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A Bibliometric Analysis of Digital Technology in Mathematics Education to Support Mathematical Critical Thinking Skills and the Achievement of SDG 4

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Abstrak

Penelitian ini bertujuan menganalisis perkembangan penelitian tentang teknologi digital dalam pendidikan matematika serta keterkaitannya dengan kemampuan berpikir kritis matematis (MCTS) dan pencapaian Tujuan Pembangunan Berkelanjutan ke-4 (SDG 4). Penelitian menggunakan analisis bibliometrik deskriptif terhadap 57 artikel ilmiah yang diperoleh dari Google Scholar, Scopus, dan OpenAlex pada rentang tahun 2016–2026. Metadata publikasi dikelola menggunakan Publish or Perish (PoP), sedangkan pemetaan jejaring kata kunci dilakukan menggunakan VOSviewer. Analisis mencakup tren publikasi tahunan, sitasi artikel dan sumber publikasi, hubungan antarkata kunci, serta analisis tematik terkait MCTS dan dimensi SDG 4. Hasil penelitian menunjukkan peningkatan publikasi yang substansial pada periode 2025–2026, dengan jumlah publikasi tertinggi pada tahun 2025 sebanyak 24 artikel. Artikel Rashid (2019) memperoleh sitasi terbanyak, yaitu 324 sitasi, sedangkan Sustainability mencatat total sitasi tertinggi di antara sumber publikasi, yaitu 595 sitasi. Pemetaan kata kunci mengidentifikasi 26 istilah yang membentuk tiga klaster tematik utama, dengan berpikir kritis sebagai kata kunci paling dominan. Analisis tematik menunjukkan bahwa teknologi digital berpotensi mendukung pengembangan MCTS melalui eksplorasi konsep, visualisasi, dan aktivitas pemecahan masalah matematis. Selain itu, keterkaitan dengan SDG 4 lebih banyak teridentifikasi pada dimensi kualitas pendidikan (43 artikel) dibandingkan dimensi pemerataan akses (22 artikel). Temuan ini menunjukkan meningkatnya perhatian penelitian terhadap teknologi digital dalam pendidikan matematika, sementara pemerataan akses teknologi tetap menjadi isu penting untuk penelitian selanjutnya.

Kata kunci: Analisis Bibliometrik; Kemampuan Berpikir Kritis; Teknologi Digital; Pendidikan Matematika; SDG 4.

Abstract

This study aims to analyze the development of research on digital technology in mathematics education and its relationship with mathematical critical thinking skills (MCTS) and the achievement of Sustainable Development Goal 4 (SDG 4). This study employed a descriptive bibliometric analysis of 57 scientific articles retrieved from Google Scholar, Scopus, and OpenAlex, covering the period from 2016 to 2026. Publication metadata were managed using Publish or Perish (PoP), while keyword network mapping was conducted using VOSviewer. The analysis covered annual publication trends, article and publication source citations, keyword relationships, and thematic analysis related to MCTS and SDG 4 dimensions. The results indicate a substantial increase in publications during 2025–2026, with 2025 recording the highest number of publications, comprising 24 articles. Rashid (2019) received the highest number of citations, with 324 citations, while Sustainability recorded the highest total citations among publication sources, with 595 citations. The keyword mapping identified 26 terms forming three main thematic clusters, with critical thinking emerging as the most dominant keyword. The thematic analysis suggests that digital technology has the potential to support the development of MCTS through concept exploration, visualization, and mathematical problem-solving activities. Furthermore, the relationship with SDG 4 was more frequently identified in the quality of education dimension (43 articles) than in the equitable access dimension (22 articles). These findings indicate the growing research interest in digital technology in mathematics education, while equitable access to technology remains an important issue for future research.

Keywords: *Bibliometric analysis, Critical Thinking Skills, Digital technology, Mathematics education, SDG4*

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Introduction

Quality education is one of the key aspects of sustainable development, as it plays an essential role in developing individual potential and improving the quality of human resources. The importance of quality education is reflected in the Sustainable Development Goals (SDGs), particularly Goal 4 (SDG 4), which emphasizes ensuring inclusive, equitable, and quality education and expanding lifelong learning opportunities for all (Siahaan et al., 2023). In the Indonesian context, improving the quality of education remains an important agenda in creating meaningful learning processes and continuously enhancing educational standards (Nurfatimah et al., 2022). Quality education is not merely concerned with providing access to education but also with ensuring that every individual has learning opportunities that support the development of their potential (Tulandi et al., 2024). Therefore, the development of learning innovations is an important aspect that needs to be considered in supporting the achievement of SDG 4.

