THE IMPACT OF STEAM APPROACHES ON STUDENT LEARNING OUTCOMES AND CREATIVITY: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

The rapid advancement of science, technology, engineering, arts, and mathematics (STEAM) in the 21st century has reshaped educational paradigms, emphasizing creativity and interdisciplinary learning. However, variations in implementation have led to inconsistent findings regarding its effectiveness. This study aims to systematically review and synthesize empirical research published between 2021 and 2025 on the impact of STEAM approaches on students' learning outcomes and creativity. Employing a Systematic Literature Review (SLR) method guided by the PRISMA protocol, the review involved four main stages: identification, screening, eligibility, and inclusion across Crossref, Scopus, and Google Scholar databases. A total of 1,344 articles were retrieved, and 38 met the inclusion criteria for analysis. The results indicate that STEAM education enhances cognitive, affective, and psychomotor learning while fostering creativity through the integration of the arts, encouraging originality and innovation. It is concluded that STEAM serves as a holistic pedagogical framework that bridges academic achievement and creativity, preparing adaptive and innovative learners for 21st-century challenges.

Keywords: creativity, learning outcomes, STEAM education

A. Introduction

The rapid advancement of technology and the growing demand for 21st-century competencies have necessitated a fundamental transformation in instructional practices at the primary-school level. Education today is no longer confined to the transmission of factual knowledge; rather, it is expected to cultivate higher-order cognitive skills, creativity, collaboration, and digital literacy. Recent research trends affirm that integrating the STEAM approach with contextual learning models can facilitate more relevant, engaging, and skill-oriented learning aligned with *21st-century skills* (Febriawati et al., 2024). Consequently, the STEAM approach deserves particular attention as a strategic framework for preparing students to think critically and innovate effectively

The choice of this topic is directly related to the contextual realities of STEAM implementation in Indonesia, which reveal both significant potential and notable challenges. Empirical studies conducted in primary schools and Islamic madrasahs demonstrate that STEAM programs combined with educational entrepreneurship or project-based learning (PBL) have effectively improved students' scientific literacy and creativity. (Trivena et al., 2025). However, these same studies indicate the need for localized adaptation strategies such as module development, teacher training, and instructional time adjustment to ensure sustainable and equitable outcomes across diverse educational contexts.

Contemporary empirical evidence further demonstrates the positive impact of STEAM on creative, collaborative, and learning achievement skills, particularly when combined with Project-Based Learning (PjBL) or structured learning modules. Both classroom-action research and quasi-experimental studies report significant improvements in students' creativity and collaboration following the implementation of STEAM-PjBL. (Muzaini et al., 2024). Moreover, integrating STEAM into non-science subjects such as literature has shown promising results in enhancing students' imagination and creative expression. (Aprinawati et al., 2025). These findings confirm that STEAM is not limited to science-related domains but also enriches interdisciplinary learning experiences.

Innovations in media and instructional materials further strengthen the effectiveness of STEAM. The development of STEAM-based student worksheets (LKPD) and learning media, along with the use of educational technology, has been reported to effectively stimulate exploration and practical skills among early-childhood and elementary learners (Dwi Maharani, 2024; Hasibuan et al., 2022). Meanwhile, studies integrating STEAM with edupreneurship or green-technology projects have demonstrated positive outcomes in students' scientific literacy and in aligning learning contexts with sustainability issues (Trivena et al., 2025). The combination of pedagogical strategies and instructional-media development thus opens opportunities for richer and

more contextualized STEAM implementation within schools.

Nevertheless, several studies have highlighted ongoing challenges that call for systemic interventions. Availability of facilities and infrastructure, teacher readiness and competence, curriculum flexibility, and institutional support remain crucial determinants for the sustainability of STEAM programs. (Dwi Maharani,, 2021; Istianah, 2023) Regional disparities and variations in school capacity risk creating inequities if STEAM is implemented only partially or inconsistently. Therefore, a comprehensive review and mapping of current evidence is essential to formulate practical and policy recommendations that can enhance STEAM implementation across various educational settings in Indonesia.

