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Research Evolution and Hotspot Detection of AIGC-Empowered Education in China, 2022–2025

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Abstract

With the breakthrough advancement of Generative Artificial Intelligence (AIGC) technology, its integration into education has become a central issue in the global digital transformation of education. To systematically reveal the research status, hotspots, and evolutionary trends in the field of AIGC-empowered education in China, this study draws on the Web of Science (WoS) Core Collection. It combines bibliometric and content analyses to examine 1,505 English-language journal articles published by Chinese scholars between 2022 and 2025. The bibliometric results show that publication output in this field has grown explosively since 2022, forming a research landscape centered on highly cited educational-technology journals and characterized by multidisciplinary integration; research hotspots are concentrated on themes such as the educational applications of large language models, instructional innovation, learning outcomes, educational ethics, and intelligent tutoring systems; and the field's development has proceeded through three stages—technology introduction, application exploration, and deep integration—with the research frontier now shifting toward personalized learning, smart-education ecosystems, and digital transformation.

Keywords

generative artificial intelligence, AIGC, smart education, education empowerment, bibliometrics

1. Introduction

Against the backdrop of the deep convergence of artificial intelligence and educational informatization, AI technology is reshaping the form and boundaries of education [1]. Generative Artificial Intelligence (AIGC), leveraging core capabilities such as large language models, multimodal content generation, and real-time human–computer interaction, is reshaping traditional teaching processes and providing new technological pathways for personalized instruction, academic writing training, teachers' digital-literacy development, and professional education reform [2]. UNESCO's report on artificial intelligence and education, which addresses safeguarding the rights of learners, explicitly states that generative AI can drive the educational paradigm from one-way knowledge transmission toward holistic competency cultivation and is a core driver for achieving global educational equity and improving the quality of talent cultivation. In response to top-level national policies such as the New Generation Artificial Intelligence Development Plan and the Education Digitalization Strategic Action Plan, Chinese academia has, since the release of ChatGPT in late 2022, produced a large body of scholarly output on the integration of AIGC and education, covering diverse sub-domains such as foreign-language teaching [3], higher education [4], vocational education [5], and smart-learning ecosystems [6].

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Bibliometric analysis is the primary method used in current studies. Bibliometric analysis is a quantitative approach that combines mathematical and statistical techniques to examine published literature from a macro perspective [7], in order to understand the distributional structure of scientific activities and discoveries as well as collaborative relationships [8]. Bibliometrics is related to, and overlaps with, scientometrics and informetrics [9]. Bibliometric analysis of published literature provides valuable indicators of scientific research and its progress. CiteSpace and VOSviewer are currently the two most widely used literature-visualization tools in academia [10]; they can construct knowledge networks based on relationships such as author co-occurrence, document co-citation, and keyword co-occurrence, and are widely applied in bibliometric analysis. These networks can be built from citation, bibliographic coupling, co-citation, and co-authorship data. VOSviewer also offers text-mining functionality that can be used to construct and visualize co-occurrence networks of important terms extracted from a set of scientific publications [11]. Several English-language bibliometric reviews have already applied this combination of tools to map specific sub-fields, but a panoramic analysis of the full corpus of WoS English-language literature by Chinese scholars from 2022 to 2025 remains absent [12].

Existing related review studies have two main limitations: first, their scope tends to adopt a global perspective and fails to focus on China's research characteristics and local practical needs; second, their analytical methods rely mainly on qualitative description, lacking quantitative support and visualization based on large-scale bibliographic data. Building on this, the present study adopts a bibliometric approach, combining tools such as CiteSpace and VOSviewer, to systematically analyze English-language journal articles on AIGC-empowered education published by Chinese scholars from 2022 to 2025, aiming to answer the following three research questions:

(1) What are the temporal characteristics and the spatial distribution patterns of institutions and authors in China's international publications on AIGC-empowered education from 2022 to 2025?

(2) What constitutes the field's core research hotspots, thematic clusters, and knowledge base?

(3) What characteristics do the research frontiers and future development trends of recent years exhibit, and what shortcomings exist in the current research?

2. Data and Methods

2.1 Data Sources and Retrieval Strategy

The data for this study were obtained from the Web of Science (WoS) Core Collection, including two sub-databases: the Science Citation Index Expanded (SCI-E) and the Social Sciences Citation Index (SSCI). WoS is widely recognized in academia as the most authoritative database, covering more than 20,000 peer-reviewed, high-quality journal articles published since 1900.

