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ARTIFICIAL INTELLIGENCE IMPLEMENTATION IN EDUCATION SYSTEMS: A GLOBAL BIBLIOMETRIC ANALYSIS

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ABSTRACT

This study explores the dynamic development of artificial intelligence (AI) implementation in education, with a particular focus on bibliometric trends of scholarly articles indexed in Scopus between 2022 and 2025. Using a quantitative approach, bibliometric analysis was conducted through Biblioshiny (R-package), VOSviewer, and Publish or Perish, with data selection guided by the PRISMA framework. After applying strict inclusion criteria, 784 eligible articles were analyzed. Results indicate a strong annual publication growth rate of 47.83%, with the United States and Hong Kong emerging as the leading contributors in terms of both volume and citation impact. Dominant keywords include ChatGPT, higher education, and generative AI, showing current research priorities. Influential journals such as Computers and Education: Artificial Intelligence and Education and Information Technologies significantly shape the field. Thematic mapping reveals that while core topics are well established, areas such as AI ethics and teacher preparedness remain underexplored. This study offers a comprehensive overview, highlights research gaps, and suggests future directions to advance AI integration in education. The findings provide practical guidance for educators, institutional leaders, and policymakers in prioritizing AI adoption, strengthening teacher capacity, and developing ethical frameworks to support sustainable AI integration within education systems.
Keywords: Artificial Intelligence, Bibliometric Analysis, ChatGPT, Generative AI, Higher Education

INTRODUCTION

Artificial Intelligence has had a significant impact on education systems around the world (Agyare et al. 2025; Al-Abdullatif 2024; Almasri 2024), transforming traditional teaching and learning methods into modern ones (Daheri et al. 2023; Zhou 2023). AI contributes to the advancement of educational technology by offering personalized learning experiences and automating administrative tasks (Holmes and Tuomi 2022). The basis of the implementation of AI in education emerged along with the need for innovative solutions to address various learning challenges (Almasri, 2024; Hwang et al., 2020; Russell & Norvig, 2016). With the emergence of new technological and ethical issues, many academics have extended this basis to date (Popenici & Kerr, 2017; Selwyn, 2022; Zawacki-Richter et al., 2019). The rapid evolution of technology demands adaptive

solutions, so on the practical side, the application of AI in education covers various fields such as intelligent tutoring systems (Demartini et al. 2024; Dimitriadou and Lanitis 2023; Li et al. 2021), learning analytics (Guzmán-Valenzuela et al. 2021; Sghir et al. 2023), personalized learning platforms (Bernacki et al. 2021; Sajja et al. 2025), and the development of education policies in different countries (Chankseliani & McCowan, 2021; Zancajo et al., 2022). The response is that AI provides a unique framework to address the challenges of Education (Holmes & Tuomi, 2022) and encompasses a wide range of socio-technical issues, thus playing a dominant role in shaping the modern education system (Russell & Norvig, 2016; Zawacki-Richter et al., 2019). Over the past decade, AI has also contributed to reshaping educational practices globally (Baker-Smith et al., 2019; Ran et al., 2020).

Although the implementation of artificial intelligence in education continues to grow, to the author's knowledge, there are limitations in exploring and measuring the impact of this field as well as the artificial intelligence research community in education (Chen et al. 2022). In general, researchers review artificial intelligence in education from a qualitative or theoretical perspective (Boubker 2024), rather than objectively using quantitative approaches such as bibliometrics (Donthu et al. 2021a). This research gap is very significant; Previous studies in the journal Educational Technology have often focused on specific subthemes of artificial intelligence in education (Donthu et al., 2021b; Velander et al., 2024). For example, there are studies on intelligent tutoring systems (Lin et al. 2023; Mousavinasab et al. 2021), artificial intelligence-based assessment tools (Baker-Smith et al. 2019), and the ethical implications of artificial intelligence in education (Lin et al. 2023). Meanwhile, the broader landscape of the implementation of artificial intelligence in education covers a wide range of topics (Bozkurt et al. 2021; Jia et al. 2022), so it is important to understand the extent to which artificial intelligence affects various domains of education (Ahmad et al., 2021; Bozkurt et al., 2021).