The urgency of this research is also closely linked to the global agenda for sustainable development. STEAM plays a strategic role in supporting SDG 4 (Quality Education) by improving educational quality, relevance, and inclusivity, while contributing to SDG 9 (Industry, Innovation and Infrastructure) and SDG 13 (Climate Action) through innovative, technology-driven, and environmentally oriented learning projects(Febriawati et al., 2024).

Although research on STEAM education has expanded significantly in recent years, there remains a need for a systematic synthesis that provides a comprehensive understanding of how the concepts, implementations, and impacts of STEAM have evolved within educational contexts. Such synthesis is essential to identify prevailing trends, challenges, and the effectiveness of STEAM in enhancing both learning outcomes and students' creative potential. Therefore, this study aims to conduct a systematic literature review (SLR) of research on STEAM education published between 2021 and 2025, to analyze its impact on student learning outcomes and creativity, as well as its relevance to the competencies required in 21st-century education. (RQ1). How have the concepts and implementations of STEAM approaches in education been developed and applied during the period 2021–2025? (RQ2) To what extent do STEAM approaches impact student learning outcomes, including cognitive, affective, and psychomotor domains, based on studies conducted

between 2021–2025? (RQ3) How do STEAM approaches influence the enhancement of students' creativity, and what is their relevance to the demands of 21st-century learning?

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B. Method

The systematic review process in this study was conducted in accordance with the PRISMA guidelines, which consist of four main stages: identification, screening, eligibility, and inclusion. (Haddaway et al., 2022). The first stage, identification, began with the retrieval of research articles published between 2021 and 2025. The search was performed across three internationally recognized academic databases, Crossref, Scopus, and Google Scholar, using the Publish or Perish software as the search tool. From this process, a total of 1,344 articles were collected, comprising 1,000 articles from Crossref, 144 articles from Scopus, and 200 articles from Google Scholar. This number demonstrates the breadth of sources considered, thereby ensuring the comprehensiveness of the review as shown in Figure 1.