In addition, WoS contains the essential metadata required for scientometric analysis. We used WoS's "Advanced Search" function to construct queries using field tags, keywords, Boolean operators (OR, AND, and NOT), and parentheses. The OR operator was applied between keywords belonging to the same set, while the AND operator was used to connect different sets; the NOT operator denoted the set of keywords to be excluded. The specific search strategy was set as follows:

TS=("Education" OR "teaching" OR "learning" OR "talent development" OR "intelligent tutor" OR "smart education") AND TS=("AIGC" OR "Generative AI" OR "ChatGPT" OR "Generative Artificial Intelligence") AND PY=2022-2025 AND DT=("Article") AND LA=English AND CU=("China")

Here, "TS" denotes a comprehensive search of the selected keywords across the article title, abstract, and keywords. The search period was set from January 1, 2022, to December 31, 2025, yielding an initial set of 1,707 articles.

2.2 Screening Criteria and Data Cleaning

To ensure the accuracy and relevance of the research data, the following screening and cleaning criteria were established:

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1) Document-type screening: only “Article”-type documents were retained; conference papers, book reviews, editorial materials, and other non-core document types were excluded.

2) Removal of duplicate records: the WoS database's deduplication function was used in combination with manual verification to remove duplicate records arising from repeated database indexing or repeated author submissions.

3) Author-affiliation verification: articles whose author affiliations were confirmed to be research institutions in mainland China, Hong Kong, or Macau were retained; articles whose author affiliations were not Chinese were excluded.

In the Web of Science Core Collection search, the publication year was limited to PY=2022-2025, and the first batch of English-language literature records retrieved was 1,707. Web of Science is a database of early-access publications. These papers were published online ahead of print from 2022 to 2025. The official journal issue is in 2026. The original data had 202 articles and a publication year of 2026. The time of this study is from 2022 to 2025. Filter out and clean the original data. All articles labelled with the 2026 publication year were deleted. Therefore, the final set of valid analytical articles was 1,505.

The first is that the required fields are full. The DOI field is now full. The abstract field is 99.88% full. The keyword field was 97.54% full. The corresponding field is 100% filled. The Subject-Category field is fully filled. Therefore, the following bibliometric analysis will be based on good data.

2.3 Research Tools and Methods

The two main tools in this paper are Excel for simple statistics and CiteSpace [13] and VOSviewer for knowledge mapping and network analysis. The general research process and methods followed the main international bibliometric conventions.

Specifically, this paper has analysed various institutions, authors, journals and papers in the field of education and artificial intelligence technology. It also talked about the development of hotspots and frontiers in this area.

The above reasons show that many scientific studies have been carried out.

The two kinds of collaboration networks are institutional and author networks.

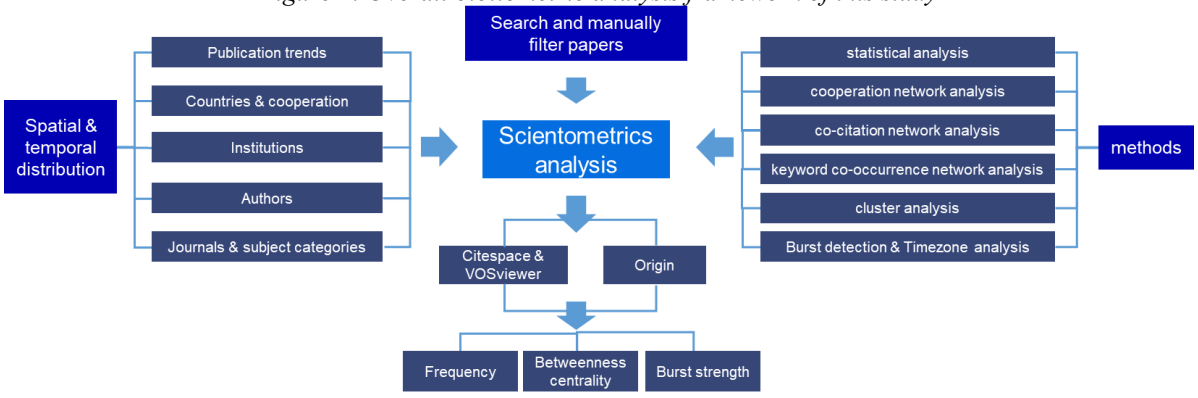
Co-citation network analysis shows the reference co-citation network of a field and its knowledge base or paradigms [14].

Cluster analysis automatically classified and labelled the references according to the reference co-citation network to reveal the basic knowledge structure of the field.

A keyword co-occurrence network was employed to show the research themes and the changes in hot topics.

