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Artificial Intelligence in Adaptive Learning for Education: A Bibliometric Analysis

Kecerdasan Buatan dalam Pembelajaran Adaptif untuk Pendidikan: Analisis Bibliometrik

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ABSTRACT

Artificial intelligence (AI) has emerged as a transformative technology in education, particularly adaptive learning which supports personalized and learner-centred experiences. Despite the rapid growth of research on AI for adaptive learning, a comprehensive understanding of its publication performance, thematic structure and technological evolution remains limited. To overcome this gap, the study aims to systematically map and evaluate the development of research on AI for adaptive learning in education using bibliometric methods. A bibliometric analysis was conducted using data from the Scopus database covering the period from 2015 to 2026. The study analyzed 2,354 publications through two complementary methods: performance analysis and science mapping. Performance analysis was used to evaluate publication growth, influential countries, sources, and highly cited documents. Science mapping techniques, including keyword co-occurrence analysis, were used to identify major research themes and the emerging AI technologies landscape. The findings show that research output has significantly risen after 2023 and recorded the highest number of publications in 2025. India emerged as the most productive country while the United States had the highest citation impact. Citation analysis highlights adaptive and personalized learning systems, intelligent educational systems and generative AI applications as key intellectual foundations of the field. Science mapping further revealed that machine learning, intelligent tutoring systems, generative AI, learning analytics and large language models are central AI technological themes in adaptive learning research. These recent trends indicate a growing shift towards conversational AI, generative AI, and personalized intelligent learning environments. In conclusion, this study provides insights into publication trends, contributors, research themes and emerging AI technologies in adaptive learning which could assist researchers, educators, policymakers and educational technology developers in improving intelligent adaptive learning systems.

Keywords: Artificial Intelligence; Adaptive Learning;Personalized Learning; Educational Technology; Bibliometric Analysis.

INTRODUCTION

The rapid application of Artificial Intelligence (AI) has transformed various aspects of society, including education (Pham & Sampson, 2022). As educational systems increasingly adopt digital technologies, AI has become a powerful tool for improving teaching and learning processes by employing intelligent decision-making, and personalized educational experiences. For instance, the study by Alsbou & Alsaraireh, (2024) demonstrates that AI-data-driven approaches yield tangible improvements in student outcomes and school decision-making efficiency with diverse educational datasets. Several groups of researchers discovered that AI-driven adaptive learning environments enhance teaching efficiency, foster innovative learning methodologies, and prepare students for the evolving demands of the modern job market (Kovalchuk et al., 2025; Sundari et al., 2024).

Numerous AI applications have been developed in education, but adaptive learning has received considerable scholarly attention. Adaptive learning is an educational approach that utilizes AI to personalize learning experiences (Akavova et al., 2023). Furthermore, this educational approach customises instructional content, learning pathways, and assessment strategies to meet the individual needs, preferences, and performance of each learner (Akintola, 2024).

In digital education, AI technologies such as machine learning, deep learning, intelligent tutoring systems, and learning analytics significantly enhance adaptive learning environments. A study by Kumar et al., (2025) demonstrates the application of machine learning in adaptive intelligent tutoring systems, offering significant benefits for personalized and data-driven learning environments. As discovered in a study by Raji et al., (2026), these AI technologies provide personalized support and real-time feedback which ultimately enhance learner engagement and academic achievement. Furthermore, recent technological advances particularly in generative AI and large language models have significantly improved innovation in adaptive educational systems (Chakraborty, 2024; Guettala, et al., 2024; Khalid et al., 2026).

Several studies declare that adaptive learning represents a learner-centred approach with advantages dynamically adjusting educational content and activities based on ongoing analysis of a learner's behaviour and progress (Apoki et al., 2022; Joshi, 2023). In contrast to traditional one-size-fits-all instructional models, AI-powered adaptive learning systems provide a more personalized experience (Joshi, 2023; Kaswan et al., 2024).

There remains a challenge in addressing diverse learning needs and improving educational effectiveness across various contexts including online learning, higher education, and professional training. Consequently, to address this challenge, educational institutions, technology developers and researchers are increasingly exploring AI-powered adaptive learning as solutions in both digital and modern education (Aggarwal, 2023; Kavitha et al., 2025).

Research into adaptive learning powered by AI has expanded across various fields including education, educational technology, computer science, data science and learning sciences. Despite this multidisciplinary approach generating a substantial body of knowledge, understanding the field's intellectual structure and its evolving technological directions remains a challenge.

Previous review studies on AI applications in education and adaptive learning predominantly utilized narrative or systematic review methods (Hariyanto et al., 2025; Merino-Campos, 2025; Plooy et al., 2024). These reviews have focused on pedagogical effectiveness technological implementation and learner outcomes but have provided limited insight into the broader research landscape including publication performance, influential contributors, thematic development and technological evolution in the field. Given the rapid advancement of new AI technologies in recent years, a comprehensive review of how research themes and technological trends have developed over time is crucial.

