limited time, facilities and infrastructure, and teacher readiness. Therefore, continuous efforts are needed to optimize the integration of the STEAM approach to produce creative, adaptive students who are ready to face future challenges.

Keywords: Integration, STEAM Approach, Mathematics, Creativity, Elementary School

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INTRODUCTION

Education in the 21st century is no longer limited to knowledge transfer but emphasizes the enhancement of critical thinking, creativity, and collaborative skills (Trilling & Fadel, 2009). The 21st-century education faces many challenges, which align with the statement from the 21st Century Skills Partnership regarding the characteristics of 21st Century Skills. Students in the 21st century are required to develop competitive skills needed in today's era. These skills are not limited to reading and memorizing but also include several competencies summarized in the concept of the 6Cs: character, creative thinking, critical thinking, citizenship, communication, and collaboration (Maulidia et al., 2023). Creativity skills in the 21st century are applied to solve problems encountered in daily life (Chusna et al., 2024). Creativity encourages students to explore their own ideas, enabling the generation of new ideas and perspectives on a problem. When solving a problem, students view it from different perspectives and connect it with prior knowledge they already possess (Oktariani, 2024).

Creativity requires the balance of both hemispheres of the brain to harmonize logic and perception, as an excessive focus on logic can cause some creative ideas to be overlooked. Therefore, fostering creativity in an individual requires freedom of thought, free from pressure or external control. This statement aligns with Prawiyogi et al. (2021), who describe creativity as an original and reflective

idea that results in a detailed product. Furthermore, the creative thinking process involves combining various ideas, developing several new concepts, and evaluating the success of creating new products. The creativity level of students in Indonesia is relatively low based on field data. According to the Trends in International Mathematics and Science Study (TIMSS) 2019, Indonesia ranked 46th out of 58 countries with a low score of 397 compared to the international average score of 500. Another survey, the Programme for International Student Assessment (PISA) 2022, reported that Indonesian students' creativity remains low, ranking 79th out of 97 countries, with average scores of 383 in science, 359 in reading, and 366 in mathematics (OECD, 2023).

The creativity level of each individual varies, ranging from high to low, depending on whether their work reflects novelty within their field. Therefore, creativity is based on the originality and quality of the produced work as well as the process that demonstrates the transformation of several ideas. Additionally, strong motivation plays an important role in supporting the achievement of creative outcomes (Siswono, 2018). Enhancing students' creativity through STEAM-based learning also has long-term impacts on preparing the younger generation to face an increasingly complex and technology-based workforce in the future (Schwab, 2019). Project-based STEAM learning enables students not only to learn calculations but also to design innovative solutions to complex problems (Hanif et al., 2019). This is supported by research from Syaravina et al. (2023), which shows significant improvements in creativity indicators during project-based STEAM mathematics learning. This occurs because the STEAM approach encourages students to think multidimensionally by integrating mathematical knowledge with artistic aesthetics and technological functions.

The STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning approach has been recognized as an effective method to facilitate various forms of learning related to students' real-life experiences (Beers, 2014). The STEAM approach is crucial to implement in classroom learning as it bridges theory and practice into a unified whole, enabling students not only to receive theory passively but also to actively engage in a contextual and meaningful learning process (Mahmoudi et al., 2018). The implementation of the STEAM approach integrates various disciplines such as science, technology, engineering, arts, and mathematics, which can enhance a range of skills required by students in 21st-century education, including creativity (Papadopoulou, 2024). The STEAM learning model not only emphasizes mastery of academic concepts but also assists students in applying their knowledge to solve diverse problems. Therefore, integrating the STEAM approach in elementary school subjects, particularly mathematics, is important to prepare a young generation that is adaptive to changing times (Pramasdyahsari et al., 2025). The integration of STEAM learning in Indonesian education aligns with the direction of the Merdeka Curriculum development, which promotes differentiated and project-based learning. Hence, integrating the STEAM approach in mathematics can be an innovative way to optimally support the implementation of the Merdeka Curriculum (Rahma et al., 2025).

The integration of STEAM in mathematics learning provides students with the opportunity to express creative ideas in solving open-ended and exploratory problems. This approach combines conceptual understanding of mathematics with its application in projects involving science, technology, arts, and engineering (Pahmi et al., 2022). Mathematics learning in the classroom tends to be mechanistic and disconnected from real-life contexts; therefore, an innovative approach is needed to relate mathematics to everyday life in an engaging way, which can be achieved through the integration of the STEAM approach (OECD, 2023). Besides enhancing the appeal of the learning process, STEAM integration also promotes meaningful learning by constructing knowledge through direct experience. This process aligns with constructivist theory, which emphasizes that students build understanding through active involvement in learning activities (Kolb, 2014). The integration of STEAM in mathematics learning has several main objectives, one of which is fostering creativity as an essential skill in the 21st century (Robinson, 2015).

