

Teaching and learning effectiveness in the AI era: A bibliometric analysis of educational trends

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Abstract

Background/purpose. Teaching and learning effectiveness has become an increasingly important issue in contemporary education, particularly due to the rapid integration of digital technology and artificial intelligence in learning environments. This study aimed to analyse global research trends, dominant themes, and emerging issues related to teaching and learning effectiveness during 2020–2026 through bibliometric mapping analysis.

Materials/methods. This study employed a bibliometric approach using data retrieved from Google Scholar through the Publish or Perish application. A total of 500 publications were initially collected, and 450 relevant publications were selected for analysis. The data were exported in RIS and CSV formats and analysed using Microsoft Excel and VOSviewer to identify publication trends, citation patterns, and co-occurrence networks of research terms.

Results. The findings revealed a significant increase in publications on teaching and learning effectiveness, particularly in 2024 and 2025. Highly cited studies were dominated by topics related to blended learning, artificial intelligence, student engagement, and educational technology. Network visualization identified several dominant research clusters, including blended learning environments, artificial intelligence integration, learner engagement, teaching effectiveness, gamification, and systematic review studies. Overlay visualization indicated that artificial intelligence, ChatGPT, and hybrid learning represent emerging research trends in recent years.

Conclusion. Research on teaching and learning effectiveness is increasingly oriented toward technology-enhanced, learner-centered, and AI-supported educational practices. The findings highlight the growing importance of adaptive and innovative instructional strategies in improving educational quality and student learning outcomes in the digital era.

Research Article

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1. Introduction

The transformation of education in the digital era has significantly influenced the way teaching and learning processes are designed, implemented, and evaluated across educational institutions worldwide. In contemporary education, teaching effectiveness is no longer viewed solely as the ability of educators to deliver instructional materials, but also as the capacity to create meaningful, inclusive, interactive, and technology-supported learning experiences that improve students' academic engagement and learning outcomes (Munna & Kalam, 2021; Michael & Modell, 2003). The rapid integration of digital technologies and artificial intelligence (AI) into educational settings has further accelerated changes in pedagogical practices, learning environments, and instructional strategies in both schools and higher education institutions (Fernández-Batanero et al., 2022). Consequently, educational researchers and practitioners increasingly emphasize the importance of adaptive and innovative teaching approaches capable of supporting effective learning in the twenty-first century educational landscape (Munna & Kalam, 2021).

Teaching and learning effectiveness is strongly associated with student engagement, active participation, inclusivity, and the appropriate selection of instructional methods that accommodate diverse learner characteristics and learning styles (Arthurs, 2007; Gilakjani, 2012). Previous studies highlighted that active learning environments, blended learning approaches, and experiential instructional strategies positively contribute to students' confidence, motivation, and academic performance (Munna & Kalam, 2021; Michael & Modell, 2003). Similarly, student-centered learning practices supported by digital technologies have become increasingly important in fostering collaborative learning, critical thinking, and interactive classroom experiences in modern education (Fernández-Batanero et al., 2022). These developments indicate that effective teaching is closely related to educators' ability to integrate pedagogical innovation with technological advancement in order to support meaningful learning experiences (Bedenlier et al., 2020).

In recent years, artificial intelligence has emerged as one of the most influential technological innovations in education. The implementation of AI-powered educational systems, adaptive learning platforms, virtual learning assistants, and automated assessment tools has transformed the dynamics of teaching and learning processes across various educational contexts (Zhang & Tur, 2024). The increasing use of AI in education also reflects the growing demand for personalized learning, flexible instructional delivery, and data-driven educational decision-making (Barrot, 2021; Fernández-Batanero et al., 2022). Furthermore, technology-enhanced learning environments have enabled educators to utilize blended learning models, online collaborative learning, and interactive digital media to improve student participation and learning effectiveness (Munna & Kalam, 2021). As a result, educational research related to teaching and learning effectiveness has experienced substantial growth during the post-pandemic and AI-driven educational transformation era (Salas-Pilco et al., 2022).