Bibliometric analysis is a robust quantitative method and a well-known approach for assessing the growth and organisation of scientific knowledge within a specific research area (Pessin et al., 2022). By analyzing bibliographic metadata, bibliometric methods can reveal publication trends, influential authors, productive institutions, citation impact and collaboration patterns. Furthermore, science mapping techniques such as keyword co-occurrence analysis help to explore conceptual structures, thematic relationships and emerging research directions. These approaches are increasingly valuable for understanding the rapid technological advancement driving interdisciplinary fields.

Due to the rapid growth and diversity of research on AI-enabled adaptive learning, a comprehensive bibliometric assessment is crucial. Therefore, this study aims to systematically map and evaluate the development of research on artificial intelligence in adaptive learning for education by examining its publication performance, thematic structure and technological trends. To achieve this aim, the study is organized with two main objectives. The first objective is to assess the productivity, impact, and publication characteristics of AI in adaptive learning research through performance-based bibliometric indicators. This objective involves investigating the publication characteristics, productivity patterns, and research impact of AI within adaptive learning research. The second objective is to identify major research themes and emerging AI technologies in adaptive learning using science mapping and keyword co-occurrence analyses.

This study provides a comprehensive overview of the field's intellectual landscape and technological development. The study could also enhance the understanding of current research developments and future directions in AI-enabled adaptive learning.

METHODOLOGY

This study employed a bibliometric analysis approach to systematically examine the landscape of research on AI in adaptive learning for education. Bibliometric analysis was selected as the methodological framework for its capacity to quantitatively map scholarly output, identify influential works, trace thematic evolution, and reveal collaborative networks within a defined body of literature (Kumar, 2025). The study's methodology comprises two phases: document source selection and bibliometric analysis.

Document Source Selection

In this phase, the study involved retrieving data from the Scopus database by end of May 2026, which offers a wide-ranging coverage of peer-reviewed literature across various disciplines and is considered a reliable resource for bibliometric research. The search strategy was constructed across the Scopus database, spanning from 2015 to 2026, using a combination of relevant keywords, including "artificial intelligence," "adaptive learning," and "education," applied across title, abstract, and keyword fields as detailed in Table 1.

Table 1: Search Strategy

Database	Search Query
Scopus	TITLE-ABS-KEY ((AI OR "artificial intelligence") AND ("adaptive learning") AND "education") AND PUBYEAR > 2014 AND PUBYEAR < 2027 AND (LIMIT-TO (LANGUAGE , "English"))

The search was limited to English-language publications and also included several criteria as outlined in Table 2. These criteria were applied to ensure the inclusion of relevant and high-quality scholarly publications for bibliometric analysis. This phase resulted in the final refined search comprising 2,354 records from diverse fields of study, which were subsequently utilized for the next phase, bibliometric analysis.

Table 2: Screening Criteria

Criteria	Inclusion	Exclusion
Timeline	2015-2026	< 2014
Language	English	Non-English

Document type	Conference paper, article, book chapter, review, book	Retracted, Editorial, Letter, Note, Erratum, Short Survey
Publication stage	Final	Article in Press

Bibliometric Analysis

The 2,354 retrieved records were exported and analyzed using both performance analysis and science mapping techniques. Through performance analysis, the study explored publication trends over time, the geographic distribution of research output, journal characteristics, citation patterns, and the most influential authors and publications. Meanwhile, science mapping was employed to analyze keyword co-occurrence and thematic clustering, thereby revealing major research themes and the conceptual structure of AI in adaptive learning research.

FINDINGS AND DISCUSSIONS

This section presents the findings of the bibliometric analysis on AI in adaptive learning research for education. The discussion is more on the key publication trends, influential contributors, and thematic developments, as well as the AI technological landscape within adaptive learning research. The bibliometric analysis findings are organized according to the main objectives and categorized into two main parts: (1) performance analysis, and (2) science mapping analysis of AI in adaptive learning research.

Performance Analysis of AI in Adaptive Learning Research

This subsection presents the performance analysis of AI in adaptive learning research to address the first objective of the study, which focuses on examining publication patterns, influential contributors, and research impact indicators. The analysis includes the following bibliometric indicators: annual production trends and research growth, source types and subject areas, leading publication sources, productive and influential authors, leading contributing countries and most cited publications including citation performance. These performance analysis indicators provide insights into the field's growth in publication patterns and structural characteristics, by showing how the AI technology has evolved to meet the increasing demand for data-driven adaptive learning in education.