The purpose of this study is three. First, this study aims to comprehensively analyze the field of implementation of artificial intelligence in the education system from the beginning, tracing the roots of this field to the latest developments (Huang et al., 2024; Samala et al., 2025). Second, this paper aims to explore the main themes in the application of artificial intelligence in the field of education. Finally, the results of this research aim to provide future research directions that can develop the field of artificial intelligence in education. A comprehensive study of the implementation of artificial intelligence in education will provide valuable knowledge insights for academics in exploring untouched

themes (Donthu et al. 2021a). Practitioners can use this study as a reference to integrate artificial intelligence-based solutions into educational practices based on current and past trends. This study conducts a bibliometric analysis of international scientific articles from leading databases such as Scopus. Through this bibliometric analysis, we explore the subthemes of AI in education using content analysis to identify future research directions. Therefore, our research questions are as follows:

RQ1. What is the current status of research on the implementation of AI in the education system?

RQ2. What are the key thematic areas that exist in research on the implementation of AI in education, and how are they developing?

RQ3. What future research directions can be identified based on the existing literature?

METHODS

Research Design

This study adopts a quantitative approach using bibliometric analysis based on the Scopus database. Bibliometric analysis is widely recognised as an effective method for examining the conceptual structure of a research field and identifying future research directions (Singh & Malik, 2022). To provide a more comprehensive understanding, this study integrates bibliometric and content analyses (Indarti et al., 2021; Pahlevi, 2023) to synthesise research streams in the cash waqf literature published between 2022 and 2025. Scopus was selected because it provides broader citation coverage than the Web of Science (WOS) database and includes a wider range of indexed journals, while WOS has relatively more limited coverage with considerable overlap with Scopus (Vargas-Sánchez & Moral-Moral, 2020; Kumar et al., 2022).

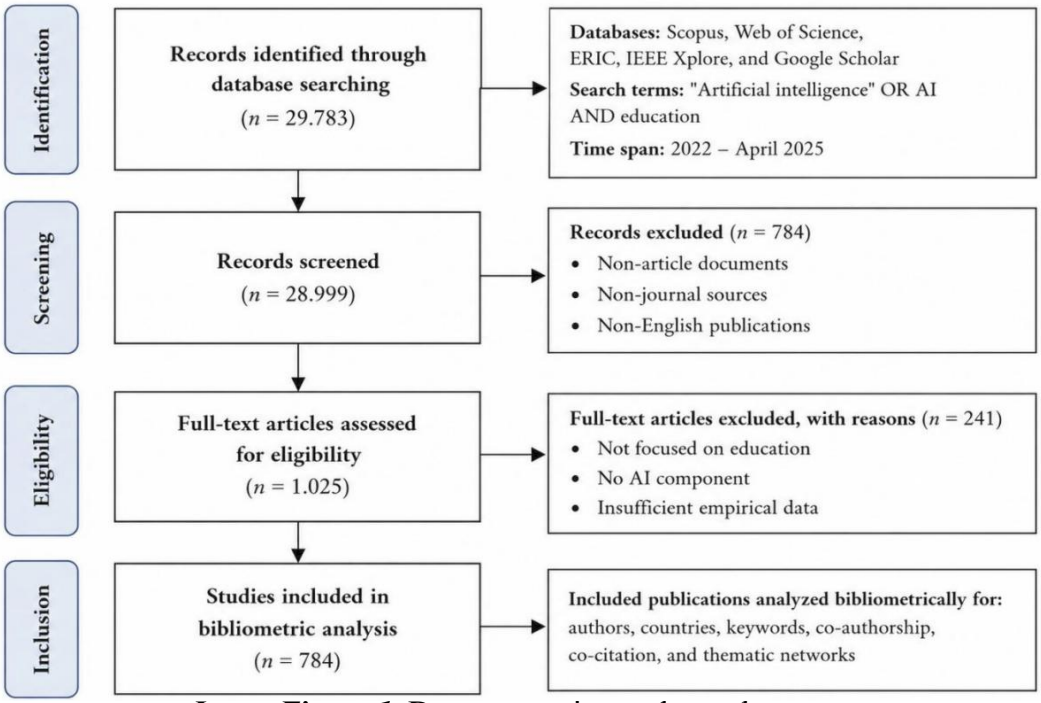
Search Strategy, Criteria and Data Collection

In this study, the data search strategy followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework adapted from Zakaria et al. (2021). Figure 1 illustrates the complete PRISMA flowchart used to identify, screen, and select the eligible publications. Data were collected from the Scopus database in April 2025 using the search query related to "education" and "artificial intelligence (AI)." The initial search identified 29,782 records based on titles, abstracts, and keywords. To ensure the quality and relevance of the dataset, explicit inclusion and exclusion criteria were applied. The inclusion criteria comprised: (1) publications indexed in the Scopus database;

