

## The Use of STEAM in Mathematics Education: A Systematic Literature Review

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### Abstract

Dynamic changes in the world of education demand the implementation of innovative learning approaches, which are not only oriented towards knowledge transfer but also develop 21st-century skills such as critical thinking, creativity, collaboration, and communication. One approach that has received wide attention in the last two decades is the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. This study aims to examine the application of the STEAM approach in mathematics education. The method used is a Systematic Literature Review (SLR) of 302 scientific articles published between 2020 and 2025. The articles were obtained from the Google Scholar and Scopus databases using strict inclusion and exclusion criteria and following the PRISMA selection process. The findings indicate that the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach generally enhances students' motivation and engagement in the mathematics learning process. However, several challenges were identified, such as limited teacher training and insufficient facilities to support interdisciplinary integration. Based on these findings, the study recommends the need for ongoing training for educators and the development of a structured STEAM curriculum to promote more innovative and transdisciplinary mathematics learning.

### Keywords

Mathematics learning, STEAM education, systematic literature review

### Introduction

Rapid developments in the world of education necessitate innovative learning approaches that prioritize not only knowledge transfer but also the development of 21st-century skills, including critical thinking, creativity, collaboration, and communication. One approach that has gained widespread attention in the last two decades is the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach. STEAM is seen as capable of addressing the challenges of modern education by integrating various disciplines into meaningful and contextual learning processes (Land, 2013; Remijan & Township, 2017). In the context of mathematics learning, the STEAM approach is believed to increase learning motivation, student engagement, and higher-order thinking

skills such as critical and creative thinking (Boonchom et al., 2020). The addition of arts elements in this approach plays an important role in overcoming conceptual barriers that often arise in conventional mathematics learning (Prabowo et al., 2024). Art-based methods such as visualisation, modelling, storytelling, and creative projects enable students to connect mathematical concepts with real-life experiences in a more personal and imaginative way (Cudero et al., 2024).

Although various studies have been conducted to evaluate the effectiveness of the STEAM approach in learning, most studies are limited, focusing on specific educational levels and geographical contexts, or are fragmentary, relying on case studies. There are not many studies that present a systematic mapping of trends, key findings, and research gaps in the application of STEAM, especially in mathematics learning. However, a comprehensive understanding of this research landscape is crucial to support the development of educational policies, curriculum design, and teaching innovations in the future. Therefore, this article is structured as a Systematic Literature Review (SLR) aimed at identifying, analysing, and synthesising the main findings from studies related to the STEAM approach in mathematics education.

The focus of this review includes publication trends, dominant research designs, implementation contexts, reported benefits, and challenges faced in implementing STEAM. One of the important questions raised in this review is: "What are the challenges and barriers faced in implementing the STEAM approach in mathematics learning?" By conducting a systematic literature review, this study aims to provide theoretical and practical contributions to developing a more effective and sustainable STEAM approach in formal education settings, particularly in mathematics education.

## Method

This study uses a qualitative approach with the Systematic Literature Review (SLR) method. The data used is secondary data obtained through a systematic review of scientific articles relevant to the topic of mathematical literacy skills in the context of STEAM-based learning. The SLR approach was chosen because it provides transparent, explicit, and replicable procedures for systematically identifying, selecting, and analysing relevant literature (Xiao & Watson, 2019).

Data collection was conducted using the Publish or Perish application, with a number of search criteria set. The researchers used the keywords: ‘Mathematics Learning; STEAM’, and limited the search results to articles published between 2020 and 2025 to ensure relevance to the current educational context. Literature sources were obtained from two reputable databases, namely Scopus and Google Scholar. The inclusion criteria established include: (1) the article is a scientific publication indexed in Scopus or Google Scholar, (2) the article discusses the topic of mathematics learning in the STEAM approach, (3) the article is available in full text, and (4) the article was published between 2020 and 2025. Meanwhile, the exclusion criteria include: (1) articles not relevant to the field of mathematics education, (2) articles not available in full text, and (3) articles that are duplicates or do not contain scientific analysis. PIECES was used for data analysis and drawing conclusions (Parker & Sikora, 2022). Because this approach is able to provide a systematic basis for assessing the success of STEAM implementation in mathematics learning, both in terms of quality, effectiveness, and usefulness in the educational context. The following is Figure 1 PIECES of Framework.