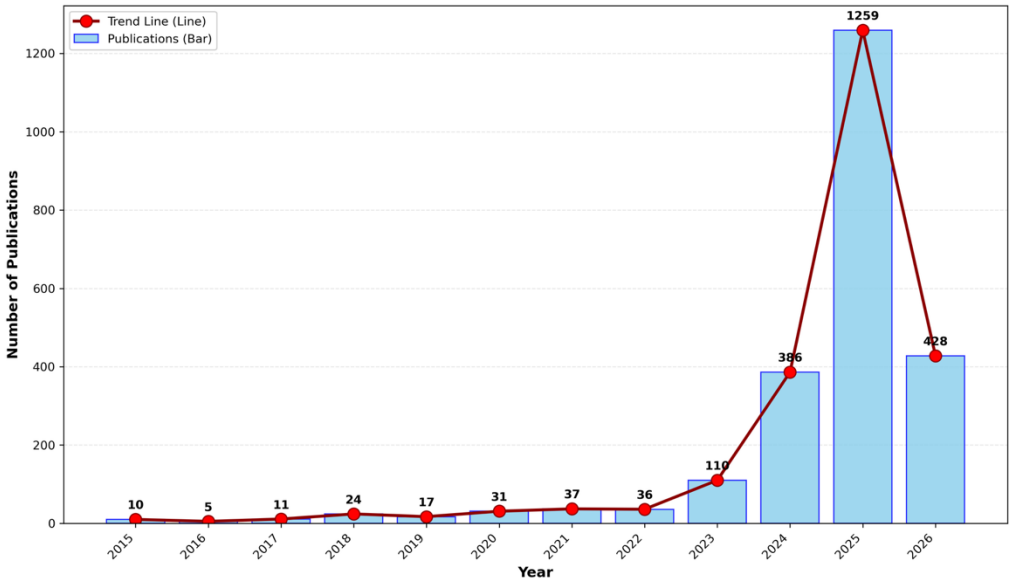
Publication Trends and Research Growth

Table 3 and Figure 1 illustrate the annual publication trends of AI in adaptive learning research from 2015 to 2026. A total of 2,354 publications were identified in the Scopus database during the study period. The results reveal that this research area remained relatively new between 2015 and 2022, with annual publications making up less than 2% of total output. During this period, the fluctuation in publication growth reflected the exploratory nature of AI applications in adaptive learning.

Table 3: Publication Year and Annual Growth

Year	Total Publications	Percentage (N=2354)	Cumulative (%)	Growth Rate (%)
2015	10	0.42	0.42	-
2016	5	0.21	0.63	-50.00
2017	11	0.47	1.10	120.00
2018	24	1.02	2.12	118.18
2019	17	0.72	2.84	-29.17
2020	31	1.32	4.16	82.35
2021	37	1.57	5.73	19.35
2022	36	1.53	7.26	-2.70
2023	110	4.67	11.93	205.56
2024	386	16.40	28.33	250.91
2025	1259	53.48	81.81	226.17
2026	428	18.19	100.00	-66.00
Total	**2354**	**100.00**		

Source: Scopus dataset (2015–2026)



Data source: Table 3

Figure 1: Publication Trends Analysis (2015-2026)

A significant turning point occurred in 2023, with publications increasing by a remarkable growth rate of 205.56% compared to 2022. This growth continued to accelerate in 2024 and 2025, with annual growth rates reaching 250.91% and 226.17%, respectively. In 2025, the dataset recorded the highest publication output, with 1,259 publications for 53.48% of the total dataset. This significant rise reflects the growing academic interest in AI-driven educational technologies, particularly the rapid development of generative AI, large language models, and intelligent learning systems. The publication trend indicates that AI-enabled adaptive learning has transitioned from an emerging research area to a rapidly growing and strategically significant field within educational technology.

Source Types and Subject Areas

This subsection presents the distribution of publications across source type and subject area to provide insights into the disciplinary composition and dissemination pattern of AI in adaptive learning research. As shown in Figure 2, conference proceedings are the largest source of publications, comprising 817 documents, closely followed by journal articles with 797 publications. This suggests that scholarly communication within the field is strongly supported by both conference and journal dissemination channels. The high volume of conference proceedings indicates a rapidly developing research field where researchers frequently present their latest findings at academic conferences before publishing them in journals. In contrast, books (461 publications) and book series (279 publications) contribute a smaller share of the total output, which reflects their relatively limited role in disseminating current research compared to conferences and journals.

