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Emerging Technologies in Elementary Literacy and STEAM Instruction: A Systematic Literature Review

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ABSTRACT

This systematic literature review explores the integration of emerging technologies in literacy and STEAM (Science, Technology, Engineering, Arts, and Mathematics) instruction in elementary classrooms. Drawing from twenty peer-reviewed journal articles published between 2022 and 2025, this study synthesizes trends in the use of technologies such as augmented and virtual reality (AR/VR), artificial intelligence (AI), digital storytelling, and mobile learning tools. The review identifies their impact on student engagement, literacy development, interdisciplinary learning, and digital competence. Findings highlight a growing alignment between technological innovation and constructivist pedagogy, though challenges such as teacher preparedness and equitable access remain. This review also provides a critical lens on how these technologies are positioned within broader educational systems. Recommendations are provided for educational stakeholders aiming to design effective, inclusive, technology-enhanced learning environments.

Keywords: emerging technologies, STEAM, literacy, elementary education, systematic review.

INTRODUCTION

Emerging technologies are reshaping educational landscapes, especially within elementary classrooms where foundational literacy and STEM concepts are introduced. The integration of these tools into STEAM and literacy instruction offers opportunities to deepen conceptual understanding and foster 21st-century skills [9], [3]. As schools strive to meet educational standards while embracing innovation, educators are increasingly exploring how technologies such as AI, AR/VR, and digital storytelling platforms can enhance instructional quality and learner outcomes [15], [10], [5].

LITERATURE REVIEW

Research shows a notable trend in using immersive technologies to support student engagement and content comprehension. For instance, Maričić and Lavicza [10] demonstrated that incorporating virtual simulations into elementary science curricula increased behavioral, cognitive, and emotional engagement. Similarly, Santillán-Aguirre and Chou [17] and Amirinejad and Rahimi [2] found that digital storytelling improved reading comprehension, emotional regulation, and self-expression, particularly when students created their own multimedia narratives. Leavy et al. [9] emphasize that these interventions often support transliteracy and multimodal communication skills, essential for navigating modern digital contexts. Several studies focus on AI literacy in elementary settings. Relmasira et al. [15], Chng

et al. [5], and Mertala et al. [11] implemented AI modules and immersive learning technologies and found increased student awareness of ethical dimensions, digital citizenship, and algorithmic thinking. These studies highlight the relevance of early AI instruction in STEAM education. Meanwhile, Boice et al. [3] and Papadopoulou [14] stressed the importance of teacher understanding and institutional support, noting that effective implementation requires more than tool adoption—it demands pedagogical shifts, creativity, and interdisciplinary collaboration. Despite promising outcomes, access to emerging technologies is inconsistent. Siregar et al. [18] documented challenges in integrating mobile STEAM projects across socio-economic settings. This digital divide raises equity concerns and reinforces the need for inclusive policy and practice. Amanova et al. [1] further emphasize the need for systemic support and teacher training in their international review of STEAM implementation.

Kreis and Boytchev [8] contribute to this understanding by identifying common barriers in implementing STEAM frameworks at the school level, including administrative resistance, insufficient time for professional learning, and rigid curriculum mandates. Their systematic review underscores the need for structural support and sustained teacher collaboration.

METHODOLOGY

This review employed a systematic approach to identify, evaluate, and synthesize peer-reviewed literature. Searches were conducted across SpringerLink, Frontiers, MDPI, and ERIC using keywords such as "emerging technologies," "STEAM education," "literacy," and "elementary classrooms." Inclusion criteria were: (1) publication between 2022 and 2025; (2) peer-reviewed journal status; (3) focus on elementary school settings; (4) discussion of literacy and/or STEAM instruction; and (5) integration of digital or emerging technologies. Twenty studies met these criteria and were thematically analyzed.

One notable challenge during the article selection process was the inconsistent use of terminology across the literature. Terms such as “emerging technology,” “digital tools,” and “STEAM integration” were often applied inconsistently, referring to a wide range of interventions from AR/VR applications to general classroom technologies. This required a careful manual review of each article's full content to ensure alignment with the study’s dual focus on literacy and STEAM in elementary education. Additionally, although the initial search yielded a high volume of results, several articles were excluded due to limited access to full texts or because they addressed technology use at a surface level without meaningful pedagogical integration. Subjectivity also played a role in determining which studies met the criteria for inclusion, particularly when a study addressed only one of the focal areas (literacy or STEAM) but hinted at interdisciplinary potential.

