JoSSEd
Journal of Science and Science Education
ISSN: 2774-1869 eISSN: 2774-2105

Mapping Digital Technology Research in STEM Education: A Systematic Literature Review and Bibliometric Analysis (2016–2025)

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Received: August 11, 2026
Revised: October 17, 2026
Accepted: October 28, 2026
Published: October 31, 2026

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DOI: 10.29303/jossed.v7i2.16405

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Abstract: This study maps the development, thematic structure, and future research directions of digital technology in STEM (Science, Technology, Engineering, and Mathematics) education during 2016–2025. A bibliometric-systematic literature review was conducted in four steps: searching ScienceDirect and SpringerLink, screening articles according to PRISMA 2020, analyzing keyword co-occurrence with VOSviewer, and synthesizing the content of the selected articles thematically. Of 1,098 records retrieved, 131 empirical research articles were analyzed. Publications in this corpus rose sharply, from one article in 2016 to 50 in 2025. Thirteen keywords met the occurrence threshold of 5 and formed three clusters: (1) artificial intelligence, educational technology, and teacher professional development; (2) immersive technologies in STEM and engineering education; and (3) computational thinking and hands-on learning. STEM education was the most prominent keyword (50 occurrences; total link strength = 40), and generative AI was among the most recent themes (average publication year = 2024.83). The synthesis identified four research gaps (limited evidence on learning outcomes, teacher readiness and ethics, humanistic dimensions of learning, and reporting of learner-level variables), from which five future research agendas were derived by combining emerging themes in the overlay map, limitations reported in earlier studies, and the learning needs of STEM education. The findings offer an evidence-based overview for designing technology-supported STEM learning and teacher professional development, and they describe trends in the selected corpus rather than in all global publications.

Keywords: Artificial intelligence; Bibliometric analysis; Digital technology; Generative AI; STEM education; Systematic literature review; VOSviewer.

Introduction

Science, Technology, Engineering, and Mathematics (STEM) education currently occupies a central position in global educational reform, aimed at developing 21st-century competencies including critical thinking, problem-solving, creativity, and interdisciplinary collaboration (Bybee, 2010; Michalsky & Cohen, 2021). Within this framework, digital technology plays a pivotal role in enriching learning processes, providing interactive visual representations, facilitating authentic problem-solving, and expanding access to high-quality educational experiences (Jiang et al., 2024; Mystakidis et al., 2022).

The evolution of digital technology in STEM education has rapidly shifted from conventional computer-assisted instruction toward intelligent, adaptive, and immersive learning environments. The integration of artificial intelligence (AI), learning analytics, augmented reality (AR), virtual reality (VR), and generative AI instruments has redefined how instructional design, learning evaluation, and teacher-student interactions occur (Farhood et al., 2025; Wu et al., 2025; Zhang et al., 2026). These advancements demonstrate that digital transformation in STEM education is not merely a technical adoption of software and hardware, but a fundamental paradigm shift in pedagogical design and cognitive engagement (Leon et al., 2025).

Despite the abundant potential of digital technologies, prior review studies have mostly examined specific technologies, such as augmented

How to Cite:
Maulidya, N. M., Ramlawati, R., & Allo, E. L. (2026). Mapping Digital Technology Research in STEM Education: A Systematic Literature Review and Bibliometric Analysis (2016–2025). *Journal of Science and Science Education*, *7*(2), 52–68. https://doi.org/10.29303/jossed.v7i2.16405

reality in higher education (Mystakidis et al., 2022), artificial intelligence in high school STEM (Akhmetova et al., 2025), or computational thinking in K–12 classrooms (Liu et al., 2024). While single-technology reviews provide in-depth insights into particular tools, they do not show how various digital technology themes are interconnected, which themes remain dominant, and how research priorities shift across time (Yeni et al., 2024).

