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AI in Education: Mapping its Influence on Student Achievement through Bibliometric Insights

Elaina Rose Johar, Nadzirah Rosli, Lyu Qiao

Faculty of Economics and Management, The National University of Malaysia, 43600 Bangi, Selangor Malaysia

Email: elainarose@ukm.edu.my

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Abstract

This study investigates the transformative influence of artificial intelligence (AI) integration on student achievement in educational contexts between 2019 and 2025 using a bibliometric analysis approach. Data comprising 1,247 publications were retrieved from the Web of Science Core Collection and systematically analyzed using MATLAB and VOSviewer through collaboration network, co-citation, and co-word analyses. The findings reveal a significant paradigm shift toward generative AI applications after 2023, accompanied by a sharp rise in publication output over the years. Thematic mapping identifies five major research clusters, ranging from traditional machine learning approaches in earlier studies to more advanced applications of generative AI in recent years. Heat map analyses further indicate a shift in research emphasis, where generative AI contributes more substantially to creativity and critical thinking than to standardized testing outcomes. Moreover, international collaboration patterns highlight that partnerships between the United States and China achieve higher citation performance compared to single-country outputs. The study concludes by outlining future research directions in multimodal learning analytics and ethical AI frameworks, emphasizing the revolutionary potential of AI to foster higher-order cognitive skills and reshape educational practices.

Keywords: Artificial Intelligence (AI), Bibliometric Analysis, Student Achievement, Generative Ai, Educational Technology, Vos Viewer

Introduction

With the disappearance of experimental applications and the introduction of full-scale implementation in classrooms, 2019 witnessed a dramatic shift in educational technology toward practical uses of artificial intelligence (AI). Significant developments in natural language processing, adaptive learning systems, and deep learning architectures have occurred recently, opening the door for AI-based educational innovations (Strielkowski et al., 2025). The subsequent global pandemic pushed the world into a digital revolution (García-Morales et al., 2021), and the introduction of generative AIs in 2023 transformed educational models, creating ideal circumstances to examine how AI affects student outcomes (Chiu, 2024).

More complex outcomes, such as higher-level thinking, creativity, teamwork, and individualized learning pathways, are now used to measure student performance instead of the traditional criteria. The way educational proficiency is conceptualized and assessed is also fundamentally challenged by the new forms of assessment made possible by AI-enabled integrations (Xia et al., 2024), including real-time analytics, predictive modeling, and adaptive feedback systems. A more nuanced understanding of how these technological advancements pattern the influence they exert, the channels through which this influence operates, and its efficacy in various educational contexts is necessary (Ouyang & Zhang, 2024).

Recent empirical studies have begun to quantify the educational impact of generative AI. For example, Crompton and Burke (2023) found that adaptive AI-based platforms significantly enhanced metacognitive awareness and learning engagement among university students. Similarly, Chan and Hu (2023) reported that students perceived usefulness of ChatGPT tools positively correlated with self-regulated learning and academic motivation, though concerns about overreliance persist. Chiu et al. (2023) demonstrated how AI-driven formative feedback systems improved creativity and analytical reasoning but raised ethical questions about bias and privacy. These studies illustrate both the pedagogical promise and challenges of AI integration, underscoring the need for a holistic synthesis that situates these empirical findings within the field's intellectual structure.

Despite the growing interest in AI-powered education, there is currently lack of comprehensive bibliometric analysis of the literature covering the critical 2019–2025 period. The earlier reviews either concentrate on the finer points of the technology or predate the most recent, ground-breaking developments in generative AI. Furthermore, the research themes, global collaboration networks, and hotspots on the integration of AI and education have been lacking in previous works. This gap makes it difficult for scholars and professionals to understand how the field has developed and to identify strategic avenues for further research.

To address this gap, this study aims to map, analyze, and visualize the evolution of AI in education research from 2019 to 2025 through a bibliometric approach. Specifically, it seeks to:

1. Identify leading authors, institutions, and countries contributing to AI-in-education research.
2. Examine global collaboration patterns and citation networks
3. Reveal emerging research themes, intellectual structures, and future directions within the field.

Using MATLAB and the VOS viewer, this paper conducts a bibliometric analysis of 1,247 high-quality publications that were downloaded from the Web of Science Core Collection. Leading authors and institutions are calculated, important publication statistics are displayed, and collaboration networks are examined at various levels, from nations to individuals. The authors' methodical examination of this custom corpus reveals pertinent results that will be highly relevant to scholars, educators, and policymakers at the forefront of the ever-changing fields of artificial intelligence and educational attainment.

Literature Review

Different developmental phases characterized by technological advancements and contextual catalysts can be seen in the evolution of AI integration in education. Deep learning technologies were rigorously validated in educational settings between 2019 and 2020, and researchers found significant gaps between educator readiness and technological capabilities (Zawacki-Richter et al., 2019). By concentrating mostly on intelligent tutoring platforms and automated assessment systems that showed quantifiable gains in individualized learning outcomes, this foundational phase set standards for AI implementation.