Some statistics were also collected at the beginning. In short, the research framework of this paper is shown in Figure 1.

Figure 1: Overall bibliometric analysis framework of this study



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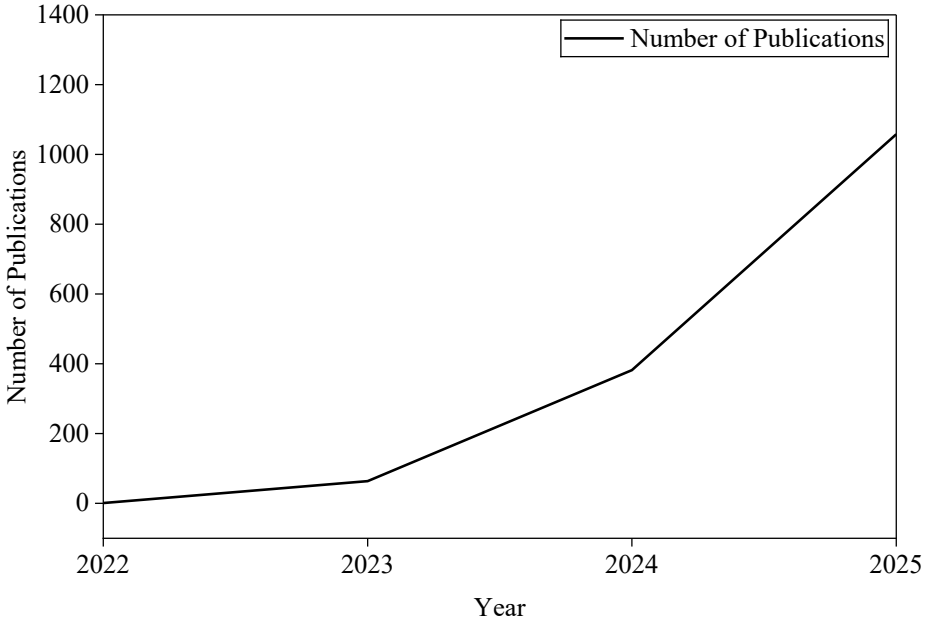
In the various mapping computations, keyword clustering used the Log-Likelihood Ratio (LLR) algorithm, with cluster reliability assessed via the silhouette coefficient and the modularity Q value; betweenness centrality was used to measure the hub value of nodes in the document co-citation and collaboration networks. All metric-evaluation criteria followed internationally accepted scientometric conventions [15].

3. Results and Discussion

3.1 Basic Characteristics of the Literature

3.1.1 Annual and Disciplinary Publication Statistics

Figure 2: Annual trend of publication output, 2022–2025



The distribution of the 1,505 collected articles per year is shown in Figure 2. The general trend of China's foreign publications on AIGC-empowered education from 2022 to 2025 can be divided into three stages. In 2022, it was still in the beginning stage, and only one valid article had been published for the whole year; this time coincided with the official release of ChatGPT, and Chinese academia had not yet established systematic empirical research, so related exploration was mainly conceptual introduction and forward-looking theoretical discussion, leaving academic output at a very low level. In early 2023-2024, the field has developed at a rapid pace, and the number of publications has increased from 64 to 382; with the continued spread of open-source large models and the gradual implementation of domestic education-digitalisation policies, interdisciplinary teams in educational technology and artificial intelligence at top universities have begun to carry out empirical studies in classrooms, and a concentrated wave of interdisciplinary research has emerged that has drawn considerable attention from the academic community. By 2025, the pace of research had increased somewhat, and the number of publications per year reached 1,058, making up 70.3% of the total valid sample. Therefore, the growth speed was relatively low, but the scale of production was quite large. Research has moved beyond simple tests for applying new tools to explore problems such as educational ethics, algorithmic fairness, adaptation at different levels of education, changes in teacher digital literacy, and reform of educational evaluation. The way of research is changing from a single index of technological effectiveness to the construction of theory and standardised empirical studies.

Therefore, the combination of AIGC and education is now a new and developing field that attracts a lot of attention. In 2023, it officially joined the front line of academic output, and by 2025, the whole research system would have gradually matured.