Three earlier studies are the closest to the present work. Xu and Ouyang (2022) reviewed AI technologies in STEM education for 2011–2021, which gives depth on one technology family but does not show how AI relates to other digital technologies. Ha et al. (2020) mapped STEM education research in ASEAN countries using Scopus data for 2000–2019, and Zhan et al. (2022) mapped the global landscape of STEM education for 2004–2021. Both applied bibliometric analysis to STEM education in general rather than to digital technology specifically, and both end before the rapid spread of generative AI in education after 2022. The present study differs in four respects: it covers digital technology broadly (including AI, generative AI, augmented and virtual reality, and computational tools); it covers 2016–2025, so that earlier and emerging themes can be compared within one dataset; it draws on ScienceDirect and SpringerLink; and it combines bibliometric keyword mapping with a thematic synthesis of article content, so that the maps are interpreted and not only described.

The ten-year period was chosen for two reasons. First, 2016–2025 spans the years in which immersive, computational, and AI-based tools were increasingly adopted in STEM classrooms and in which generative AI emerged after late 2022, so that earlier and newer technology themes can be examined together. Second, a decade is long enough to observe changes in keyword usage over time, which is required to answer the research question on temporal evolution.

To bridge this critical research gap, a comprehensive study combining a Systematic Literature Review (SLR) with quantitative bibliometric mapping is essential (Marzi et al., 2025). SLR ensures transparent and rigorous literature selection based on predefined eligibility criteria, while bibliometric analysis via VOSviewer allows for keyword co-occurrence mapping, cluster identification, total link strength evaluation, and temporal trend tracking (van Eck & Waltman, 2010).

Accordingly, this study aims to systematically review and map research on digital technology in STEM education over a full decade (2016–2025). Specifically, this research addresses four central Research Questions (RQs):

1. What is the annual publication trend of research on digital technology in STEM education from 2016 to 2025?
2. What thematic clusters and dominant keyword networks emerge from the literature?
3. How have research themes evolved temporally across the ten-year period?
4. What research gaps and strategic future research agendas can be identified from the synthesis of SLR and bibliometric mapping?

Each research question is answered by a specific part of the method: RQ1 by the annual publication counts of the selected articles; RQ2 by keyword co-occurrence and network visualization; RQ3 by overlay visualization based on average publication year; and RQ4 by the thematic synthesis of the selected articles combined with the bibliometric patterns.

Method

Research Design

This study adopts a bibliometric-systematic literature review (B-SLR) design, which combines the transparent, criteria-based selection of a Systematic Literature Review (SLR) with bibliometric mapping and content-based synthesis (Marzi et al., 2025). The identification, screening, eligibility, and inclusion stages were conducted and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) statement (Page et al., 2021).

The study proceeded in four sequential stages. Stage 1 was literature search and selection: records were retrieved from two databases, deduplicated, screened by title and abstract, and assessed in full text against the inclusion and exclusion criteria. Stage 2 was data extraction: bibliographic metadata (authors, year, source, abstract, and author keywords) of the selected articles were exported for bibliometric processing, and the content of each article was coded for the synthesis. Stage 3 was bibliometric analysis: author keywords were standardized and analyzed in VOSviewer, and annual publication counts were tabulated. Stage 4 was thematic synthesis: the coded content was grouped into themes and compared with the bibliometric clusters to identify research gaps and future research agendas. Each stage is described in the following subsections.

Data Source and Search Strategy

Literature was retrieved from two international academic databases: ScienceDirect and SpringerLink. These platforms were selected because they host many leading education and educational technology journals (for example, Computers & Education and Education and Information Technologies) and allow bibliographic records, including author keywords, to be exported for

processing in VOSviewer. Other indexing databases (e.g., Scopus, Web of Science, and ERIC) and other publishers were not searched. The corpus is therefore a selected sample of the literature, and this limitation is discussed at the end of the Results and Discussion section.

The search was conducted in June 2026 and restricted to peer-reviewed original research articles published between 2016 and 2025. The same Boolean string was applied on both platforms: ("STEM education" OR "STEM learning" OR "integrated STEM") AND ("digital technology" OR "digital technologies" OR "educational technology"). On ScienceDirect, the string was searched in the title, abstract, and author-specified keywords fields, with the article type set to research articles and the publication years set to 2016–2025. On SpringerLink, the string was entered in the advanced search with the content type set to article and the same date range. The initial search retrieved a total of 1,098 articles (478 from ScienceDirect and 620 from SpringerLink), as summarized in Table 1.