(2) articles published between 2022 and 2025; (3) document type limited to journal articles; (4) source type restricted to journals; (5) publications written in English; and (6) studies addressing the implementation of AI in educational contexts. The exclusion criteria included conference papers, book chapters, reviews, editorials, notes, letters, non-English publications, duplicate records, and articles that were not relevant to AI implementation in education. The screening process was conducted in several stages. First, records were identified through the Scopus search query. Second, automatic filtering was applied using the Scopus functions LIMIT-TO (DOCTYPE, "ar"), LIMIT-TO (SRCTYPE, "j"), LIMIT-TO (LANGUAGE, "English"), and the publication year filter (2022–2025). Third, titles, abstracts, and keywords were manually screened to assess their relevance to the research objectives. After removing records that did not satisfy the inclusion criteria (n = 28,998), a final dataset of 784 journal articles was retained for descriptive, bibliometric, and thematic analyses.

Tools and Data Analysis

This study utilised R-Biblioshiny (Aria & Cuccurullo, 2017), Microsoft Excel, VOSviewer (van Eck & Waltman, 2019), and Harzing's Publish or Perish (Harzing, 2011) to perform bibliometric analysis, including data processing, visualisation, citation analysis, and network mapping. By integrating bibliometric, network, and content analyses, the study examined publication trends, leading authors, journals, countries, institutions, citation patterns, research collaborations, and the main research themes in the cash waqf literature.



Insert Figure 1. Data processing and search strategy

FINDINGS AND DISCUSSION

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Descriptive Analysis

The bibliometric analysis covering the period 2022–2025 reveals a rapidly growing body of literature with a total of 784 documents and 14,146 citations accumulated over three years. On average, each paper received 18.07 citations, while the annual citation rate reached 4,715.33, indicating strong scholarly attention. The impact is further reflected in the h-index of 53 and g-index of 106, suggesting both breadth and depth of influential publications. Research diversity is demonstrated by 2,181 author keywords, contributed by 2,723 authors across 408 publication sources. Collaboration is a significant feature, with an average of 3.81 co-authors per document and 23.63% of works involving international co-authorship, although 143 single-authored papers remain notable. The dataset also includes 35,258 references, underscoring the extensive engagement with prior scholarship. Importantly, the annual growth rate of 47.83% highlights the dynamic expansion of this research domain, signaling its increasing academic relevance and global recognition (Table 1).

Table 1. Main Information About the Dataset

Description (metrics)	Result (data)
Publication Trend Over Time	2022 – 2025
Total Publications	783
Total Citations	14,146
Citation Years	3 (2022 – 2025)
Citations per Year	4,715.33
Average citation per Paper	18.07
h_index	53
g index	106
Author keyword	2,181
Author	2,723
Sources	408
Authors of single-authored docs	143
International co-authorship	23.63%
References	35,258
Co-author pe doc	3.81
Annual growth rate	47.83

Research Trend Analysis

The subject area distribution highlights the interdisciplinary nature of the research analyzed. The largest contribution comes from Social Sciences with 501 documents (63.98%), indicating that the topic is predominantly explored from social and educational perspectives. Computer Science follows with 313 documents (39.97%), reflecting the

significant role of technological development, particularly artificial intelligence, in shaping this field. Engineering accounts for 104 documents (13.28%), emphasizing technical and applied aspects, while Medicine (70 documents; 8.94%) and Psychology (59 documents; 7.54%) show that health and behavioral sciences are also important contributors. Additionally, Arts and Humanities and Business, Management and Accounting each contribute 48 documents (6.13%), illustrating that cultural, ethical, and managerial dimensions are also considered. Overall, this distribution demonstrates that the research area is highly multidisciplinary, integrating social, technological, health-related, and managerial insights.

