Vol.6 Iss.3 2025 Economics & Management Review
https://doi.org/10.37420/j.emr.2025.028

Bibliometric analysis of artificial intelligence in higher education based on the WoS database

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Abstract:

This study employs a bibliometric analysis to map the global research landscape of artificial intelligence (AI) in higher education, utilizing data from the Web of Science database. The results reveal a rapidly evolving field characterized by a tripartite integration of technology, management, and ethics. Research has progressed through distinct phases: foundational technological exploration (2016–2018), organizational integration and application (2019–2022), and current emphasis on generative AI and ethical governance (2023–2025). Geographically, the field is dominated by contributions from China, the United States, and England, with emerging participation from institutions in India, Macau, and Hong Kong. Influential journals such as MIS Quarterly and Harvard Business Review underpin the interdisciplinary knowledge base, bridging management science, information systems, and educational technology. While the study highlights growing collaboration networks and thematic diversification, it also identifies imbalances in research representation and practical implementation challenges. Future efforts should prioritize mixed-methods approaches, cross-disciplinary collaboration, and ethical frameworks to ensure AI's equitable and effective integration into higher education systems. This research provides a comprehensive foundation for scholars, policymakers, and educators navigating the AI-driven transformation of higher education.

Keywords:

artificial intelligence(*AI*)*, bibliometric analysis, higher education*

1.Introduction

Artificial Intelligence (AI) technology is profoundly reshaping the higher education ecosystem, a transformation that has attracted widespread attention in the academic community(Haenlein & Kaplan, 2019). Research indicates that AI-driven adaptive learning systems are transforming traditional teaching models by offering personalized educational experiences(Dwivedi et al., 2021), while intelligent teaching assistants significantly enhance educational efficiency by managing routine teaching tasks(Sharma et al., 2023). Notably, immersive learning environments supported by VR/AR technologies are creating new possibilities for higher education(UNESCO, 2025).

Interdisciplinary integration is a key feature of AI applications in education today. In fields such as business, medicine, and engineering, the introduction of AI technology has not only led to the creation of new interdisciplinary courses(Ng et al., 2024), but is also changing traditional research paradigms(Xu et al., 2025).

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This technological convergence is redefining the roles of educators and learners, necessitating a rethinking of the core competencies that will define future education(Russell, 2009). However, issues such as data privacy and algorithmic bias have emerged as significant challenges, calling for the establishment of a comprehensive ethical governance framework(Haenlein & Kaplan, 2019).

In light of the rapid development in this research field, while existing literature provides rich case studies and theoretical discussions(Dwivedi et al., 2021), there remains a lack of systematic understanding of the broader research landscape. Specifically, the evolution trajectory of this field, shifts in research hotspots, and the distribution of key authors and institutions have not been comprehensively revealed(Sharma et al., 2023). Additionally, the formation mechanisms and future development trends of global collaboration networks require further exploration.

To address this gap, this study employs bibliometric methods to systematically analyze AI research in higher education, based on the Web of Science Core Collection database. The research will focus on the following key issues:

The growth trends of the literature in this field, the distribution of core journals, and their influence characteristics;

The structural features of the knowledge network and the evolving patterns of research topics;

Emerging research frontiers and future development directions.

By systematically reviewing the state of research, this study aims to provide scholars, educators, and policymakers with a panoramic view of the field, offering a reference for future research and practice. The findings will help capture the developmental trends of AI applications in higher education and promote the sustainable development of the field.

2.Research design

This study employs a systematic bibliometric analysis to conduct a panoramic scan and trend exploration of artificial intelligence (AI) research in the field of higher education. The research data is sourced from the Web of Science (WoS) Core Collection database, with a systematic search strategy constructed (e.g., TS= ("artificial intelligence" OR "machine learning" OR "deep learning" OR ChatGPT) AND TS=("higher education" OR universit* OR college)) to collect the data. The document types are limited to "Article" and "Review," and the time span includes all records from the database's inception through 2025. After rigorous data cleaning and standardization processes (including merging synonymous authors, institutions, and keywords), a total of 500 valid documents were obtained for analysis in this study. On this basis, the research employs a combination of descriptive statistics and scientific mapping analysis methods, utilizing professional tools such as CiteSpace to conduct in-depth analyses across dimensions including publication trends, country/institutional collaboration networks, keyword co-occurrence clustering, and citation co-occurrence. This approach aims to reveal the distribution of research strengths, the evolution of knowledge structures, and the emerging hotspot trends in the field.