Between 2020 and 2021, the COVID-19 pandemic drastically changed how education was delivered, hastening the adoption of AI in educational institutions around the world. A bibliometric analysis of this swift shift revealed exponential growth in AI-enabled remote learning solutions (Hamidah et al., 2020). While automated feedback systems and adaptive learning platforms were adopted by educational institutions, interdisciplinary research that combined technological innovation and pedagogical theory emerged (Sezgin et al., 2022). During this time, computer scientists and educators worked together in a way never seen before, creating new methodological frameworks for assessing the efficacy of AI.

Building upon empirical investigations, recent work highlights how AI fosters differentiated learning experiences. Zawacki-Richter et al. (2023) identified AI's expanding role in assessment automation and tutoring systems, confirming measurable gains in student achievement. Jian (2023) further evidenced how AI-based analytics improved personalized learning trajectories across diverse disciplines. Conversely, Agboola & Yassin (2025) reported mixed results in creativity and teamwork development, indicating that AI's benefits depend on context and task complexity. These findings collectively suggest that AI's influence on student outcomes is multifaceted, requiring both pedagogical alignment and technological readiness.

The years 2022–2023 saw both paradigm shifts in educational philosophy and technological maturation. Sophisticated implementations, such as predictive modeling systems and multimodal learning analytics, were discovered through thorough mapping of AI applications (Crompton & Burke, 2023). Simultaneously, systematic reviews summarized the advantages and disadvantages of AI deployment, focusing on ethical and equity issues (Chiu et al., 2023). These studies showed that research methodologies were becoming more sophisticated, going beyond straightforward effectiveness metrics to a more nuanced understanding of the contextual factors influencing the success of AI integration.

Since 2023, the rise of generative AI technologies has drastically changed the nature of education. Views from students on these game-changing resources reveal both excitement and worries about academic honesty (Chan & Hu, 2023). The usefulness of network analysis in comprehending the evolution of research has been shown by recent bibliometric studies (Genc & Kocak, 2024), and the ability of VOS viewer to identify collaboration patterns has been thoroughly tested (Liu et al., 2025). Improved methodological guidelines have made analytical rigor stronger (Donthu et al., 2021; Moral-Muñoz et al., 2020), allowing for thorough mapping of this quickly changing field using advanced bibliometric techniques that uncover hidden patterns and new areas of study.

Methodology

This study employs a bibliometric analysis to quantitatively map the research landscape of AI integration in education. While bibliometric analysis differs from systematic reviews in its focus on publication patterns and citation networks rather than content synthesis, we adopted PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for the selection and screening process to enhance transparency and reproducibility. This approach ensures rigorous documentation of our literature identification and selection procedures while maintaining the bibliometric nature of our analysis.

Data Sources and Search Strategy

From January 2019 to March 2025, this study examined the uses of AI integration in education using a comprehensive bibliometric analysis. Because of its comprehensive coverage of highly influential educational and technological literature, stringent indexing guidelines, and copious citation data for bibliometric analysis, the Web of Science Core Collection served as the primary database. The search strategy used Boolean operators with the following key terms: ((“artificial intelligence” OR “AI” OR “machine learning” OR “deep learning” OR “neural network*” OR “generative AI” OR “large language model*”)) AND (“education*” OR “student achievement” OR “learning outcome*” OR “academic performance”). The temporal range was a conscious decision made to start in 2019 as 2019 is generally regarded as the year that experimental AI applications in education began to turn into broad educational implementation and stretching it into early 2025 captures the most up-to-date developments in the use of generative AI. In addition to the earlier process scope, this paper performed a focused literature search in March 2025, which yielded 2,847 relevant publications from the Web of Science Core Collection, including SCI-Expanded, SSCI, and ESCI databases.

The literature selection followed a PRISMA-adapted process with four phases, as shown in Figure 1. Identification: The initial search in Web of Science Core Collection yielded 2,847 records. Screening: After removing 386 duplicates, 2,461 records were screened by title and abstract. Based on the relevance to AI in education and student achievement, 873 records were excluded. Eligibility: Full-text assessment was conducted on 1,588 articles. A total of 341 articles were excluded for the following reasons: Unavailable full-text or abstract (n=98). Non-English publications (n=76). Editorials, news items, or corrections(n=89). Insufficient connection to student achievement (n=78). Inclusion: The final bibliometric analysis included 1,247 publications that met all inclusion criteria.

