

STEM IN PRIMARY SCHOOLS OF INDONESIA: TRENDS, MODELS, AND IMPACTS

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ABSTRAK

Pendidikan STEM yang mengintegrasikan sains, teknologi, teknik, dan matematika semakin diakui sebagai pendekatan penting untuk mengembangkan literasi sains dan keterampilan abad ke-21 pada pendidikan dasar. Meskipun implementasi pendidikan STEM berkembang pesat di berbagai negara, kajian yang secara khusus membahas penerapannya di sekolah dasar di Indonesia yang masih relatif terbatas. Di Indonesia, sekolah dasar memiliki peran strategis dalam sistem pendidikan nasional, namun tren penelitian, model pembelajaran, dan dampak penerapan STEM dalam konteks ini belum banyak dipetakan secara sistematis. Penelitian ini bertujuan untuk menganalisis tren penelitian, mengidentifikasi model pembelajaran yang dominan, serta mengkaji dampak implementasi pendidikan STEM di sekolah dasar di Indonesia. Penelitian ini menggunakan pendekatan *systematic literature review* terhadap publikasi yang terindeks dalam basis data Scopus pada periode 2015–2026. Hasil penelitian menunjukkan bahwa kajian tentang pendidikan STEM di sekolah dasar Islam di Indonesia meningkat secara signifikan dalam dua dekade terakhir, dengan dominasi artikel di kuartil Q2 dan Q3 untuk jurnal dan *Journal of Physics: Conference Series* untuk prosiding. Topik penelitian yang dominan adalah strategi pembelajaran. Kata kunci yang paling sering muncul adalah STEM, sekolah dasar, dan siswa. Metode penelitian yang dominan adalah penelitian eksperimen. Pendekatan STEM secara umum merupakan pendekatan yang paling sering digunakan, dengan model pembelajaran yang sering diintegrasikan adalah Project-Based Learning. Dampak implementasi STEM di Sekolah Dasar paling dominan pada keterampilan abad ke-21 khususnya berpikir kritis, yang diikuti oleh literasi.

Kata kunci : Pendidikan STEM, Pendidikan dasar, Pendidikan SD, Tinjauan Pustaka Sistematis

ABSTRACT

STEM education, which integrates science, technology, engineering, and mathematics, is increasingly recognized as an important approach to developing scientific literacy and 21st-century skills in elementary education. Although the implementation of STEM education is growing rapidly in various countries, studies specifically addressing its application in elementary schools in Indonesia are still relatively

limited. In Indonesia, elementary schools play a strategic role in the national education system, but research trends, learning models, and the impact of STEM implementation in this context have not been systematically mapped. This study aims to analyze research trends, identify dominant learning models, and assess the impact of STEM education implementation in elementary schools in Indonesia. This study uses a systematic literature review approach to publications indexed in the Scopus database for the period 2015–2026. The results of the study indicate that studies on STEM education in Islamic elementary schools in Indonesia have increased significantly in the last two decades, with articles dominating in the Q2 and Q3 quartiles for journals and the Journal of Physics: Conference Series for proceedings. The dominant research topic is learning strategies. The most frequently appearing keywords are STEM, elementary schools, and students. The dominant research method is experimental research. The STEM approach is generally the most frequently used approach, with the most frequently integrated learning model being Project-Based Learning. The impact of STEM implementation in elementary schools is most dominant on 21st-century skills, especially critical thinking, followed by literacy.

Keywords: *STEM education, Primary education, Elementary Education, Systematic Literature Review (SLR)*

INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) based education has become a major focus of global education reform. The STEM approach is seen as an effective strategy for equipping students with 21st century skills, such as critical thinking, science creativity, collaboration, and complex problem solving (Hebebcı & Usta, 2022; Tijani & Adeduyigbe, 2026). International institutions such as the OECD and UNESCO emphasize the importance of STEM integration in the curriculum as an effort to increase human resource competitiveness while addressing global challenges, including climate change, the environmental crisis, and digital transformation (Pagkratis, 2024). In this context, basic education is a crucial foundation for instilling science and technology literacy from an early age.