Table 2. Subject area

Subject Area	TP	%
Social Sciences	501	63,98%
Computer Science	313	39,97%
Engineering	104	13,28%
Medicine	70	8,94%
Psychology	59	7,54%
Arts and Humanities	48	6,13%
Business, Management and Accounting	48	6,13%

Meanwhile, the table 3 highlights the seven most prominent journals publishing research related to artificial intelligence in education, ranked by total publications (TP). Leading the list is Computers and Education: Artificial Intelligence (Q1) with 28 publications (3.58%) and a strong citation performance of 654 total citations (C/P: 23.36). Following closely is Education and Information Technologies (Q1) with 24 publications (3.07%) and 635 citations (C/P: 26.46). Education Sciences (Q1) and Sustainability Switzerland (Q1) share the third spot, each contributing 22 publications (2.81%), with total citations of 470 and 455 respectively. The European Journal of Education (Q1) and Journal of Applied Learning and Teaching (Q1) follow with 12 publications each (1.53%), with the latter showing the highest citation per publication (C/P: 51.42). Rounding out the list is IEEE Access (Q1), contributing 11 publications (1.40%) with 109 citations. All listed journals are Q1-ranked, indicating their high impact in the field.

Table 3. Top 7 Journals Contributing to the Literature

Source Title and Scopus Rank	TP	%	TC	C/P	h	g	SJR 2024	Publisher
Computers And Education Artificial Intelligence (Q1)	28	3,58%	654	23,36	10	25	5,22	Elsevier B.V.
Education And Information Technologies (Q1)	24	3,07%	635	26,46	12	24	1,65	Kluwer Academic Publishers

Education Sciences (Q1)	22	2,81%	470	21,36	6	21	0,73	(MDPI)
Sustainability Switzerland (Q1)	22	2,81%	455	20,68	10	20	0,69	(MDPI)
European Journal Of Education (Q1)	12	1,53%	363	30,25	4	12	0,98	Wiley-Blackwell Publishing Ltd
Journal Of Applied Learning And Teaching (Q1)	12	1,53%	617	51,42	8	12	1,76	Kaplan Singapore
IEEE Access (Q1)	11	1,40%	109	9,91	4	10	0,85	Institute of Electrical and Electronics Engineers Inc.

Note(s): "TP=total number of publications;TC=total citations; C/P=average citations per publication; and h=h-index; g=g-index"

Most Influential Countries, Affiliates, and Productive Author

Table 4 presents the top 10 countries contributing to research on artificial intelligence in education. The United States leads with 161 publications (20.56%) and a total of 3,192 citations. China follows with 131 publications (16.73%) and 863 citations. In third place is the United Kingdom, contributing 55 publications (7.02%) and 1,451 citations. Other significant contributors include Saudi Arabia and South Korea, each with 40 publications (5.11%). India ranks next with 38 publications (4.85%), followed by Australia with 37 publications (4.73%). Notably, Hong Kong, despite having only 29 publications (3.70%), records a total of 1,659 citations. Spain and Germany round out the list with 29 (3.70%) and 26 (3.32%) publications, respectively. Overall, while the United States dominates in terms of publication output, Hong Kong stands out for its citation impact. With five countries represented, Asia plays a significant role in the development of AI research in education.

Table 4. Top 10 Countries by Number of Publications

Country	TP	%	TC	C/P	Continent
United States	161	20,56%	3192	19,83	North America
China	131	16,73%	863	6,59	Asia
United Kingdom	55	7,02%	1451	26,38	Europe
Saudi Arabia	40	5,11%	147	3,68	Asia
South Korea	40	5,11%	404	10,10	Asia
India	38	4,85%	145	3,82	Asia
Australia	37	4,73%	325	8,78	Oceania
Hong Kong	29	3,70%	1659	57,21	Asia
Spain	29	3,70%	101	3,48	Europe
Germany	26	3,32%	246	9,46	Europe

Table 5 shows the top 10 institutions in AI research in education with a touch of global collaboration. Topping the list are two institutions from Hong Kong, namely The

Education University of Hong Kong (14 publications, 1.79%) and The University of Hong Kong (11 publications, 1.40%), demonstrating the research strength of the region. Other prestigious institutions come from various parts of the world, such as University College London and Beijing Normal University (9 publications, 1.15% each), and the University of Cambridge (7 publications, 0.89%). Not to be left behind, the University of South Africa, the Chinese University of Hong Kong, and Anadolu Üniversitesi in Turkey also made significant contributions.