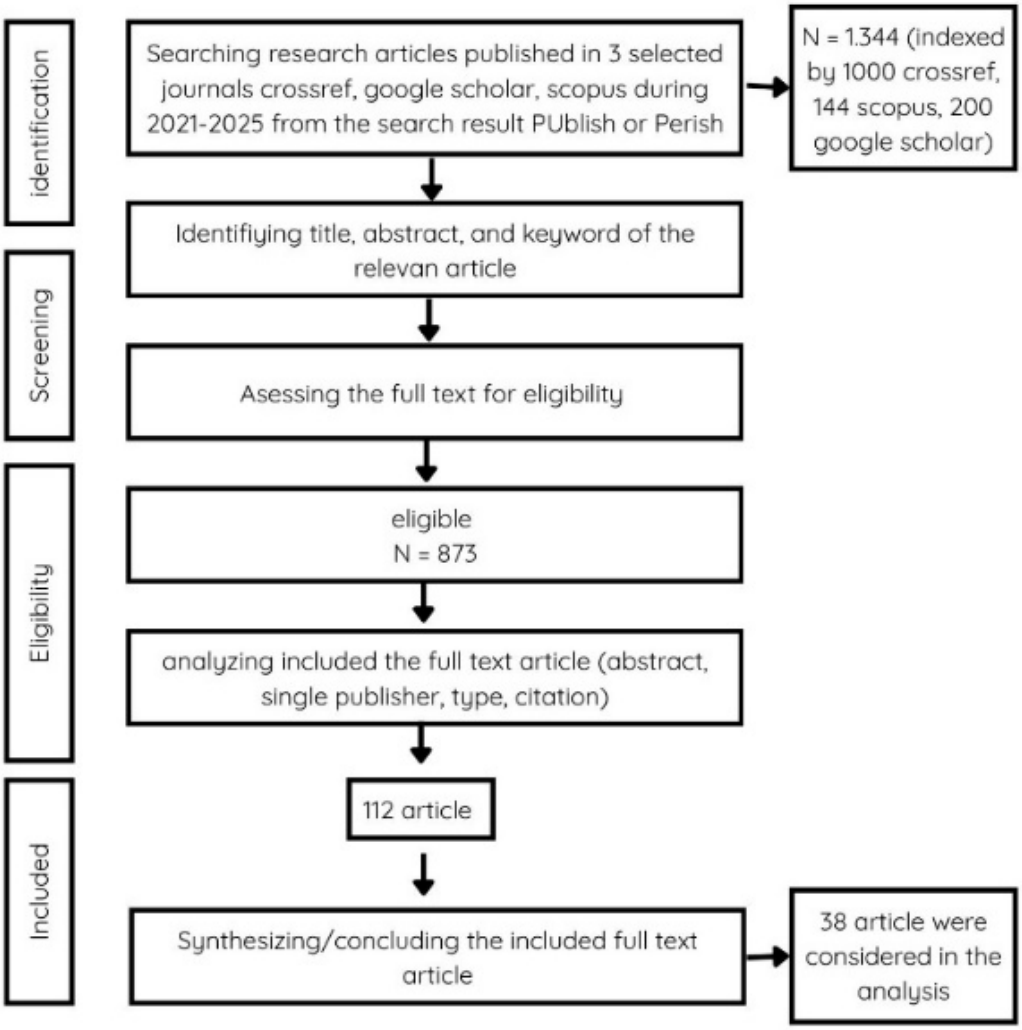

Figure 1. PRISMA Method

The second stage, screening, involved evaluating the collected articles based on their titles, abstracts, and keywords to ensure their alignment with the research focus. This stage was intended to exclude irrelevant articles and minimize potential bias resulting from the inclusion of unsuitable sources. Following this initial screening process, 873 articles were deemed eligible to proceed to the next stage.

In the eligibility stage, a thorough examination of the full texts was undertaken for all articles that passed the screening process. The evaluation considered various aspects, including the quality of abstracts, the appropriateness of the article types relative to the research objectives, the credibility of the

publisher, and the relevance of citation data. This rigorous assessment resulted in 112 articles meeting the eligibility criteria and aligning with the objectives of the systematic review. (Paul & Criado, 2020).

The final stage, inclusion, involved synthesizing and drawing conclusions from the eligible studies. Of the 112 eligible articles, 38 were ultimately selected for in-depth consideration in the final analysis. These articles were regarded as representative in addressing the research questions and provided a robust foundation for discussion and academic implications. This systematic procedure ensured both transparency and rigor in the selection process, thereby enhancing the validity, reliability, and relevance of the literature review. (Moher et al., 2009).

C. Results and Discussion

The Concepts and Implementations of STEAM Approaches (2021–2025)

The trend of STEAM Publications from 2021–2025 is illustrated by the line chart, showing the progression of STEAM-related research publications from 2021 to 2025. A steady increase is observable from 2021 (5 articles) to 2023 (9 articles), followed by relatively stable growth in 2024 (8 articles) and 2025 (9 articles). This trend suggests a consistent and sustained scholarly interest in STEAM education, reflecting its growing recognition as a strategic framework for addressing contemporary educational challenges. The upward trajectory demonstrates that STEAM remains a dynamic and evolving field of inquiry within the international academic landscape, as displayed in Figure 2.

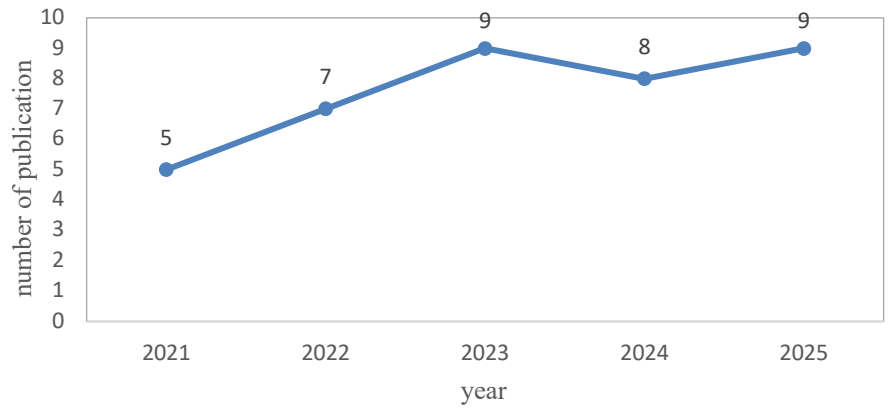

Figure 2. Line Chart: Trend of STEAM Publications (2021–2025)

The quantitative distribution of studies illustrated by the bar chart provides a visual representation of the distribution of the 38 reviewed articles according to the three research questions, as shown in Figure 3.