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3.Data analysis

3.1Descriptive analysis

In recent years, research on artificial intelligence in the field of higher education has experienced explosive growth. As shown in the table, the annual publication volume in this field has surged from only 4 papers in 2019 to 63 papers in 2023. In 2024, the field reached a true turning point, with the number of publications soaring to 188, nearly three times the figure of 2023. This dramatic increase, particularly the leap in 2024, is likely closely related to the groundbreaking advancements in generative AI technologies such as ChatGPT, along with their widespread discussion and application globally. This marks a shift in the field's research from the preliminary exploration stage to a new era of rapid development and deep innovation.

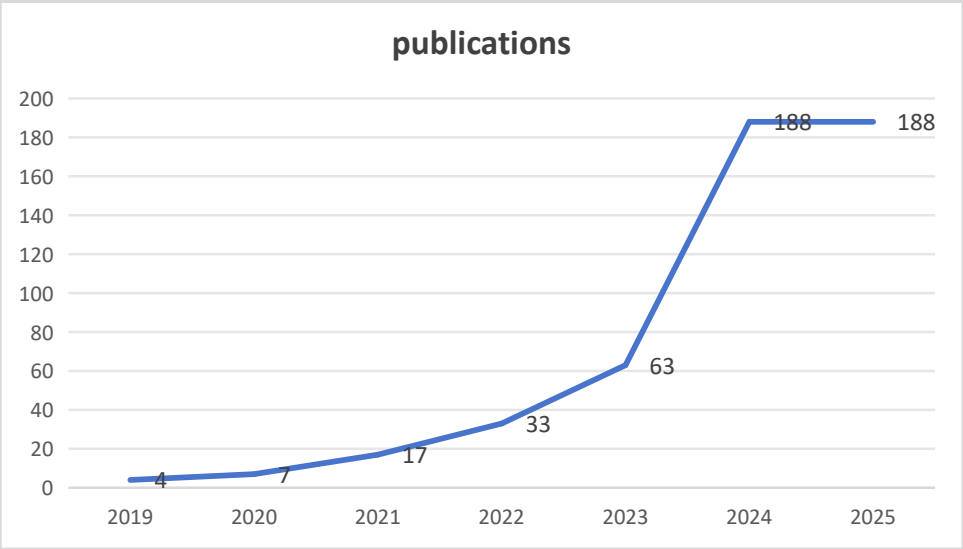


Figure 1 publication of artificial intelligence in higher education in WoS

3.2Statistic results of public areas

Data analysis reveals that global research on artificial intelligence in higher education exhibits a tripolar structure centered on China, the United States, and England. China ((People's Republic of China), with the highest publication frequency of 163, ranks first, demonstrating its substantial research output. However, its centrality index (0.04) is relatively low, indicating that there is room for further development in its international collaboration network. In contrast, the United States (USA) and England (ENGLAND) not only rank second and third in publication volume but also occupy the absolute core positions of the global collaboration network, with the highest centrality indices (0.19 and 0.30, respectively). These countries dominate international knowledge exchange and cooperation. France, Australia, Germany, and other countries form a solid second tier, possessing both high publication volumes and centrality, making them important participants in international collaborations. Additionally, the inclusion of countries such as Malaysia, Sweden, and Saudi Arabia reflects the growing global attention on this research topic, highlighting a diversified research landscape.

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Table 1 Top 20 of public areas

Rank	Frequency	Degree	Centrality	public areas
1	163	21	0.04	Peoples R China
2	128	29	0.19	Usa
3	90	38	0.3	England
4	56	27	0.09	India
5	51	32	0.25	France
6	44	30	0.09	Australia
7	39	23	0.13	Germany
8	29	17	0.1	Italy
9	28	20	0.03	South Korea
10	26	23	0.09	Sweden
11	22	22	0.04	Malaysia
12	21	17	0.02	Finland
13	19	17	0.04	Netherlands
14	17	16	0.01	Canada
15	16	23	0.07	Taiwan
16	16	12	0.01	New Zealand
17	14	17	0.04	Saudi Arabia
18	13	14	0.02	South Africa
19	13	7	0.02	Spain
20	12	22	0.04	Wales