Table 5. Top 10 Publishing Institutions

Institution	TP	%	Country
The Education University of Hong Kong	14	1,79%	Hong Kong
The University of Hong Kong	11	1,40%	Hong Kong
University College London	9	1,15%	United Kingdom
Beijing Normal University	9	1,15%	China
University of South Africa	8	1,02%	South Africa
Chinese University of Hong Kong	8	1,02%	Hong Kong
Anadolu Üniversitesi	8	1,02%	Turkey
University of Cambridge	7	0,89%	United Kingdom
International University of La Rioja	7	0,89%	Spain
University of Florida	6	0,77%	United State

Table 6 highlights the top 10 most productive authors in this research area, showcasing a diverse international contribution. The most productive author is Su, J. from Hong Kong with 7 publications (0.89%), amassing 403 citations and an impressive average of 57.57 citations per publication. Tlili, A. from China also contributed 7 publications (0.89%), although with a lower citation average of 10.14. Other notable contributors include Bozkurt, A. from Turkey with 5 publications and 190 citations (38.00 average), as well as Chan, C.K.Y. from Hong Kong, who, despite having 4 publications (0.51%), achieved an outstanding citation average of 227.25. Chiu, T.K.F. and Holmes, W., from Hong Kong and the United Kingdom respectively, each produced 4 publications with high impact, recording citation averages of 123.50 and 153.75. Rounding out the group, authors from the United States, Sweden, and Spain further emphasize the global reach and influence in this research field.

Table 6. Authors with the Highest Publication Output

Author Name	TP	%	TC	C/P	h	g	Country
Su, J.	7	0,89%	403	57,57	5	7	Hong Kong
Tlili, A.	7	0,89%	71	10,14	3	7	China
Bozkurt, A.	5	0,64%	190	38,00	4	5	Turkiye
Chan, C.K.Y.	4	0,51%	909	227,25	3	4	Hong Kong
Chiu, T.K.F.	4	0,51%	494	123,50	3	4	Hong Kong

Holmes, W.	4	0,51%	615	153,75	4	4	United Kingdom
Kim, J.	4	0,51%	381	95,25	5	10	United State
Al-Rahmi, W.M.	3	0,38%	76	25,33	3	3	Sweden
Bannister, P.	3	0,38%	26	8,67	3	3	Spain
Burgos, D.	3	0,38%	18	6,00	2	3	United State

Note(s): "TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index".

Citation Analysis

Based on Table 7, several key studies have notably advanced the understanding of AI in education. Kung Th (2023) leads with 1861 total citations on ChatGPT's performance in medical education, averaging 620.33 citations per year. Lim Wm (2023) and CHAN CKY (2023) follow with studies on generative AI's future and student perceptions, receiving 594 and 463 citations respectively. Additional impactful contributions come from Chan CKY (2023) on a comprehensive AI policy framework, Rudolph J (2023) on the emerging AI chatbot landscape, and Holmes W (2022) who examines AI ethics and current practices. Collectively, these studies underscore AI's transformative potential in reshaping educational practices.

Table 7. Top 10 Cited Publications in the Study Field

Author	Title	TC	C/Y
Kung Th, 2023	"Performance of ChatGPT on USMLE: Potential for AI-assisted medical education using large language models"	1861	620,33
Lim et al, 2023	"Generative AI and the future of education: Ragnarök or reformation? A paradoxical perspective from management educators"	594	198,00
CHAN et al, 2023	"Students' voices on generative AI: perceptions, benefits, and challenges in higher education"	463	154,33
Chan Cky, 2023	"A comprehensive AI policy education framework for university teaching and learning"	429	143,00
Rudolph J, 2023	"War of the chatbots: Bard, Bing Chat, ChatGPT, Ernie and beyond. The new AI gold rush and its impact on higher education"	396	132,00
Holmes W, 2022	"Ethics of AI in Education: Towards a Community-Wide Framework"	315	78,75
Michel, 2023	"Challenges and Opportunities of Generative AI for Higher Education as Explained by ChatGPT"	276	92,00
Holmes et al, 2022	"State of the art and practice in AI in education"	267	66,75
Celik I, 2023	"Towards Intelligent-TPACK: An empirical study on teachers' professional knowledge to ethically integrate artificial intelligence (AI)-based tools into education"	255	85,00

Su J, 2023	"Unlocking the Power of ChatGPT: A Framework for Applying Generative AI in Education"	237	79,00