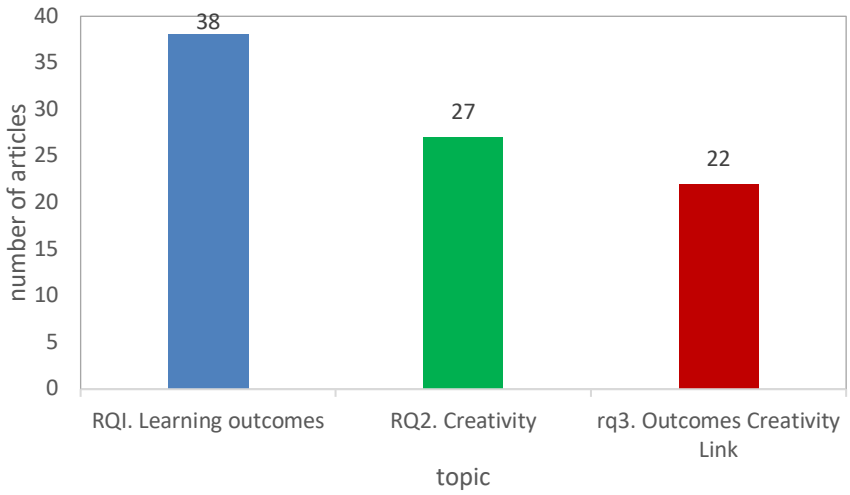

Figure 3. Distribution of Articles by Research Questions

First, the highest number of studies (n = 38) focused on RQ1: the influence of STEAM approaches on learning outcomes across cognitive, affective, and psychomotor domains. This indicates that the primary scholarly attention in the 2021–2025 period has been directed toward evaluating the effectiveness of STEAM in improving academic achievement and holistic learning competencies.

Second, a substantial number of studies (n = 27) addressed RQ2: the contribution of STEAM to student creativity. This reflects an increasing recognition that creativity is not only a supplementary outcome but also a central goal of STEAM education. The findings reinforce the importance of art integration in fostering originality, fluency, and innovation in problem-solving.

Third, RQ3: the interrelation between learning outcomes and creativity was examined in 22 studies. While fewer in number, these studies are significant because they reveal the synergistic relationship between knowledge acquisition and creativity. This intersection emphasizes the relevance of STEAM in preparing students with competencies aligned to 21st-century demands, particularly the “4Cs” (critical thinking, creativity, collaboration, and communication).

In summary, the bar chart underscores that the literature predominantly evaluates the impact of STEAM on measurable learning outcomes, while also increasingly highlighting creativity and its interconnection with achievement as critical pillars for future-ready education.

The Influence of STEAM Approaches on Student Learning Outcomes: Cognitive, Affective, and Psychomotor Domains

Findings from the review of 38 journal articles (2021–2025) confirm that the implementation of STEAM approaches positively affects student learning outcomes across the cognitive, affective, and psychomotor domains. In the cognitive domain, STEAM-based modules such as robotics, inquiry-driven science, and mathematics-integrated engineering projects enhanced students' conceptual understanding, problem-solving skills, and higher-order thinking abilities. In the affective domain, students demonstrated increased motivation, engagement, and curiosity. The integration of art within STEM provided opportunities for self-expression, ownership of learning, and the cultivation of positive attitudes. In the psychomotor domain, STEAM activities involving experimentation, design, and physical practice improved students' coordination, craftsmanship, and practical application of theoretical knowledge.