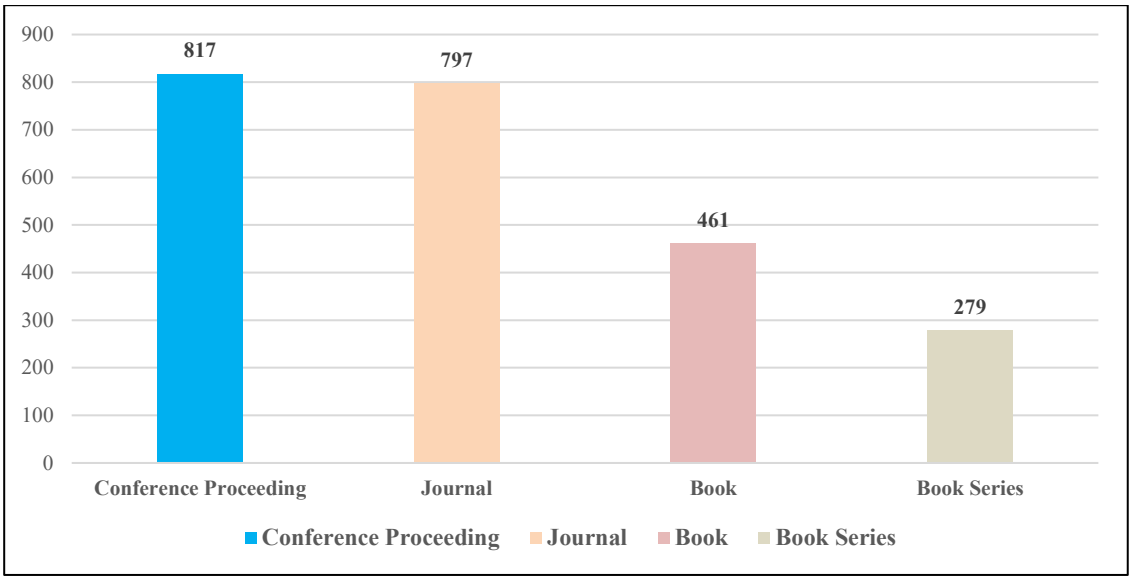


Figure 2: Publication By Source Types

Publication by Subject Area

Regarding the subject areas shown in Figure 3, the results show a strong concentration of publications in Computer Science which dominates the field with 1,676 publications, making up the largest share of research output. This is followed by Social Sciences (1,039 publications) and Engineering (730 publications), demonstrating the field's interdisciplinary nature. The substantial Social Sciences contribution suggests a growing interest in understanding the societal behavioural and organizational implications of technological advances. Meanwhile, Engineering research focuses on practical applications and system development.

Other notable subject areas include Mathematics (374 publications), Decision Sciences (286) and Medicine (170). Business Management and Accounting also have 170 publications. Moderate contributions are seen in Arts and Humanities and Psychology each with 120 publications. This reflects the growing integration of human-centred perspectives into the field. Conversely, disciplines like Pharmacology, Toxicology and Pharmaceutics (five publications), Dentistry (seven publications), Earth and Planetary Sciences (eight publications) and Chemistry (eight publications) demonstrate relatively low research activity.