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Figure 3: Bar chart of major disciplines

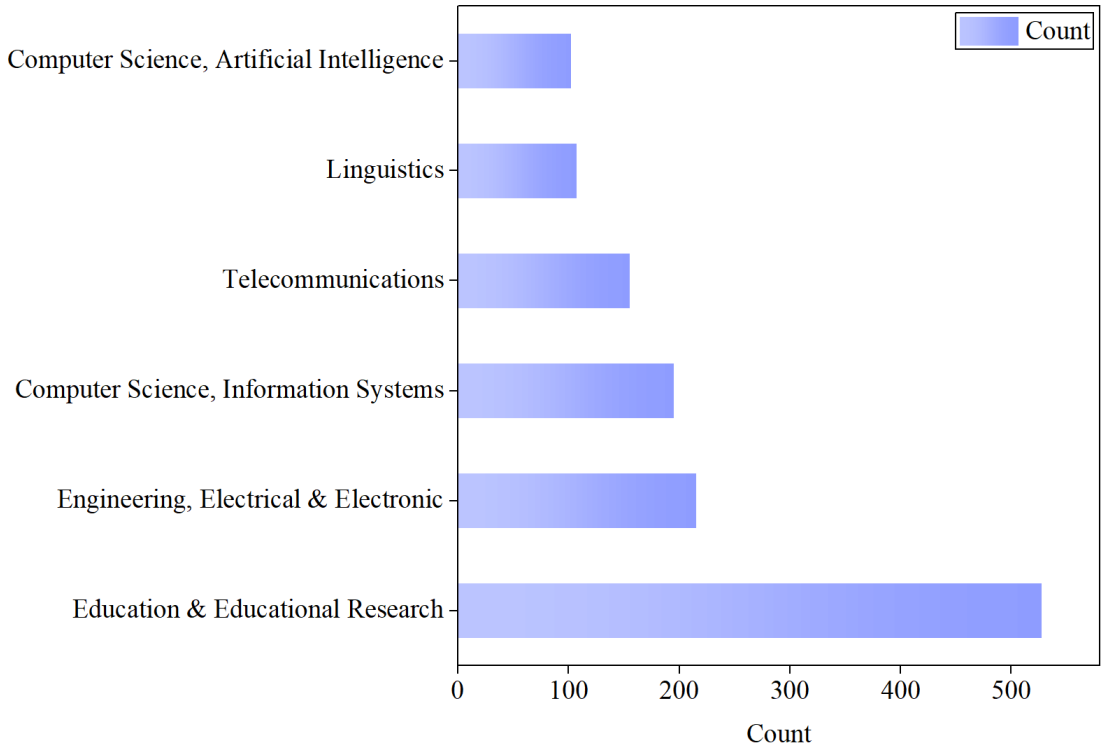


Figure 3 displays the subject-category statistics from the Web of Science, showing the interdisciplinary nature of the field.Education and Educational Research have 527 articles and are more numerous than all other categories. The above results show that domestic research is concentrated on educational institutions and talent cultivation, and it is education-oriented and technology-driven.

The others have been produced. Engineering, Electrical and Electronic has 215 papers. Computer Science, Information Systems has 195 papers. Telecommunications has 155 papers. Linguistics has 107 papers and Computer Science and Artificial Intelligence have 102 papers.

The above is the structure shown. Education is the foundation that provides the theoretical basis and application cases. Engineering, computer science and telecommunications are the supporting technical foundations. The first is a large model that can communicate intelligently and share information. Linguistics is a supporting foundation for teaching language, developing human-computer interaction and prompts, etc. The above will constitute the system of interdisciplinary research.

How do all the scenes in this world connect? According to the above analysis, STEM-related subjects produced 774 papers and exceeded the education category. The two directions of research in China's field of AIGC-empowered education are shown above. Some scholars have taken an educational approach to this issue and are focusing on instructional reform, learning results and the growth of teachers and students. Some other scholars have taken a technical route and concentrated on model optimisation and system construction. The two views develop independently, but this also shows that some technology-oriented research is out of touch with the actual needs of education, and further integration of technology application and educational theory is still required [16].

3.1.2 Core Research Institutions and Their Collaboration Network

Table 1: Top 10 most productive institutions

Rank	Institution	TP	TC	TC/TP	Frequency	Centrality	Year
1	University of Hong Kong	98	5875	59.9	98	0.00	2023
2	Zhejiang University	75	1652	22.03	75	0.03	2024
3	Chinese University of Hong Kong	66	4143	62.77	66	0.08	2023
4	Chinese Academy of Sciences	65	1841	28.32	65	0.10	2022
5	Nanyang Technological University	60	2299	38.32	60	0.06	2023
6	Education University of Hong Kong	58	2053	35.40	58	0.02	2023

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Rank	Institution	TP	TC	TC/TP	Frequency	Centrality	Year
7	Tsinghua University	52	1536	29.54	52	0.03	2023
8	Shanghai Jiao Tong University	49	1159	23.65	49	0.04	2023
9	Hong Kong Polytechnic University	47	1771	37.69	47	0.03	2023
10	Sichuan University	42	848	20.19	42	0.01	2023

Note: TP: the total number of publications; TC: the total citations of TP; Frequency: the frequency of nodes in the network; Centrality: the betweenness centrality of nodes in the network; Year: the first-appearing year of the institution in the dataset.