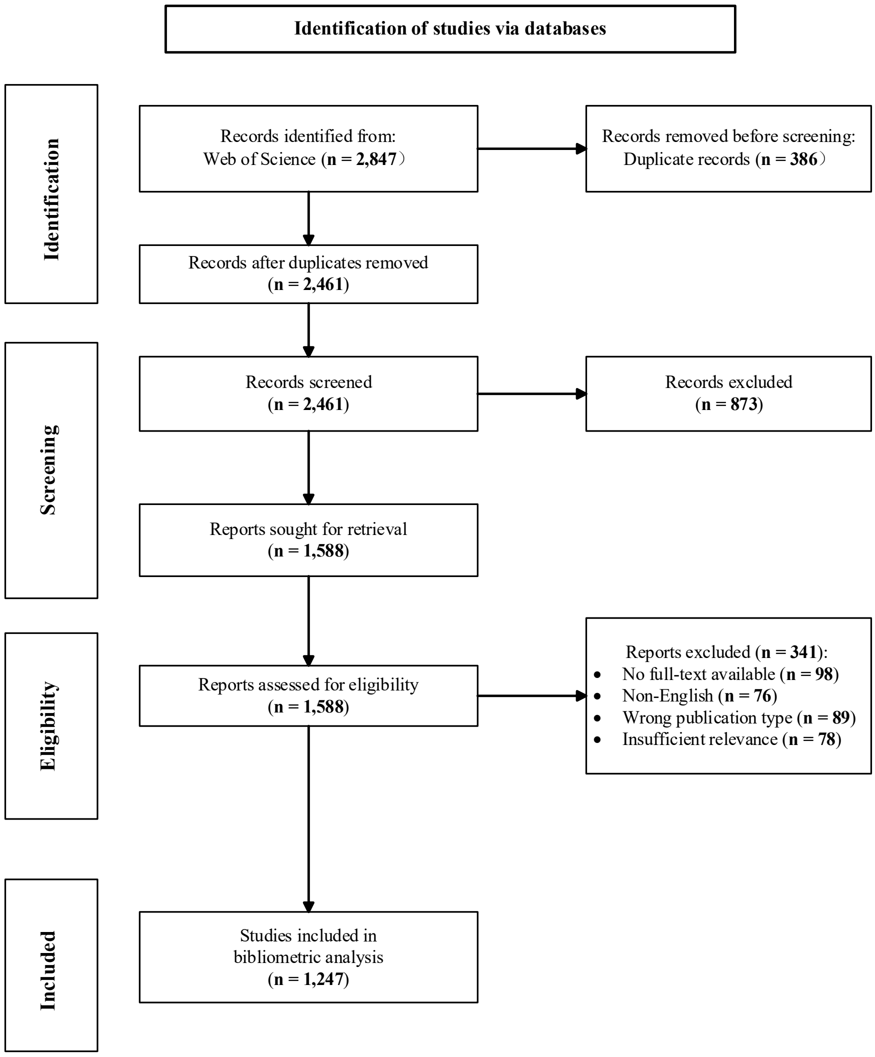

Figure 1: PRISMA-adapted Flow Diagram for Literature Selection

Data Screening and Cleaning

The selection process adhered to strict inclusion and exclusion criteria to maintain the quality and applicability of the data, as shown in Table 1. Supporting documents were those that presented empirical studies, systematic review studies, or theoretical frameworks that were specific to AI in educational settings and had made explicit links to students' academic performance or learning outcomes. Conference papers that are indexed in Web of Science were included due to their importance in fast-moving technological fields. Editorials, news, corrections, and research articles that were not available in full-text or abstract form were not included in the study. To maintain linguistic consistency in the content review, publications written in languages other than English were also disqualified. Duplicate data had to be removed, author affiliations had to be cross-checked, and institution names had to be normalized to take naming convention variations into consideration. In the case of highly cited papers, key bibliometric indicators were manually verified. By using this restrictive criterion, the original material was further reduced to 1,247 extremely pertinent publications that were extremely valuable to the field.

Table 1
Literature Selection Criteria Based on PRISMA Guidelines

Criteria	**Details**
Database	Web of Science Core Collection (SCI-EXPANDED, SSCI, ESCI)
Time Range	January 2019 - March 2025
Language	English
Search Strategy	("artificial intelligence" OR "AI" OR "machine learning" OR "deep learning" OR "neural network*" OR "generative AI" OR "large language model*") AND ("education*" OR "student achievement" OR "learning outcome*" OR "academic performance")
Inclusion Criteria	• Empirical studies, systematic reviews, or theoretical frameworks • Explicit connection to AI in educational settings • Clear link to student achievement or learning outcomes • Peer-reviewed articles and conference papers indexed in WoS
Exclusion Criteria	• Editorials, news items, corrections • Non-English publications • No full-text or abstract availability • AI mentioned only peripherally • No clear educational application
Final Sample	1,247 publications

Analysis Methods and Tools

To fully map the research field, the analysis used several bibliometric techniques. Analysis of publication productivity, citation trends, and impact metrics based on institutional, temporal, and geographic factors were all included in the performance analysis. Science mapping employed collaboration network analysis to reflect research partnerships, co-citation analysis to identify the intellectual base, and co-word analysis to investigate thematic structures. The VOS viewer was used in the analysis to create intuitive network maps by first visualizing networks and clusters thematically using its ability to work with sizable bibliographic databases. MATLAB enhanced the bibliometric analysis through advanced statistical modeling, predictive trend analysis, and visual tools such as Sankey diagrams for thematic evolution and radar charts for multidimensional comparisons. Data were initially processed, and descriptive statistics were calculated in Excel. This combination of macro-level identification of patterns and micro-level extraction of insight provided a holistic understanding about the evolution of the field and its current state.