In Indonesia, STEM implementation has begun to receive significant attention, particularly since the enactment of the 2013 Curriculum policy and its transformation into the Independent Curriculum. Learning approaches that integrate various disciplines in real world contexts are considered relevant for improving the quality of learning in elementary schools (Rokhimawan et al., 2025).

Various studies have shown that implementing STEM at the elementary school can improve students' conceptual understanding, higher order thinking skills, and interest in science and technology (Nasution & Setyaningrum, 2024; Zainil et al., 2022). However, STEM implementation in Indonesia still faces various challenges, such as limited resources, teacher preparedness, and the lack of contextual and adaptive learning models to student characteristics.

An important context for further exploration within the scope of STEM implementation in primary schools in Indonesia is the integration of values-based education, particularly in schools that combine scientific knowledge with moral and cultural dimensions. In the Indonesian context, primary education plays a strategic role in shaping not only students' cognitive competencies but also their character and social responsibility. This creates opportunities to develop STEM approaches that are not solely focused on academic achievement but also on fostering ethical awareness and responsible behavior (Alfiyah et al., 2024). From a broader educational perspective, integrating STEM with value-based learning can support the development of environmental awareness, ethics, and social responsibility among students, which are essential competencies in the 21st century (Baehaqi et al., 2024; Mohamed S.H. et al., 2024).

Several studies have shown that embedding moral and cultural values into science learning can strengthen students' affective dimensions, such as environmental stewardship, gratitude, and responsibility toward nature (Mohamed S.H. et al., 2024). This approach is also closely aligned with the concept of Education for Sustainable Development (ESD), which emphasizes the role of education in promoting sustainable behavior and long-term environmental awareness (Fathurohman et al., 2023).

However, studies on STEM implementation in elementary schools in Indonesia are still relatively limited and scattered across various publications with varying approaches. In fact, the integration of STEM with value-based and contextual learning has the potential to produce a holistic learning model, which not only develops academic competence but also supports the development of students' character (Baehaqi et al., 2024). This has resulted in the lack of a

comprehensive synthesis that can describe research trends, learning models used, and the impact of STEM implementation in the context of education.

This study aims to conduct a systematic analysis of scientific publications related to STEM implementation in primary schools in Indonesia. Specifically, this study focuses on three main aspects: 1) What are the global research trends in STEM education for elementary schools in terms of publications, topics, and keyword evolution? 2) How is STEM integrated into learning models, methods, and media in elementary education? 3) What are the impacts of STEM integration on elementary student?

By examining these three aspects, this study is expected to provide both theoretical and practical contributions. Theoretically, this study enriches the body of knowledge on STEM integration in primary education, particularly in the context of Indonesia, which remains underrepresented in the international literature. Practically, the findings of this study can serve as a reference for teachers, curriculum developers, and policymakers in designing contextual, integrative, and sustainability-oriented STEM learning. Furthermore, this study is expected to open opportunities for future research, particularly in the development of innovative and relevant STEM learning models that can effectively address the demands of 21st-century skills and global challenges.

METHOD

This study used a qualitative approach using the Systematic Literature Review (SLR) method to identify, evaluate, and synthesize research findings related to STEM implementation in primary education, specifically in the context of Indonesia and Islamic schools. The SLR method was chosen because it produces a comprehensive, systematic, transparent, and replicable synthesis of scientific evidence, thereby enhancing the validity and reliability of the research findings.

This study followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, which includes four main stages: identification, screening, eligibility, and inclusion. The data source was obtained from the Scopus database, which was selected for its internationally reputable

scientific publications. The search process was conducted using article titles, abstracts, and keywords (TITLE-ABS-KEY).

The publication period was limited to 2005 to December 2025 to capture the early developments and current trends in STEM research. The search strategy was developed using Boolean operators combining three main concepts: STEM, basic education, and the Indonesian context/Islamic schools. The search string used was as follows: TITLE-ABS-KEY (("STEM" OR "STEM education" OR "STEM learning") AND ("primary school" OR "elementary school")) AND PUBYEAR > 2015 AND PUBYEAR < 2026 AND (LIMIT-TO (AFFILCOUNTRY, "Indonesia")).

This study established the following inclusion criteria.