Keyword Analysis

Table 8 presents the keyword distribution in research on the implementation of artificial intelligence (AI) in education, Artificial Intelligence emerges as the most dominant keyword, appearing in 346 publications or 44.19% of the studies, highlighting the central focus on AI technology itself. Other prominent keywords include ChatGPT (17.11%) and Generative AI (11.62%), reflecting particular attention to the application of large language models and generative technologies in educational contexts. Additionally, terms such as Higher Education (16.73%), Learning (5.62%), and Teaching (6.13%) indicate that many studies emphasise the integration of AI into teaching and learning processes, particularly in higher education. Keywords like Human (12.26%), Students (10.86%), and Medical Education (5.49%) highlight the focus on learners and specific learning contexts, including medical education. The presence of keywords related to Machine Learning (4.73%), Contrastive Learning (4.34%), and Ethics (4.09%) demonstrates that technical and ethical considerations are also significant areas of interest. Overall, this keyword distribution reflects a balanced emphasis on AI technologies, educational contexts, learners, and ethical and methodological issues, underscoring the multidimensional nature of research on AI in education.

Table 8. Twenty Most Frequent Keywords

Keywords	TP	%	Keywords	TP	%
Artificial Intelligence	346	44,19%	Teaching	48	6,13%
ChatGPT	134	17,11%	Generative Artificial Intelligence	47	6,00%
Higher Education	131	16,73%	Learning	44	5,62%
Human	96	12,26%	Medical Education	43	5,49%
Generative AI	91	11,62%	High Educations	38	4,85%
Students	85	10,86%	Machine Learning	37	4,73%
Article	66	8,43%	Contrastive Learning	34	4,34%
Humans	61	7,79%	Female	33	4,21%
AI	56	7,15%	Ethics	32	4,09%
Artificial Intelligence (AI)	56	7,15%	Education	32	4,09%

Source: Scopus database

The thematic map analysis presented in Figure 5, which is constructed on the basis of density (the degree of theme development) and centrality (the degree of thematic relevance), provides a comprehensive overview of how research on artificial intelligence (AI) in education is currently structured. The map is divided into four quadrants, each

reflecting a different stage of thematic maturity and connectivity within the broader research landscape.

In the Niche Themes quadrant, topics such as post-secondary education, Education 4.0, and language learning demonstrate significant internal development, suggesting that these areas have established a relatively strong conceptual and methodological foundation. However, their limited interconnection with other dominant themes indicates that they remain specialized and somewhat fragmented. While their influence across the broader field of AI in education is still limited, these themes are valuable for addressing particular needs within specific contexts, such as curriculum digitalization in higher education or the integration of AI-based tools in foreign language acquisition.

By contrast, the Motor Themes quadrant represents the driving forces of the field. Themes such as academic performance, AI tools, adaptive learning, and natural language processing not only exhibit high density but also occupy a central position in the network of research. Their dual characteristics of maturity and relevance make them highly influential in shaping the direction of AI scholarship in education. These themes act as engines of innovation, with the potential to generate new pedagogical models, enhance personalized learning experiences, and support evidence-based decision-making in educational policy. Their presence in this quadrant suggests that they are likely to remain at the forefront of future academic and practical advancements.

The Emerging or Declining Themes quadrant reveals areas of uncertainty, encompassing topics such as sustainable education, self-efficacy, and design education. The relatively low values of density and centrality imply that these areas are either still in their formative stage or beginning to lose scholarly momentum. For example, sustainable education may gain relevance as global educational systems emphasize long-term resilience and green innovation, whereas design education could either expand through cross-disciplinary collaboration or fade due to limited uptake in mainstream discourse. This quadrant thus captures themes at a crossroads, with their future significance highly dependent on whether scholars and institutions choose to expand their integration into broader research narratives.

Finally, the Basic Themes quadrant highlights fundamental topics such as artificial intelligence, education, ChatGPT, online learning, and generative AI. These themes are marked by high centrality but relatively lower density, meaning that they are widely recognized and frequently referenced but have yet to be explored with sufficient depth and theoretical rigor. Their position signifies a critical opportunity for further investigation.

For instance, while ChatGPT and generative AI have already gained widespread attention in academic and public discourse, systematic studies that evaluate their pedagogical, ethical, and policy implications are still emerging. These themes therefore represent the building blocks of the field, offering fertile ground for more comprehensive theoretical frameworks and empirical applications in the near future.

Taken together, the thematic mapping underscores the multidimensional and evolving nature of AI in education research. It illustrates a landscape where some themes are consolidating their position as engines of innovation, others remain specialized or uncertain, and foundational areas still require deeper exploration. This analytical perspective not only identifies the current state of the literature but also provides meaningful insights into potential research trajectories, thereby guiding scholars, educators, and policymakers toward areas of strategic importance for the advancement of AI-driven educational practices.