The advancement of digital technology has created various opportunities to improve the quality of learning processes, including in mathematics education. The integration of digital technology enables mathematical content to be presented through various forms of representation and interactive media, such as instructional videos, digital games, simulations, mathematical software, and online learning environments. The use of these technologies can help students explore mathematical concepts and solve mathematical problems through more varied learning experiences (Sudihartinih et al., 2021). Rahma and Nurlaelah (2024), through a meta-analysis of studies involving secondary school students in Indonesia, also demonstrated that digital technology-assisted learning has a positive effect on mathematics achievement, although the magnitude of the effect varies depending on educational level and the subject matter being taught. In line with these developments, Engelbrecht and Borba (2024) discussed various advances in the use of digital technology in mathematics education, including changes in teaching practices and perspectives on technology integration. These developments indicate that digital technology functions not only as a tool for delivering instructional content but also has the potential to transform the ways in which students interact with mathematical concepts and problems.

Beyond supporting conceptual understanding, the use of digital technology in mathematics learning is also associated with the development of higher-order thinking skills, including mathematical critical thinking skills. These skills are essential to ensure that students are not only able to obtain answers but also capable of interpreting information, analyzing problems, drawing conclusions, evaluating solution strategies, and explaining their reasoning based on mathematical concepts. The integration of digital technology provides students with opportunities to explore, visualize, and test various mathematical problems. For example, Angraini et al. (2024) examined the use of augmented reality to develop computational thinking skills in mathematics education. Meanwhile, studies on multimedia, digital games, and artificial intelligence-based technologies have demonstrated various opportunities for using technology to support learning activities and the development of students' competencies. Nevertheless, the relationship between the use of digital technology and mathematical critical thinking skills requires further investigation, particularly to identify the development of research focuses and the directions of existing studies.

On the other hand, the use of digital technology in mathematics education is also related to various dimensions of SDG 4 achievement. These relationships can be examined in terms of improving

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learning quality, ensuring equitable access to learning resources, promoting inclusive education, and developing students' competencies. Engelbrecht and Borba (2024) discussed developments in the use of digital technology in mathematics education, while Freiberg (2025) addressed issues concerning digital textbooks and the digital divide in education. Regarding inclusion, Gómez Niño et al. (2026) examined teachers' conceptions of using artificial intelligence to support inclusive mathematics learning. Meanwhile, Meylani and Kutluca (2025) connected the use of AI in mathematics education with SDG 4. These studies indicate that digital technology is associated with various dimensions of quality education. However, its implementation continues to face challenges, including disparities in technology access, teachers' readiness, and the alignment of technology use with learning needs.

Previous studies have examined the development of digital technology in mathematics education and its application to specific aspects of learning. Engelbrecht and Borba (2024), for instance, investigated developments in the use of digital technology in mathematics education, while Angraini et al. (2024) explored the application of augmented reality to develop computational thinking skills. Other studies have also linked digital technology to inclusive education and the achievement of SDG 4 (Gómez Niño et al., 2026; Meylani & Kutluca, 2025). Nevertheless, based on the scope of the literature examined in this study, there remains a need for an integrated mapping that brings these various perspectives together within a single bibliometric study. Such mapping is necessary not only to identify publication trends and academically influential articles based on citation counts but also to examine the structure of research themes, developments in studies on digital technology for supporting mathematical critical thinking skills, and their connections with various dimensions of SDG 4. Accordingly, this study is expected to provide a more comprehensive overview of research developments and future directions in this field.

Based on the foregoing discussion, this study aims to analyze the development of research on digital technology in mathematics education and its connections with mathematical critical thinking skills and the achievement of Sustainable Development Goal 4 (SDG 4) through a bibliometric approach. Specifically, this study seeks to address the following five research questions: (1) How has research on digital technology in mathematics education to support mathematical critical thinking skills (MCTS) and SDG 4 developed in terms of publication trends over the period 2016–2026?, (2) Which articles and publication sources have received the highest number of citations in research on digital technology in mathematics education to support MCTS and SDG 4?, (3) What are the emerging research keywords, and how are they interconnected in studies on digital technology and mathematics education in relation to MCTS and SDG 4?, (4) How is the use of digital technology associated with the development of mathematical critical thinking skills in mathematics education research?, (5) How is research on digital technology in mathematics education related to the dimensions of SDG 4 achievement, particularly quality education and equitable access? The findings of this study are expected to provide a structured overview of research developments, identify emerging keywords and research linkages, and examine the use of digital technology in supporting the development of mathematical critical thinking skills and the provision of quality and equitable mathematics education.