Table 1. Inclusion Criteria

Category	Inclusion Criteria
Type of publication	Scientific articles published in journals or proceedings
Journal specifications	International peer reviewed journals or proceedings indexed Scopus
Publication year	Publication articles are limited from 2005 to December 2025
Research Topics	A study that discusses STEM in Indonesian Primary Schools
Variable	STEM implementation in the context of elementary education (SD/MI)
Research Place	Indonesia
Research Subject	Students in primary or elementary schools

The article selection process followed the PRISMA process. The search yielded an initial selection of articles from the Scopus database and additional sources. After removing duplicates, articles were screened based on title and abstract to ensure relevance to the research topic. Next, articles that passed the screening stage were analyzed in full text to assess eligibility based on the inclusion criteria. Articles that did not meet the criteria were eliminated. In the final stage, 41 articles were selected and included in the systematic analysis.

Data from each selected article was systematically extracted using a data extraction table. Data analysis was carried out using quantitative descriptive analysis techniques. The results of the analysis are presented in the form of synthesis tables and data visualizations to facilitate interpretation.

DISCUSSION

This section elaborates the findings of the study by addressing the three research questions, focusing on publication trends, research topics and keyword evolution, the integration of STEM in learning models, methods, and instructional strategies, as well as the impact of STEM on students' learning outcomes in elementary schools. The results are systematically analyzed to reveal patterns in research development, thematic focus, and pedagogical practices. Furthermore, the discussion highlights how these trends contribute to the enhancement of students' competencies and identifies critical gaps in the existing literature on STEM education at the elementary level.

The analysis begins by examining publication trends, research topics, and keyword developments in STEM research in elementary schools. This study aims to map the direction of research development, identify dominant key focuses, and uncover emerging themes in the literature. Therefore, the analysis in this section provides a solid foundation for understanding how STEM research in elementary education has evolved over time and how this influences future research directions.

The global research trends in STEM education for elementary schools in terms of publications, topics, and keyword evolution

The analysis begins by examining publication trends, research topics, and keyword developments in STEM research in elementary schools. This study aims to map the direction of research development, identify dominant key focuses, and uncover emerging themes in the literature. Therefore, the analysis in this section provides a solid foundation for understanding how STEM research in elementary education has evolved over time and how this influences future research directions.

Table 2. STEM in Elementary Schools Publication Trends

Publication Type	Status	Journal Name	Quantity
Journal	Scopus Q2	European Journal of Educational Research	1
	Scopus Q3	International Journal of Evaluation and Research in Education	2
		International Journal of Interactive Mobile Technologies (iJIM)	1
	Scopus Q2	International Journal of Serious Games	1

Publication Type	Status	Journal Name	Quantity
	Scopus Q2	Issues in Educational Research	1
	Scopus Q3	Journal of Education and e-Learning Research	3
	Scopus Q3	Jurnal Pendidikan IPA Indonesia	4
	Scopus Q3	Multidisciplinary Science Journal	2
	Scopus Q2	Open Education Studies	1
	Scopus Q3	Participatory Educational Research (PER)	2
	Scopus Q3	Pegem Journal of Education and Instruction	1
Prosiding		2019 International Conference on Science Education and Technology, ICOSETH 2019	1
		2020 Seminar on Advances in Mathematics, Science, and Engineering for Elementary Schools, SAMSES 2020	1
		2nd International Seminar on Applied Mathematics and Mathematics Education, ISAMME 2020	1
		Journal of Physics: Conf. Ser. (ICOLSSTEM 2019)	1
		Journal of Physics: Conf. Ser. (ICRLP 2022)	1
		Journal of Physics: Conf. Ser. (SAMSES 2018)	4
		Journal of Physics: Conf. Ser. (SAMSES 2020)	2
		Journal of Physics: Conf. Ser. (SNF 2022)	1
		Journal of Physics: Conf. Series	7
		Journal of Physics: Conference Series (IJCSE 2020)	1
		Seminar on Advances in Mathematics, Science and Engineering for Elementary School, SAMSES 2018	2