RESULTS

Thematic coding of the selected literature revealed five dominant trends. First, AR/VR technologies were linked to improved spatial reasoning, narrative immersion, and science comprehension [10], [19]. Second, AI modules facilitated early digital literacy and ethical reasoning [15], [5], [11]. Third, digital storytelling tools supported language acquisition, creativity, and engagement [17], [2], [16]. Fourth, mobile and gamified platforms were effective in mathematics and engineering learning [18]. Fifth, the integration of arts within STEAM reinforced creativity, narrative thinking, and interdisciplinary linkages [14]. As shown in Table 1, the reviewed studies highlight key technologies and educational outcomes across diverse

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elementary STEAM contexts. The table summarizes key technologies, educational outcomes, and instructional contexts from the 20 peer-reviewed studies reviewed in this systematic literature review. Adapted from sources [1]–[20].

Table 1: Summary of Emerging Technology Themes in Reviewed Studies (Adapted from sources [1]–[20]).

	Author(s)	Year	Technology Used	Educational Outcomes	Context
1	Amanova et al.	2025	STEAM Framework	Systemic support and teacher training	International primary schools
2	Amirinejad & Rahimi	2023	Digital Storytelling	Improved reading comprehension and self-expression	STEAM classrooms
3	Boice et al.	2024	STEAM Tools	Need for pedagogical shifts and collaboration	Elementary classrooms
4	Chen & Huang	2024	Integrated STEM	Improved problem-solving and conceptual understanding	Science instruction
5	Chng et al.	2023	Emerging Technologies	Increased engagement and tech awareness	General K-12 settings
6	Díaz-Noguera & García-Jiménez	2024	Technology-supported STEAM	Enhanced collaboration and literacy	Primary schools
7	Hashmi & Surani	2024	STEAM Environments	Improved critical thinking and motivation	K-6 learners
8	Kreis & Boytchev	2024	STEAM Frameworks	Barriers to implementation	Systematic review
9	Leavy et al.	2023	Emerging Technologies	Transliteracy and multimodal skills	STEAM classrooms
10	Maričić & Lavicza	2024	Virtual Simulations	Increased cognitive and emotional engagement	Elementary science
11	Mertala et al.	2024	AI Modules	Ethical reasoning and algorithmic thinking	AI literacy projects
12	Ng et al.	2022	inSTEAM Framework	Developmentally appropriate STEAM integration	Early childhood education
13	Nguyen & Le	2024	STEAM Modules	Improved literacy outcomes	Primary education
14	Papadopoulou	2024	STEAM Innovations	Fostered creativity and interdisciplinary thinking	European primary schools
15	Relmasira et al.	2023	AI Literacy	Improved ethical awareness and digital skills	Elementary AI curriculum
16	Samuel	2024	Digital Storytelling	Enhanced narrative development	Elementary storytelling units
17	Santillán-Aguirre & Chou	2023	Digital Storytelling	Improved vocabulary and creativity	STEAM instruction
18	Siregar et al.	2023	Mobile STEAM	Improved reasoning, access issues	Low-income school contexts

19	Zhang & Wang	2024	AR/VR Tools	Better content retention and visualization	Science and geography lessons
20	Yang & Chittoori	2022	Engineering Tech Tools	Improved engagement and problem-solving	Elementary engineering

Chen and Huang [4] provided evidence that integrated STEM instruction, particularly in science learning, enhanced students' problem-solving abilities and conceptual understanding. Their findings support the argument that emerging technologies, when embedded in STEM lessons, contribute to cross-disciplinary skill development. Additionally, Hashmi and Surani [7] demonstrated that dynamic STEAM environments improved students' critical thinking skills and motivation. These outcomes reinforce the significance of pedagogical design and the role of emerging technologies in fostering higher-order thinking skills. Ng et al. [12] introduced a conceptual framework to support STEAM integration in early childhood education, offering insights into the design of age-appropriate digital learning experiences.