As shown in table 1, the University of Hong Kong ranks first with 98 articles, well ahead of other institutions; it is followed by Zhejiang University (75), the Chinese University of Hong Kong (66), the Chinese Academy of Sciences (65), Nanyang Technological University (60), the Education University of Hong Kong (58), Tsinghua University (52), Shanghai Jiao Tong University (49), the Hong Kong Polytechnic University (47), and Sichuan University (42).

In terms of institution type, the research force exhibits a diverse multi-actor pattern: joint cross-disciplinary research among domestic universities and research institutes currently occurs far less frequently than among European and American research teams [17]; the international-collaboration advantage of Hong Kong and Macau institutions can serve as a reference model for domestic collaborative development. Most mainland institutions are general-purpose “double first-class” universities, teacher-training institutions and research institutes. Nanyang Technological University is the only overseas institution on the list, and it has established a stable transnational academic cooperation with the domestic team and Singaporean universities. This distribution is in line with the cross-disciplinary nature of AIGC-empowered education, and the research body will include teacher-training universities, comprehensive universities, STEM-oriented institutions, specialized research institutes, etc.

The three research clusters of the cooperation network are in different regions. The first is the Guangdong-Hong Kong-Macao Greater Bay Area cluster led by the University of Hong Kong, the Chinese University of Hong Kong, the Education University of Hong Kong and the Hong Kong Polytechnic University. Secondly, there is the Yangtze River Delta cluster centred around Zhejiang University and Shanghai Jiao Tong University. Thirdly, there is the Beijing-Tianjin-Hebei cluster led by Tsinghua University and the Chinese Academy of Sciences. Being in the same place, there are a relatively large number of institutions, and due to this, intra-regional academic exchange has been relatively active.

Figure 4: Collaboration network of major research institutions

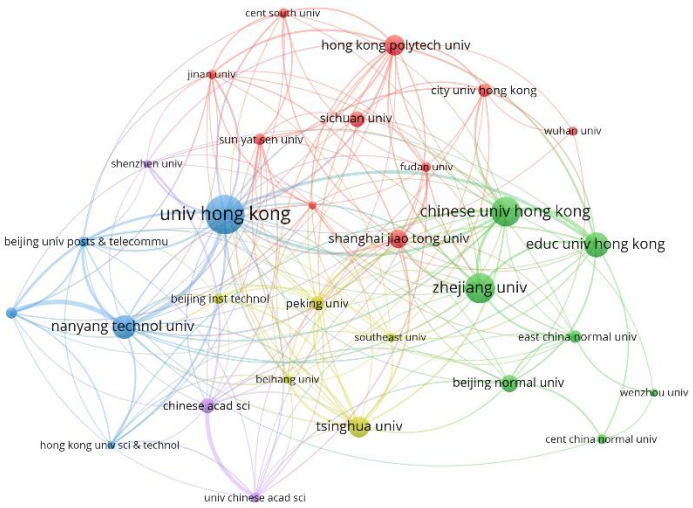


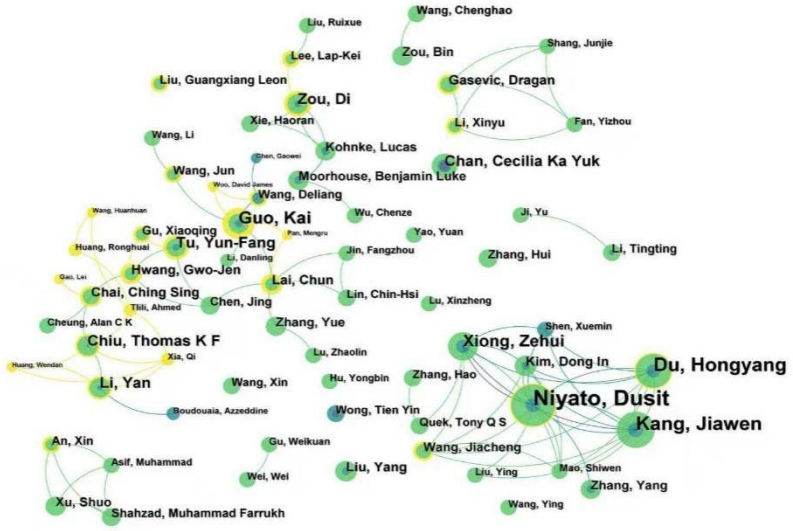
Table 4 shows that there are certain deficiencies in the current research collaboration situation. Most of the research has been conducted by the departmental teams in the same institution, and there has been little sustained cross-regional collaboration on this issue. There is a vast amount of new cooperative space between teacher-training universities and artificial intelligence research platforms. Hong Kong and Macao universities

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have used their internationalised platforms to connect with overseas academic networks and have continued to promote international academic exchange in this area.