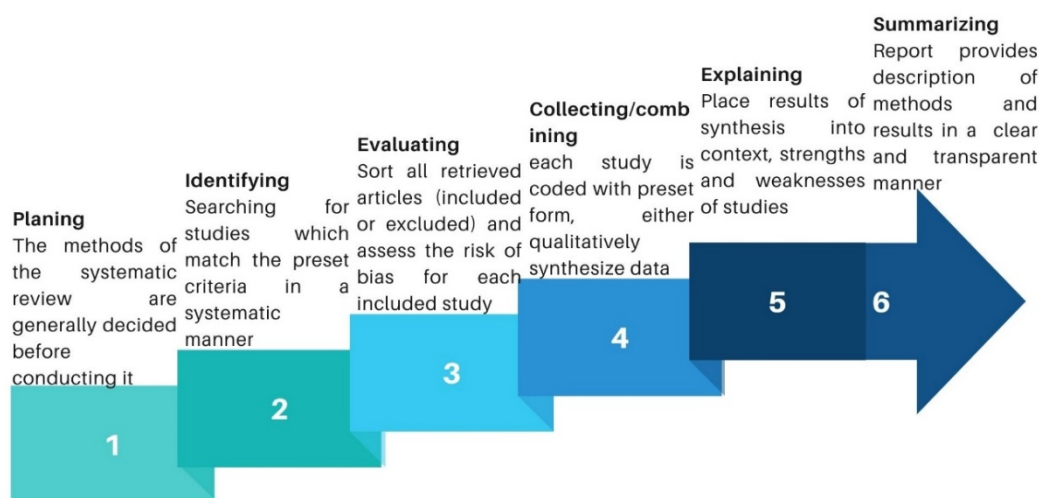


Figure 1. PIECES of Framework

The initial collection process yielded 302 scientific articles from both databases. Next, a screening and selection process was carried out based on predetermined inclusion and exclusion criteria. Articles that did not meet these criteria were eliminated, including those that were not relevant to the topic or were inaccessible. After the screening process, seven articles remained that were considered suitable for further analysis. The collected data were analysed using content analysis techniques to identify patterns,

research trends, methodologies used, and key findings related to the application of the STEAM approach in improving mathematical literacy. The results of this analysis were then synthesised to formulate conclusions and identify research gaps that could serve as a basis for further studies.

## Results and Discussion

### Planning

At this stage, researchers plan which topics will be studied in depth through a systematic literature review before beginning their search for articles. Therefore, the researcher establishes selection criteria. Selection criteria consist of two criteria, namely inclusion and exclusion criteria, which are applied during the article search to ensure that the selected articles are relevant to the research question. These criteria can be seen in Table 1.

Table 1. Inclusion and Exclusion Criteria

No	Inclusion	Exclusion
1	Articles are scientific publications indexed in Scopus or Google Scholar.	Articles that are not relevant to the field of mathematics education.
2	Articles discuss topics related to mathematics learning in the STEAM approach.	Articles that are not available in full text.
3	Articles are available in full access.	Articles that are duplicates or do not contain scientific analysis.
4	Articles are published between 2020 and 2025.	

### Identifying, Evaluating and Collecting

The next step in the identification stage is to develop a search strategy. The search strategy for this study utilises databases accessible through Google Scholar, specifically those indexed by Scopus, using the Publish or Perish application to generate articles that can be researched based on keywords tailored to the researcher's needs. This step is important to ensure that the literature identification process is systematic, transparent and replicable. In addition, the use of reputable databases such as Scopus and tools such as Publish or Perish allows researchers to reach relevant, credible and up-to-date

literature, thus improving the quality and validity of the literature review results. The search sequence used to generate articles from the database for this study is as follows.

1. Mathematics Education
2. STEAM.

The author collected 100 pieces of literature from the Scopus database and 202 pieces of literature from Google Scholar using the keyword ‘mathematics learning’ using the Publish or Perish application. The literature collected was limited to publications from 2020 to 2025 to obtain the most recent data. The author then selected the literature by eliminating articles that were not educational in the field of mathematics and those that were inaccessible, leaving 9 articles to be discussed.

