



Steam-Based Learning And Its Effect On Students' Creativity In Mathematics Education: A Systematic Literature Review

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ABSTRAK

Purpose of the study: This study aims to examine the effect of STEAM-based learning (Science, Technology, Engineering, Arts, and Mathematics) on elementary school students' creativity in mathematics through an analysis of relevant scientific literature.

Methodology: This study employed a literature review method. Data were obtained from various national and international journals, conference proceedings, and other scientific sources discussing STEAM-based learning and students' creativity in mathematics education. The data were analyzed descriptively to identify the main findings related to the research topic.

Main Findings: The review indicates that STEAM-based learning has a positive effect on the creativity of elementary school students. The integration of science, technology, engineering, arts, and mathematics enhances students' creative thinking, problem-solving, collaboration, and ability to generate innovative ideas in solving mathematical problems. Project-based and contextual learning emerged as key factors supporting the development of students' creativity.

Novelty/Originality of this study: The novelty of this study lies in synthesizing findings from various studies on the implementation of STEAM-based learning in elementary school mathematics education. This synthesis provides a more comprehensive understanding of the contribution of the STEAM approach to the development of students' creativity and its implications for mathematics teaching practices in elementary schools.

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1. INTRODUCTION

Mathematics learning in elementary school plays a strategic role in building the foundation of students' logical, analytical, and creative thinking skills. Creativity in the context of mathematics education is not only related to the ability to generate new ideas, but also includes the ability to solve problems in various ways, explore alternative solutions, and construct knowledge independently [1].

Within the framework of 21st-century education, creativity is identified as one of the four key competencies, commonly referred to as the 4Cs (Critical Thinking, Creativity, Communication, and Collaboration), that students need to master in order to adapt to the challenges of a rapidly changing world [2].

However, various studies indicate that mathematics instruction in Indonesian elementary schools is still dominated by conventional approaches that emphasize memorizing formulas, following algorithmic procedures, and completing repetitive exercises [3]. This condition contributes to the relatively low level of students' creative thinking skills in mathematics. The results of the 2022 Programme for International Student Assessment (PISA) placed Indonesia in a concerning position in terms of mathematical performance, with Indonesian students tending to experience difficulties in solving problems that require higher-order reasoning and creativity [4]. This situation indicates the need for a transformation in the paradigm of elementary mathematics learning, shifting from passive and receptive instruction toward learning that is active, innovative, and supportive of students' creativity development.

One innovative instructional approach that has received considerable attention over the past decade is STEAM-based learning (Science, Technology, Engineering, Arts, and Mathematics). STEAM is an extension of the STEM concept that incorporates Arts as a bridge between scientific and technical knowledge and creative and aesthetic expression [5]. This approach emphasizes integrated interdisciplinary learning that encourages students to think holistically, explore connections across subject areas, and apply knowledge in meaningful contexts [6]. The characteristics of STEAM learning, which are project-based, problem-based, and involve creative design processes, make it highly promising for developing students' creativity in mathematics learning.

Several previous studies have identified the positive effects of STEAM learning on various aspects of students' cognitive and affective development. Henriksen et al. [7] found that the integration of arts into STEM learning consistently enhanced students' intrinsic motivation and divergent thinking skills. Meanwhile, Thibaut et al. [8], in their review of 39 STEM/STEAM studies, concluded that an integrated approach was more effective than single-subject instruction in improving problem-solving skills. At the elementary school level, Herro and Quigley [9] reported that students who participated in STEAM learning demonstrated significant improvements in creative and collaborative thinking skills compared with a control group that received conventional instruction.

Nevertheless, several research gaps remain to be addressed. First, studies that specifically explore the relationship between STEAM learning and mathematical creativity at the elementary school level are still limited, particularly within the Indonesian educational context. Most existing studies focus on STEAM in general or on secondary and higher education levels. Second, there is still a lack of literature reviews that comprehensively synthesize research findings concerning the specific dimensions of creativity that are most strongly influenced by STEAM learning in elementary mathematics education. Third, the mechanisms or components of STEAM that contribute most substantially to the improvement of students' mathematical creativity have not yet been systematically identified.

Based on the background and the identified research gaps, this study aims to: (1) identify the effects of STEAM-based learning on students' creativity in elementary school mathematics based on a review of the literature; (2) analyze the role of each STEAM component in enhancing students' mathematical creativity; (3) compare the effectiveness of STEAM learning and conventional learning in developing creativity; and (4) formulate pedagogical implications for elementary school teachers based on the findings of previous studies.