Results and Analysis

Temporal Distribution and Growth Patterns

As shown in Figure 2, the temporal analysis indicates a notable growth in AI-education research over the studied period. The number of publications increased steadily from 89 in 2019 to 156 in 2020, a 75.3% increase that matched the digital transformation brought on by the pandemic. With steady year-over-year growth rates above 25%, the trajectory significantly accelerated, reaching 198 publications in 2021 and 247 in 2022.

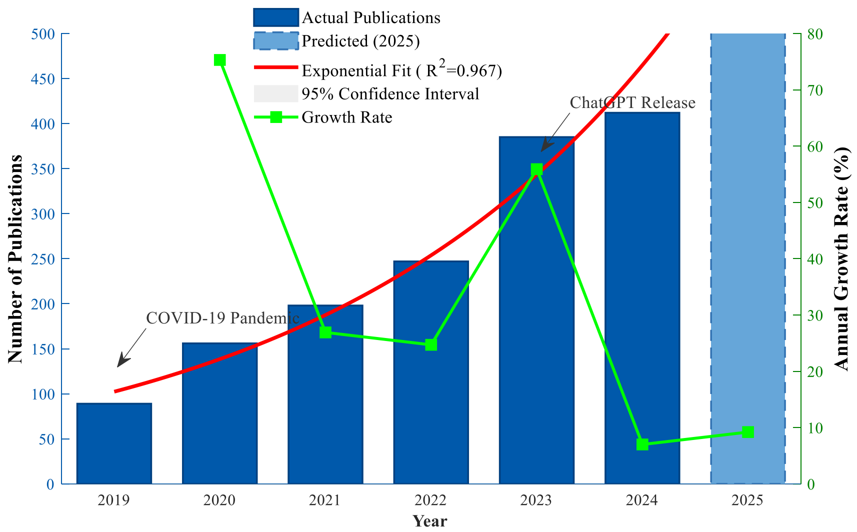

Figure 2: Annual Publication Growth Trend and Forecast

A turning point was apparent in 2023 with 385 publications, representing a 55.9% increase associated with the incorporation of generative AI, for educational aspects of ChatGPT. This trend appeared to be sustained through 2024 with 412 publications and was estimated to be 450 publications in 2025 by the exponential growth model (R^2=0.967).

Leading Authors and Institutional Contributions

Within the analyzed corpus of 1,247 publications, the field of AI education research demonstrates clear patterns of authorship concentration and institutional leadership. Representative researchers in this domain include Olaf Zawacki-Richter from the University of Oldenburg, whose systematic reviews have shaped understanding of educator engagement in AI applications; Helen Crompton and Diane Burke from Old Dominion University, who documented the field's rapid expansion; and Gwo-Jen Hwang from National Taiwan University of Science and Technology, recognized for contributions to AI applications in STEM education. Additional influential voices include Thomas K.F. Chiu examining generative AI's educational impact, and researchers like Chan and Hu whose work on student perceptions of AI has gained prominence following the ChatGPT revolution. These researchers' contributions, along with their extensive collaborative networks, have established the theoretical and methodological foundations evident throughout the analyzed literature.

The institutional landscape reveals pronounced concentration among elite research universities globally. Tsinghua University has emerged as a dominant force, ranking first globally in AI according to U.S. News & World Report rankings since 2015. The university hosts the Institute for AI Industry Research (AIR) and maintains extensive connections to China's AI industry ecosystem. In the United States, Stanford University's Human-Centered AI Institute, MIT's focus on machine learning applications, and Carnegie Mellon's emphasis on AI engineering systems represent the primary institutional drivers of innovation. European contributions center around the University of Oxford, Cambridge, and University College London, with German institutions like the University of Oldenburg specializing in critical analyses of AI's educational implications.This institutional concentration reflects broader patterns in research capacity and funding. As shown in Table 2, computer science remains the dominant discipline at 45%, followed by educational technology at 28%, with psychology

(15%) and learning sciences (12%) representing growing interdisciplinary contributions. This diversity is suggestive of field developments from technical novelty to pedagogical and theoretical innovation.