Methods

This study employed a bibliometric analysis method with a descriptive approach to map research developments on digital technology in mathematics education and its connections with mathematical critical thinking skills and Sustainable Development Goal 4 (SDG 4). Bibliometric analysis was used to identify publication trends, the academic influence of articles based on citation counts, and the structure and interrelationships of research keywords. In addition, thematic analysis was conducted to examine the relationship between the use of digital technology and the development of mathematical critical thinking skills, as well as its contributions to

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two dimensions of SDG 4 achievement: quality education and equitable access.

The research data consisted of scholarly articles retrieved from Google Scholar, Scopus, and OpenAlex, covering the publication period from 2016 to 2026. The literature search employed combinations of keywords covering three thematic groups: digital technology and mathematics education, mathematical critical thinking skills, and digital technology and SDG 4. These keyword combinations were used to retrieve articles relevant to both the primary research focus and the supporting contexts of this study.

The article selection process was conducted in several stages. The initial searches across the three sources yielded 1,406 publication records. The articles were then classified according to their relevance into three categories: nine articles directly addressing the primary research focus, 34 articles related to critical thinking and mathematics education, and 206 articles related to SDG 4. After removing duplicate records across the categories, a final corpus of 57 articles was obtained. Article selection considered the relevance of titles and abstracts to digital technology, mathematics education, critical thinking or related mathematical competencies, and the dimensions of SDG 4. Contextual articles were retained when they provided a theoretical foundation or supporting perspectives on critical thinking, mathematics education, digital technology, or the achievement of SDG 4.

Publication metadata were collected and managed using Publish or Perish (PoP), while bibliometric network mapping and visualization were performed using VOSviewer. The analyzed metadata included article titles, author names, publication years, publication sources, citation counts, DOIs, URLs, and abstracts. Data analysis was conducted in several stages in accordance with the research questions. First, publication trends were analyzed based on the annual number of articles on digital technology in mathematics education in relation to MCTS and SDG 4 published during the 2016–2026 period. Second, citation analysis was conducted on articles and publication sources based on citation counts to identify the most highly cited articles and the publication sources with the highest total citation counts. Third, keyword structures and interrelationships were analyzed using term co-occurrence analysis in VOSviewer based on title and abstract data. This analysis aimed to identify terms that frequently appeared together and to map the relationships among research themes. The mapping process employed a minimum occurrence threshold of five, meaning that only terms appearing at least five times across the collection of 57 articles were included in the visualization. Fourth, thematic analysis of article titles and abstracts was conducted to identify the forms of digital technology used in mathematics education and their relationships with the development of mathematical critical thinking skills. Fifth, the relationship between the research literature and SDG 4 achievement was analyzed by classifying articles into two dimensions: quality education and equitable access. This classification was based on an examination of the main focus presented in each article's title and abstract. The results were subsequently presented in tables, publication trend graphs, bibliometric network maps, and descriptive narratives to address each research question.

Results and Discussion

Based on the data collection and selection process of publications on digital technology in mathematics education to support mathematical critical thinking skills and the achievement of SDG 4, a total of 57 articles met the research relevance criteria. The publication data consisted of article metadata, including titles, author names, publication years, abstracts, DOIs, and article links. The metadata were subsequently analyzed to identify research developments concerning digital technology in mathematics education over the 2016–2026 period. The results of this analysis are presented in a table showing the number and percentage of publications for each year.