The network visualization illustrates clusters of keywords such as *learning outcomes*, *motivation*, *problem solving*, and *skills*. The interconnections among these nodes reveal that STEAM research is not limited to a single dimension but collectively addresses cognitive, affective, and psychomotor outcomes. This suggests that STEAM approaches operate as holistic pedagogical models capable of fostering multidimensional learning, as shown in Figure 4.

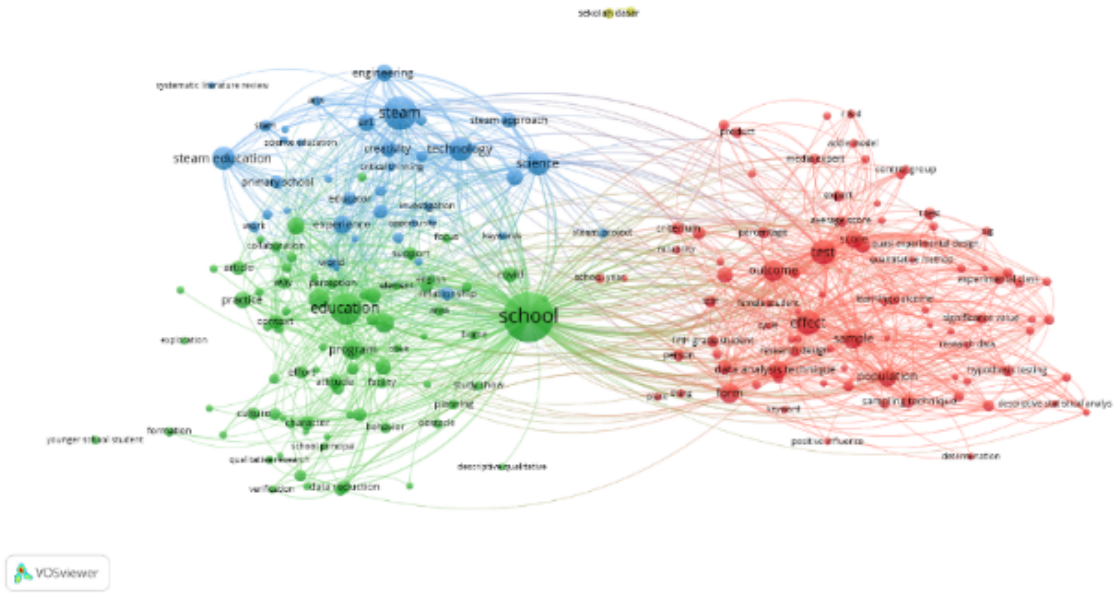

Figure 4. Network Visualization of STEAM Research (2021–2025)

The Distribution of Learning Outcomes Research illustrated by **t**he bar chart provides a breakdown of the 38 studies focusing on learning outcomes (RQ1) into the three educational domains. The majority of the studies (22 articles) concentrated on the cognitive domain, highlighting improvements in problem-solving, conceptual understanding, and higher-order thinking. Meanwhile, 10 articles examined the affective domain, emphasizing enhanced motivation, engagement, and curiosity among students. Finally, 6 studies addressed the psychomotor domain, documenting the benefits of STEAM in strengthening practical skills, experimentation, and craftsmanship as displayed in Figure 5.

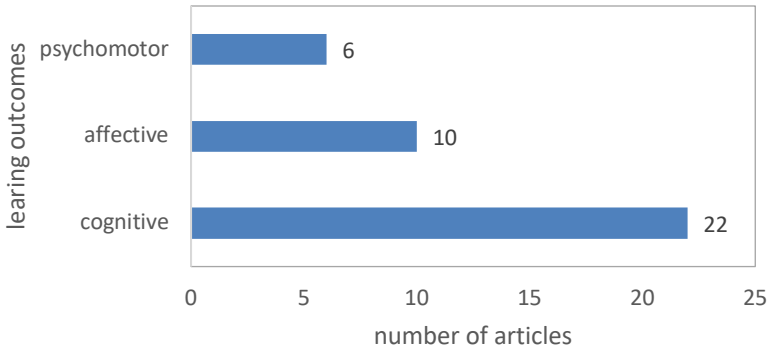

Figure 5. Distribution of Learning Outcomes Research

This distribution indicates that while cognitive outcomes are most frequently assessed, affective and psychomotor aspects are also integral components of STEAM learning, reinforcing its holistic impact on student development.