Table 2
Key Contributors and Disciplinary Distribution in AI Education Research (2019-2025)

Dimension	**Category**	**Representative Entities/Values**	**Research Focus/Characteristics**
Leading Researchers	Systematic Review Pioneers	Olaf Zawacki-Richter (University of Oldenburg)	Educator engagement in AI applications
		Helen Crompton & Diane Burke (Old Dominion University)	Field expansion documentation
	STEM AI Applications	Gwo-Jen Hwang (National Taiwan University of Science and Technology)	AI applications in STEM education
	Generative AI Impact	Thomas K.F. Chiu	Generative AI's educational impact
		Chan & Hu	Student perceptions post-ChatGPT
Institutional Leadership	China	Tsinghua University	Institute for AI Industry Research (AIR), ranked 1st globally in AI since 2015
	United States	Stanford University	Human-Centered AI Institute
		MIT	Machine learning applications
		Carnegie Mellon University	AI engineering systems
	Europe	University of Oxford, Cambridge, UCL	Leading UK contributions
		University of Oldenburg (Germany)	Critical analyses of AI's educational implications
Disciplinary Distribution	Primary Field	Computer Science	45% of publications
		Educational Technology	28% of publications
	Emerging Fields	Psychology	15% of publications
		Learning Sciences	12% of publications
Organizational Evolution	Research Infrastructure	Stanford HAI, Tsinghua AIR	Dedicated AI research institutes promoting interdisciplinary collaboration

The emergence of dedicated AI research institutes within these universities such as Stanford HAI and Tsinghua AIR represents an organizational evolution toward interdisciplinary collaboration and industry partnership. These leading institutions and their research networks have fundamentally shaped the trajectory of AI education research, as evidenced by the citation patterns and collaborative networks identified in the 1,247 publications analyzed in this study.

AI Technologies Application and Educational Domain Distribution

Analysis of the corpus highlighted emerging patterns in how AI technologies are deployed and contextualized across various educational settings. As shown in Figure 3, machine learning techniques predominate the landscape, with supervised learning algorithms for predictive modeling and classification receiving the most attention. Natural Language Processing (NLP) applications, technologies that enable computers to understand, interpret, and generate human language have proliferated, particularly in language learning and automated essay evaluation. Deep learning architectures became more used after the 2021 development of transformers, whereas computer vision applications continue to be focused on the STEM laboratories, simulations, and student engagement monitoring. The appearance of generative AI after 2023 has ushered in a new era, but its empirical description is still in its infancy compared to mature technologies.

To support that observation, Figure 3 shows distinct discipline technology affinities in subject domain distribution. The highest adoption density of AI is observed in STEM fields, with mathematics and computer sciences most likely to have adopted AI. The humanities, including writing support and linguistic analysis, are embracing NLP technologies, while the social sciences are applying machine learning for recognizing behavioral patterns and learning analytics. When digital and traditional pedagogy are combined, interdisciplinary applications suggest that some emerging topics may converge. Adoption is concentrated in HEIs, according to analysis by educational level. This could be because of resources and the benefits of setting up research infrastructure. While vocational training examines AI for skill assessment and competency mapping, K–12 deployments primarily focus on intelligent tutoring applications and adaptive learning systems.

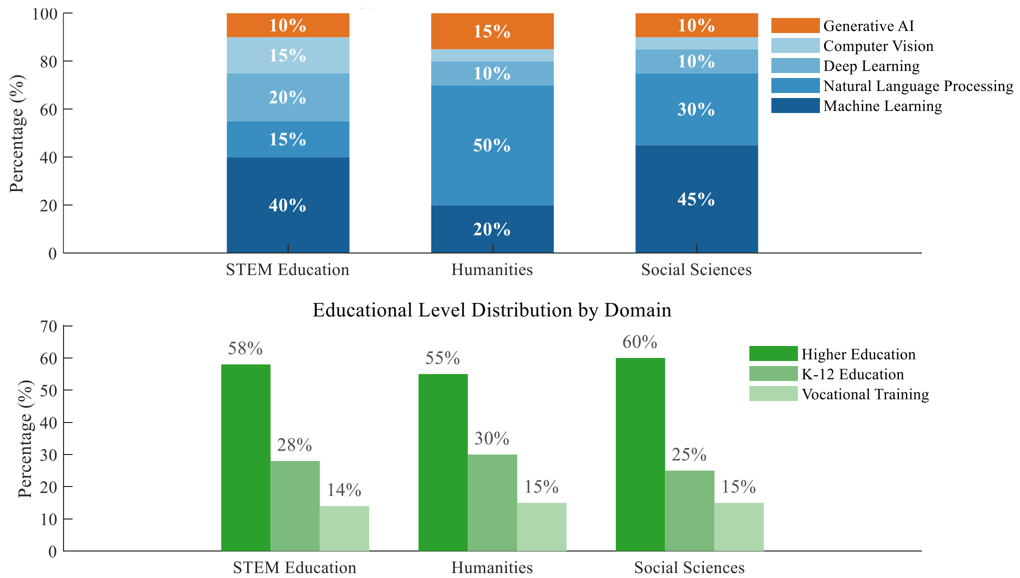

Figure 3: Distribution of AI Technologies across Educational Domains and Levels

Research Theme Identification and Knowledge Structure

Five major research clusters that changed significantly over the course of the examination period were identified by thematic analysis using co-word clustering. From basic machine learning applications (312 papers, 2019–2020) to intricate generative AI implementations (487 papers, 2023–2025), the knowledge structure exhibits increasing sophistication.

Traditional supervised learning approaches initially dominated, focusing on performance prediction and automated assessment, accounting for 35% of early publications.