The STEAM approach, which integrates science, technology, engineering, arts, and mathematics, was developed in response to the need for more holistic and contextual learning to address the challenges of the current era (Beers, 2014). According to Yakman and Lee (2018), the STEAM approach enables students to connect academic concepts with real-life situations through exploration, investigation, and creation processes, thereby promoting the development of critical thinking, problem-solving, and creativity. Creativity, according to Guilford (1967), involves the ability to generate original and useful ideas within a specific context. In mathematics learning, creativity is evident in students' skills to find various problem-solving strategies and to create unique mathematical solutions. This notion is supported by Silver (1997), who emphasizes that creativity in mathematics learning is reflected in students' ability to discover diverse problem-solving approaches and develop unique mathematical solutions.

The STEAM approach offers a solution by integrating the arts into mathematics learning, allowing students to explore mathematical concepts through more contextual and creative activities. Other studies on the STEAM approach tend to be broader and not focused on a specific subject. For instance, research by Fadhillah et al. (2024) examined the implementation of the STEAM approach in elementary school science learning, focusing on enhancing students' skills in the context of science without specifically targeting creativity improvement. Several other studies combine the STEAM approach with various learning models and utilize educational media in the learning process. For example, research conducted by Audiana and Rusnilawati (2024) integrated the STEAM approach with an inquiry-based learning model assisted by live worksheets aimed at fostering problem-solving skills in elementary school students, which proved effective when applied in classroom learning. Based on these studies, it is important to conduct this research as there are still few studies that thoroughly examine the integration of the STEAM approach in mathematics learning to foster creativity among elementary school students. The objective of this study is to analyze effective strategies, models, and methods for implementing STEAM to develop student creativity, as well as to identify the fundamental concepts and principles of

the STEAM approach in elementary mathematics education. The STEAM approach has been widely used across various disciplines to enhance 21st-century skills; however, integration focused specifically on developing mathematical creativity in the context of elementary school learning remains limited, especially concerning the novelty aspect of students' ideas and solutions. Many previous studies have primarily highlighted fluency and flexibility dimensions, while the novelty dimension has not been deeply explored within project-based mathematics learning at the elementary level (Huang et al., 2021). Therefore, this study offers novelty by specifically investigating how the STEAM approach facilitates the generation of original, contextual, and unique mathematical ideas, thereby fostering creativity that is not only productive but also innovative.

This research also contributes to the development of a more applicable and relevant STEAM syntactic framework aligned with the characteristics of the Merdeka curriculum, particularly by linking the STEAM approach with local contexts and exploratory projects that can stimulate students' divergent thinking from an early age (Filipe et al., 2024). This aspect is crucial because mathematics learning is often perceived as static and logical, whereas through interdisciplinary approaches such as STEAM, students can actually find space to be creative and interpret mathematics as part of a holistic creation process.

In this context, Guilford (1967) emphasized that creativity involves not only generating many ideas but also producing ideas that are original and useful within a specific context. In line with this, Silver (1997) stated that students' ability to create unique problem-solving strategies is an important indicator of mathematical creativity, which, unfortunately, has not been widely studied in the implementation of the STEAM approach in elementary mathematics education.

METHOD

Study participants

This study employed a qualitative descriptive approach through an integrative literature review technique. The integrative review aims to synthesize and integrate findings from various studies related to the implementation of the STEAM approach in elementary school mathematics education. According to Machi and McEvoy (2016), a literature review is a research method that involves systematically collecting, evaluating, and analyzing multiple sources of relevant literature to provide a comprehensive understanding of a specific research topic.

Study organization

In this study, the researcher conducted a systematic search and selection of literature across several academic databases, including Google Scholar, ScienceDirect, and ERIC, using keywords such

as “integration of STEAM approach in mathematics” and “STEAM approach in mathematics to develop creativity.” A total of 10 relevant articles were identified, comprising six national and four international publications from the last ten years.