3.1.3 Distribution of Core Authors

Figure 5: Author collaboration network



The author collaboration network identifies the core researchers in the field and reflects the closeness of collaboration among them. Figure 5 presents a scatter-plot and label visualization of the collaboration network among all listed authors, which is constructed from the bibliometric database.The overall spatial distribution shows that China's international-publication field on AIGC-empowered education has not yet formed a single mega-collaborative community covering a broad range of scholars. Collaboration is fragmented into several distinct and limited-scale clusters, and these clusters are connected mainly by fine and low-intensity ties.The largest and most cohesive cluster occupies the lower-right region of the map, centered on Niyato, Dusit, and densely interconnected with Kang, Jiawen, Du, Hongyang, Xiong, Zehui, and a group of secondary collaborators including Zhang, Yang, Wang, Jiacheng, Mao, Shiwen, and Quek, Tony Q S. A second, moderately sized cluster forms around Guo, Kai, Tu, Yun-Fang, and Hwang, Gwo-Jen, linking outward to Chiu, Thomas K F, Chai, Ching Sing, and Li, Yan. Two further clusters appear near the top of the map: one centered on Zou, Di together with Xie, Haoran and Kohnke, Lucas, and another centered on Chan, Cecilia Ka Yuk alongside Gasevic, Dragan and Li, Xinyu. Beyond these core groups, the periphery of the network is dominated by small, isolated dyads and triads—such as An, Xin–Asif, Muhammad–Xu, Shuo–Shahzad, Muhammad Farrukh and Liu, Yang–Gu, Weikuan–Wei, Wei—that have no visible connection to the main clusters, underscoring the field's overall collaborative fragmentation.

Table 2: Publication frequency and betweenness centrality of highly productive authors

Rank	Author	TP	TC	TC/TP	Frequency	Year
1	Niyato, Dusit	35	1386	39.60	35	2023
2	Kang, Jiawen	24	1080	45.00	24	2023
3	Du, Hongyang	21	972	46.29	21	2023
4	Xiong, Zehui	15	710	47.33	15	2023
5	Chan, Cecilia Ka Yuk	11	2723	247.55	11	2023
6	Guo, Kai	10	579	57.90	10	2024
7	Zou, Di	9	280	31.11	9	2023
8	Chiu, Thomas K F	9	1010	112.22	9	2024
9	Li, Yan	9	339	37.67	9	2024
10	Kim, Dong In	8	455	56.88	8	2023

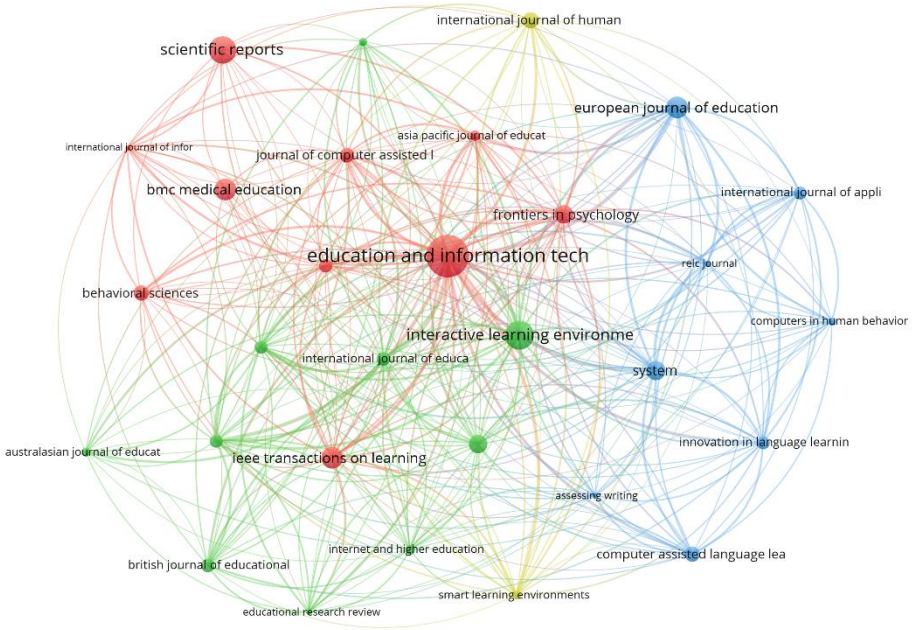
As shown in Table 2, Niyato, Dusit leads the field with 35 publications and 1,386 total citations, followed by Kang, Jiawen (24 publications, 1,080 citations) and Du, Hongyang (21 publications, 972 citations); these three authors, together with Xiong, Zehui (15 publications, 710 citations), form the core of the largest collaborative cluster identified in Figure 5, and their output is concentrated from 2023 onward. Notably, Chan,