Table 2 shows that STEM research in elementary schools is published through two main channels: reputable international journals and conference proceedings. In the journal category, all articles are indexed by Scopus, with a predominance of articles in the Q2 and Q3 quartiles, reflecting relatively good academic quality. Some of the journals with the highest publication contributions include the Indonesian Science Education Journal (Jurnal Pendidikan IPA Indonesia) (4 articles), the Journal of Education and e-Learning Research (Journal of Education and e-Learning Research) (3 articles), and the International Journal of Evaluation and Research in Education (Journal of Participatory Educational Research), and the Multidisciplinary Science Journal (Journal of Multidisciplinary Science) (2 articles each). Meanwhile, other journals such as the European Journal of Educational Research (JER), the International Journal of Interactive Mobile

Technologies (iJIM), the International Journal of Serious Games (Journal of Issues in Educational Research), Open Education Studies (Open Education Studies), and the Pegem Journal of Education and Instruction (Pegem Journal of Education and Instruction) each contributed one article. This distribution indicates that STEM research publications at the elementary school level have spread across various international journals, although they remain concentrated in a few specific journals.

On the other hand, conference proceedings also make a significant contribution to STEM research publications. This is evident from the dominance of the *Journal of Physics: Conference Series* which includes various editions and conference activities, with the highest number of publications reaching 7 articles, as well as additional publications from several events such as SAMSES 2018 (4 articles), SAMSES 2020 (2 articles), and other activities such as ICOSETH and ISAMME. Publication of proceedings began to appear in 2018 (SAMSES), increased in 2019–2020 (ICOSETH, ICOLSSTEM, SAMSES, ISAMME), and continued until 2022 (ICRLP, SNF) although in more limited numbers. This pattern shows that proceedings are still an important forum for the dissemination of STEM research results, especially in the early stages of research development.

Table 3. STEM in Elementary Schools Research Topics

Research Topics	Quantity	Percentage (%)
Learning evaluation and assessment	2	4.88%
Learning media	8	19.51%
Learning strategies	28	68.29%
Student perception	1	2.44%
Teaching materials	2	4.88%

In line with this publication trend, Table 3 shows that the distribution of STEM research topics in elementary schools is still dominated by pedagogical aspects, particularly learning strategies, which account for 68.29%. This indicates that most research focuses on how STEM is implemented in the learning process through various instructional approaches, such as PjBL, PBL, and inquiry based learning (Nasution & Setyaningrum, 2024; Sarwi et al., 2021). Furthermore, learning media ranks second with 19.51%, reflecting the increasing use of

technology and innovative learning resources in STEM learning (Dewi et al., 2025; Zainil et al., 2022). Meanwhile, other topics such as learning evaluation and assessment, teaching materials, and student perceptions are still relatively limited, each below 5%, indicating that evaluative aspects and student perspectives have not yet become a primary focus in STEM research (Nurlenasari et al., 2019). This finding aligns with several previous studies that suggest that STEM research tends to be oriented toward learning implementation rather than developing evaluation instruments and analyzing student learning experiences, thus opening up opportunities for further research to examine these aspects in greater depth.