The increasing number of publications on teaching and learning effectiveness demonstrates that this topic has become one of the major concerns in educational research. Several previous studies have investigated teaching effectiveness through literature reviews, systematic reviews, and empirical classroom studies focusing on active learning, blended learning, gamification, student motivation, and digital pedagogy (Munna & Kalam, 2021). Other studies have specifically explored AI integration, online learning environments, and educational technologies in supporting student learning outcomes and instructional innovation (Fernández-Batanero et al., 2022). However, most previous studies remain limited to conceptual discussions, systematic literature reviews, or topic-specific analyses. Comprehensive bibliometric studies that map the global development, thematic trends, research clusters, and emerging directions of teaching and learning effectiveness research in the AI era remain relatively limited (Salas-Pilco et al., 2022).

In addition, the rapid development of educational technology and AI has shifted educational priorities from traditional teacher-centered instruction toward more flexible, learner-centered, and technology-supported learning ecosystems (Bedenlier et al., 2020). This transformation requires educators and educational institutions to continuously adapt teaching strategies, assessment practices,

and learning environments to meet the evolving needs of students in digital society (Munna & Kalam, 2021). Therefore, understanding the current research landscape, dominant themes, influential studies, and future research directions related to teaching and learning effectiveness becomes increasingly important for supporting educational innovation and evidence-based pedagogical practices.

Based on these considerations, this study aims to analyze the development of research trends related to teaching and learning effectiveness in the AI era through a bibliometric approach. The study specifically maps publication trends, influential publications, thematic keyword relationships, and emerging educational issues related to active learning, blended learning, student engagement, inclusive learning, and artificial intelligence in education. The findings of this study are expected to provide a comprehensive overview of the current state of educational research while also contributing to the future development of teaching and learning practices in digital and AI-supported educational environments.

2. Literature Review

Teaching and learning effectiveness has become one of the central issues in contemporary education due to the rapid transformation of educational practices in the digital era. Effective teaching is generally associated with the ability of educators to create interactive, inclusive, student-centered, and meaningful learning environments that support students' academic achievement and engagement (Michael & Modell, 2003; Munna & Kalam, 2021). Previous educational theories also emphasize that learning effectiveness is influenced by various instructional approaches, learning styles, classroom interactions, and motivational factors that shape students' cognitive and emotional development (Bruner, 1957; Schunk, 2009). In addition, active learning, experiential learning, and blended learning approaches are increasingly recognized as effective strategies for improving participation, collaboration, and critical thinking skills among learners in higher education and digital learning environments (Salas-Pilco et al., 2022). Consequently, the integration of pedagogical innovation and educational technology has become an important aspect of improving teaching and learning effectiveness in modern education systems (Bedenlier et al., 2020).

The emergence of artificial intelligence and technology-enhanced learning has further accelerated educational transformation across schools and higher education institutions worldwide. Recent studies demonstrate that AI-supported educational technologies, online learning platforms, adaptive learning systems, and digital pedagogical approaches significantly influence teaching practices, student engagement, and learning experiences (Fernández-Batanero et al., 2022; Zhang & Tur, 2024). Furthermore, student engagement, inclusive learning, and blended learning environments are increasingly connected with digital innovation and AI-assisted instruction in contemporary educational research (Ouyang et al., 2023). Several previous studies have explored educational trends through systematic literature reviews and bibliometric analyses focusing on digital learning, STEM education, gamification, and AI integration in education (Bond et al., 2020; Yim & Su, 2025). However, comprehensive bibliometric studies specifically mapping the development of teaching and learning effectiveness research in the AI era remain relatively limited. Therefore, this study attempts to fill the existing gap by providing a bibliometric analysis of publication trends, influential studies, thematic keyword relationships, and emerging educational directions related to teaching and learning effectiveness in contemporary digital education.

Table 1 presents several previous studies related to teaching effectiveness, educational technology, artificial intelligence, and bibliometric research in education. The table indicates that previous studies mainly focused on systematic literature reviews, conceptual discussions, and topic-specific analyses concerning digital learning and educational innovation. In contrast, the present study specifically emphasizes bibliometric mapping of teaching and learning effectiveness research in the AI era by integrating publication trends, co-occurrence analysis, influential studies, and emerging educational themes. Thus, this study contributes to providing a broader and more comprehensive understanding of the evolution of teaching and learning effectiveness research in contemporary education.

Table 1. Research on Teaching and Learning Effectiveness.