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Cecilia Ka Yuk records the highest total citation count in the table (2,723) despite a comparatively modest output of 11 publications, yielding the lowest TP/TC ratio (0.00) among the top ten authors and indicating disproportionately high per-article impact rather than sheer productivity. Most other high-output authors, such as Guo, Kai, Zou, Di, Chiu, Thomas K F, Li, Yan and Kim, Dong In, have TP/TC ratios of about 0.01-0.03 and are thus considered more typical in terms of output-proportional citations. Most of the top authors (Guo, Kai, Li, Yan, and Chiu, Thomas K F are slightly later) have had their first appearance year in 2023, supporting the earlier finding that core author teams in this field formed quickly after the development of AIGC technology. Given the fragmented topology of the network, it can be observed that although a small number of highly productive, close-knit teams—such as the Niyato/Kang/Du/Xiong cluster—produce most of the output in this field, high-impact scholarship is not limited to these teams, and substantial cross-cluster collaboration among all the research circles in this field is still absent.

3.1.4 Distribution of Core Journals and Co-citation Characteristics

Figure 6: Journal co-citation network



The journal co-citation network shows the relationships among the academic institutions in this field and how knowledge is spread; at the same time, the document co-citation network can find the basic works in the field and clarify the development path of disciplinary knowledge [18]. To clarify the publication venues and knowledge bases of China's international output on AIGC-empowered education, this paper constructed journal co-citation and document co-citation network maps, as shown in Figures 6 and 7 respectively, and compiled basic bibliometric information on high-productivity journals in Table 3.

The journal co-citation network (Figure 6) shows that the network can be divided into three clusters by clustering, and these clusters are shown in different colours. Many connections among the nodes are shown to have wide cross-citation in different journal clusters and relatively broad academic exchange in the sub-directions of this field.

Further analysis of the journal-level bibliometric data in Table 3 shows that the publication places are distributed unevenly. On the one hand, a large proportion of the output has been published in top-tier SSCI educational-technology journals; for example, the British Journal of Educational Technology, Computers & Education, and the International Journal of Educational Technology in Higher Education have continued to publish related studies, and Chinese scholars' research on AIGC-empowered education has gained considerable attention in the international educational-technology community. At the same time, there are many journals covering various fields such as education, linguistics, computer science and medicine; apart from the main

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educational journals, journals in medical education, human-computer interaction, and linguistics also accept related papers, corresponding to sub-domains such as medical education, language teaching and intelligent interaction.

Table 3: List of highly cited core journals

Rank	Journal	Pubs.	Citations	IF	Subject Category
1	Education and Information Technologies	76	1769	5.4	Education & Educational Research
2	Interactive Learning Environments	44	661	5.3	Education & Educational Research
3	Scientific Reports	40	260	3.9	Multidisciplinary Sciences
4	IEEE Transactions on Learning Technologies	29	427	4.9	Education & Educational Research; Computer Science, Interdisciplinary Applications
5	BMC Medical Education	28	285	3.2	Education & Educational Research; Education, Scientific Disciplines
6	European Journal of Education	28	561	3.6	Education & Educational Research
7	System	24	565	5.6	Linguistics; Education & Educational 8Research
8	Educational Technology & Society	23	138	6.0	Education & Educational Research
9	Frontiers in Psychology	22	477	2.9	Psychology, Multidisciplinary
10	International Journal of Human-Computer Interaction	18	419	4.9	Ergonomics; Computer Science, Cybernetics
11	Behavioral Sciences	17	167	2.5	Psychology, Multidisciplinary
12	Computer Assisted Language Learning	17	224	6.6	Language & Linguistics; Education & Educational Research; Linguistics
13	Journal of Computer Assisted Learning	16	174	4.6	Education & Educational Research
14	British Journal of Educational Technology	15	399	8.1	Education & Educational Research
15	Humanities & Social Sciences Communications	15	258	3.6	Humanities, Multidisciplinary; Social Sciences, Interdisciplinary
16	International Journal of Educational Technology in Higher Education	15	1811	16.7	Education & Educational Research
17	Computers & Education	14	423	10.5	Education & Educational Research; Computer Science, Interdisciplinary Applications
18	International Journal of Applied Linguistics	14	117	1.7	Language & Linguistics; Linguistics; Education & Educational Research
19	Journal of Educational Computing Research	14	201	4.9	Education & Educational Research
20	Innovation in Language Learning and Teaching	13	329	4.6	Linguistics; Education & Educational Research