3.3 statistics of co-cited journals

The knowledge foundation in this field exhibits significant interdisciplinary characteristics. Its core knowledge primarily originates from top-tier authoritative journals in multiple fields, including management, marketing, information systems, and innovation management. Among these, MIS Quarterly, with the highest citation frequency (199 times), stands out as the most important source of knowledge, highlighting the central role of information systems research. At the same time, two leading business journals—MIT Sloan Management Review (with a surge value of 7.49) and Harvard Business Review (with a surge value of 7.35)—experienced the most explosive influence between 2019 and 2023, indicating that the application of artificial intelligence in higher education and management practices is a recent frontier topic that has garnered significant attention from both academia and industry. Furthermore, the high co-citation frequency of journals such as the Journal of Marketing and Management Science contributes to a solid knowledge system that integrates both theoretical depth and practical orientation.

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Table 2 Top 20 of co-cited journals

Rank	Frequency	Burst	Burst Begin	Burst End	Degree	Centrality	Sigma	Co-cited journal	Year
1	199	2.36	2020	2022	49	0.03	1.06	MIS Quarterly	2020
2	158	2.99	2020	2022	40	0.02	1.07	Journal of Marketing Research	2020
3	151	2.12	2020	2021	45	0.02	1.05	Journal of Management	2020
4	147	2.65	2019	2021	33	0.01	1.03	Business Horizons	2019
5	146	3.16	2019	2022	48	0.06	1.19	Journal of Marketing	2019
6	139	5.77	2019	2023	47	0.05	1.29	California Management Review	2019
7	139	4.91	2020	2022	30	0	1.01	Journal of Service Research	2020
8	137	4.5	2019	2021	33	0.05	1.23	Management Science	2019
9	132	7.35	2019	2023	42	0.01	1.08	Harvard Business Review	2019
10	116	2.88	2020	2021	34	0.01	1.02	Information Systems Research	2020
11	110	2.92	2020	2022	46	0.02	1.05	Industrial Marketing Management	2020
12	95	3.1	2021	2022	27	0.01	1.02	Journal of Management Information Systems	2021
13	82	2.23	2020	2022	38	0.01	1.03	Journal of Product Innovation Management	2020
14	81	2.29	2021	2022	33	0.05	1.11	Decision Support Systems	2019
15	73	7.49	2020	2023	40	0.02	1.19	MIT Sloan Management Review	2020
16	67	4.28	2021	2022	43	0.04	1.16	International Journal of Production Economics	2021
17	64	2.33	2021	2023	35	0.02	1.06	International Journal of Production Research	2021
18	63	2.27	2020	2021	20	0.01	1.01	Marketing Science	2020
19	59	3.14	2020	2022	30	0.02	1.07	Journal of Interactive Marketing	2020
20	58	2.32	2021	2022	33	0.02	1.06	European Journal of Marketing	2021