Creativity emerged as one of the most consistent outcomes reported in the reviewed literature. Across educational levels, STEAM activities encouraged students to generate original ideas, develop flexible problem-solving strategies, and integrate multiple domains of knowledge into innovative solutions. Creativity was evidenced in indicators such as originality, fluency of ideas, elaboration, and the ability to combine aesthetic and scientific reasoning..

The overlay visualization highlights the keywords *creativity*, *innovation*, and *critical thinking* as recent research trends (2023–2025, represented in yellow). This demonstrates a shift in scholarly attention from primarily measuring academic performance to emphasizing creativity as a central educational objective. The visualization validates that STEAM's contribution to creativity is increasingly recognized and prioritized within contemporary educational research, as shown in Figure 6.

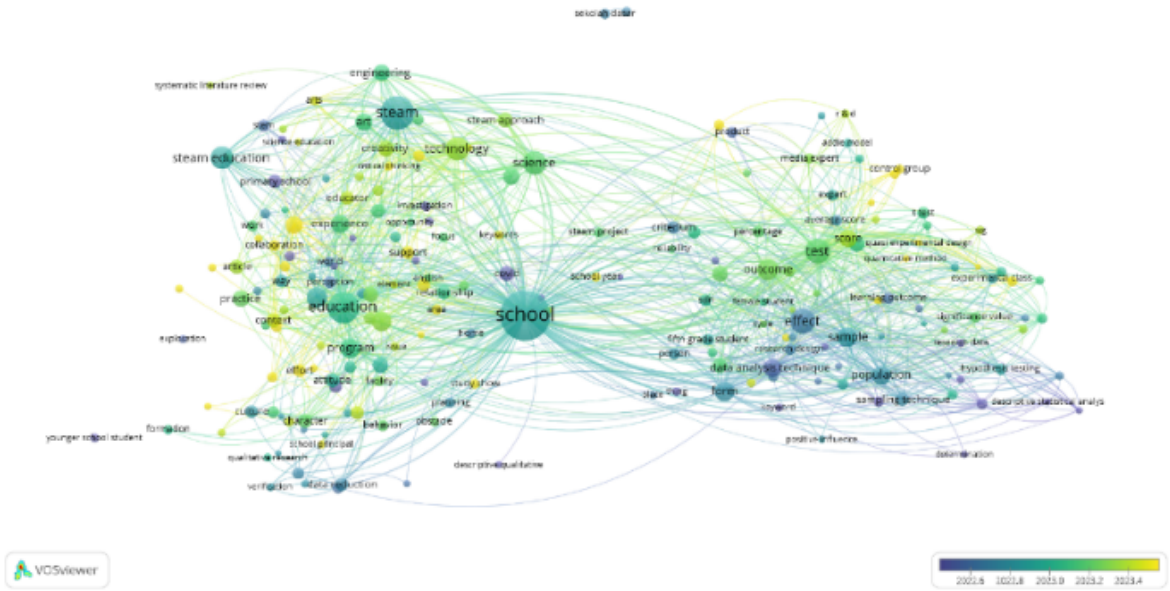

Figure 6. Overlay Visualization of STEAM Research (2021–2025)

The Interrelation Between Learning Outcomes and Creativity as a Foundation for 21st-Century Education

The synthesis of findings underscores a reciprocal relationship between learning outcomes and creativity in STEAM education. Students who achieved deeper conceptual understanding were more capable of producing creative solutions, while creative tasks simultaneously reinforced mastery of disciplinary knowledge. This synergy positions STEAM as a critical framework for equipping learners with competencies aligned to the demands of 21st-century education.

The density visualization shows that *learning outcomes* and *creativity* frequently co-occur, as indicated by the bright yellow high-density zones, as displayed by Figure 7.