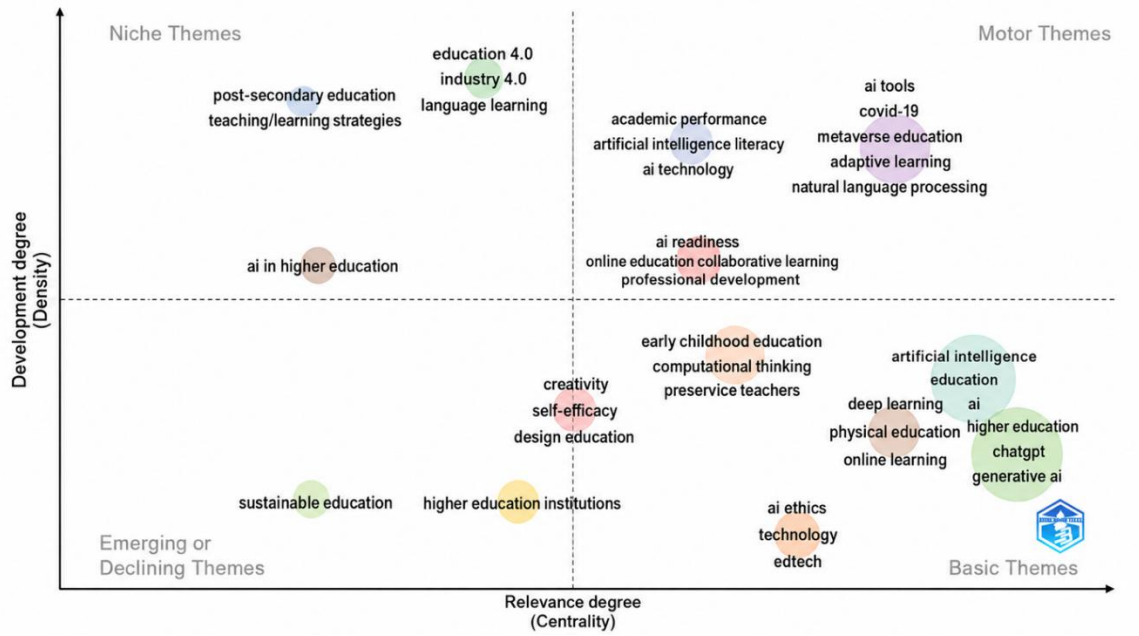

Figure 5. Thematic Analysis Map Using Author Keywords

Discussion

RQ1: Current Status of AI Research in Education

The bibliometric analysis demonstrates that research on AI implementation in education has experienced remarkable expansion between 2022 and 2025. This rapid growth is likely driven by the widespread adoption of generative AI technologies, particularly ChatGPT, which has transformed teaching, learning, assessment, and academic support across educational institutions. The increasing availability of AI-

powered educational tools, combined with accelerated digital transformation following the COVID-19 pandemic, has further stimulated scholarly interest in understanding the opportunities and challenges of AI integration within education. The high h-index (53) and g-index (106) suggest that this research field has progressed beyond an emerging topic to become an influential area of educational scholarship, generating studies with substantial academic impact.

The disciplinary distribution further indicates that AI implementation in education is inherently interdisciplinary. The dominance of Social Sciences reflects continuing efforts to understand how AI affects pedagogy, curriculum design, learning outcomes, and educational equity, while significant contributions from Computer Science and Engineering demonstrate ongoing technological innovation aimed at improving intelligent learning systems and AI applications. Contributions from Medicine, Psychology, Arts and Humanities, and Business also indicate growing recognition that successful AI implementation requires consideration of ethical, cognitive, cultural, and organisational dimensions rather than technological advancement alone. These findings have important implications for education policy and practice. For policymakers, the rapid expansion of AI research highlights the need to establish comprehensive governance frameworks that address AI ethics, data privacy, academic integrity, and responsible AI adoption.

For educational institutions, the interdisciplinary nature of the field underscores the importance of investing in teacher professional development, AI literacy, and curriculum redesign to ensure that AI technologies are integrated effectively and responsibly. Consequently, future educational strategies should move beyond technology adoption alone and emphasize pedagogically informed, ethical, and sustainable AI implementation that enhances learning outcomes while mitigating potential risks.