No	Title	Reference
1	Teaching and learning process to enhance teaching effectiveness: a literature review	Munna & Kalam (2021)
2	A systematic review of ChatGPT use in K-12 education	Zhang & Tur (2024)
3	Digital competences for teacher professional development: Systematic review	Fernández-Batanero et al. (2022)
4	Scientific mapping of social media in education: A decade of exponential growth	Barrot (2021)

3. Methodology

3.1 Research Design

This study employed a bibliometric research design using a quantitative descriptive approach to analyze the development of research trends related to teaching and learning effectiveness in the AI era. Bibliometric analysis was selected because it enables researchers to systematically map scientific publications, identify influential studies, visualize keyword relationships, and explore emerging research directions within a particular field of study (Husaeni & Nandiyanto, 2022). In addition, bibliometric methods have increasingly been utilized in educational research to examine the evolution of educational technology, digital learning, and artificial intelligence integration in teaching and learning practices (Barrot, 2021).

3.2 Data Source

The data used in this study were collected from Google Scholar using the Publish or Perish (PoP) application as the primary data retrieval tool. The publication search was conducted for studies published during the period 2020–2026 using several keywords related to teaching and learning effectiveness, including “teaching effectiveness,” “learning effectiveness,” “student engagement,” “active learning,” “blended learning,” and “artificial intelligence in education.” The initial search retrieved a maximum of 500 publications. After the screening and relevance selection process, the retrieved data were exported in RIS and CSV formats to support bibliometric mapping and descriptive statistical analysis.

3.3 Data Collection Procedure

The data collection process was conducted through several systematic stages. First, the researchers determined the search keywords and publication time span relevant to the research topic. Second, publication data were collected using the Publish or Perish application indexed by Google Scholar. Third, the retrieved publications were screened based on title relevance, duplication, keyword suitability, and publication relevance to teaching and learning effectiveness research in the digital and AI era. Finally, the selected publication data were organized and exported into RIS and CSV formats for further bibliometric visualization and trend analysis. This procedure was conducted to ensure that the analyzed publications were relevant to the objectives of the study and represented current educational research trends.

3.4 Data Analysis

The collected data were analyzed using descriptive statistical analysis and bibliometric visualization techniques. Microsoft Excel was utilized to analyze annual publication trends, citation frequencies, and publication distributions. Meanwhile, VOSviewer software was used to perform co-occurrence analysis and visualize thematic relationships among keywords through network visualization, overlay visualization, and density visualization. The bibliometric analysis focused on identifying dominant research themes, influential publications, emerging educational trends, and

thematic clusters associated with teaching and learning effectiveness, active learning, blended learning, student engagement, inclusive learning, and artificial intelligence in education.

4. Results

4.1. Teaching and Learning Effectiveness Research Trend 2020–2026

Table 1 and Figure 1 present the annual distribution of publications related to teaching and learning effectiveness during the period 2020–2026 indexed in Google Scholar and retrieved through the Publish or Perish application. The findings demonstrate a substantial increase in publication trends over the observed years, indicating that teaching and learning effectiveness has become an increasingly important topic in contemporary educational research, particularly in relation to digital transformation, student engagement, and artificial intelligence integration in education.

Based on Table 1, the number of publications remained relatively low during the early observation period, with 22 publications (4.89%) in 2020, followed by 27 publications (6.00%) in 2021 and 30 publications (6.67%) in 2022. However, a significant increase began to emerge in 2023 with 55 publications (12.22%). The publication growth reached its highest point in 2024 with 166 publications (36.89%), indicating the rapid expansion of scholarly attention toward teaching effectiveness, blended learning, active learning, and AI-supported educational practices in the post-pandemic educational era. Although the number slightly decreased in 2025 to 133 publications (29.56%), the publication volume remained substantially high compared to previous years, reflecting the continuing relevance of teaching and learning effectiveness research in modern education.

Meanwhile, the lowest publication frequency was identified in 2026 with 17 publications (3.78%). This lower number may be influenced by the incomplete publication indexing process for the ongoing year during the data collection period. Overall, the results indicate that research related to teaching and learning effectiveness has experienced rapid growth, especially after the acceleration of digital learning transformation and the integration of artificial intelligence technologies into educational environments. These findings also suggest that educational researchers increasingly emphasize innovative pedagogical practices, student-centered learning, and technology-enhanced teaching strategies to improve educational quality and learning outcomes in contemporary education contexts.