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Table 1. Trends in Publications on Digital Technology in Mathematics Education to Support Mathematical Critical Thinking Skills and SDG 4 during the 2016–2026 Period

Year	Number of Articles	Persentase
2016	0	0,00%
2017	0	0,00%
2018	1	1,75%
2019	2	3,51%
2020	4	7,02%
2021	0	0,00%
2022	1	1,75%
2023	0	0,00%
2024	5	8,77%
2025	24	42,11%
2026	20	35,09%
Total	**57**	**100%**

Note: *The data for 2026 represent publications recorded up to the data collection date.*

The bibliometric analysis of the 57 articles selected for the research corpus revealed that publication trends concerning digital technology in mathematics education during the 2016–2026 period generally showed an upward pattern, although fluctuations occurred in several years. During the 2016–2020 period, the number of publications remained relatively low, with the highest number being four articles in 2020. Subsequently, during the 2021–2023 period, publication activity showed an uneven pattern, with only one article published in 2022 and no articles recorded in either 2021 or 2023.

An increase in publications became evident in 2024, with five articles, followed by a substantial rise to 24 articles in 2025. Meanwhile, 20 articles were recorded in 2026. The year 2025 had the highest number of publications, accounting for 42.11% of the total articles. Overall, 77.19% of the articles in the research corpus were published during the 2025–2026 period. These findings indicate that the publications included in this study were predominantly concentrated in the final two years of the observation period. Further details are presented in Figure 1.

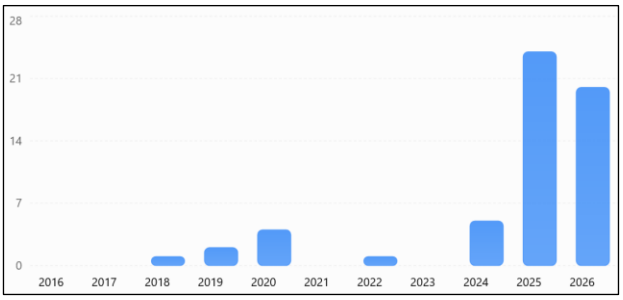


Figure 1. Publication Trends on Digital Technology in Mathematics Education to Support Mathematical Critical Thinking Skills and SDG 4 during the 2016–2026 Period

Overall, these publication trends indicate that research on digital technology in mathematics education has evolved dynamically over the years. The publications in the research corpus show a strong concentration in the 2025–2026 period, with 2025 emerging as the most productive year.

Table 2. Top Ten Most Cited Articles on Digital Technology in Mathematics Education to Support Mathematical Critical Thinking Skills and SDG 4 during the 2016–2026 Period

Rank	Article Title	Authors	Year	Number of Citations
1	Entrepreneurship Education and Sustainable Development Goals: A Literature Review and a Closer Look at Fragile States and Technology-Enabled Approaches	L. Rashid	2019	324
2	Educator Competences in Sustainability Education: A Systematic Review of Frameworks	A. Corres dkk	2020	211
3	Fourth Industrial Revolution: Opportunities, Challenges, and Proposed Policies	E.K. Zervoudi	2020	139
4	Assistive Technology Supporting Inclusive Education: Existing and Emerging Trends	D. Chambers	2020	126

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Rank	Article Title	Authors	Year	Number of Citations
5	Generative AI Tool Use Enhances Academic Achievement in Sustainable Education through Shared Metacognition and Cognitive Offloading among Preservice Teachers	J. Iqbal dkk.	2025	82
6	Systematic Review on Which Analytics and Learning Methodologies Are Applied in Primary and Secondary Education in the Learning of Robotics Sensors	D. Amo dkk.	2020	75
7	Will AI Become a Threat to Higher Education Sustainability? A Study of Students' Views	V. Okulich-Kazarin dkk.	2024	66
8	Advancing Conceptual Understanding: A Meta-Analysis on the Impact of Digital Technologies in Higher Education Mathematics	A. Sofroniou	2025	47
9	Technologies in Inclusive Education: Solution or Challenge? A Systematic Review	M.V. Samaniego López dkk.	2025	32
10	Principals' Technology Leadership and Teachers' ICT Integration: A Systematic Review on Capacity Building for Quality Improvement and Sustainable Education	Q. Yang dkk.	2025	31

Subsequently, an analysis was conducted to identify the articles and publication sources with the highest citation counts in research on digital technology in mathematics education during the 2016–2026 period. Based on the ranking of citation counts across the 57 articles, the ten most cited articles were identified, as presented below.

Based on Table 2, the article by Rashid (2019) ranked first with 324 citations. This article discusses entrepreneurship education in relation to the achievement of the Sustainable Development Goals (SDGs), including technology-based approaches. Its high citation count indicates that the article has received considerable academic attention, particularly in discussions of education and sustainable development.