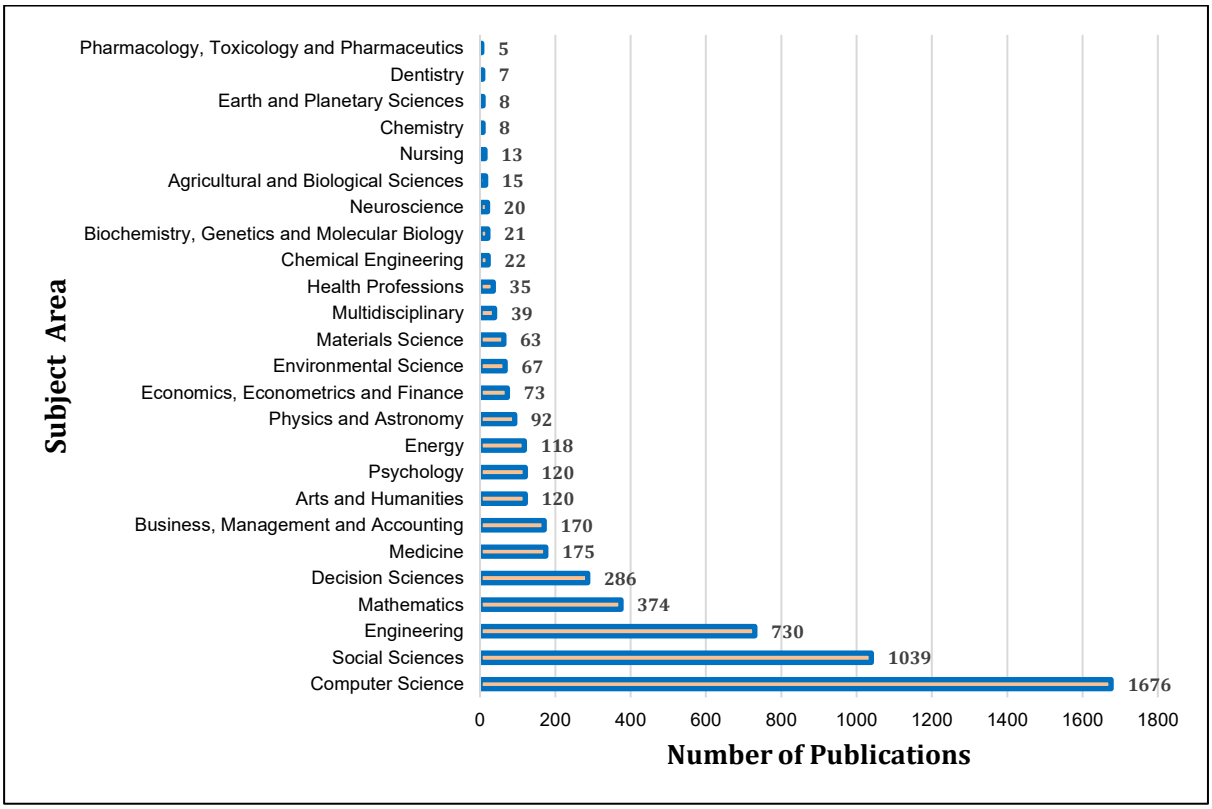


Figure 3: Publication By Subject Area

Overall, the research field is predominantly driven by technological and computational disciplines with Computer Science as the primary knowledge base. However, the significant representation of Social Sciences, Engineering, Business and Health-related disciplines reflects the field's expanding interdisciplinary scope. This shows researchers are increasingly considering technical advancements' social organizational and practical implications. This diversity of subject areas highlights the broad applicability and growing importance of the research topic across various academic fields.

Leading publication sources

Table 4 lists the top ten publication sources that have contributed to AI in adaptive learning research. The results show that the field is supported by a diverse range of journals and conference proceedings covering educational technology, computer science, artificial intelligence, and learning analytics domains. The leading sources demonstrate impressive publication productivity and impact, as evidenced by their h-index and SJR2025 rankings. The dominance of high-impact journals indicates that AI-enabled adaptive learning is gaining recognition as a significant interdisciplinary research field. Furthermore, the presence of both journal articles and conference proceedings highlights the dynamic nature of AI research, where technological innovations are frequently shared at conferences before appearing in journal publications.

Table 4: Top 10 Leading Publication Sources

Source Title	Total Publications	Publication Type	h-index	SJR2025
Lecture Notes in Networks and Systems	72	Book Series	57	0.165
Ceur Workshop Proceedings	34	Conferences and Proceedings	74	0.166
Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics	33	Book Series	535	0.393

Communications in Computer and Information Science	31	Book Series	82	0.181
Lecture Notes in Computer Science	29	Book Series	535	0.393
IEEE Access	22	Journals	338	0.884
Shodhkosh Journal of Visual and Performing Arts	22	Journals	1	-
Education Sciences	21	Journals	85	0.878
ACM International Conference Proceeding Series	20	Conferences and Proceedings	177	0.191
Frontiers in Education	15	Journals	65	0.744

Productive And Influential Authors

Table 5 presents the top 10 productive and influential authors based on three key measurement metrics: total publications, total citations, and h-index. The results reveal that a relatively small group of scholars has significantly advanced the field through continuous publication activity and scholarly influence. Among these authors, Troussas C. leads in productivity, with eight publications, but has a moderate impact, as shown by 32 total citations and an h-index of 3. In contrast, Dahbi A., Ezzaim A., and Haidine, A. each have seven highly influential publications, earning 153 citations and an h-index of 7, which suggests their work is both frequent and highly regarded in the academic community.

Similarly, Aqqal, A. and Samala, A.D. demonstrate considerable influence despite publishing fewer papers by six of each. Their citation counts are impressive, with 146 and 108 respectively, and they both have respectable h-index values. Other authors like Saddhono, K., Krouska, A., Rawas, S., and Saini, R. show varying levels of influence, which generally align with their publication output. However, Saini, R. stands out with lower impact despite six publications, evidenced by only four citations and an h-index of 1.

Table 5: Top 10 Productive and Influential Authors

Author	Total Publications	Total Citations	h-index
Troussas, C.	8	32	3
Dahbi, A.	7	153	7
Ezzaim, A.	7	153	7
Haidine, A.	7	153	7
Saddhono, K.	7	34	4
Aqqal, A.	6	146	6
Krouska, A.	6	26	3
Rawas, S.	6	55	2
Saini, R.	6	4	1
Samala, A.D.	6	108	3

Leading Contributing Countries

Table 6 highlights the top 10 countries leading in research output within the field, with highlights on total publications, total citations, average citations per publication, and continental distribution. Based on the evidence shown by the geographical distribution of publications in Table 6, it reveals that research on AI for adaptive learning is predominantly conducted in Asian countries. For instance, India ranks first as the most productive country with 551 publications, followed closely by China with 312 publications.