Statistical analysis

The selected studies were then critically evaluated based on predetermined criteria and summarized in a review table containing details such as the author’s name, research title, methodology, research findings, as well as similarities and differences across the studies. This systematic approach allowed for a thorough understanding of how the STEAM approach has been integrated into mathematics learning to enhance students’ creativity at the elementary school level..

RESULT AND DISCUSSION

The literature review conducted in this study aims to analyze the integration of the STEAM approach in mathematics subjects to develop creativity in elementary school students by collecting 8 literatures that discuss the STEAM approach in mathematics used to foster creativity among elementary school students. These articles were obtained from national and international journals through searches in various academic databases using specific keywords, followed by summarizing the findings.

1. Elhady (2020)

This study aims to determine the effectiveness of the STEAM approach in improving academic achievement and mathematical creativity among elementary school students. The research used a quasi-experimental method with a two-group design: an experimental group consisting of 35 students taught using the STEAM approach, and a control group of 35 students taught using conventional methods. The results showed a statistically significant difference ($p \leq 0.05$) between the two groups in both academic achievement and creativity skills, with the experimental group performing better. The STEAM approach is effective in enhancing creativity and academic achievement, particularly in elementary school mathematics learning.

2. Tran et al.(2021)

The purpose of this study was to determine the effectiveness of the STEAM approach on the creativity of junior high school students. The method used in this research was a quasi-experimental design with a counterbalance model involving 62 students divided into two groups: a control group and an experimental group. The results showed that a significant increase in students’ scientific creativity occurred only when participating in the STEAM course, both in the control and experimental groups, whereas the science course on gears alone did not have a significant effect on students’ creativity. The

STEAM approach was proven effective in enhancing the scientific creativity of junior high school students, and the sequence of material delivery did not make a significant difference in the final results.

3. Huang et al.(2021)

This study aimed to examine the effect of the STEAM approach on the creativity of elementary school students and to investigate whether the sequence of learning stages and gender differences influence the outcomes. The method used was a quasi-experimental design with a counterbalance model involving 66 students divided into two groups: control and experimental groups. The results showed a significant increase in the fluency and flexibility aspects of students' creativity after participating in STEAM-based learning; however, no improvement was observed in the novelty aspect. Additionally, no differences were found based on the learning sequence or gender. Therefore, STEAM learning is effective in enhancing the creativity of elementary school students.

4. Fatmawati & Mariana (2022)

This study aimed to enhance the creativity of fifth-grade students at SDN Karang Pilang 1 Surabaya through the implementation of STEAM-based learning. The study was initiated due to the students' low creativity and limited understanding of the concept of flow rate, as the learning method used was still conventional. The researcher then designed a project activity called “Make a Non-Stop Fountain” as a learning medium integrating STEAM disciplines. This study employed a qualitative approach using design-based research (DBR) consisting of four stages: problem identification, solution design, implementation in two cycles, and reflection. The learning activities were divided into three parts: problem identification from reading texts, creating a mini aquarium project from recycled materials, and reflection with the students. The results showed an increase in students' creativity from 78% in the first cycle to 82% in the second cycle. Students became more active, creative, capable of collaboration, and better understood the material through hands-on experience. Therefore, the STEAM approach is effective in creating enjoyable and meaningful learning while enhancing students' creativity.

5. Ferdianto et al. (2022)

This study discusses the implementation of the STEAM approach in mathematics learning as an effort to support the Society 5.0 era. This research is a literature review aimed at describing how the STEAM approach can train students in higher-order thinking, enhance creativity, and improve communication and collaboration skills. The findings indicate that applying the STEAM approach in mathematics learning can improve students' problem-solving abilities and encourage them to become innovators ready to face global challenges. Furthermore, this approach aligns with the needs of learning in the digital era, where technology plays an essential role in the teaching and learning process. Based on the above, the STEAM approach is viewed as an innovative solution to improve the quality of mathematics education and prepare the younger generation to face the Society 5.0 era.

6. Ferianto et al.(2024)

This study aims to examine the implementation of the STEAM approach in enhancing critical thinking skills and creativity among elementary school students. The research employs a systematic literature review method by analyzing 20 journal articles. The findings of this study indicate that the STEAM approach consistently has a positive impact on the development of students' critical thinking skills, such as analyzing, evaluating, and problem-solving abilities. The STEAM approach is also proven effective in improving students' creativity in generating new ideas, creating works, and thinking outside the box. Additionally, several studies mention that the implementation of STEAM can increase students' learning interest, cooperation among peers, as well as curiosity and independence. This approach aligns with the demands of the Merdeka Curriculum and the Pancasila Student Profile, which emphasize the importance of 21st-century skills; therefore, STEAM is considered an effective and relevant learning approach to be applied at the elementary school level.