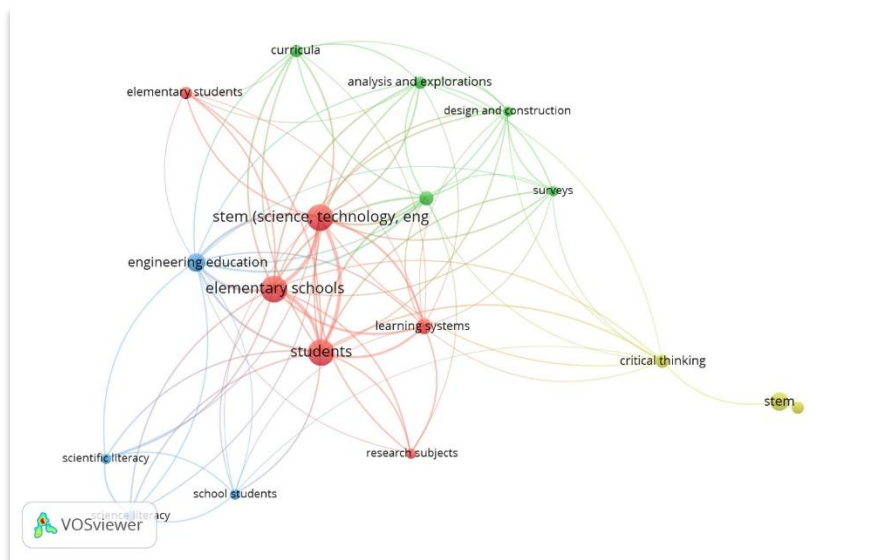


Figure 1. STEM in Elementary Schools Research Keywords Trends

In addition to topic distribution analysis, research trends were also strengthened through author keyword mapping using VOSviewer, as shown in Figure 1. This visualization demonstrates the interrelationships between keywords that form several key clusters in STEM research in elementary schools. The core cluster is dominated by keywords such as STEM, elementary schools, and students, indicating that the primary focus of research remains on the implementation of STEM in the context of elementary school student learning (Dewi et al., 2025; Zainil et al., 2022). Another cluster highlights the relationship between engineering education and scientific literacy, indicating that the integration of engineering and

scientific literacy aspects is a crucial part of STEM learning development (Afriana et al., 2016; B et al., 2021). This cluster indicates that STEM not only addresses learning practices but also exists at the curriculum level (Lidinillah et al., 2019).

Conversely, keywords such as critical thinking appear to be located on the periphery of the network, indicating that although higher order thinking skills are beginning to gain attention in STEM research, they have not yet become a primary focus in the literature (Zainil et al., 2022). The interconnectedness of these keywords also reinforces the findings in Figure 1, where the dominance of the topic of learning strategies is reflected in the large number of terms related to implementation, learning design, and exploratory activities. Thus, this VOSviewer map shows that the trend of STEM research in elementary schools is moving towards the integration of student centered, design based, and skills oriented learning, although there are still opportunities for development in the aspects of evaluation and higher order thinking skills.

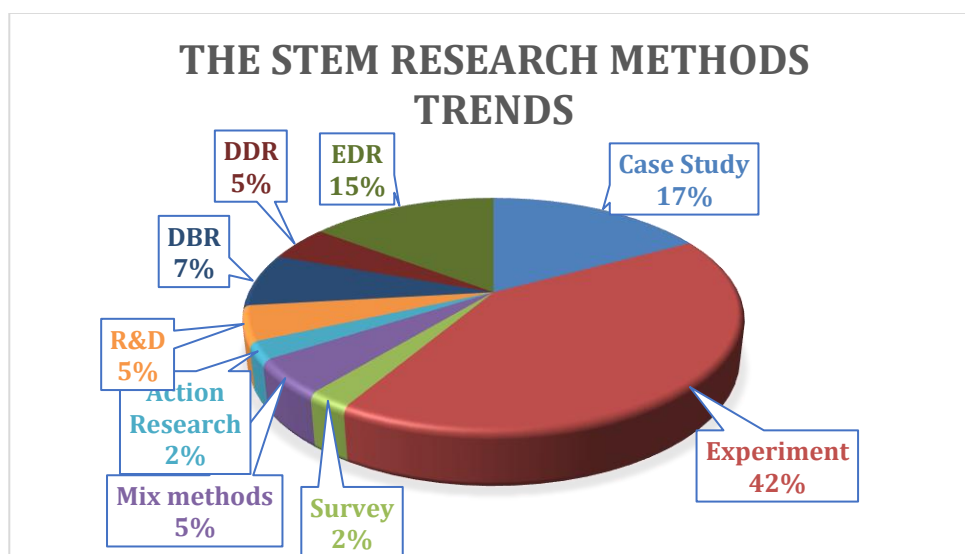


Figure 2. Distribution of Research Methods in STEM Education

In addition to publication trends and research topics, an analysis was also conducted of the research approaches and methods used in STEM studies in elementary schools. Based on the data presented, quantitative approaches dominate, with experimental methods being the most frequently used method, accounting for 17 studies (41.46%). This indicates that most STEM research focuses on testing the effectiveness of a model, method, or learning media on student learning outcomes (Elbashir et al., 2024; Ni Wayan Rati et al., 2025). Meanwhile, qualitative

approaches through case studies were also quite significant, accounting for 7 studies (17.07%), reflecting efforts to deeply understand the process of implementing STEM in learning contexts (Firdaus et al., 2020; Jannah et al., 2021).