The search string deliberately used umbrella terms for both STEM education and digital technology, so that specific technologies (e.g., AI, augmented reality, virtual reality, and computational thinking) would emerge from the authors' own keywords and not be imposed by the search terms. The consequence is that studies on a specific technology that do not use these umbrella terms in their title, abstract, or keywords may not have been retrieved. The results are therefore interpreted as trends in the selected corpus and not as a complete representation of all global publications on digital technology in STEM education. Articles published in 2026 that are cited in this paper (e.g., Boolzen et al., 2026; Zhang et al., 2026) served only as supporting literature for interpretation and were not part of the analyzed dataset.

Table 1. Summary of Initial Database Search Results

Database Source	Publication Period	Document Type	Retrieved Count
ScienceDirect	2016–2025	Research Article	478
SpringerLink	2016–2025	Research Article	620
Total Dataset	2016–2025	Research Article	1,098

Inclusion and Exclusion Criteria

To ensure methodological quality, the screening criteria were defined as operational rules and applied in the same way at the title-and-abstract stage, the full-text stage, and the final verification (Table 2). Only empirical research was accepted: conceptual, theoretical, and review articles were excluded so that every article in the corpus reports original data.

Table 2. Inclusion and Exclusion Criteria for Article Selection

Inclusion Criteria	Exclusion Criteria
Peer-reviewed original research articles that report empirical data (quantitative, qualitative, or mixed methods).	Review papers, conceptual or theoretical papers without empirical data, book chapters, conference abstracts, and editorials.
Published between 2016 and 2025.	Published before 2016 or after December 2025.
Digital technology (e.g., AI, AR/VR, simulations, learning analytics, or coding tools) is the main intervention, tool, or object of study in a STEM teaching or learning context.	Digital technology is mentioned only as background, or the study concerns general technology outside STEM or non-digital educational tools.
Complete bibliographic metadata (author keywords, publication year, and abstract) suitable for bibliometric processing.	Records with missing author keywords, publication year, or abstract that could not be completed from the publisher's page.
Retrieved from ScienceDirect or SpringerLink.	Duplicate records or articles from other, unverified sources.

Records with incomplete metadata were not dropped automatically: missing keywords, years, or abstracts were first checked against the publisher's article page and completed where possible, and records that remained incomplete were excluded at the eligibility stage. Before analysis, a final check confirmed that each of the 131 selected articles met all five inclusion criteria and none of the exclusion criteria

PRISMA Selection Procedure

The selection process followed four PRISMA stages: (1) Identification: 1,098 total records identified (ScienceDirect n = 478, SpringerLink n = 620). Six duplicate records were removed, leaving 1,092 records. (2) Screening: Title and abstract screening excluded 620 non-relevant records, leaving 472 articles for full-text eligibility assessment. (3) Eligibility: Full-text evaluation excluded 341 articles that did not meet the inclusion criteria (e.g., no empirical STEM context, or incomplete metadata that could not be completed). (4) Inclusion: A final corpus of 131 empirical research articles was selected for complete bibliometric and systematic synthesis.