Table 1. Annual report research on teaching and learning effectiveness.

No	Years	Documents	Percentages
1	2020	22	4,89%
2	2021	27	6,00%
3	2022	30	6,67%
4	2023	55	12,22%
5	2024	166	36,89%
6	2025	133	29,56%
7	2026	17	3,78%
Total		450	100%

Source: Research Data (2026)

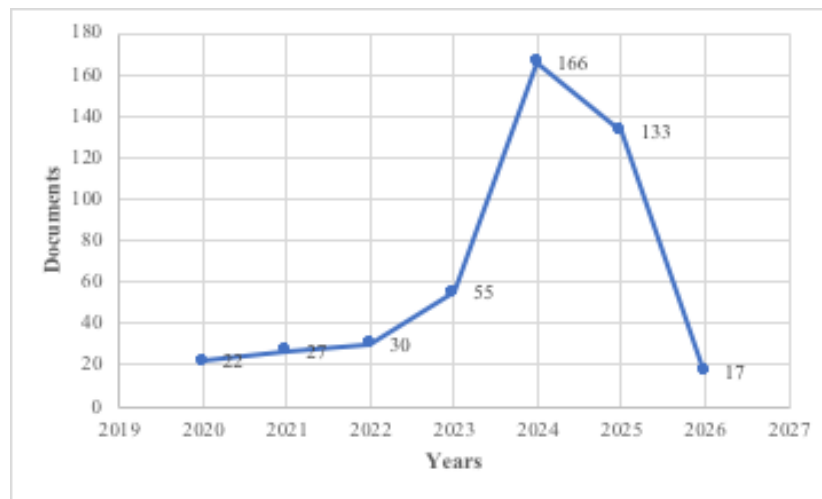


Figure 1. Annual report of publications

4.2. Most Influential and Highly Cited Publications

Table 2 presents the most influential and highly cited publications related to teaching and learning effectiveness in the AI era. The findings reveal that recent educational research has increasingly focused on student engagement, artificial intelligence integration, online learning environments, blended learning, adaptive learning systems, and active learning strategies. The dominance of highly cited studies related to AI-supported learning and educational technology indicates that contemporary educational research is strongly oriented toward digital transformation and technology-enhanced pedagogical practices.

The most highly cited publication was Mapping research in student engagement and educational technology in higher education: A systematic evidence map by [Bond et al. \(2020\)](#), which obtained 1,930 citations. This study demonstrates that student engagement and educational technology have become central themes in higher education research. The second most influential publication was the impact of artificial intelligence on learner–instructor interaction in online learning by [Seo et al. \(2021\)](#) with 1,357 citations, highlighting the growing importance of AI in supporting communication and interaction within online learning environments. Similarly, adaptive learning and personalized instructional systems also emerged as dominant research themes, as reflected in the highly cited study by [El-Sabagh \(2021\)](#) concerning adaptive e-learning environments and student engagement.

In addition, several highly cited publications specifically emphasize the increasing integration of artificial intelligence in educational assessment, self-regulated learning, blended learning, and learning analytics ([Owan et al., 2023](#); [Ouyang et al., 2023](#)). The appearance of studies related to ChatGPT, hybrid intelligence, and AI-assisted learning systems among the most influential publications further indicates the rapid shift toward AI-supported educational ecosystems in contemporary teaching and learning practices ([Ng et al., 2024](#); [Cukurova, 2025](#)). Furthermore, blended learning, flipped classrooms, educational games, and active learning approaches continue to receive considerable scholarly attention due to their positive contribution toward student motivation, participation, and learning outcomes in digital learning environments ([Yu et al., 2021](#); [Nguyen et al., 2021](#)).

The findings also reveal that student engagement remains one of the most dominant and interconnected themes in teaching and learning effectiveness research. Several influential studies consistently associate student engagement with technology integration, self-regulated learning, collaborative learning, and inclusive educational environments ([Salas-Pilco et al., 2022](#); [Heilporn et al., 2021](#)). This trend suggests that effective teaching in the AI era is increasingly characterized by the ability of educators to combine pedagogical innovation, interactive learning environments, and educational technology to support meaningful and personalized learning experiences. Overall, the highly cited publications demonstrate that educational research in recent years has progressively evolved from traditional instructional approaches toward adaptive, technology-enhanced, and AI-supported learning ecosystems.