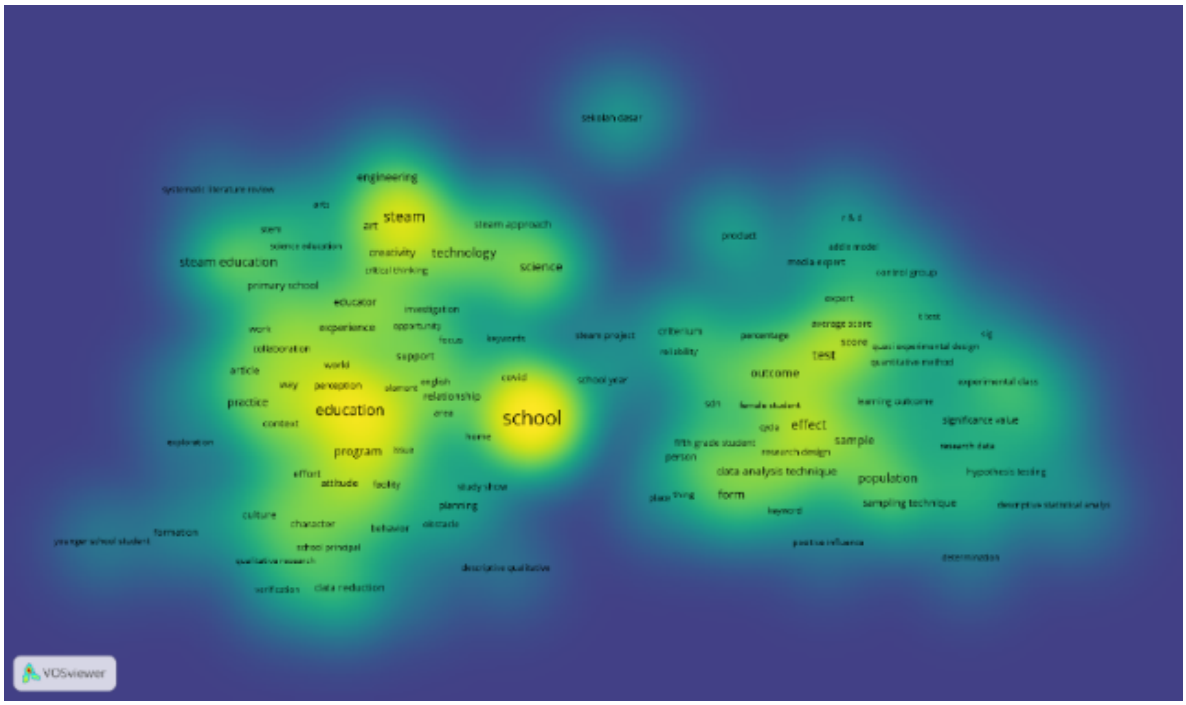

Figure 7. Density Visualization of STEAM Research (2021–2025)

. This reflects the scholarly consensus that learning achievement and creativity are interdependent dimensions within STEAM education. The visualization affirms the integration of creativity and learning. Outcomes are central to the relevance of education in the 21st century, where competencies such as critical thinking, creativity, collaboration, and communication are indispensable.

Collectively, these findings position STEAM not merely as an instructional innovation but as a strategic educational framework that bridges academic achievement with creativity and equips students with essential competencies for future challenges.

C. Discussion

Addressing Research Question 1 (RQ1), how the concepts and implementations of the *Science, Technology, Engineering, Arts, and Mathematics* (STEAM) approach have been developed and applied between 2021 and 2025, the reviewed studies reveal a clear paradigm shift from disciplinary integration toward an interdisciplinary learning model emphasizing *design thinking*, collaboration, and authentic problem-solving (Choirunnisa et al., 2023).