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3.4Scholarly contribution

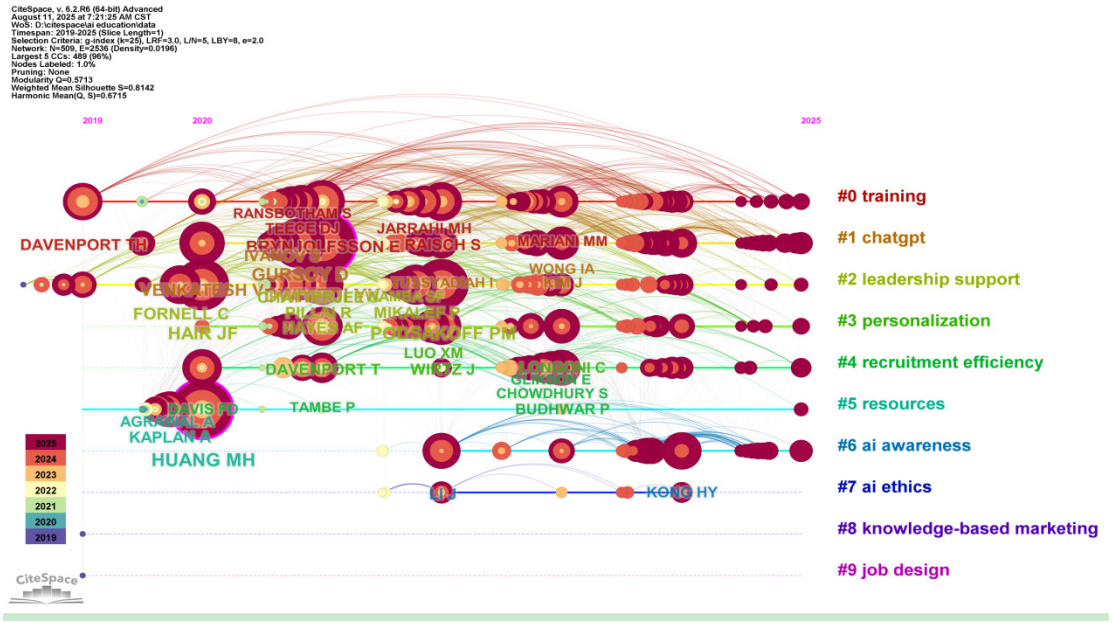


Figure 2 timeline of authors and research topics

Research on artificial intelligence (AI) in higher education has undergone a clear and profound evolutionary process over the past decade (2016-2025). The overall focus of the research has followed a trajectory from "technological foundation to scene deepening, and then to value reflection and social expansion." Early research (2016-2018), led by core scholars such as Davenport T and Kaplan R, concentrated on foundational explorations and quality assurance issues related to AI in education, such as "formative assessment" and "quality issues." These laid the theoretical and practical foundations for the entire field, with collaboration predominantly centered on small, in-depth partnerships led by core scholars.

Starting in 2019, research entered the mid-stage of scene application and management empowerment (2019-2022). With the emergence of new core authors such as Luo W and Tambe P, the collaboration network expanded from a "single-center" to a "multi-center" model. Research themes diversified into several directions, including management efficiency (e.g., "recruitment efficiency"), resource and leadership support, and teaching innovation (e.g., "personalization"). This marked a shift where AI technology, initially a tool for classroom teaching, deepened its role as a core driver in enhancing the overall operational and managerial effectiveness of higher education institutions.

In the recent and upcoming period (2023-2025), research has entered a new stage characterized by technological explosion and ethical-social expansion. Generative AI (especially ChatGPT), as a phenomenon-level technological hotspot, has completely transformed teaching and research models, drawing a large number of scholars to form theme-driven collaborative clusters. Meanwhile, the field's research has shown profound reflexivity and interdisciplinarity: The rise of the "AI ethics" theme reflects a heightened concern about risks such as algorithmic bias and data privacy. Furthermore, themes such as "knowledge-based marketing" and "job design" signal a shift in research focus from the internal education system to broader societal systems (e.g., labor markets, knowledge commercialization), indicating that the field is advancing toward a mature stage

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where technological application and value ethics are equally emphasized.

Table 3 Top 20 of institutions

Rank	Frequency	Degree	Centrality	Sigma	Label
1	20	26	0.19	1	State University System of Florida
2	18	16	0.12	1	Hong Kong Polytechnic University
3	16	27	0.22	1	University of Macau
4	15	15	0.1	1	Indian Institute of Management (IIM System)
5	13	14	0.08	1	Aston University
6	12	32	0.28	1	Kyung Hee University
7	11	12	0.03	1.09	Indian Institute of Technology System (IIT System)
8	10	17	0.08	1	Macau University of Science & Technology
9	9	18	0.04	1	City University of Macau
10	9	10	0.02	1.04	Indian Institute of Technology (IIT) - Kharagpur
11	9	7	0.01	1	University of Florida
12	8	21	0.07	1	University of Newcastle
13	8	15	0.06	1	University of Oulu
14	8	11	0.07	1	Pennsylvania Commonwealth System of Higher Education (PCSHE)
15	8	8	0.06	1	University of Vaasa
16	7	25	0.18	1	Swansea University
17	7	13	0.01	1	Taylor's University
18	7	6	0.02	1	Auckland University of Technology
19	7	4	0.01	1	Hainan University
20	7	4	0.01	1	Shandong University