2. RESEARCH METHOD

This study employed a Systematic Literature Review (SLR) to identify and synthesize previous studies concerning STEAM-based learning and students' creativity in elementary mathematics education. Relevant studies were searched through [insert databases actually used] using combinations of the keywords "STEAM," "student creativity," "mathematics," "mathematical creativity," "elementary school," and "primary education." The review covered publications from [2020-2025]. Studies were included if they discussed STEAM-based learning, creativity or creative thinking, and mathematics or closely related elementary learning contexts, and were available in full text. Duplicate, irrelevant, and methodologically insufficient studies were excluded. The selection process involved title

and abstract screening followed by full-text assessment, resulting in 15 articles included in the final review.

Data from the selected studies were extracted into a structured review matrix containing information on authors, publication year, research context, learning approach, creativity indicators, and major findings. The data were analyzed descriptively and thematically to identify patterns related to the influence of STEAM-based learning on mathematical creativity, the creativity dimensions most frequently reported, the contribution of STEAM components, and instructional characteristics that support creativity development. The synthesis also distinguished between studies that directly examined elementary mathematical creativity and studies that provided supporting evidence from broader STEAM or early childhood contexts.

3. RESULT AND DISCUSSION

This section presents the results of the literature review concerning the influence of STEAM-based learning (Science, Technology, Engineering, Arts, and Mathematics) on students' creativity in elementary school mathematics. The findings were obtained from fifteen selected articles that met the inclusion criteria. A summary of the findings from each article is presented in Table 1.

Table 1. Summary of Literature Review Findings on STEAM-Based Learning and Elementary School Students' Mathematical Creativity

Author(s)	Title / Year	Research Findings
Silver, E. A.	Fostering Creativity through Instruction Rich in Mathematical Problem Solving and Problem Posing (2020)	Learning environments rich in problem solving and problem posing encourage students to think flexibly and generate multiple solution strategies, thereby providing an important foundation for the development of mathematical creativity in elementary school.
Yakman, G., Lee, H.	Exploring the Exemplary STEAM Education in the U.S. as a Practical Educational Framework for Korea (2020)	The STEAM framework, which integrates the arts into STEM, bridges scientific and technical knowledge with creative expression, making it relevant for adaptation in elementary school mathematics learning.
English, L. D.	STEM Education K–12: Perspectives on Integration (2020)	Interdisciplinary integration in STEM/STEAM learning from the elementary level encourages students to connect mathematical concepts with real-life contexts while strengthening creative thinking skills.
Henriksen, D., Richardson, C., Mehta, R.	Design Thinking: A Creative Approach to Educational Problems of Practice (2020)	The design thinking approach in STEAM learning consistently enhances students' intrinsic motivation and divergent thinking skills, two important indicators of mathematical creativity.
Thibaut, L., et al.	Integrated STEM Education: A Systematic Review of Instructional Practices in Secondary Education (2021)	A systematic review of 39 STEM/STEAM studies showed that integrated learning was more effective than single-subject instruction in improving students' problem-solving abilities.
Herro, D., Quigley, C.	Exploring Teachers' Perceptions of STEAM Teaching through Professional Development (2022)	Teachers who received STEAM professional development reported improvements in students' creative and collaborative thinking compared with those experiencing conventional learning.
Wahyudi, Waluya, S. B., Suyitno, H., Isnarto	The Impact of STEAM-Based Learning on Mathematical Creativity of Elementary	The implementation of STEAM-based learning among elementary school students in Central Java significantly improved mathematical