Meanwhile, other approaches focused on development and innovation also demonstrated diverse contributions. Educational Design Research (EDR) ranked second with 6 studies (14.63%), followed by Design Based Research (DBR) with 3 studies (7.32%), and Research and Development (R&D) and Didactic Design Research (DDR) each with 4.88%. Furthermore, there is also the use of mixed methods (4.88%) and action research (2.44%), albeit in a more limited amount (Rochman et al., 2019). This finding indicates that in addition to focusing on effectiveness testing, STEM research in elementary schools is also starting to move towards developing innovative learning designs (Elbashir et al., 2024; Ni Wayan Rati et al., 2025). However, the dominance of experimental methods indicates that research still tends to be outcome based, rather than process exploration or in depth model development, thus opening up opportunities for research with a more comprehensive design and qualitative approach in the future.

STEM integrated into learning models, methods, and learning media in elementary education

Figure 3. illustrates the STEM integration framework in elementary school education, classified into three main components: learning models, supporting methods, and learning media. In the learning models section, STEM is generally the most dominant approach, followed by more specific models such as Project Based Learning (PjBL), Inquiry Based STEM, and Problem Based Learning (PBL) (Herwinarso et al., 2023; Martaningsih et al., n.d.; Nasution & Setyaningrum, 2024). Innovative approaches such as STEM Makerspace, culturally integrated STEM (Ethno STEM), and digital based STEM are also used, albeit with less frequency (Pada et al., 2025).

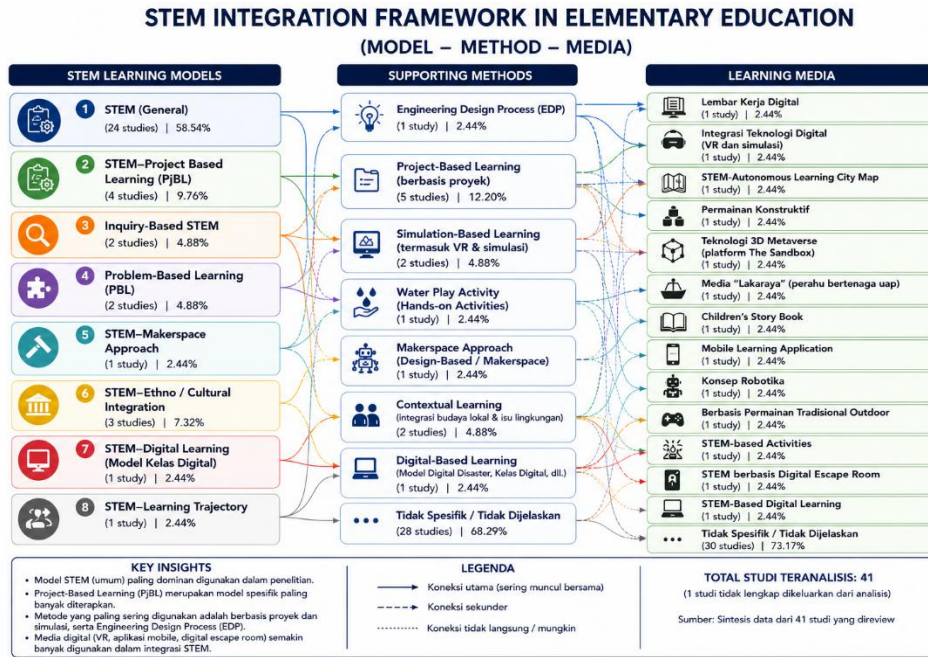


Figure 3. STEM Integration Framework in Elementary Education (Models, Methods, and Learning Media)

In the supporting methods component, STEM implementation is supported by various experiential and design based learning methods, such as the Engineering Design Process (EDP), project based learning, simulation based learning, and hands on activities like water play (Jannah et al., 2021; Nur et al., 2019). Furthermore, contextual methods that integrate local culture and environmental issues are also emerging, although not yet dominant (Ni Wayan Rati et al., 2025; Pada et al., 2025)(Author, Year). However, most studies still do not explicitly describe the methods used, as evidenced by the high number of "unspecific" categories.