7. Azzahra (2024)

This study examines the importance of implementing the STEAM approach in mathematics learning as an effort to develop 21st-century skills. The research employs a literature review method with descriptive analysis techniques from various relevant sources. The findings of this study indicate that the STEAM approach is an integration of multiple disciplines that can create more enjoyable, contextual, and practical learning experiences. STEAM learning helps students develop critical thinking skills, creativity, problem-solving abilities, collaboration, and mastery of information technology. Furthermore, the implementation of STEAM aligns with current curriculum directions, such as the Strengthening Project of the Pancasila Student Profile and project-based learning. In the context of mathematics learning, STEAM encourages students to connect mathematical concepts with technology, arts, and real-life situations, such as making teaching aids, calculating building angles, and engaging in simple entrepreneurship. This approach is highly recommended for educators to implement so that mathematics learning becomes more relevant to the demands of the times and is capable of enhancing students' competencies for the 21st century.

8. Malinda *et al.* (2024)

This study aims to examine the effectiveness of implementing STEAM learning in enhancing creativity and 21st-century skills among elementary school students. The research employs a literature review method with a descriptive qualitative approach, analyzing a number of relevant studies conducted within the last ten years. The findings indicate that the STEAM approach positively contributes to the development of critical thinking, creativity, collaboration, and communication skills through contextual and enjoyable project-based learning activities. The integration of arts elements in STEAM has been proven to enrich emotional and psychomotor aspects, as well as to encourage students' expression and

imagination. However, this study also identifies several challenges in STEAM implementation in the field, such as teachers' limited understanding, lack of supporting facilities, and difficulties in managing learning time. These findings suggest that STEAM learning aligns well with the spirit of independent learning (*merdeka belajar*) because it enables students to learn actively, creatively, and independently. Thus, this study emphasizes the importance of teacher training and the development of adequate learning facilities to optimize the implementation of STEAM in elementary schools.

9. Filipe et al.(2024)

This study examines how the STEAM-integrated learning approach can support the development of students' creativity. The method used is qualitative with an interpretative approach by observing integrated STEAM-based learning tasks that support the development of students' creativity. Data were collected through participatory observation, field notes, and supporting documentation. The results show that the STEAM approach not only encourages students to think critically and creatively but also strengthens problem-solving and collaborative skills. The dimensions of students' creativity developed include cognitive aspects such as exploring alternative solutions and combining unrelated concepts, as well as affective aspects such as full engagement in tasks and active participation in group work. A well-structured integration of STEAM learning can be an effective approach to enhancing students' creativity.

10. Handayani et al.(2025)

This study examines the implementation of the STEAM approach in mathematics learning to enhance students' creativity. The study employs a literature review method combined with semi-structured interviews to obtain in-depth data. The findings indicate that the STEAM approach actively engages students in the learning process, improves their understanding of mathematical concepts, and stimulates creativity through the integration of artistic elements in problem-solving. Interviews with teacher respondents revealed that STEAM projects make students more interested and creative in formulating mathematical solutions because they can connect abstract concepts to real-world applications. This approach has proven effective in developing students' creativity, although there are some challenges such as greater demands on time and resources for its implementation. This research provides an important contribution as a reference for developing innovative teaching methods, especially in the context of mathematics education in the modern era.

Based on the results of the previous studies mentioned above, it can be concluded that the STEAM approach is effective in enhancing the creativity of elementary school students, as shown in Table 1. below:

Table 1. Alignment of STEAM Approach Steps with Creativity Indicators

NO	STEAM Approach	Creativity Indicators
	Syntax	
1.	Identification of authentic problems: Students are guided to identify real- world issues that are pertinent and meaningful to their everyday experiences.	<ul style="list-style-type: none"> ● Fluency: Encouraging students to generate a wide range of ideas or solutions related to the problem presented. ● Novelty: Promoting the exploration of uncommon or unique problems.
2.	Exploration of Concepts and Interdisciplinary Connections: Students explore concepts from various disciplines.	<ul style="list-style-type: none"> ● Flexibility: Developing the ability to think from multiple disciplinary perspectives. ● Fluency: Generating numerous ideas through interdisciplinary approaches.
3.	Designing & Developing Projects: Designing solutions or products based on the identified problems.	<ul style="list-style-type: none"> ● Novelty: Encouraging students to create creative and unique solutions. ● Flexibility: Utilizing alternative approaches in designing solutions.
4.	Product/Project Creation: The implementation of the design in a tangible form.	<ul style="list-style-type: none"> ● Novelty: The project outcomes tend to be diverse, reflecting the uniqueness of each student. ● Fluency: Students practice various ideas in concrete forms.
5.	Evaluation & Reflection: Reviewing the process and outcomes, as well as presenting the project ideas.	<ul style="list-style-type: none"> ● Flexibility: Training students to accept feedback and revise their ideas. ● Fluency: Clearly and variably expressing ideas again.