Table 3. Most cited articles on teaching and learning effectiveness.

No	Cites	Title	Year	Cites Per Year	Ref.
1	1930	Mapping research in student engagement and educational technology in higher education: A systematic evidence map	2020	321.67	Bond et al. (2020)
2	1357	The impact of artificial intelligence on learner–instructor interaction in online learning	2021	271.40.00	Seo et al. (2021)
3	1107	Adaptive e-learning environment based on learning styles and its impact on development students' engagement	2021	221.40.00	El-Sabagh (2021)
4	805	Exploring the potential of artificial intelligence tools in educational measurement and assessment	2023	268.33.00	Owan et al. (2023)
5	732	Beware of metacognitive laziness: Effects of generative artificial intelligence on learning motivation, processes, and performance	2025	732.00.00	Fan et al. (2025)
6	676	A systematic review on trends in using Moodle for teaching and learning	2022	169.00.00	Gamage et al. (2022)
7	663	An examination of teachers' strategies to foster student engagement in blended learning in higher education	2021	132.60	Heilporn et al. (2021)
8	663	The effect of educational games on learning outcomes, student motivation, engagement and satisfaction	2021	132.60	Yu et al. (2021)
9	618	Student engagement in online learning in Latin American higher education during the COVID-19 pandemic: A systematic review	2022	154.50.00	Salas-Pilco et al. (2022)
10	555	Integration of artificial intelligence performance prediction and learning analytics to improve student learning in online engineering course	2023	185.00.00	Ouyang et al. (2023)
11	474	Supporting students' self-regulated learning in online learning using artificial intelligence applications	2023	158.00.00	Jin et al. (2023)
12	468	Artificial intelligence (AI) learning tools in K-12 education: A scoping review	2025	468.00.00	Yim & Su (2025)
13	446	Facilitating student engagement through educational technology in higher education: A systematic review in the field of arts and humanities	2020	74.33.00	Bedenlier et al. (2020)
14	412	Empowering student self-regulated learning and science education through ChatGPT: A pioneering pilot study	2024	206.00.00	Ng et al. (2024)

educational research in the AI era increasingly emphasizes interactive, adaptive, and technology-supported learning environments aimed at improving learner participation and educational performance.

The first cluster (red), consisting of 11 items, includes blended course, blended learning, blended learning environment, case study, course, effect, effective learning, motivation, performance, research, and satisfaction. This cluster reflects the strong relationship between blended learning implementation and educational effectiveness in contemporary learning environments. The presence of terms such as motivation, performance, and satisfaction indicates that blended learning research is largely associated with student learning outcomes and learner experiences within hybrid educational settings.

The second cluster (green), comprising 8 items, includes analytic, artificial intelligence, challenge, future, innovation, integration, learner, and student engagement. This cluster demonstrates the growing scholarly attention toward the integration of artificial intelligence in education and its relationship with student engagement and educational innovation. The emergence of terms such as future and challenge also suggests that researchers increasingly discuss both the opportunities and limitations of AI implementation in teaching and learning practices.

The third cluster (blue), consisting of 6 items, includes application, chatgpt, generative artificial intelligence, student involvement, teaching effectiveness, and use. This cluster specifically highlights the rapid development of generative artificial intelligence technologies, particularly ChatGPT, in educational contexts. The close relationship between ChatGPT, student involvement, and teaching effectiveness indicates that recent educational research increasingly explores the role of AI-assisted learning systems in supporting interactive and personalized learning experiences.

The fourth cluster (yellow), consisting of 5 items, includes artificial intelligence technology, efficiency, hybrid learning, learner engagement, and training. This cluster emphasizes the practical implementation of AI technologies and hybrid learning environments to improve educational efficiency and learner engagement. The appearance of training within this cluster also reflects the importance of developing educators' digital competencies and technological readiness in AI-supported educational environments.

The fifth cluster (purple), consisting of 3 items, includes blended, machine learning, and systematic review. This cluster indicates the growing use of machine learning approaches and systematic review methods in analyzing educational data and evaluating technology-enhanced learning systems. Meanwhile, the sixth cluster (light blue), consisting of 2 items, includes gamification and system, demonstrating the increasing interest in game-based learning systems and interactive educational technologies to support student motivation and engagement.