The distribution of global higher education AI research institutions exhibits significant regional concentration and multipolar characteristics. In terms of research output, the State University System of Florida in the United States topped the list with the highest frequency of 20, demonstrating America's strong capabilities in this field. However, a more notable feature of the rankings is the collective rise of Chinese institutions (particularly those in Hong Kong and Macao) and Indian institutions. Institutions such as The Hong Kong Polytechnic University (PolyU), the University of Macau, the Macao University of Science and Technology, and City University of Hong Kong made the list, indicating that Hong Kong and Macao have become highly active forces in this global research field. Similarly, multiple branches of the Indian Institute of Technology (IIT) system and its Management Institute (IIM) system ranked at the top, reflecting India's high emphasis on and substantial investment in national strategic technology research. Furthermore, the centrality metric, which measures the pivotal role of collaborative hubs, reveals that certain institutions' network influence significantly outweighs their publication output. For instance, Kyung Hee University in South Korea and Swansea University in the UK demonstrate exceptional centrality (0.28 and 0.18 respectively), indicating they serve as crucial connectors within international research networks despite having relatively low absolute publication counts. Similarly, institutions like Florida State University in the US and Newcastle University in the UK exhibit both substantial publication output and high centrality. This reveals another defining characteristic of the research field: it constitutes a global academic network driven by high-productivity institutions and highly

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central collaborative hubs, featuring both broad participation and key cooperative nodes.

3.5Keyword Analysis

Research in the domain of artificial intelligence in higher education demonstrates a distinct dual-driven characteristic, combining technological application and management empowerment. On one hand, studies intensely focus on cutting-edge technologies themselves and their impacts. Core keywords such as "artificial intelligence," "generative AI," and "big data" underscore the foundational role of these technologies, while terms like "impact," "performance," and "digital transformation" reflect a sustained attention to their practical effects. On the other hand, research shows a pronounced inclination toward organizational management and adoption. Frequently occurring keywords such as "management," "adoption," "acceptance," "framework," and "capability" collectively indicate that scholars are not only concerned with how the technology "works" but are also delving deeper into how it is "integrated into higher education institutions." This involves a series of managerial issues, including decision-making, organizational change, user acceptance, and capacity building. This shift reflects that the field has moved beyond a purely technocentric perspective and entered a new phase characterized by the deep integration of technology and organizational management.

Table 4 Top 20 keywords

Rank	Frequency	Degree	Centrality	Sigma	Keywords	Year	Rank	Freq-uency	Degree	Centrality	Sigma	Label	Year
1	297	19	0.02	1	artificial intelligence	2019	21	23	30	0.06	1.19	digital transformation	2021
2	81	36	0.07	1	management	2019	22	23	28	0.05	1	challenges	2021
3	71	26	0.05	1	technology	2019	23	23	24	0.04	1	adoption	2021
4	70	7	0.02	1	generative ai	2023	24	21	34	0.07	1	capability	2019
5	60	22	0.04	1	performance	2021	25	20	35	0.09	1	firm performance	2020
6	48	19	0.02	1	impact	2022	26	20	23	0.06	1	perceptions	2022
7	44	45	0.11	1	big data	2020	27	19	19	0.03	1	human resource management	2023
8	42	24	0.05	1	artificial intelligence (ai)	2020	28	18	38	0.13	1	business	2021
9	41	31	0.07	1	information technology	2019	29	18	33	0.08	1	satisfaction	2022
10	41	22	0.03	1.08	innovation	2021	30	18	20	0.05	1	antecedents	2022
11	33	30	0.07	1	acceptance	2020	31	18	18	0.04	1	systems	2022
12	32	19	0.02	1	framework	2021	32	17	30	0.07	1	automation	2021
13	32	18	0.03	1	model	2022	33	17	18	0.03	1	user acceptance	2023
14	31	21	0.04	1	decision making	2021	34	16	23	0.04	1	work	2022
15	30	18	0.03	1	knowledge	2021	35	16	21	0.05	1	perspective	2022
16	29	26	0.06	1	trust	2021	36	15	24	0.03	1	anthropom-orphism	2022
17	27	16	0.02	1	information	2019	37	15	22	0.03	1	strategy	2022
18	26	38	0.11	1	future	2020	38	14	21	0.05	1	pls sem	2022
19	26	24	0.03	1.07	dynamic capability	2022	39	13	19	0.03	1.06	big data analytics	2021
20	26	19	0.03	1	behavior	2021	40	13	19	0.02	1	tourism	2022

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3.6Major co-citation bursts

This timeline of AI-related research keywords in higher education (spanning 2010 to 2025) clearly illustrates an evolutionary trajectory from "technological foundation → scenario application → parallel advancement of cutting-edge breakthroughs and social reflection."

In the early stage (approximately 2010-2015), research focused on the "underlying technologies and fundamental concepts" of AI applications in education. Keywords such as "machine learning" (providing the algorithmic foundation for educational intelligence applications) and "computational thinking" (cultivating students' mindset to adapt to the AI era) became central, laying the technical and cognitive groundwork for the subsequent integration of AI and higher education.