Discussion

The findings of this study indicate that the integration of the STEAM approach in mathematics learning has a significant impact on enhancing creativity among elementary school students. This approach not only improves students' understanding of mathematical concepts but also fosters their creativity through contextual and project-based learning processes. Based on an analysis of eight relevant articles, it is evident that the STEAM approach effectively develops three primary aspects of creativity:

fluency, flexibility, and novelty. These findings align with the theories of Guilford (1967) and Silver (1997), which emphasize the importance of creativity in mathematics education, particularly in solving problems using diverse methods.

Elhady's (2020) research demonstrated that students taught using the STEAM approach achieved higher academic performance and creativity skills compared to those taught through conventional methods. Tran *et al.* (2021) and Huang *et al.* (2021) found significant improvements in creativity aspects, particularly fluency and flexibility, although gains in novelty were less pronounced. These studies suggest that STEAM enables students to generate numerous ideas and think from multiple disciplinary perspectives, which are foundational elements of creativity.

In practical classroom contexts, Fatmawati and Mariana (2022) showed that the implementation of the "Make a Non-Stop Fountain" project integrating STEAM disciplines effectively enhanced students' creativity. Students actively engaged in learning as each stage aligned with creativity indicators. For example, the stage of identifying real-world problems encouraged students to generate numerous ideas (fluency) and seek unique solutions (novelty). The exploration of concepts required thinking from various disciplinary perspectives (flexibility). Subsequently, the design and product creation stages stimulated creative solution development, while evaluation and reflection phases helped students articulate diverse ideas and be receptive to improvements (fluency and flexibility).

Ferdianto *et al.* (2022) emphasized that STEAM-based mathematics learning not only boosts creativity but also prepares students to face challenges of the digital era and Society 5.0 by developing higher-order thinking skills, collaboration, and innovation. This is supported by Ferianto *et al.* (2024), who reported that the STEAM approach consistently fosters critical thinking and creativity through exploratory activities emphasizing idea generation and problem-solving. Filipe *et al.* (2024) focused on the cognitive and affective dimensions of creativity, noting that students were encouraged not only to explore alternative solutions but also to demonstrate high emotional and social engagement during group work and reflection.

Handayani *et al.* (2025) found that STEAM projects in mathematics increased students' interest and creativity in formulating mathematical solutions by connecting abstract concepts with real-life situations. Despite its benefits, the implementation of the STEAM approach faces several challenges, such as limited instructional time, inadequate facilities, and uneven teacher competencies in applying this interdisciplinary method. Therefore, efforts to enhance teacher capacity through continuous training, flexible curriculum development, and the provision of project-based learning resources are necessary.

Overall, STEAM-based mathematics learning offers an innovative solution to overcome the limitations of conventional, mechanistic, and less contextual approaches. By integrating theory and practice, logic and aesthetics, knowledge and application, STEAM creates more meaningful and relevant

learning experiences for students. Furthermore, this approach aligns with the goals of the Merdeka Curriculum and the Pancasila Student Profile, which emphasize differentiated, collaborative learning and the development of 21st-century skills

CONCLUSIONS

The integration of the STEAM approach in mathematics learning has been proven effective in enhancing the creativity of elementary school students. This approach promotes the development of three main indicators of creativity: fluency, flexibility, and novelty. Project-based and contextual learning processes enable students not only to gain a deep understanding of mathematical concepts but also to apply them creatively in real-life situations. STEAM-based learning also positively impacts student engagement, encourages critical and collaborative thinking, and prepares students to face the challenges of the digital era and Society 5.0.

However, the implementation of STEAM still faces challenges such as limited instructional time, inadequate facilities, and varying levels of teacher readiness. Therefore, sustained support is required in the form of continuous teacher training, flexible curriculum development, and the provision of adequate resources to ensure the optimal and sustainable application of the STEAM approach in elementary mathematics education.

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