The overlay visualization presented in Figure 3 illustrates the temporal evolution of research trends related to teaching and learning effectiveness. Earlier studies were primarily concentrated on blended learning environments, learning motivation, and effective instructional strategies. However, more recent studies increasingly focus on artificial intelligence, ChatGPT, learner engagement, generative AI, and hybrid learning systems. This trend demonstrates the rapid transformation of educational research from conventional digital learning approaches toward AI-supported and data-driven learning ecosystems in contemporary education.

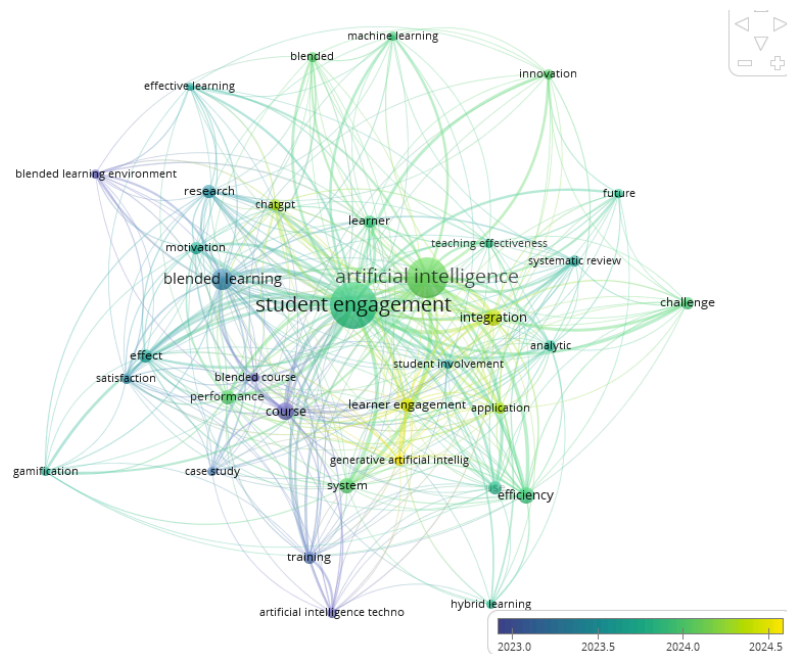


Figure 3. Overlay visualization based on co-occurrence of terms.

Furthermore, the density visualization shown in Figure 4 demonstrates the most dominant and frequently connected themes within the research network. Terms such as blended learning, artificial intelligence, student engagement, teaching effectiveness, and ChatGPT appear with higher density levels, indicating that these topics have become the major research concentrations in recent educational studies. The density map also confirms that educational researchers increasingly prioritize technology-enhanced learning, interactive pedagogical practices, and AI-assisted instructional systems as important components in improving teaching and learning effectiveness in the digital era.

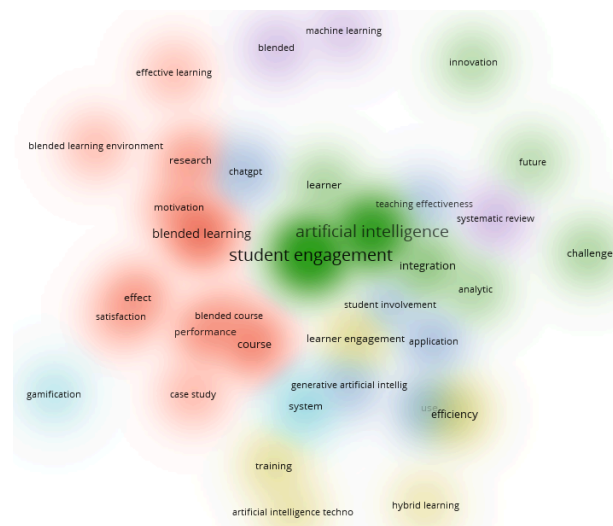


Figure 4. Density visualization based on the co-occurrence of terms.