During the mid-term (approximately 2016-2020), the research focus shifted toward the "practical implementation and ecological expansion of AI in higher education." On one hand, keywords like "AI adoption" and "technology adoption" concentrated on the introduction and integration of AI technology by higher education institutions. On the other hand, keywords such as "immersive technology" (e.g., VR/AR combined with AI to enrich educational experiences) and "start-up ecosystem" (involving promoting technological commercialization and educational innovation) propelled AI from a "laboratory concept" into practical application scenarios within higher education.

From the recent period to the future (2021-2025 and beyond), research is deepening simultaneously in two directions: "breakthroughs in AI frontier technologies" and "socio-ethical issues triggered by technology." Frontier studies focus on three interlinked hotspots: the sustained interest in artificial intelligence itself, the use of AI-Generated Content tools such as ChatGPT to reshape teaching and research, and the rapid uptake of Large Language Models as the most visible AI breakthrough to date. In the realm of social reflection, keywords such as "AI ethics" (addressing ethical risks like algorithmic bias, data privacy, and educational equity) and "AI awareness" (fo-cusing on the cognition and literacy cultivation of AI among university faculty and students) reflect in-depth contemplation of the technology's societal impactOverall, the evolution of AI-related research in higher education is a process of "technology-driven → scenario-responsive → bidirectional iteration between technology and social value." It began with consolidating technological and conceptual foundations in the early stage, moved to focusing on technology adoption in educational scenarios in the mid-term, and is now simultaneously pursuing breakthroughs in frontier technologies while reflecting on their social implications. The research dimensions continue to expand alongside the development of AI technology and the evolving needs of education.

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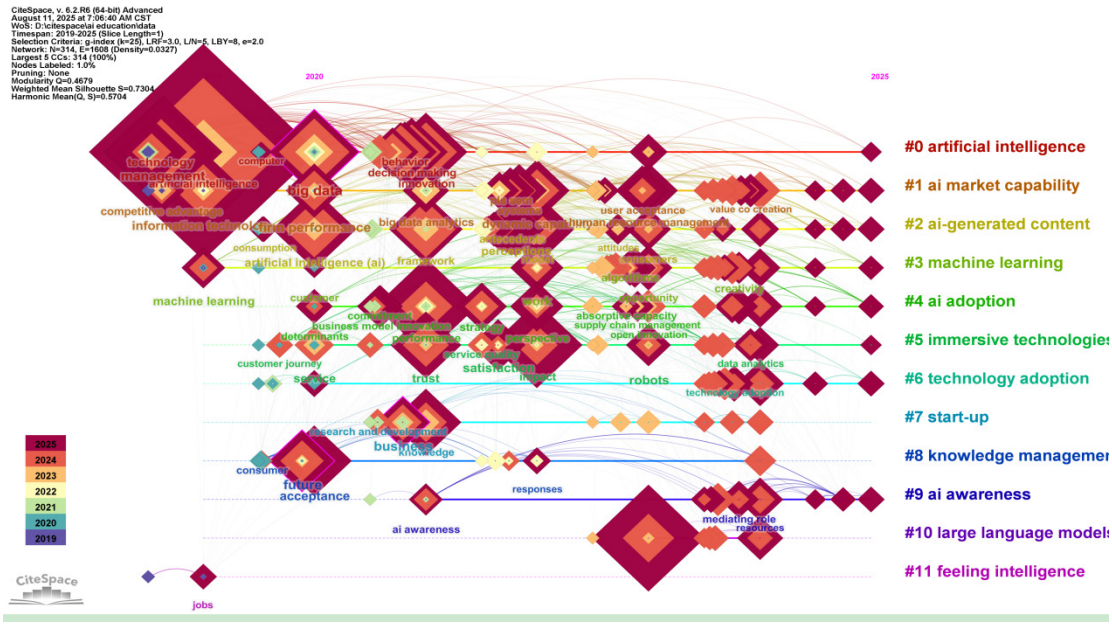


Figure 3 timeline of co-citation bursts

4.Discussion and conclusion

4.1 Discussion

This study, through a systematic bibliometric analysis, reveals the developmental trends and inherent patterns of global artificial intelligence (AI) research in higher education. The findings indicate that the field demonstrates a distinct tripartite integration characteristic of "technology-management-ethics"(Bond et al., 2018), forming a research landscape centered around China, the US, and the UK with multipolar participation.