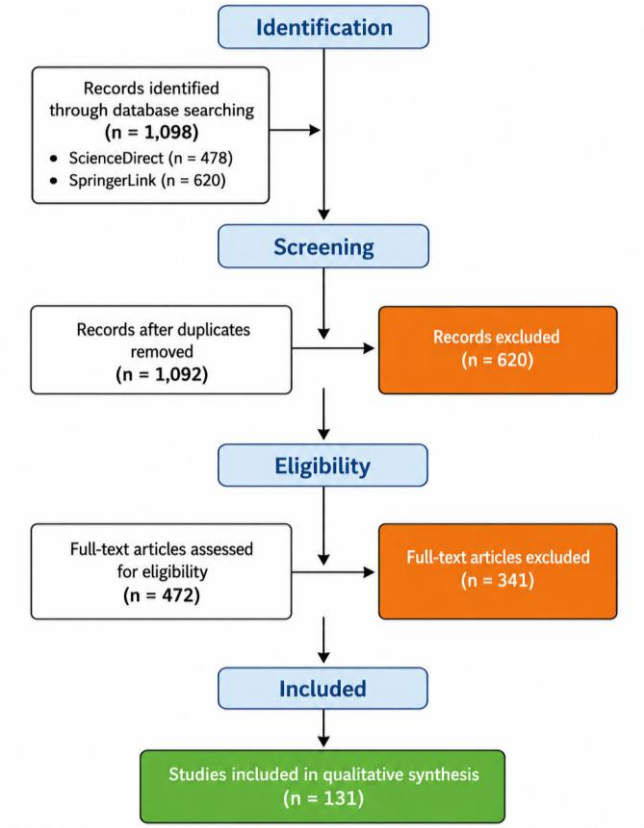

Figure 1. PRISMA 2020 Literature Selection Flowchart for Digital Technology in STEM Education

Data Cleaning and Standardization

To eliminate statistical bias and metadata noise during network mapping, keyword data were standardized via a thesaurus file in VOSviewer. Cleaning focused on three core areas: (1) Acronym and Abbreviation Standardization (e.g., merging 'AR' into 'augmented reality', 'AI' into 'artificial intelligence'), (2) Plural and Singular Harmonization (e.g., merging 'digital technologies' into 'digital technology'), and (3) Conceptual Term Alignment (e.g., merging 'generative artificial intelligence' and 'ChatGPT' into 'generative AI').

Bibliometric Analysis and Synthesis

Bibliometric co-occurrence analysis was conducted in VOSviewer (v1.6.20) on the standardized author keywords of the 131 articles. A minimum occurrence threshold of 5 yielded 13 keywords. VOSviewer generated three complementary visualizations: a network visualization (cluster structure), an overlay visualization (temporal evolution based on average publication year, APY), and a density visualization (thematic concentration). Each keyword is described by two indicators: occurrences, the number of articles in which the keyword appears, and total link strength (TLS), the sum of the strengths of its co-occurrence links with the other keywords in the map. Annual publication counts (RQ1) were tabulated from the publication year of each article.

Thematic Synthesis

The thematic synthesis addressed the content of the 131 articles and was used to interpret, not to replace, the bibliometric results. Each article was coded for the type of digital technology, the STEM discipline and education level, the research focus, the main findings, and the reported limitations. The coded content was then grouped inductively into themes by comparing recurring technologies, pedagogical purposes, and limitations across articles, and these themes were compared with the VOSviewer clusters to check whether the keyword structure agreed with the article content. A research gap was recorded when a limitation or omission recurred across the articles or when a topic was absent from the keyword network. Future research agendas were derived from the gaps, the emerging themes in the overlay map, and the needs of STEM learning (RQ4). In the Results and Discussion, bibliometric findings (what the maps show) are reported separately from conceptual interpretations (what the supporting literature suggests).

Result and Discussion

Annual Publication Trends (2016–2025)

The 131 selected articles show a clear upward trend in publications over the ten-year period (Figure 2). Output was low between 2016 and 2020 (1, 2, 1, 6, and 5 articles per year; 15 articles in total, about 11% of the corpus), began to rise in 2021 (10 articles), and increased steadily to 17, 18, and 21 articles in 2022, 2023, and 2024. Publications then increased sharply to 50 articles in 2025, about 38% of the corpus and more than double the 2024 figure. These values describe the publication pattern within the 131 selected articles; no growth model was fitted, so they should not be read as the growth rate of all publications on this topic. The rise coincides with the wider adoption of AI-based tools, especially generative AI after late 2022, and with the growing use of immersive and computational tools in STEM classrooms, and it is consistent with earlier bibliometric evidence that STEM education research has expanded in recent years (Ha et al., 2020; Zhan et al., 2022). Because the corpus is limited to two databases and a fixed set of search terms, the trend indicates growing attention to the topic in the selected sources and does not by itself establish a global research priority.