5. Discussion

The findings of this study demonstrate that research on teaching and learning effectiveness has experienced substantial growth during the period 2020–2026, particularly following the rapid expansion of digital learning and artificial intelligence integration in education. The sharp increase in publications in 2024 and 2025 indicates that educational researchers increasingly focus on innovative, technology-supported, and student-centered learning practices to improve educational quality and learning outcomes. This trend aligns with previous studies emphasizing that contemporary education is undergoing a transformation from traditional instructional approaches toward more adaptive, interactive, and technology-enhanced learning environments (Munna & Kalam, 2021). The

dominance of blended learning and student engagement themes further confirms that effective teaching in the digital era is strongly associated with interactive learning environments that support learner participation, motivation, and academic performance (Bond et al., 2020; Heilporn et al., 2021).

Another important finding is the increasingly dominant role of artificial intelligence in teaching and learning effectiveness research. Terms such as artificial intelligence, ChatGPT, generative artificial intelligence, and machine learning appeared as emerging and highly interconnected topics within the visualization network. This finding suggests that AI technologies are increasingly viewed as transformative educational tools capable of supporting adaptive learning, personalized instruction, learning analytics, and self-regulated learning processes (Ouyang et al., 2023; Jin et al., 2023). Previous studies also highlighted that AI-assisted educational systems can improve learner engagement and instructional efficiency through intelligent and data-driven learning environments (Seo et al., 2021; Ng et al., 2024). However, the appearance of terms such as challenge and future indicates that researchers continue to discuss ethical concerns, academic dependency, and the pedagogical implications of AI integration in education (Cukurova, 2025; Fan et al., 2025).

The bibliometric mapping additionally reveals that learner-centered pedagogical approaches remain central to teaching and learning effectiveness research in the AI era. Themes related to motivation, gamification, hybrid learning, learner engagement, and effective learning demonstrate that educational innovation increasingly prioritizes meaningful and inclusive learning experiences. This finding is consistent with educational theories emphasizing that effective learning environments should accommodate diverse learner characteristics through active, collaborative, and experiential instructional strategies (Bruner, 1957; Schunk, 2009). Previous studies also confirmed that active learning, blended learning, and gamification positively contribute to students' cognitive engagement, participation, and higher-order thinking skills in digital learning environments (Nguyen et al., 2021; Yu et al., 2021).

Overall, the results indicate that teaching and learning effectiveness research has evolved toward a multidimensional educational framework integrating pedagogy, educational technology, artificial intelligence, and student engagement. The increasing focus on AI-supported learning systems, blended learning environments, and interactive pedagogical practices reflects the growing need for adaptive and future-oriented educational strategies capable of responding to the challenges of contemporary digital education. Therefore, the findings of this study provide important implications for educators, researchers, and educational institutions in designing innovative, inclusive, and evidence-based teaching practices in the AI era.

6. Conclusion

This study concludes that research on teaching and learning effectiveness experienced significant growth during 2020–2026, with strong emphasis on blended learning, student engagement, artificial intelligence, and technology-enhanced instruction. The bibliometric visualization revealed that contemporary educational research increasingly integrates AI-based learning systems, interactive pedagogical approaches, and learner-centered environments to improve educational quality and learning outcomes. Furthermore, the findings indicate that teaching effectiveness in the digital era is closely associated with adaptive, inclusive, and innovative instructional practices capable of supporting meaningful student engagement and sustainable learning development.

7. Suggestion

Future studies are recommended to explore teaching and learning effectiveness using more diverse methodological approaches, including experimental studies, mixed methods, longitudinal research, and learning analytics to complement the dominance of bibliometric and systematic review studies identified in this research. Researchers and educational practitioners are also encouraged to investigate the long-term pedagogical implications of artificial intelligence, blended learning, and gamification in various educational contexts. In addition, educational institutions should strengthen

teachers' digital competencies and instructional innovation to support adaptive, inclusive, and technology-enhanced learning environments aligned with the demands of 21st-century education.

Declarations

Author Contributions. S.S: Literature review, conceptualization, methodology, data analysis. S.N.F.: review-editing, I.P.: original manuscript preparation. All authors have read and approved the published on the final version of the article.

Conflicts of Interest. The authors declare no conflict of interest.

Funding. This research received no external funding.

Ethical Approval. Ethical approval was not required for this study because the research utilised publicly accessible bibliographic data obtained from Google Scholar through the Publish or Perish application and did not involve human participants.

Data Availability Statement. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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