The second position was occupied by the article by Corres et al. (2020), with 211 citations. This article examines educators' competencies in sustainability education through a systematic review of various competency frameworks. Furthermore, the article by Zervoudi (2020) received 139 citations, while the article by Chambers (2020) received 126 citations. Both articles reflect research interest in technological developments, the challenges of their implementation, and the use of assistive technologies to support inclusive education.

Among the ten most cited articles, the study by Sofroniou (2025) has the most direct relevance to the focus of this research, namely the use of digital technology in mathematics education. The article, entitled *Advancing Conceptual Understanding: A Meta-Analysis on the Impact of Digital Technologies in Higher Education Mathematics*, received 47 citations and examines the impact of digital technologies on conceptual understanding in mathematics. Overall, these findings indicate that the most cited articles in the research corpus do not exclusively focus on mathematics education but also cover sustainability education, educational technology, STEM, and inclusive education. Thus, citation counts reflect the level of academic attention received by an article rather than directly indicating its relevance to the specific focus of this study.

The subsequent analysis involved classifying articles according to their journal names or publication sources. This classification aimed to identify the publication sources that contributed the largest number of articles to the research corpus while also determining which sources accumulated the highest citation counts.

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Table 3. Leading Publication Sources on Digital Technology in Mathematics Education to Support Mathematical Critical Thinking Skills and SDG 4 during the 2016–2026 Period

No	Journal or Publication Source	Number of Articles	Citations
1	*Sustainability*	6	595
2	*Industrial Robotics: New Paradigms*	1	139
3	*Journal of Education Sciences*	4	94
4	*Scientific Reports*	1	82
5	*Sensors*	1	75
6	*Mathematics Education Research Journal*	1	30
7	*STEM Education*	1	17
8	*Perspectives on STEM Education: Theory and Practice*	1	15
9	*Educational Studies in Mathematics*	1	11
10	*Information Universality*	1	8

Based on the table, *Sustainability* ranked first with six articles and a total of 595 citations. This figure indicates that this publication source made the largest contribution to the cumulative citation count within the research corpus. The high total citation count was primarily associated with several articles that received considerable academic attention, including those by Rashid (2019) and Corres et al. (2020). In second place was *Industrial Robotics: New Paradigms*, with one article and a total of 139 citations. Although only one article from this source was included in the research corpus, its citation count was relatively high. This indicates that a publication source's contribution to the total citation count is determined not only by the number of articles it publishes but also by the citation impact of each article it contains.

The analysis of publication sources reveals that the articles in the research corpus are distributed across various publication fields, ranging from sustainability education and technology to STEM and mathematics education. *Sustainability* recorded the highest total citation count, whereas *Education Sciences* and several mathematics education journals made contributions that were more closely aligned with the substantive focus of this study. Furthermore, VOSviewer was used to conduct an analysis of keyword clustering.

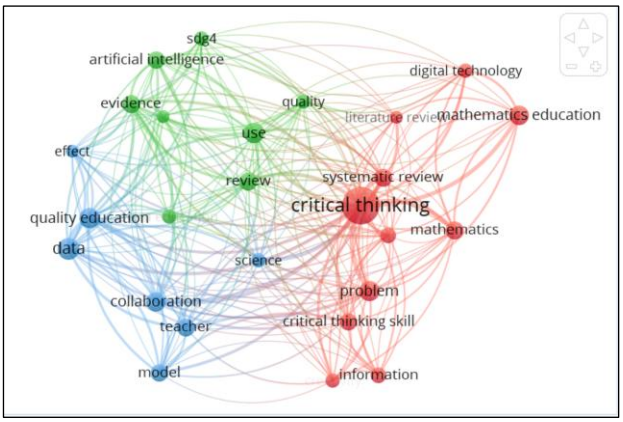


Figure 2. Keyword Network of Research on Digital Technology in Mathematics Education to Support Mathematical Critical Thinking Skills and SDG 4 Using VOSviewer

The term co-occurrence analysis conducted using VOSviewer on the 57 articles identified 26 keywords that met the minimum occurrence threshold of five. These keywords were distributed across eight clusters, which were subsequently grouped into three main themes based on their semantic relationships. Based on the VOSviewer clustering results, the keyword network of research on digital technology in mathematics education to support mathematical critical thinking skills and SDG 4 can be described through three main thematic clusters.