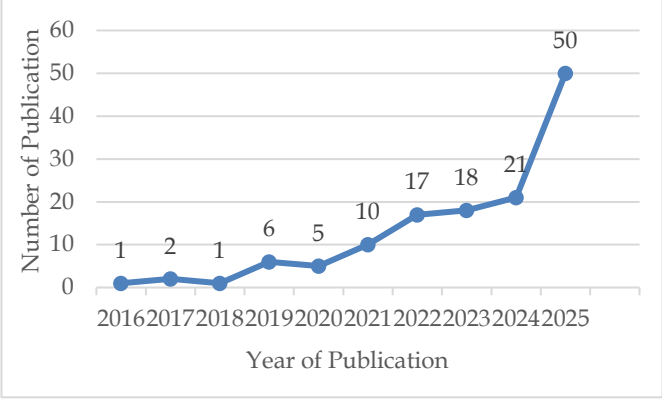

Figure 2. Annual Publication Trend of Research on Digital Technology in STEM Education (2016–2025)

Thematic Keyword Mapping and Cluster Analysis

Keyword co-occurrence analysis mapped 13 keywords into three clusters (Figure 3; red = Cluster 1, green = Cluster 2, blue = Cluster 3). The clusters were formed by VOSviewer from the co-occurrence links; the names below were assigned by the authors according to the keywords each cluster contains and the links between them. Occurrences and TLS values are reported in Table 3.

Cluster 1 (red): AI-supported science education and teacher professional development. This is the largest cluster (six keywords): artificial intelligence (19 occurrences), science education (15), educational technology (14), teacher professional development (7), generative AI (6), and the generic term 'stem'. It is named after its most frequent and best-connected keywords, which link AI and educational technology with science education, teacher professional development, and generative AI. The cluster indicates that AI research in STEM is closely tied to science learning and to teachers' readiness, so teacher competence becomes a condition for using adaptive feedback and personalized learning in STEM classes (Farhood et al., 2025; Fteiha et al., 2025).

Cluster 2 (green): immersive technologies in STEM and engineering education. It contains STEM education (50 occurrences), augmented reality (10), engineering education (8), and virtual reality (6). STEM education is the largest node in the map and is directly linked to augmented reality, virtual reality, and engineering education, which explains why the immersive tools and engineering education are grouped around the general field label. The cluster points to the use of immersive tools to make abstract content visible and to support design and problem-solving tasks in engineering contexts (Jiang et al., 2024; Suhail et al., 2024).

Cluster 3 (blue): computational thinking and hands-on learning. It includes computational thinking (8 occurrences), hands-on learning (5), and mathematics education (5). These keywords describe learning activities and subject links more than specific technologies, and they connect computational and mathematical reasoning with hands-on and digital game-based STEM learning (L. H. Wang et al., 2022). The cluster contributes to STEM learning mainly through problem-solving and logical reasoning skills.

Across the three clusters, STEM education acts as the hub of the network: it is the most frequent keyword and is linked to keywords in all clusters (Figure 3). Technology-specific topics (AI, AR, VR, and computational thinking) are therefore discussed in relation to STEM learning in general and not as isolated areas.

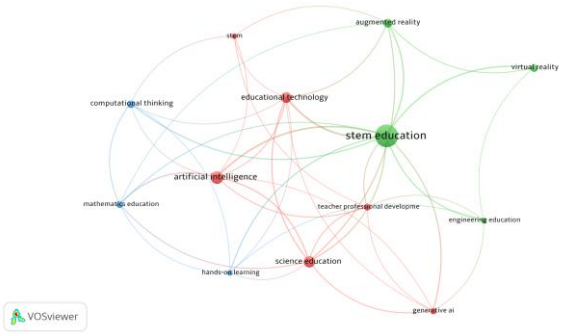

Figure 3. Network Visualization Map of Keyword Co-occurrence in VOSviewer

Keyword Frequency and Total Link Strength (TLS) Analysis

Two indicators in Table 3 were used to identify the dominant themes. Occurrences show how many articles use a keyword and thus how prominent a topic is. Total link strength (TLS) is the sum of the strengths of a keyword's co-occurrence links with the other keywords in the map and thus shows how strongly the topic is connected to the rest of the network. A theme was regarded as dominant when it scored high on both indicators.