From the perspective of research theme evolution, AI research in higher education has undergone three stages: from technological foundation exploration (2016-2018) to management integration and application (2019-2022), and currently to the coexistence of technological breakthrough and ethical reflection (2023-2025) (Bond et al., 2018). This evolutionary trajectory reflects the deepening and expansion of research focus: early concerns about the feasibility of educational applications of AI technology itself(Haenlein & Kaplan, 2019), mid-term emphasis on adoption and management at the organizational level(Dwivedi et al., 2021), and recent increased attention to the impact of emerging technologies like generative AI and corresponding ethical governance issues.

Analysis of international collaboration networks shows that while China leads in publication output, countries like the US and the UK occupy crucial positions within the collaboration networks, acting as bridges for knowledge exchange(Bond et al., 2018). In terms of institutional distribution, besides traditional comprehensive universities, technical institutions represented by the Indian Institute of Technology System and emerging forces represented by higher education institutions in Macau, China are particularly prominent, demonstrating the diversification of research entities in this field. Analysis of the knowledge base indicates that the

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field is built upon foundations from multiple disciplines such as management information systems and educational technology, while also being significantly influenced by business management practices(Verganti et al., 2020), possessing distinct interdisciplinary and practice-oriented characteristics.

4.2 Conclusions

This study, employing bibliometric methods, systematically delineates the developmental landscape of global AI research in higher education, arriving at the following main conclusions:

Firstly, AI research in higher education has formed a relatively complete disciplinary ecology(Wise et al., 2024). Research themes extend from technological applications to organizational change and ethical governance (Abulibdeh et al., 2024; Turner et al., 2021), the research community encompasses multiple countries and regions globally(Chen et al., 2024), and the knowledge base integrates theoretical achievements from multiple disciplines (Bond et al., 2024).

Secondly, the research exhibits clear phased developmental characteristics. It is currently in a new innovation cycle driven by generative AI, while simultaneously undergoing profound ethical reflection and governance exploration.

Finally, significant research imbalances exist within the field. Developed countries dominate theoretical innovation and research networks, while numerous challenges remain at the practical application level, necessitating more interdisciplinary and cross-regional collaboration.

5.Future agenda and limitation

This study has the following limitations: Firstly, the data source is limited to the Web of Science database, potentially omitting other important literature (Aksnes & Sivertsen, 2019; Khizar et al., 2023). Secondly, the bibliometric method itself struggles to delve deeply into the specific connotations of the research content(Donthu et al., 2021). Finally, due to the rapid development of AI technology, the research conclusions require continuous updating.

Future research can deepen in the following directions: First, strengthen the application of qualitative research methods to deeply explore the specific application mechanisms and effects of AI in education. Second, expand the geographical scope of research, paying particular attention to the practical experiences of developing countries and regions. Third, deepen interdisciplinary collaboration, promoting in-depth dialogue between the educational community and the technology community. Fourth, enhance longitudinal tracking studies to examine the long-term effects and impacts of AI educational applications.

It is recommended that subsequent research adopt mixed-methods approaches, combining bibliometric analysis with methods such as case studies and experimental research, while establishing continuous monitoring mechanisms to promptly track the latest developments in this rapidly evolving field. Furthermore, special attention should be paid to research on issues such as AI ethics governance and educational equity, ensuring that artificial intelligence technology better serves the developmental goals of higher education(Verganti et al., 2020).

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Acknowledgment

2024 Special Research Project on Curriculum and Textbook for Primary,Secondary and Higher Education:Interdisciplinary Approach and Integration Innovation of"Critical Thinking,Numeracy,Creativity and Specialization"in the Compilation of Digital Textbooks for Management Majors(CSJC-Z2024145);

Central University Basic Research Project of Northwest Minzu University:Research on the Mechanism of Strengthening the Sense of Community of the Chinese Nation in the Great Wall Cultural and Tourism Space Empowered by Digital Technology(31920240034).

Gansu Provincial Higher Education Teaching Achievement Incubation Project: Empowering with Digital Intelligence and Integrating Ideological, Innovative, and Professional Education — A New Talent Cultivation Model for Management Disciplines（高等教育教学成果培育项目《数智赋能与“思创专”融通：管理类新质人才培养模式探索与实践》）.

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