RQ2: Main Thematic Areas and Their Development

The thematic map analysis identifies four primary quadrants, each reflecting distinct stages of development and centrality within AI research in education. Motor Themes, including adaptive learning, AI tools, academic performance, and natural language processing, exhibit both high maturity and centrality, signifying their pivotal role as drivers of innovation. These themes not only dominate current research but also shape future directions, serving as foundational areas for designing intelligent educational systems, enhancing personalised learning experiences, and informing evidence-based pedagogical strategies. Basic Themes, such as artificial intelligence, ChatGPT, online learning, and generative AI, remain highly central yet comparatively underexplored,

highlighting substantial opportunities for further theoretical refinement and empirical validation. These topics form the conceptual backbone of AI in education research, offering fertile ground for studies that integrate ethical considerations, technological development, and pedagogical effectiveness.

Niche Themes, including Education 4.0 and language learning, demonstrate notable internal development, suggesting well-established methodologies and frameworks within specific contexts. However, their limited connectivity with other dominant themes indicates that they are specialised and exert minimal influence across broader research networks. While these themes provide valuable insights for targeted applications, such as curriculum digitalisation and language acquisition, their impact remains largely confined to specific subfields. Meanwhile, Emerging or Declining Themes, such as sustainable education and self-efficacy, occupy a less developed and less central position, reflecting either the early stage of scholarly exploration or a waning research interest. These themes warrant careful monitoring, as they have the potential to gain prominence in response to evolving educational priorities, societal demands, or interdisciplinary integration. Overall, the thematic mapping illustrates a dynamic and multi-layered research landscape, highlighting areas of consolidation, potential growth, and emerging challenges, thereby guiding scholars toward strategically significant avenues for advancing AI-driven educational innovation.

RQ3: Future Research Directions

Based on the current literature, several specific directions for future research on AI implementation in education can be identified. First, future studies should examine teacher readiness to integrate AI into teaching and learning, including AI literacy, pedagogical competencies, professional development, and teachers' attitudes toward AI adoption. Second, more research is needed to develop and evaluate AI ethics policies that address issues such as transparency, accountability, algorithmic bias, data privacy, and the responsible use of AI in educational settings. Third, given the rapid adoption of generative AI tools such as ChatGPT, future research should investigate assessment integrity, focusing on academic honesty, authentic assessment design, AI-assisted learning, and effective strategies for preventing misuse while maintaining educational quality. Fourth, researchers should explore AI implementation in low-resource education contexts, including rural schools, developing countries, and institutions with limited digital infrastructure, to better understand barriers, equity issues, and context-specific implementation strategies. Finally, comparative and cross-national studies are needed to

evaluate how differences in educational policies, institutional capacity, and technological infrastructure influence AI adoption and educational outcomes. Such research would provide stronger evidence for developing inclusive, ethical, and sustainable AI implementation strategies across diverse education systems.

CONCLUSION

This bibliometric study provides a comprehensive overview of research on artificial intelligence (AI) implementation in education between 2022 and 2025. The analysis reveals that the field has experienced rapid growth, with a high number of publications, citations, and strong scholarly impact, indicating that AI in education is an increasingly significant area of academic interest. The research is highly interdisciplinary, with dominant contributions from Social Sciences and Computer Science, while fields such as Engineering, Medicine, Psychology, Arts and Humanities, and Business also play important roles. The thematic analysis identifies key areas of focus. Motor Themes, such as adaptive learning, AI tools, academic performance, and natural language processing, are well developed and central, acting as primary drivers of innovation. Basic Themes, including artificial intelligence, ChatGPT, online learning, and generative AI, remain widely recognised but continue to offer opportunities for further theoretical and empirical investigation. Niche Themes and Emerging or Declining Themes highlight specialised and developing research areas that warrant greater interdisciplinary collaboration. Based on the current literature, future research should prioritise teacher readiness for AI integration, AI ethics and governance policies, assessment integrity in the era of generative AI, and AI implementation in low-resource educational contexts. Overall, this study demonstrates that AI in education has become a central and influential research field with substantial opportunities for advancing educational theory, policy, and practice.

Despite these contributions, this study has several limitations. The analysis was limited to publications indexed in the Scopus database, included only English-language journal articles, and covered a relatively short publication period (2022–2025). Consequently, relevant studies indexed in other databases, published in other languages, or conducted outside the selected time frame may not have been captured. Future bibliometric research could address these limitations by incorporating multiple databases, broader language coverage, and longer time spans to provide a more comprehensive understanding of the global development of AI implementation in education.

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