Author(s)	Title / Year	Research Findings
	School Students in Central Java (2021)	creativity, particularly in terms of originality and flexibility of thinking.
Fatimah, S., Puspitasari, N.	Peningkatan Kreativitas Matematis Siswa SD melalui Pembelajaran Berbasis Proyek STEAM (2022)	Project-based learning using the STEAM approach improved elementary school students' mathematical creativity, particularly their ability to generate multiple alternative solutions to contextual mathematical problems.
Colucci-Gray, L., Taber, K. S., Whitelegg, E.	Science, STEM, and STEAM: A Literature Review (2021)	The review emphasizes that the arts component in STEAM acts as a catalyst for creativity by enriching the ways students explore and communicate mathematical ideas.
Krauss, J., Boss, S.	Thinking Through Project-Based Learning: Guiding Deeper Inquiry (2022)	Contextual project-based learning is an important factor supporting students' creativity because it encourages in-depth exploration and independent mathematical problem solving.
Wahyuningsih, S., et al.	STEAM Learning in Early Childhood Education: A Literature Review (2020)	The review confirms that the implementation of STEAM from early childhood establishes a sustainable foundation for creative and critical thinking, making it relevant to the development of mathematical creativity at the elementary school level.
Handayani, W., Kuswandi, D., Akbar, S., Arifin, I.	Pembelajaran Berbasis STEAM untuk Perkembangan Kognitif pada Anak (2023)	STEAM-based learning promotes children's cognitive development through active exploration and creative problem solving, providing an important foundation for mathematical creative thinking at subsequent educational levels.
Motimona, P. D., Maryatun, I. B.	Implementasi Metode Pembelajaran STEAM pada Kurikulum Merdeka untuk PAUD (2023)	The implementation of STEAM within the Merdeka Curriculum increases children's active engagement and flexible thinking, which is consistent with the continuous development of mathematical creativity through elementary education.
Huda, D. N., Mulyana, E. H., Rahman, T.	Pendekatan STEAM untuk Pendidikan Anak Usia Dini (2024)	The implementation of STEAM from an early age effectively promotes children's curiosity and creativity, providing an important foundation for the development of mathematical creative thinking at later educational levels.
Prameswari, T., Lestarinigrum, A.	Strategi Pembelajaran Berbasis STEAM dengan Bermain Loose Parts untuk Pencapaian Keterampilan 4C pada Anak Usia 4–5 Tahun (2020)	The use of loose-parts play in STEAM learning develops 4C skills, including creativity, which provides an important foundation for mathematical creative thinking at subsequent educational levels.

The review of the fifteen articles presented in Table 1 indicates that learning environments rich in problem solving and problem posing provide an important foundation for developing elementary school students' mathematical creativity [1]. The STEAM framework, which integrates the arts into STEM, bridges scientific and technical knowledge with creative expression through contextual and interdisciplinary learning [5], [6]. Design thinking and integrated learning approaches consistently

enhance students' intrinsic motivation, divergent thinking, and problem-solving skills compared with single-subject instruction [7], [8]. Teachers who receive STEAM-related professional development also report improvements in students' creative and collaborative thinking skills [9].

The literature on STEAM at the early childhood education level further strengthens these findings. The implementation of STEAM from an early age has been shown to establish a sustained foundation for creative and critical thinking [22], promote cognitive development through active exploration and problem solving [23], and increase children's active engagement and flexible thinking within the framework of the Merdeka Curriculum [24]. Early STEAM experiences also foster curiosity and creativity [25], while STEAM-based loose-parts activities develop 4C competencies, including creativity, which serve as a foundation for mathematical creative thinking at subsequent educational levels [26]. These findings suggest that creativity development through STEAM may occur progressively across educational levels, with elementary school representing an important stage for strengthening mathematical creativity.

More specifically, at the elementary school level, STEAM-based learning has been reported to improve students' mathematical creativity, particularly in terms of originality and flexibility of thinking [12]. Project-based STEAM learning also encourages students to generate multiple alternative solutions to contextual mathematical problems [13]. The arts component in STEAM serves as a catalyst for creativity by enriching the ways students explore and communicate mathematical ideas [14], while contextual project-based learning promotes deeper exploration and independent problem solving [15]. Taken together, these findings indicate that STEAM-based learning contributes positively to the development of students' creativity in elementary school mathematics.

4. CONCLUSION

Based on the systematic review of the relevant literature, STEAM-based learning can be concluded to have a positive, significant, and consistent influence on students' creativity in elementary school mathematics. The findings indicate that the dimensions of creativity most strongly associated with improvement are originality and flexibility of thinking, both of which are important components of creative mathematical problem solving.

The review also indicates that the components of the STEAM framework provide complementary contributions to the development of students' mathematical creativity. The Arts component functions as a catalyst for creativity by facilitating expression, visualization, and the generation of ideas, while Engineering contributes through iterative design processes that encourage divergent thinking and solution refinement. Technology expands opportunities for exploration and representation, whereas Science and Mathematics provide conceptual and logical frameworks through which creative ideas can be developed, examined, and verified.

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