Cluster 1. The red cluster illustrates the relationship between critical thinking, mathematics education, and digital technology. The keyword *critical thinking* serves as the central focus, as it has the highest occurrence frequency and link strength.

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The presence of the keywords *mathematics education*, *mathematics*, and *digital technology* indicates that research on critical thinking is also associated with technology-based mathematics learning contexts.

Cluster 2. The green cluster represents research on the use of technology, artificial intelligence, and educational development in relation to quality education and SDG 4. The keyword *artificial* intelligence reflects research interest in the development of AI-based technologies, while *professional development* and *STEM education* indicate connections with competency development and instructional approaches.

Cluster 3. The blue cluster represents themes related to quality education, data utilization, instructional models, and the role of teachers. The keywords *data* and *quality education* each have a total link strength (TLS) of 59, indicating strong connections with other keywords. Meanwhile, *collaboration* reflects research attention to cooperation in the implementation and development of learning processes.

Overall, the mapping results reveal that research on digital technology in mathematics education is associated with three main thematic groups: critical thinking and mathematics education, technology and educational sustainability, and quality education and learning collaboration. The keyword *critical thinking* occupies the most dominant position in the network, while its connections with *mathematics education* and *digital technology* demonstrate the relevance of these themes to the focus of this study. Furthermore, the occurrence of the keywords *SDG 4* and *quality education* indicates that the research included in the corpus is also related to efforts to support educational quality.

The relationship between digital technology and the development of mathematical critical thinking skills can be observed through the use of technology as a means of exploring concepts, examining mathematical relationships, and supporting problem-solving processes. Through a meta-analysis of 88 empirical studies, Sofroniou et al. (2025) identified various types of technology used in higher education mathematics, including Computer Algebra Systems (CAS), artificial intelligence (AI), visualization tools, augmented reality technologies, statistical software, game-based learning, and cloud-based learning. These technologies enable students to manipulate mathematical representations, visualize abstract concepts, and explore relationships between concepts. Such activities are relevant to mathematical reasoning and problem-solving processes, which are essential components in the development of critical thinking skills.

Table 4. Synthesis of Articles on the Use of Digital Technology and Its Relationship with Mathematical Critical Thinking Skills

No	Article Details	Digital Technology/Approach	Application in Mathematics Learning	Relationship with MCTS
1.	Sofroniou et al. (2025), *Advancing Conceptual Understanding: A Meta-Analysis on the Impact of Digital Technologies in Higher Education Mathematics*	CAS, AI, visualization tools, AR, statistical software, digital games, and cloud-based learning	Facilitates the manipulation of mathematical representations, visualization of abstract concepts, and exploration of relationships between concepts	Supports mathematical reasoning, analysis, and problem-solving activities
2.	Putri et al. (2026), *From Traditional to Digital: A Mini Review on Flipped Classroom in Mathematics Education*	*Digital-based flipped classroom*	Facilitates concept exploration and active student engagement in learning	Encourages active engagement and the development of critical thinking skills

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No	Article Details	Digital Technology/Approach	Application in Mathematics Learning	Relationship with MCTS
3.	Arif dan Trimurtini (2026), *Literature Review of Deep Learning Integrated E-Learning Media Research Trend in Mathematics 2022–2026*	*Deep learning-integrated e-learning*	Examines the use of digital learning media in mathematics education	Is associated with the development of critical thinking and problem-solving skills

A more direct relationship is also evident in the article *From Traditional to Digital: A Mini Review on Flipped Classroom in Mathematics Education* (2026). This article highlights the use of digital-based tools in the flipped classroom approach to help students explore mathematical concepts and promote critical thinking skills through active engagement in learning. Meanwhile, the article *Literature Review of Deep Learning Integrated E-Learning Media Research Trend in Mathematics 2022–2026* (2026) discusses the use of e-learning media in mathematics education, with the aim of supporting the development of critical thinking and problem-solving skills.

These findings indicate that digital technology has the potential to support the development of mathematical critical thinking skills when integrated into learning activities that encourage students to explore concepts, analyze information, and solve mathematical problems. Thus, digital technology serves not only as a medium for delivering instructional content but also as a means of facilitating conceptual exploration, active engagement, and mathematical problem-solving, all of which are important components in the development of critical thinking skills.