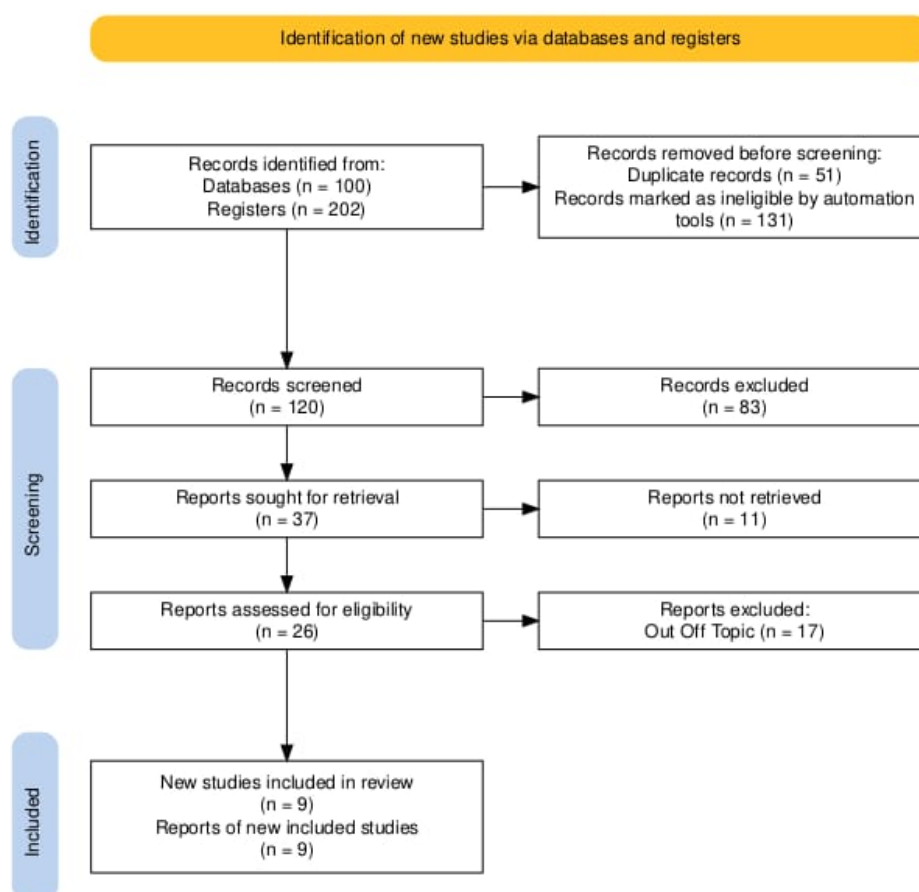


Figure 1. Prism Flow Diagram for Sample Selection

Based on the initial selection process, a total of 302 articles were identified from two sources. From the total of 302 articles, an initial screening was conducted to remove 51 duplicates and 131 articles deemed ineligible by the automated system. As a result, 120 articles that met the criteria advanced to the next screening stage. From the 118 articles, a selection was made based on the title and abstract. Of these, 83 articles were

eliminated because they did not meet the predetermined inclusion criteria. As a result, 37 articles were selected for further review of their full-text versions. However, 11 articles could not be accessed in full, leaving only 26 articles for further evaluation of their eligibility. The 26 articles obtained in full text were then evaluated based on topic criteria. From this evaluation, 17 articles were excluded as they were deemed irrelevant or off-topic. Finally, 9 articles were deemed eligible and included in the systematic literature review.

Table 2. Identities in Articles

No.	Title	Author	Year	Focus
1	Can you create? Visualising and modelling real-world mathematics with technologies in STEAM educational settings	(Haas et al., 2023)	2023	Real visualisation and mathematical modelling in the STEAM environment
2	Challenging Examples of the Wise Use of Computer Tools for the Sustainability of Knowledge and Developing Active and Innovative Methods in STEAM and Mathematics Education	(Körtesi et al., 2022)	2022	Technology-based innovation in STEAM education
3	The Effect of STEAM in Mathematics Learning on 21st Century Skills: A Systematic Literature Reviews	(Pahmi et al., 2022).	2022	The impact of STEAM on 21st century skills
4	Brazilian and Spanish mathematics teachers' predispositions towards gamification in STEAM education	(Paula et al., 2021)	2021	Teachers' attitudes towards gamification in the context of STEAM
5	Teacher growth in exploiting mathematics competencies through STEAM projects	(Ortiz et al., 2023).	2023	Developing mathematics teachers' competencies through STEAM projects
6	An Investigation of Indonesian In-Service Mathematics Teachers' Perception and Attitude Toward STEAM Education	(Boonchom et al., 2020).	2021	Indonesian teachers' perceptions of STEAM education
7	Incorporating STEAM Pedagogy in Teaching Mathematics	(Pant et al., 2020)	2022	The application of STEAM pedagogy in mathematics teaching
8	Developing STEAM-Teaching Module in Supporting Students' Literacy Ability in Elementary School	(Susanto et al., 2024)	2024	Developing STEAM modules to improve elementary school students' literacy in the context of Merdeka Curriculum.

9	Mathematics module based on STEAM and Quranic approach: A study for student's perception	(Muzakkir et al., 2024)	Assessing students' perceptions of math modules based on STEAM and Qur'anic approaches at the secondary school level.
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## Explaining

The purpose of this stage is to identify and analyse the strengths and weaknesses of each article used as the object of study based on predetermined criteria. Table 3 below provides a comprehensive overview of the strengths and weaknesses of the articles studied.