Table 6: Top 10 Leading Contributing Countries

No.	Country	Total Publications	Total Citations	Avearge Citation	Continent
1	India	551	2939	5.33	Asia
2	China	312	3482	11.16	Asia
3	United States	275	4201	15.27	North America
4	Malaysia	112	852	7.60	Asia
5	Indonesia	104	297	2.85	Asia
6	Morocco	72	422	5.86	Africa

7	United Arab Emirates	70	731	10.44	Asia
8	Saudi Arabia	69	714	10.34	Asia
9	Spain	67	1149	17.14	Europe
10	United Kingdom	66	620	9.39	Europe

However, publication quantity does not necessarily correspond to research impact. Despite the United States ranking third in publication volume with 275 publications, it has achieved the highest total citation count (4,201 citations), indicating greater scholarly influence and research impact. In terms of average citations, Spain had the highest rate at 17.14 citations per publication. The United States followed with 15.27 citations per publication and China with 11.16 citations per publication.

The findings reveal a significant difference between research productivity and research impact between leading countries. While Asian countries lead in research productivity, North American and Western countries maintain considerable influence through highly cited and impactful publications in shaping the field's intellectual development. Overall, the findings also show a diverse global contribution, with significant participation from Asia, notable influence from North America and Europe, and emerging contributions from Africa.

Most Cited Publications

Table 7 lists the top 10 most cited publications shaping AI in the adaptive learning field, including their total citation counts and average annual citations. These publications dataset spans from 2021 to 2025, encompassing a diverse range of journals and research themes, which were ranked based on total citation counts. The most cited publication was authored by Zhai et al., (2021), receiving 994 citations and an impressive average of 165.67 citations per year. This comprehensive study explored the evolution of AI in education from 2010 to 2020 and has become a foundational reference for subsequent research.

Then it was followed by Gligorea et al., (2023), who published 729 papers and achieved the highest average annual citation rate of 182.25 citations. Their work focused on adaptive learning through AI in e-learning and highlighted the rapid scholarly interest in this topic despite its relatively recent publication. The finding indicates that Adaptive and Personalized Learning Systems is a highly active research theme, appearing in three of the ten entries (Kabudi et al., 2021; Murtaza et al., 2022; Sajja et al., 2024). Furthermore, this significant contribution highlights the importance of learner-centred educational systems in adaptive and personalized learning research.

Table 7: Top 10 Cited Publications

No.	Author	Year	Title	Source	Total Citations	Average Citations per Year	Research Themes
1	Zhai et al.	2021	A Review of Artificial Intelligence (AI) in Education from 2010 to 2020	Complexity	994	165.67	Intelligent Educational Systems and AI Integration
2	Gligorea et al.	2023	Adaptive Learning Using Artificial Intelligence in e-Learning: A Literature Review	Education Sciences	729	182.25	Adaptive and Personalized Learning Systems
3	Kabudi et al.	2021	AI-enabled adaptive learning systems: A systematic mapping of the literature	Computers and Education: Artificial Intelligence	623	103.83	Adaptive and Personalized Learning Systems
4	Rasul et al.	2023	The role of ChatGPT in higher education: Benefits, challenges, and future research directions	Journal of Applied Learning and Teaching	533	133.25	Generative AI and Conversational Adaptive Learning
5	Wang et al.	2024	Artificial intelligence in education: A systematic literature review	Expert Systems with Applications	504	168.00	Intelligent Educational Systems and AI Integration

6	Wang et al.	2023	Exploring the Potential Impact of Artificial Intelligence (AI) on International Students in Higher Education: Generative AI, Chatbots, Analytics, and International Student Success	Applied Sciences (Switzerland)	380	95.00	Generative AI and Conversational Adaptive Learning
7	Sajja et al.	2024	Artificial Intelligence-Enabled Intelligent Assistant for Personalized and Adaptive Learning in Higher Education	Information (Switzerland)	357	119.00	Adaptive and Personalized Learning Systems
8	Strielkowski et al.	2025	AI-driven adaptive learning for sustainable educational transformation	Sustainable Development	331	165.50	Intelligent Educational Systems and AI Integration
9	Murtaza et al.	2022	AI-Based Personalized E-Learning Systems: Issues, Challenges, and Solutions	IEEE Access	314	62.80	Adaptive and Personalized Learning Systems
10	Huang et al.	2021	A review on artificial intelligence in education	Academic Journal of Interdisciplinary Studies	288	48.00	Intelligent Educational Systems and AI Integration

Several highly cited studies explored the theme of Intelligent Educational Systems and AI integration, represented by four publications including Zhai et al., (2021), Wang et al., (2024), Strielkowski et al., (2025) and Huang et al., (2021). As presented in Table 7, recent publication by Strielkowski et al., (2025) in this theme have accumulated 331 citations and an impressive average of 165.50 citations annually. This research theme highlights the rapid pace of output and impact citation in the AI in education field.