On this basis, STEM education is the central node (50 occurrences, TLS = 40), followed by artificial intelligence (19 occurrences, TLS = 19), science education (15; 19), educational technology (14; 18), and augmented reality (10; 13). The two indicators do not always rank keywords in the same way. STEM education occurs far more often than any other keyword, but its TLS is lower than its occurrences (40 versus 50), which means that it often appears in articles without other keywords retained in the map. By contrast, science education, educational technology, and augmented reality have TLS values higher than their occurrences (19 versus 15, 18 versus 14, and 13 versus 10), which indicates that these mid-frequency keywords connect many other topics and serve as bridges between clusters. Artificial intelligence combines high frequency with a TLS equal to its occurrences (19). Comparing AI with generative AI (19 versus 6 occurrences; TLS 19 versus 8), the broader AI keyword is much more established, whereas

generative AI is infrequent but connected to several other keywords.

Table 3. Summary of Core Network Parameters for Dominant Keywords (ordered by occurrences)

Keyword	Occurrences	TLS	Cluster
STEM education	50	40	2
Artificial intelligence	19	19	1
Science education	15	19	1
Educational technology	14	18	1
Augmented reality	10	13	2
Engineering education	8	11	2
Computational thinking	8	10	3
Teacher professional development	7	9	1
Generative AI	6	8	1
Virtual reality	6	7	2
Hands-on learning	5	7	3
STEM	5	6	–
Mathematics education	5	5	3

Temporal Evolution and Emerging Themes (Overlay Analysis)

Bibliometric finding. In the overlay visualization (Figure 4), keywords are colored by the average publication year (APY) of the articles in which they occur. A keyword is therefore called recent only relative to the other keywords in this dataset, and novelty is determined by APY and not by the keyword's subject. Computational thinking and hands-on learning are at the older end of the color scale, most other keywords (including STEM education, science education, augmented reality, and educational technology) are in the middle range, and artificial intelligence, virtual reality, and especially generative AI, engineering education, and 'stem' are at the recent end. Generative AI had an APY of 2024.83, which makes it one of the most recent themes in the dataset.

Interpretation from the literature. The ordering suggests that, within this dataset, attention moved from computational and hands-on activities toward AI-based and generative AI-based approaches. The overlay colors only show when keywords were used, so the meaning of this shift for learning rests on the synthesis of the selected and supporting literature and not on the colors. Recent reviews discuss a movement from rule-based Intelligent Tutoring Systems toward environments in which AI acts as a reflective partner that supports self-regulated learning (Wu et al., 2025; Zhang et al., 2026), although the evidence on cognitive learning outcomes remains heterogeneous (Boolzen et al., 2026). This change of learning paradigm is therefore a conceptual interpretation from the literature and not a result of the overlay map itself.

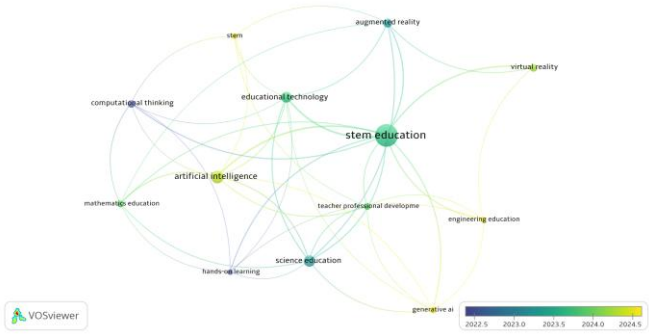

Figure 4. Overlay Visualization Map Showing Keyword Temporal Evolution (APY)

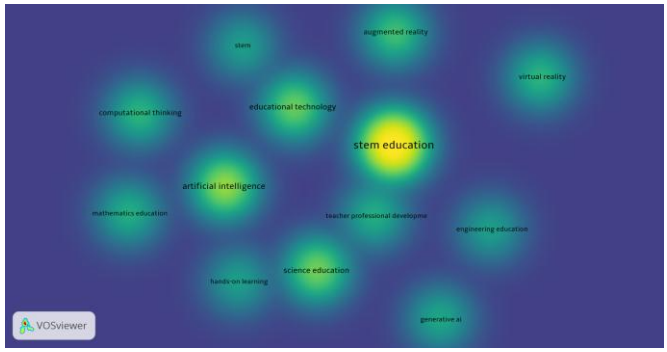

Figure 5. Density Visualization Map Highlighting Keyword Concentrations in VOSviewer