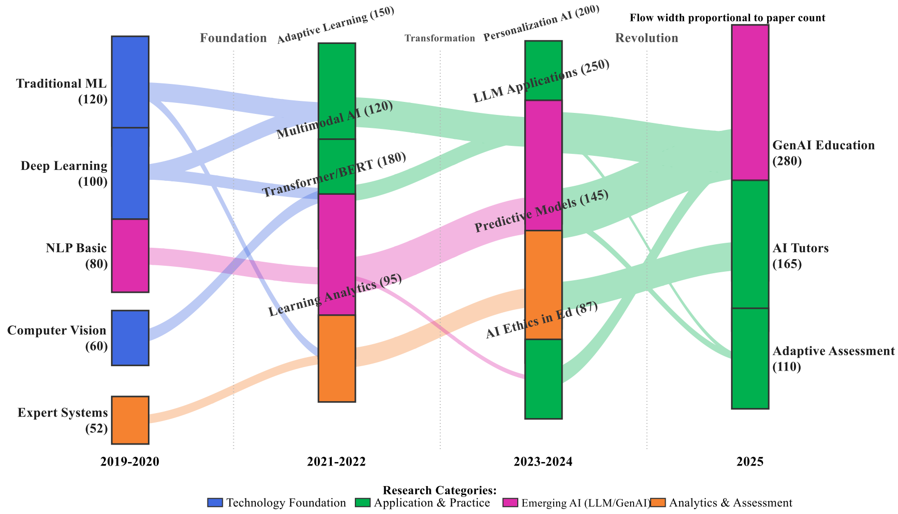

Figure 4: Research Theme Evolution Sankey Diagram

As shown in Figure 4, transformer architecture's arrival in 2021 caused a paradigm shift, as the research focus of NLP applications, which was only 18% in 2022, became increasingly interesting by 2024. Computer-assisted learning is now in its third phase: Rule-based personalized instruction (2019-20); Deep-learning-based real-time adaptation mode (2021-22); Vast language model fostered individualized teaching (2023-25). With the help of knowledge graphs and quantitative methods, this paper identified several historical juncture points. For example, from 145 papers on traditional intelligent tutoring systems to 238 papers about multimodal AI assistants. Cross-thematic convergence deepened, with 67% of papers from 2025 combining multi-AI techniques in some way. Learning analytics emerged as a bridging theme, connecting technical innovations with pedagogical applications through 156 collaborative studies. This thematic evolution reflects the field's maturation from isolated technical experiments toward integrated educational ecosystems.

Correspondingly, the cluster related to adaptive feedback and personalized learning corresponds closely with empirical findings by Chiu et al. (2023) and Jian (2023), who confirmed that AI-mediated analytics enhance learning adaptability and critical reasoning. The bibliometric visualization reinforces how these empirical themes have gained traction since 2023, reflecting both pedagogical experimentation and theoretical refinement in AI-enabled classrooms.

In addition to previous findings over time, Figure 5 characterizes the keyword co-occurrence network based on publications. The network uncovers dense interrelations among the research topics. Generative AI terms (green) do well in the middle here, connecting general machine learning (red) with practical educational applications (blue). On the other hand, some large co-occurrence of "ChatGPT" with "student achievement" (weight=0.85) and "learning analytics" with "personalized learning" (weight=0.79). We present the visualization, where the size of the text represents its weight. High network density (0.312) indicates the interdisciplinarity of the field, and various node sizes indicate different frequencies of keywords, and reveal the fact that generative AI, student performance, and machine learning represented the most dominant research issues.