Meanwhile, recent publications such as Rasul et al., (2023) and Wang et al., (2023) exploring generative AI and ChatGPT in education have rapidly accumulated citations, reflecting a growing academic interest in conversational AI applications and intelligent educational assistants. The rapid increase in citations for these publications suggests a significant shift in research focus towards emerging AI technologies and their educational impact.

The finding of the citation distribution across these leading publications reflects a sustained and growing scholarly discussion about integrating AI to improve learning adaptability, personalization, and systemic educational change. Collectively, these highly cited studies reveal three dominant knowledge domains by three major thematic areas: intelligent educational systems and AI integration, adaptive and personalized learning systems, and generative AI applications in education.

Science Mapping Analysis of AI in Adaptive Learning Research

As detailed in the second objective, the study utilized science mapping techniques to explore the conceptual structure, and emerging AI technology in adaptive learning research. Specifically, keyword co-occurrence analysis and thematic clustering were employed to identify key research themes and the dominant integration of AI technologies in the adaptive learning landscape.

Keyword Co-Occurrence Network Analysis and Thematic Themes

This subsection presents keyword co-occurrence analysis and thematic clustering results to reveal the conceptual structure and thematic composition of AI within adaptive learning research. Figure 4 illustrates the keyword co-occurrence network of author keywords created using the Vosviewer software tool. The study excluded the search terms “artificial intelligence”, “AI”, “adaptive learning”, and “education” to minimise redundancy and enhance the visibility of domain-specific themes. This resulted in a network revealing several thematic clusters representing key research directions and technological applications in AI-driven adaptive learning.

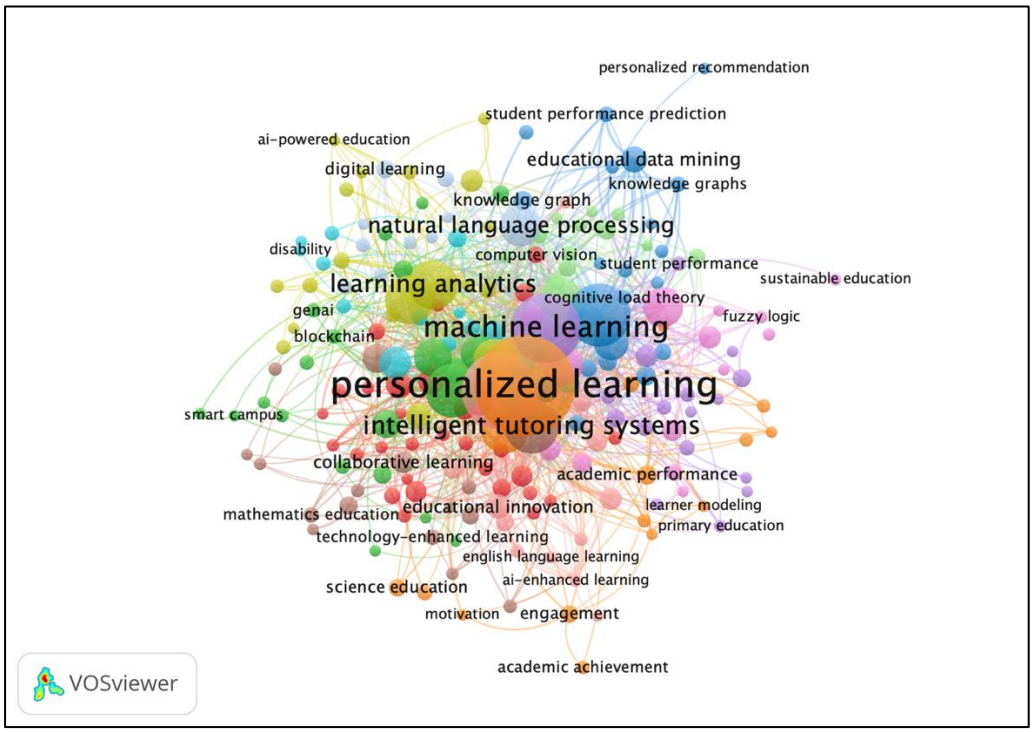


Figure 4: Co-Occurence Analysis of Author Keywords

The keyword occurrence network reveals interconnected thematic clusters representing major research areas. The largest cluster focuses on personalized learning and machine learning, highlighting learner customisation as a key focus for AI in education. Another key cluster focuses on intelligent tutoring systems, educational technology, and collaborative learning, which reflects the ongoing significance of AI-driven instructional support.

A third cluster emphasises learning analytics, educational data mining, and predictive modeling, showing that these thematic themes highlight the importance of data-driven approaches in understanding and improving learning. More recent clusters incorporate generative AI, ChatGPT, and large language models alongside natural language processing, suggesting the rise of new intelligent educational interactions and content generation. These thematic clusters highlight the interdisciplinary nature of AI in adaptive learning research, integrating concepts on education, computer science, data analytics, and artificial intelligence.