The density visualization (Figure 5) shows where keyword occurrence and link strength are concentrated. The highest concentration is around STEM education, followed by artificial intelligence, science education, and educational technology, which agrees with their occurrence and TLS values in Table 3. These areas form the established core of the field: digital technology is studied mainly as a means of supporting STEM and science learning, and AI is the most developed technology theme. Generative AI, virtual reality, augmented reality, engineering education, computational thinking, hands-on learning, mathematics education, teacher professional development, and 'stem' show lower density and appear as relatively sparse themes. Read together with the overlay map, the sparse areas are of two kinds: recent themes that are still developing (generative AI and engineering education) and older themes that received limited attention in the corpus (computational thinking, hands-on learning, and mathematics education). Read together with the network map, these sparse themes are connected to the core mainly through STEM education, science education, and AI, which suggests room for studies that link them with each other, for example immersive tools with computational thinking, or generative AI with engineering education and teacher professional development. The three maps are therefore complementary: the network map shows how keywords

are grouped, the overlay map shows when they were used, and the density map shows where research is concentrated and where it remains sparse.

Synthesis of Findings, Research Gaps, and Future Research Agendas

Synthesizing the content analysis of the selected articles with the bibliometric maps revealed four research gaps. Each gap is stated together with the evidence on which it rests.

Pedagogical and Contextual Integration Gap. Technology keywords such as artificial intelligence, augmented reality, and virtual reality meet the occurrence threshold, whereas no keyword denoting learning achievement, learning outcomes, or scientific literacy reaches 5 occurrences (Table 3). Together with the tendency of the reviewed articles to report technical adoption without measuring specific STEM learning gains, this indicates that pedagogical evidence lags behind technology adoption. The evidence on cognitive learning outcomes of generative AI is also heterogeneous (Boolzen et al., 2026).

Teacher Readiness and Ethical AI Gap. Teacher professional development is connected to AI and generative AI within Cluster 1 but occurs in only seven articles, and no keyword on ethics or AI literacy reaches the threshold. This pattern matches the deficits in teacher AI literacy and ethical governance frameworks reported in studies of teacher readiness and regulation (Fteiha et al., 2025; García-López & Trujillo-Liñán, 2025).

Structural Imbalance Gap. Technology-oriented keywords dominate the network, while no keyword on cognitive load, critical thinking, or student agency is retained. This points to a heavy emphasis on technical AI features over humanist dimensions such as cognitive load, critical thinking, and student agency.

Contextual Variable Methodological Gap. Studies of generative AI in STEM insufficiently report prompt quality, student AI literacy, and cognitive delegation behaviors. A recent meta-analysis documents the same underreporting of learner-level variables (AI literacy and metacognitive skills) and process-level mechanisms (task delegation, prompt quality, and verification behavior) (Boolzen et al., 2026).

Five strategic future research agendas follow from these gaps. They were determined with three criteria: (a) emerging themes in the overlay map, such as generative AI; (b) limitations repeatedly reported in earlier studies; and (c) learning needs in STEM education, namely scientific literacy, critical thinking, problem solving, and teachers' competence to integrate digital technology. The agendas are:

1. Pedagogical integration of generative AI and cognitive impact evaluation (Gaps 1, 3, and 4; emerging theme in the overlay map): designing AI use that triggers critical inquiry instead of passive cognitive offloading, and measuring its effect on critical thinking and conceptual understanding (Boolzen et al., 2026; Zhang et al., 2026).
2. Teacher–AI partnership and AI-TPACK frameworks (Gap 2; Cluster 1): strengthening teachers' pedagogical decision-making and ethical AI competence so that they can integrate digital technology into STEM and science learning (Fteiha et al., 2025).
3. AR/VR integration in engineering design and problem solving (Gaps 1 and 3; Cluster 2, where engineering education is linked to AR and VR and is among the most recent keywords): embedding immersive tools into authentic engineering design tasks to support problem solving and lower cognitive load (Suhail et al., 2024).
4. Aligning computational thinking with hands-on physical-digital learning (Cluster 3, where computational thinking and hands-on learning show lower density): developing hybrid learning experiences that connect coding with physical robotics and IoT sensors (L. H. Wang et al., 2022).
5. Addressing regional inequality, methodological rigor, and data ethics (Gaps 2 and 4): conducting cross-national longitudinal studies and establishing student data privacy protections (El Fathi et al., 2025; Zhan et al., 2022). This agenda rests on prior literature, because the present study did not analyze country-level distribution.