The relationship between research on digital technology in mathematics education and the achievement of Sustainable Development Goal 4 (SDG 4) was analyzed based on two dimensions: quality education and equitable access. The results indicate that discussions on the use of digital technology in mathematics education are more frequently directed toward supporting the quality of learning than toward expanding access to education.

Table 5. The Relationship between Digital Technology in Mathematics Education & the Dimensions of SDG 4

SDG 4 Dimension	Number of Articles	Article Details/References	Forms of Digital Technology Use	Contribution to SDG 4
Quality Education	**43 (75,44%)**	Engelbrecht & Borba (2024); Rahma & Nurlaelah (2024)	Mathematical software, learning applications, videos, and artificial intelligence for conceptual exploration and learning interaction	Supports improvements in the quality of learning processes and students' mathematical achievement
Equitable Access	**22 (38,60%)**	Engelbrecht & Borba (2024); Rahma & Nurlaelah (2024)	Online learning platforms and digital textbooks to expand access to learning resources	Provides alternative access to learning materials, although challenges remain in the form of the digital divide, limited access to devices, and inadequate internet infrastructure

In the quality education dimension, 43 articles discussed the use of digital technology to support mathematics learning processes and outcomes. Technologies such as mathematical software, learning applications, videos, and artificial intelligence enable conceptual exploration and enhance interaction in the learning process (Engelbrecht & Borba, 2024). In line with these

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findings, Rahma and Nurlaelah (2024) demonstrated that digital technology-assisted learning has a positive effect on the mathematics achievement of secondary school students in Indonesia.

In the equitable access dimension, 22 articles discussed the use of digital technology to expand access to learning resources. Online learning platforms and digital textbooks provide alternative means of accessing learning materials. However, equitable access continues to face challenges, including the digital divide, limited access to devices, and inadequate internet infrastructure (Freiberg, 2025).

Overall, the studies included in the 57-article corpus indicate that digital technology is associated with two dimensions of SDG 4 achievement: quality education and equitable access. Discussions were more predominantly focused on quality education than on equitable access. This indicates that research attention has been directed more toward improving learning processes, while issues concerning disparities in access to technology still require further attention.

CONCLUSION

Based on the analysis of 57 articles published during the 2016–2026 period, research on digital technology in mathematics education has shown an increase in publications, particularly in 2025, which was the most productive year with 24 articles. The article by Rashid (2019) received the highest number of citations, with 324 citations, while *Sustainability* was the publication source with the highest total citation count, amounting to 595 citations. The VOSviewer mapping identified 26 terms grouped into three main thematic groups, with *critical thinking* emerging as the most dominant term, recording 30 occurrences and a total link strength (TLS) of 120. These findings indicate that critical thinking is one of the important themes in research on digital technology in mathematics education.

The thematic analysis revealed that digital technology is associated with the development of mathematical critical thinking skills through various learning activities, such as conceptual exploration, visualization of mathematical representations, examination of relationships between concepts, information analysis, and problem-solving. Various technologies, including Computer Algebra Systems (CAS), artificial intelligence, visualization tools, augmented reality, statistical software, as well as game-based and cloud-based learning, have the potential to facilitate these activities. In addition, digital-based flipped classroom approaches and e-learning media also demonstrate relevance in supporting active engagement and the development of critical thinking and mathematical problem-solving skills. Thus, digital technology serves not only as a means of delivering instructional content but also has the potential to support mathematical critical thinking processes when integrated into appropriate learning activities.

In relation to the achievement of SDG 4, research on digital technology in mathematics education has focused more extensively on the quality education dimension, represented by 43 articles (75.44%), than on the equitable access dimension, represented by 22 articles (38.60%). In the quality education dimension, digital technology plays a role in supporting learning processes and students' mathematical achievement. Meanwhile, in the equitable access dimension, digital technology provides alternative ways of accessing learning resources through online learning platforms and digital textbooks, although challenges remain in the form of the digital divide, limited access to devices, and inadequate internet infrastructure. Overall, the findings indicate that research on digital technology in mathematics education has addressed both the improvement of learning quality and the development of mathematical critical thinking skills. However, future research needs to strengthen empirical evidence regarding the contribution of digital technology to mathematical critical thinking skills and expand investigations into equitable access to technology in support of SDG 4 achievement.

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