Meanwhile, in the learning media component, there is significant variation, with a strong tendency toward the use of digital technologies such as virtual reality (VR), simulations, mobile applications, and digital escape rooms (Ginting et al., 2025; Jannah et al., 2021) . On the other hand, locally context based media such as traditional games, children's storybooks, and products based on local wisdom are also still used, albeit in more limited quantities (Apriliya et al., 2019; Atmojo et al., 2025a). Interestingly, most studies also do not specify the media used in detail, indicating a gap in reporting on STEM implementation.

Overall, this diagram indicates that STEM integration in elementary schools remains partial, with not all studies fully linking learning models, methods, and media. However, there is a tendency that project based approaches, experiential methods, and digital media are the main combination in STEM implementation, while culture based integration and innovation such as makerspaces are still at the development stage.

The impacts of STEM integration on elementary students’ cognitive, affective, and 21st-century skills

The analysis was conducted by identifying the cognitive, affective, and 21st-century skills studied in the article. The following are the results.

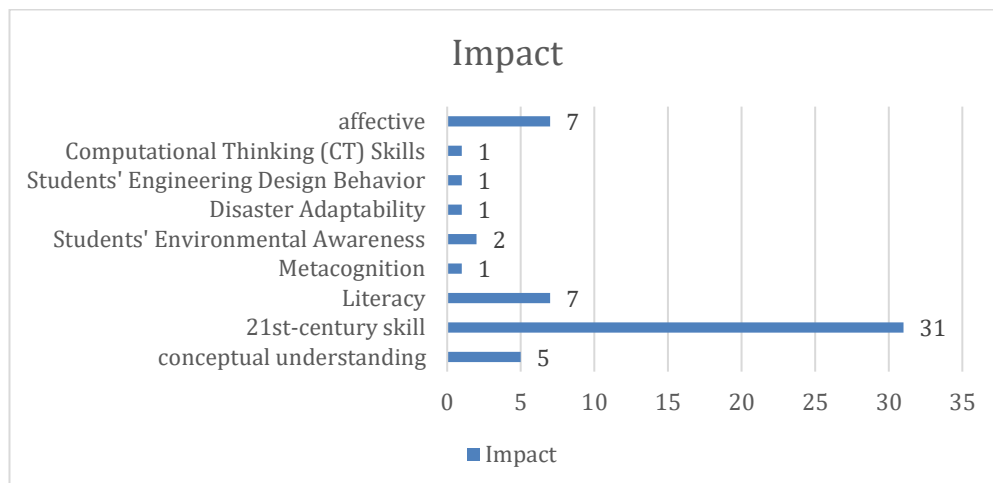


Figure 4. The Graph of Cognitive, Affective, and 21st Century Skills Studied

The most researched skills are 21st century skills which include critical thinking, creative thinking, collaboration, communication, high order thinking skills, and problem solving skills. Among the six 21st-century skills, critical thinking is the most researched ability (Atmojo et al., 2025; Hermita et al., 2023; Siregar et al., 2023). The second most researched abilities in STEM research are literacy and affective skills. The literacies studied include literacy, scientific literacy, social science literacy, and mathematics literacy, with scientific literacy being the most researched (Asrizal et al., 2019; Astra et al., 2022). Meanwhile, affective skills studied include participation and activeness, fun, attitude, and math anxiety.

CONCLUSION

In conclusion, this study shows that STEM education research in Indonesian elementary schools has increased significantly over the last two decades, with publications dominated by Q2–Q3 journals. Research trends mainly focus on learning strategies, with STEM, elementary schools, and students as the dominant keywords. Experimental methods are the most commonly used approaches, while Project Based Learning emerges as the most widely integrated learning model. STEM implementation positively impacts students' 21st century skills, particularly critical thinking, as well as various forms of literacy. Future studies are recommended to develop more contextual, integrative, and sustainable STEM models, while strengthening research on evaluation, assessment, and longitudinal approaches.

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