*Pedagogical implications***.** The findings carry four implications for STEM teaching. First, the central position of STEM education and science education in the network suggests that digital tools should be selected according to learning goals such as scientific literacy, critical thinking, and problem solving, and not adopted for their own sake. Second, immersive tools and computational thinking activities (Clusters 2 and 3) fit tasks in which students must visualize, model, or build, and they can support problem solving when they are tied to authentic tasks. Third, the growth of AI-related research raises the demand for teacher competence: teachers need AI literacy, pedagogical design skills (AI-TPACK), and ethical awareness to judge when AI supports students' thinking and when it replaces it. Fourth, because learning outcomes rarely appear among the prominent keywords, claims about the benefits of digital technology should be treated with caution until studies measure learning gains directly.

Limitations. This study has several limitations. First, the data came from two publisher platforms (ScienceDirect and SpringerLink), so relevant articles indexed only in other databases or published by other

publishers may not have been captured. Second, the search string used umbrella terms, so relevant articles that do not use them in their title, abstract, or keywords may be missing, and the occurrence threshold of 5 retained only 13 keywords, so infrequent but emerging topics are not visible in the maps. Third, author keywords vary in wording; although a thesaurus was used, some conceptual overlap may remain, and the choice of keywords influences the clustering. Fourth, bibliometric networks are interpretive: cluster boundaries, colors, and distances depend on the analysis settings, and co-occurrence shows association and not the quality or causal effect of the evidence; the APY of recent keywords such as generative AI is based on a small number of recent articles. These limitations do not reduce the value of the findings, but they define their scope: the results describe trends in the selected corpus and should not be generalized to all global publications. Future studies could add databases such as Scopus and Web of Science, expand the search terms for specific technologies, and appraise the quality of the included studies.

Conclusion

This study mapped research on digital technology in STEM education through a bibliometric-systematic literature review of 131 empirical articles published in 2016–2025 and retrieved from ScienceDirect and SpringerLink. Publications in the selected corpus rose sharply, especially in 2025, which shows growing attention to the topic (RQ1). Keyword mapping grouped the field into three themes: AI with educational technology and teacher professional development, immersive technologies in STEM and engineering education, and computational thinking with hands-on learning, with STEM education as the connecting core (RQ2). Generative AI appeared as one of the most recent themes (RQ3), and the synthesis identified gaps in evidence on learning outcomes, teacher readiness and ethics, humanistic dimensions of learning, and reporting of learner-level variables, which lead to five future research agendas (RQ4). The main contribution is an integrated overview that connects bibliometric patterns with the content of the articles, so that the structure of the field, its newer directions, and its evidence gaps can be seen in one framework.

For educators, the findings suggest that digital technology should be selected according to STEM learning goals such as scientific literacy, critical thinking, and problem solving, and that teachers need professional development in AI literacy, technology-integrated pedagogical design, and ethical use. For researchers, the findings point to the need for studies that measure learning outcomes and cognitive processes, report learner-level variables such as AI literacy and prompt quality, and examine immersive and computational approaches together with AI.

These conclusions describe trends in the selected corpus and are bounded by the choice of databases, search terms, and keyword threshold. Future research can extend the corpus to other databases and appraise the quality of the included studies to strengthen the evidence base.

Acknowledgments

The author would like to express his gratitude to all those who provided support and contributions during the preparation of this article. He hopes this article will be useful and contribute to the development of science, particularly in the field of science education.

Author Contributions

Conceptualization, N.M.M.; methodology, R. and E.L.A; software, N.M.M.; validation, R. and E.L.A; formal analysis, N.M.M.; investigation, N.M.M.; resources, N.M.M.; data curation, N.M.M.; writing—original draft preparation, N.M.M.; writing—review and editing, N.M.M.; visualization, N.M.M. The author has read and agreed to the published version of the manuscript

Funding

Researchers independently funded this research

Conflicts of Interest

The authors declare no conflict of interest.

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