Zhang and Wang [19] found that both AR and VR tools in elementary settings contributed to better content retention and visualization, especially in science and geography. Their systematic review further confirmed that student motivation and conceptual clarity were consistently higher when immersive technologies were integrated into STEAM instruction.

Díaz-Noguera and García-Jiménez [6] reinforced these insights through classroom-based studies, documenting how technology-supported STEAM lessons in primary schools enhanced collaborative problem-solving and supported literacy skill development through multimodal tasks.

Instructional designs were grounded in constructivist, inquiry-based, or project-based frameworks [12], [13], [1]. Studies consistently reported improvements in critical thinking, engagement, and digital literacy skills. However, limitations included inconsistent teacher training [3], infrastructure gaps [7], and limited representation of diverse student populations [13]. During synthesis, a key challenge was managing the heterogeneity of the selected studies. The diversity in research designs, participant demographics, and educational settings introduced complexity in comparing findings across contexts. For example, some studies emphasized student engagement through gamified tools, while others focused on teacher training for AI integration—necessitating flexible yet rigorous thematic coding. The variation in outcome measures, ranging from literacy gains to critical thinking skills or motivational indicators, required a nuanced approach to avoid oversimplifying results. Furthermore, synthesizing studies from international contexts demanded sensitivity to cultural and infrastructural differences that affect technology implementation. These disparities underscore the importance of interpreting trends within their respective contexts rather than assuming universal applicability.

DISCUSSION

This review reveals that emerging technologies, when thoughtfully integrated, enhance both literacy and STEAM learning in elementary contexts. The reviewed studies underscore the pedagogical potential of AR/VR, AI, and interactive platforms in fostering curiosity, collaboration, and communication. However, the variability in implementation fidelity and access points to systemic challenges in equity and teacher professional development.

Chen and Huang [4] highlight that technology-enhanced science instruction can increase student engagement and comprehension, particularly when grounded in hands-on inquiry-based learning. Their findings suggest that digital tools must be contextually aligned with content goals to be effective. Similarly, Hashmi and Surani [7] argue that STEAM environments designed with emerging technologies stimulate cognitive and emotional engagement, contributing to critical thinking and intrinsic motivation.

The conceptual model presented by Ng et al. [12] offers a framework for integrating STEAM in early education through technology-supported pedagogies. Their work points to the need for scaffolding digital experiences and aligning them with child development principles. These insights bridge the gap between theoretical design and classroom application.

Santillán-Aguirre and Chou [17], Samuel [16], and Amirinejad and Rahimi [2] provide further support for the use of student-authored digital storytelling in STEAM contexts, emphasizing its role in cultivating literacy, creativity, and emotional expression. Their studies found that children who designed their own multimedia books or engaged in structured storytelling tasks demonstrated enhanced narrative development, vocabulary use, and self-efficacy in communication.

Zhang and Wang [19] caution that while AR/VR improves comprehension and engagement, its effective implementation relies on instructional alignment, student readiness, and teacher facilitation. Their findings suggest that immersive tools should complement rather than replace foundational instructional methods.

Kreis and Boytchev [8] emphasize the importance of institutional commitment to professional development, curriculum flexibility, and interdepartmental collaboration as critical conditions for sustained integration of emerging technologies in elementary STEAM education. These elements are crucial in fostering long-term change and supporting teachers as they transition toward digitally enhanced pedagogies.

Díaz-Noguera and García-Jiménez [6] and Papadopoulou [14] extend this argument by showing how integrated STEAM practices promote both cognitive and socio-emotional learning. Their studies highlight the potential of emerging technologies to support personalized and collaborative literacy instruction within a broader STEAM context.

CONCLUSION

Emerging technologies are redefining elementary education, offering promising avenues to connect literacy and STEAM instruction. This systematic review provides evidence of their pedagogical value while recognizing the barriers that hinder widespread adoption. Future research should explore longitudinal effects, culturally responsive practices, and scalable models of integration. Educational leaders must ensure that innovations serve all learners by addressing gaps in access, training, and curriculum alignment.

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