Table 3. Strengths and Limitations of Articles

No.	Author	Strengths	Limitations
1	A	Effectively integrating technology for visualisation and mathematical modelling in real-world contexts, providing practical examples of learning.	The study is limited to specific contexts; it does not yet show the long-term impact on student understanding.
2	B	Offering innovative approaches and digital technologies to support knowledge retention and active learning.	It does not discuss in depth the limitations of implementation in real classrooms; the context of application is not clearly explained.
3	C	Provides a systematic review of the influence of STEAM on 21st-century skills; broad and structured data coverage.	Does not discuss empirical impact directly; tends to be descriptive without critical synthesis.
4	D	Highlights cross-national perceptions of gamification in STEAM; strengthens cross-cultural insights.	Focuses only on teacher attitudes; does not cover the effectiveness of implementation on student learning outcomes.
5	E	Focuses on teacher professional development through STEAM projects; demonstrates interconnections between competencies.	Still limited to documenting the teacher development process, it does not evaluate outcomes for students comprehensively.
6	F	Provides contextual data in Indonesia; relevant for local policy development.	Only covers teacher perceptions; not followed by actual implementation data in learning.
7	G	Explains the integration of STEAM pedagogy in concrete terms; emphasises participatory and project-based approaches.	Does not measure long-term effectiveness; lacks discussion of practical challenges in its implementation.
8	H	Provides a practical and validated STEAM-based module to support elementary students' literacy; demonstrates potential	Limited to a specific regional context; lacks broader theoretical integration and does not represent a systematic review of existing literature.

		to enhance learning motivation and engagement.	
9	I	Combines STEAM and Quranic approaches in a culturally meaningful way; uses mixed methods to explore student perceptions deeply.	Focuses only on perceptions without evaluating actual learning outcomes or long-term impact on student achievement.

Overall, the results of the literature analysis indicate that the STEAM approach in mathematics education has promising potential as an innovative and relevant learning strategy for the demands of the 21st century. However, further practice-based research and evaluation are needed to test the effectiveness of this approach in greater depth, including identifying implementation challenges that may arise in various levels and contexts of mathematics education.

### Summarizing

A review of seven scientific articles shows that the STEAM approach to mathematics learning offers a number of advantages. Among them is the ability of this approach to effectively integrate technology and art into the learning process, thereby encouraging active student engagement, enhancing creativity, and developing 21st-century skills such as critical thinking, collaboration, and communication. Additionally, several articles highlight the contribution of STEAM to teacher professional development and the provision of contextual, interdisciplinary, and project-based pedagogical approaches. However, several limitations warrant attention. Some studies are descriptive in nature without strong empirical data, thus failing to demonstrate the long-term impact of STEAM implementation on student learning outcomes. Furthermore, most research is still limited to teachers' perceptions or conceptual studies without a comprehensive evaluation of implementation practices. The limitations of context, the lack of generalisation of findings, and the minimal discussion of technical and logistical barriers in the application of STEAM are also weaknesses that need to be considered in further research development. Therefore, although the STEAM approach shows significant potential for improving the quality of mathematics education, further comprehensive, practice-based, and contextual studies are needed to optimise its implementation in diverse educational environments.

A systematic analysis of seven scientific articles shows that the STEAM approach in mathematics education contributes positively to promoting innovative learning that meets the demands of the 21st century. Most articles emphasise the importance of

integrating technology, art, and real-world contexts to visualise mathematical concepts more practically (Haas et al., 2023; Körtesi et al., 2022). In addition, STEAM is considered capable of strengthening the development of essential skills such as creativity, collaboration, and problem solving (Pahmi et al., 2022). However, this study also reveals the limitations of this approach. Many studies are descriptive without being supported by strong empirical data, and do not directly measure the impact of STEAM implementation on student learning outcomes (Pant et al., 2020; Paula et al., 2021). In addition, contextual limitations, lack of generalisation of findings, and minimal discussion of technical obstacles in the field are important points that need to be followed up in further research (Ortiz et al., 2023; Boonchom et al., 2020). These findings indicate that although STEAM has great potential to revolutionise mathematics learning, its implementation requires a more holistic, practice-based approach that takes into account local dynamics in order to be effective and sustainable.

## Conclusion

This systematic review shows that the STEAM approach in mathematics learning has significant potential in supporting the development of 21st-century skills, such as critical thinking, creativity, collaboration, and communication. The integration of interdisciplinary disciplines, especially between technology, art, and mathematics, can create contextual, engaging, and meaningful learning for students. Additionally, this approach contributes to the professional development of teachers, particularly in designing project-based learning and utilising technology. However, most of the analysed studies remain limited to descriptive contexts and have not provided strong empirical data regarding the long-term effectiveness of STEAM implementation. Some studies also only focus on teachers' perceptions without including evidence of the impact on student learning outcomes. Furthermore, limitations in terms of generalising findings and the lack of studies on the technical and logistical challenges of implementing STEAM are important considerations for future research. Therefore, further research efforts that are more applied and practice-based are needed to comprehensively evaluate the effectiveness of the STEAM approach across various levels and contexts of education. These studies can contribute significantly to the formulation of strategic recommendations in curriculum development, educational policy formulation, and mathematics learning innovations that are more inclusive, adaptive, and relevant to the demands of the times.

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