The *STEAM Project-Based Learning (PjBL)* model significantly enhanced elementary students' scientific literacy and critical thinking skills through exploratory projects grounded in real-life contexts. Teachers in Romania acknowledged the importance of STEAM as an interdisciplinary framework, but implementation remained limited due to inadequate training and infrastructure, underscoring the need for teacher professional development to optimize STEAM-based instruction. (Imaduddin, et al., 2021). During the COVID-19 pandemic, (Priyantini et al., 2021) Found that online STEAM-based instruction successfully maintained students' curiosity and learning motivation through creative, inquiry-based science activities delivered virtually. In a similar vein, (Dermawan & Andartiani, 2022)

Developed a STEAM-based *Electronic Student Worksheet (E-LKPD)* that facilitated autonomous and interactive learning, allowing students to actively construct their own knowledge and skills. From a technological perspective, incorporating *Augmented Reality (AR)* into STEAM learning significantly improved student engagement, conceptual understanding, and retention compared to traditional methods. (Priyantini et al., 2021). Moreover, through an *e-textiles* project, demonstrated that integrating art and technology created a more meaningful and creative learning experience that fostered collaboration and aesthetic-technical skills. (Guimeráns-Sánchez et al., 2024).

Regarding Research Question 2 (RQ2), to what extent STEAM approaches affect student learning outcomes in the cognitive, affective, and psychomotor domains, evidence across the studies consistently indicates positive impacts and significant improvements in students' *scientific literacy* scores following STEAM–PjBL implementation, evidencing notable cognitive gains. (Melia Astiana et al., 2021).

In the affective domain, the increased motivation, curiosity, and positive attitudes toward science learning through project-based, inquiry-driven activities (Priyantini et al., 2021). In terms of psychomotor outcomes, STEAM-based E-LKPD activities developed students' manipulative and technical skills through hands-on design and experimentation using digital media. (Dermawan & Andartiani, 2022). E-*textiles* projects improved fine motor coordination and basic technical abilities. (Guimeráns et al., 2024).

Synthesizing the broader evidence, in a systematic review that most STEAM studies conducted between 2021 and 2025 reported significant improvements across cognitive, affective, and psychomotor domains, although many relied on short-term interventions and lacked standardized assessment instruments (Anderson, 2021).

Addressing Research Question 3 (RQ3), how STEAM approaches influence the enhancement of students' creativity and their relevance to 21st-century learning demands empirical evidence strongly supports STEAM's role in fostering creative, innovative, and collaborative thinking. STEAM-based instruction significantly improved students' creative thinking, particularly in *fluency* and *flexibility*, suggesting that combining science and art cultivates divergent thinking and innovation. (Tran et al., 2021).

In a contextualized application, a *wall garden*-based STEAM model that enhanced ecological creativity and collaboration, as students worked together to design sustainable environmental solutions within their school context (Priyantini et al., 2021). Complementing this, *e-textiles* projects encouraged students to express ideas through the fusion of art and technology, thereby developing creativity alongside practical problem-solving and design skills (Guimeráns et al., 2024). From a socio-collaborative perspective, the gender

composition within STEAM learning groups affected social dynamics and outcomes, with mixed-gender teams exhibiting more effective communication and creative synergy (Priyantini et al., 2021). On a conceptual level, STEAM education nurtures the essential *4C skills*: creativity, collaboration, critical thinking, and communication, which are fundamental to 21st-century education (Anderson, 2021). Collectively, these findings affirm that STEAM not only enhances learning outcomes across domains but also plays a crucial role in cultivating creativity and essential competencies for the digital age through project-based, technology-integrated, and interdisciplinary learning designs.

D. Conclusion

This systematic literature review (2021–2025) concludes that the implementation of STEAM approaches has evolved into an integrated educational framework that effectively enhances student learning outcomes and creativity. The reviewed studies reveal that STEAM-based learning significantly improves cognitive, affective, and psychomotor domains by fostering higher-order thinking, engagement, and practical skills. Furthermore, the integration of art within STEM not only enriches conceptual understanding but also catalyzes creativity, encouraging originality, innovation, and flexible problem-solving aligned with 21st-century competencies. The interrelation between learning outcomes and creativity demonstrates that STEAM education cultivates holistic learners who are capable of critical thinking, collaboration, and inventive inquiry. Thus, STEAM emerges as a transformative pedagogical model that bridges academic achievement and creative development, positioning it as a key driver in preparing students to meet the complex demands of the modern world.

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