Emerging AI Technologies Landscape

Using author keyword co-occurrence analysis, the study further identified and analyzed AI technologies employed in adaptive learning. This analysis provides valuable insights into the technological landscape of adaptive learning research. Table 8 lists the frequency of AI technologies identified in the retrieved publications, which emphasizes the most prominent AI techniques and their dominance in adaptive learning research.

Table 8: Emerging AI Technologies Landscape in Adaptive Learning Research

Rank	AI Technology	Occurrences
1	Machine Learning	149
2	Intelligent Tutoring Systems	93
3	Generative AI	91
4	Learning Analytics	77

5	Large Language Models	57
6	Natural Language Processing	57
7	Deep Learning	51
8	Neural Network	43
9	Reinforcement Learning	40
10	Educational Data Mining	23

As listed in Table 8, Machine Learning emerges as the most frequently studied technology, with 149 occurrences, highlighting its foundational role in adaptive learning systems. Machine learning techniques are widely used for learner modeling, performance prediction, recommendation systems, and adaptive content delivery. Intelligent Tutoring Systems was ranked second place with 93 occurrences, demonstrating its ongoing significance as a core mechanism for providing personalized instructional support. Generative AI followed closely with 91 occurrences, indicating its rapid rise as a transformative technology within adaptive learning environments.

The increasing prominence of Learning Analytics (77 occurrences), Large Language Models (57 occurrences) and Natural Language Processing (57 occurrences) reflects a growing interest in data-driven learning personalization. This includes intelligent educational assistants and AI-mediated interactions such as automated feedback systems and personalized content generation. Meanwhile, other AI technologies such as Deep Learning, Neural Networks, Reinforcement Learning, and Educational Data Mining further contribute to driving the development of an intelligent and technological landscape of adaptable educational systems. In addition, the growing prominence of Generative AI and Large Language Models, also among the most frequently discussed AI technologies, indicates a major shift in adaptive learning research.

The findings indicate a clear technological evolution within the field, although previous studies have concentrated on rule-based adaptive systems, as in studies (Angelov, 2002; Raj & V G, 2019; Takács, 2014) and predictive machine learning models (Gupta et al., 2022; Rincón-Flores et al., 2019).

However, based on these analysis findings, recent research within this field is increasingly exploring conversational AI, intelligent assistants, automated feedback generation, and personalised content creation. This evolution suggests future adaptive learning systems will become more interactive, autonomous and learner-centered.

CONCLUSION

This bibliometric study analyzed 2,354 publications indexed in the Scopus database from 2015 to 2026 to systematically examine the evolution of research on AI in adaptive learning for education. The analysis was conducted with two primary objectives: (1) to evaluate publication performance and scholarly impact of the field, and (2) to identify key thematic structures and dominant technological developments within the field.

The performance analysis revealed a significant increase in research output, particularly from 2023 onwards. This growth reflects a rapid expansion of scholarly interest for AI in adaptive learning. India, China, and the United States were the leading countries in publication productivity, while the United States achieved the highest citation impact. Analysis of the most cited and influential publications further indicated that adaptive and personalized learning systems, intelligent educational technologies, and AI integration represent the principal intellectual foundations driving research and innovation in the field.

The science mapping analysis discovered the conceptual structure and technological trends evolution of AI in adaptive learning research. Key thematic areas included personalized learning, intelligent tutoring systems, learning analytics, educational data mining, and AI-driven educational support systems. Machine learning emerged as the most widely adopted AI technology, while generative AI, large language models, and natural language processing were identified as rapidly growing research domains. These findings suggest a significant transition from traditional adaptive learning systems towards more

intelligent, interactive, and data-driven educational ecosystems that enhance personalization and learner engagement.

This study provides a comprehensive overview of publication trends, influential contributors, thematic structures, and emerging technologies in AI-enabled adaptive learning. The findings offer valuable guidance for researchers seeking to identify future research directions, as well as for educators and policymakers aiming to leverage AI-driven approaches to enhance personalized learning and educational effectiveness.

Despite its contributions, this study has several limitations. First, the analysis was restricted to publications indexed in the Scopus database and limited to English-language documents, which excluded relevant research from other databases and languages. Future research could expand the scope of analysis by incorporating databases like Web of Science and employing more advanced science mapping techniques to provide deeper insight into the evolution of AI applications in education.

Overall, AI in adaptive learning is rapidly expanding and becoming an increasingly influential research domain. The findings suggest a growing shift towards intelligent, data-driven, and personalized learning environments. Furthermore, the ongoing development of generative AI, large language models, and other emerging technologies will further transform adaptive learning systems, unlocking new opportunities for innovation, personalization, and improved educational outcomes.

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