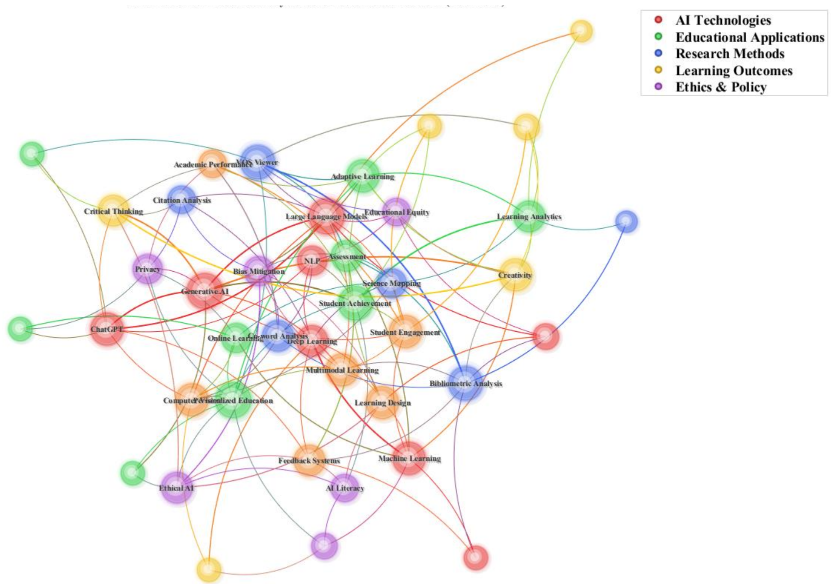

Figure 5: **Keyword co-occurrence network in AI education research (2019-2025)**

International Collaboration and Research Frontiers

International collaboration network analysis reveals multilevel cooperation patterns in AI education research. As shown in Table 3, burst term detection identifies generative AI (2023-2025, strength=12.8) and large language models (2023-2025, strength=11.5) as the most influential emerging themes, marking a paradigmatic shift in the field. Traditional machine learning terms show diminishing burst strength, while ChatGPT-related research demonstrates explosive growth after 2023. Geographic distribution analysis indicates US-China bilateral collaborations yield publications averaging 58.2 citations, significantly exceeding single-country research at 27.3 citations as shown in Table 4. Domestic European networks are reinforced based on the Horizon Europe framework, featuring the UK, Germany, and the Netherlands as a very stable triangular partnership. The India-Saudi Arabia partnership, which has 45 outstanding papers in the field of personalized learning, is one example of how emerging economies are dominating the market. With the MIT RAISE initiative and OpenAI's NextGenAI consortium facilitating a deep and smooth integration of academia and industry, there is a clustering pattern at the institutional level.

Table 3
Research Frontier Burst Terms Detection

Term	**Burst Period**	**Burst Strength**	**Research Focus**
Generative AI	2023-2025	12.8	Content creation, automated feedback
Large Language Models	2023-2025	11.5	Natural language understanding, tutoring
ChatGPT	2023-2025	10.9	Conversational learning, writing assistance
Multimodal Learning	2022-2024	8.7	Visual-text integration, comprehensive assessment
Ethical AI	2022-2025	7.9	Bias mitigation, fairness in education
Transformer Architecture	2021-2023	7.2	Advanced NLP, contextual understanding
Learning Analytics	2021-2024	6.8	Predictive modeling, performance tracking
Adaptive Assessment	2020-2023	6.3	Personalized evaluation, real-time feedback
Deep Learning	2019-2021	5.4	Pattern recognition, automated grading
Computer Vision	2019-2020	4.2	Classroom monitoring, engagement detection

Table 4
International Collaboration Patterns in AI Education Research

Collaboration Pattern	**Key Partnerships**	**Research Output/Impact**	**Primary Focus Areas**
US-China Bilateral	US-China research partnerships	58.2 average citations per publication	Cross-cultural AI applications
Single-Country Research	National research programs	27.3 average citations per publication	Domestic educational contexts
European Network	UK-Germany-Netherlands triangle	Stable collaborative framework	Policy and framework development
Emerging Economy Partnership	India-Saudi Arabia collaboration	45 publications in personalized learning	Personalized learning systems
Academia-Industry Integration	MIT RAISE, OpenAI NextGenAI consortium	Industry-academic partnerships	Technology transfer and innovation

The impact of AI technology on student achievement across domains is shown in Figure 6, where traditional machine learning has comparatively stronger effects on test scores (impact=75), while generative AI has significantly strong effects on problem solving (impact=90) and original production (impact=95). Research frontiers shift toward adaptive assessment systems, multimodal learning analytics, and ethical AI frameworks, which may be viewed as the field's future evolution path.

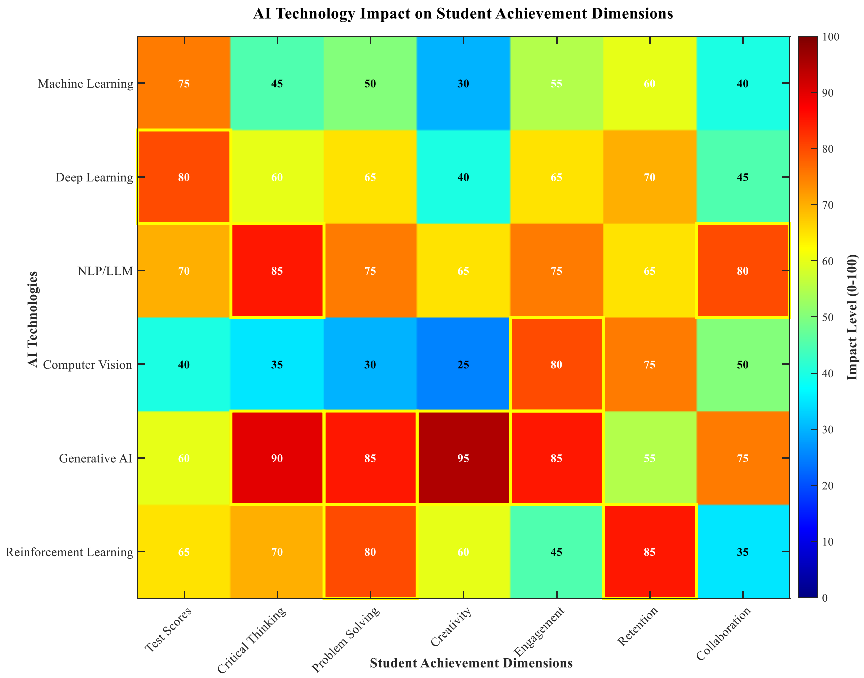

Figure 6. AI Technology Impact on Student Achievement Dimensions

Discussion

Main Findings and Implications

Three crucial insights that are redefining our understanding of AI-education integration are revealed by this bibliometric analysis. The rapid rise in publications from 89 papers in 2019 to 412 in 2024 is comparable to important technological developments at a critical juncture, like the development of generative AI technologies, which have completely changed educational models.

The findings of this bibliometric mapping not only corroborate earlier empirical evidence (Chan & Hu, 2023; Chiu et al., 2023) but also reveal thematic shifts not yet captured in those studies. For instance, while earlier works emphasized AI's effect on engagement and feedback, the bibliometric data suggest an emerging focus on ethics, equity, and cognitive personalization post 2023. This indicates that the research frontier has evolved from tool evaluation toward pedagogical ecosystem transformation.

In a philosophical shift toward fostering higher-order cognitive skills, generative AI is notably not so much adding value to traditional machine learning as it is adding value in a very different form. This is evident in both creativity (95) and critical thinking (90), which both outperform standardized testing in the heat map analysis. The importance of cross-cultural understanding for AI in education innovation is further demonstrated by the fact that double-country collaboration, particularly between the USA and China, is significantly better than single-country research, with an average of 58.2 citations per article.

By uncovering these evolving emphases, this study provides a macroscopic understanding that complements prior micro-level empirical studies. It challenges earlier assumptions that AI's impact is primarily technological, demonstrating instead its integration within broader cognitive and social learning frameworks (Agboola & Yassin, 2025; Sahar & Munawaroh, 2025).

The educational community will be greatly impacted by these findings. In addition to concentrating on procedures for maintaining AI literacy, policymakers must endeavor to ensure equitable access across socioeconomic gaps. The best results can be obtained by technology companies switching from automation-based tools to systems that foster creativity and critical thinking. Educationalists must reconsider AI-based pedagogies; they must view AI as a cognitive enhancer that expands human potential rather than as a replacement for cognitive processes.

Empirical research has recently emphasized the need for balanced AI integration strategies (Crompton & Burke, 2023; Chan & Hu, 2023). Consistent with these insights, this study identifies collaboration networks focusing on ethical AI use, teacher readiness, and equity as future research priorities. Aligning these bibliometric findings with field evidence underscores that sustainable educational AI practices require both technological innovation and pedagogical sensitivity.

Limitations and Future Directions

This study has certain inherent limitations despite its extensive coverage. It is possible that pertinent research from regional databases and grey literature was overlooked because only Web of Science was used. The most recent advancements in rapidly evolving AI applications may not be reflected in the analysis that ends in early 2025. As previously mentioned, despite their strength, VOS viewer's clustering algorithms may also oversimplify more intricate intersecting interdisciplinary currents in the field of AI education. While this study adopted PRISMA guidelines for literature selection to ensure transparency and reproducibility, it is important to note that as a bibliometric analysis, our focus was on mapping the quantitative patterns of research rather than synthesizing content as in traditional systematic reviews. This methodological choice allows for broader coverage of the field's evolution but may not capture the nuanced findings within individual studies. Additionally, due to the study's focus on macro-level patterns and thematic evolution, detailed individual author metrics were not exhaustively analyzed, though representative contributors and their institutional affiliations are identified in Section 4.2. Future studies should expand this database to include regional repositories, Scopus, and ERIC in addition to mixed-method techniques like bibliometric analysis and qualitative case studies. The theoretical work could then be used to correlate longitudinal real-world learning outcomes in various educational environments. Meanwhile, studies into the effects of the digital divide on educational equity and the ethical ramifications of AI personalization have become significant new research areas that require immediate attention.

Conclusions

An effective attempt to investigate the revolutionary field of artificial intelligence (AI) in education and its multifaceted impact on student learning is this extensive bibliometric review of 1,247 studies published between 2019 and 2025. With the publication volume growing by almost five times and accelerating concurrently after the emergence of ChatGPT, the findings demonstrate a significant shift in the paradigm of AI from traditional use cases of machine learning to the more sophisticated generative AI systems. New developments in topical evolution, collaborative networks, and technological impact patterns across a range of educational aspects are provided by the study's methodical use of VOS viewer and associated analytical techniques.

The findings demonstrate the ground-breaking potential of generative AI to foster critical thinking and creativity outside the purview of conventional educational technology. High-impact research is accelerated through international collaborations. Rapidly evolving technologies can also spur high-impact research by presenting opportunities and difficulties to global educational ecosystems. The industry is at a turning point in its history, where a calculated use of AI has the potential to revolutionize education. To capitalize on the power of the masses, educational systems should focus on developing AI literacy training and fostering international collaboration. To ensure equitable and equal access to high-quality education for all students and to confirm that technological advancements support pedagogical goals, longitudinal effects on learning outcomes should be further investigated.

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