The document co-citation network (Figure 7) shows the composition of the field's knowledge base; node size is the co-citation frequency, and the links between nodes indicate the degree of citation linkage among documents. The top highly cited papers are shown in Table 4. Dwivedi (2023) is the largest and most central node in the network; it is considered the foundation of the field's theoretical system and has been widely referenced in later research. In terms of publication time, the main content of the network consists of articles from 2023, and articles from 2024–2025 are still being added gradually, indicating that related frontier research has developed rapidly since the release of ChatGPT. The various branches of this cluster have different research directions, such as technology-acceptance theory, classroom applications of large models, medical education and language education, etc.; each branch is based on classical foundational works and together form an entire knowledge system in the field of AIGC-empowered education. At the same time, there are other problems in the world of GenAI in education, such as the late release of ethics-related literature and fragmented theoretical development; most of the existing research is qualitative discussion on risk and lacks localized, quantitative governance frameworks [19].

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Figure 7: Document co-citation network

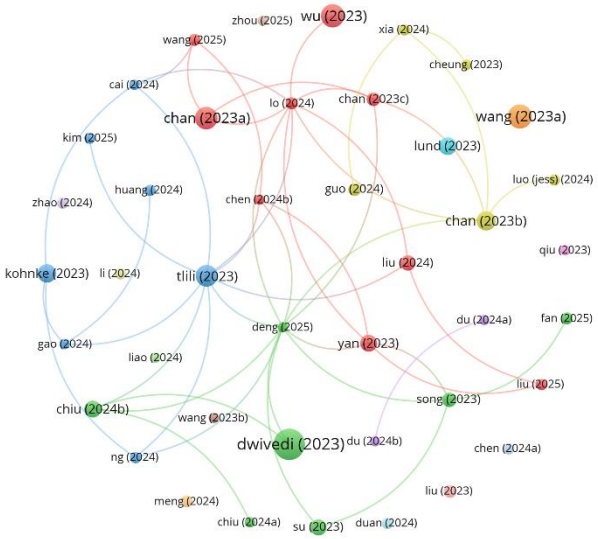


Table 4: List of highly cited documents

Rank	Title	Citations
1	"So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy [20]	2,641
2	Students' voices on generative AI: perceptions, benefits, and challenges in higher education [21]	1,279
3	A Brief Overview of ChatGPT: The History, Status Quo and Potential Future Development [22]	1,063
4	What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education [23]	986
5	A comprehensive AI policy education framework for university teaching and learning [24]	718
6	The impact of Generative AI (GenAI) on practices, policies and research direction in education: a case of ChatGPT and Midjourney [25]	576
7	ChatGPT and a new academic reality: Artificial Intelligence-written research papers and the ethics of the large language models in scholarly publishing [26]	523
8	Impact of ChatGPT on learners in a L2 writing practicum: An exploratory investigation [27]	476
9	Collaborating with ChatGPT in argumentative writing classrooms [28]	424
10	An expectancy value theory (EVT) based instrument for measuring student perceptions of generative AI [29]	421
11	Beware of metacognitive laziness: Effects of generative artificial intelligence on learning motivation, processes, and performance [30]	384
12	Enhancing academic writing skills and motivation: assessing the efficacy of ChatGPT in AI-assisted language learning for EFL students [31]	379
13	Measuring EFL learners' use of ChatGPT in informal digital learning of English based on the technology acceptance model [32]	375
14	Integrated image-based deep learning and language models for primary diabetes care [33]	318
15	To resist it or to embrace it? Examining ChatGPT's potential to support teacher feedback in EFL writing [34]	306
16	Factors Influencing University Students' Behavioral Intention to Use Generative Artificial Intelligence: Integrating the Theory of Planned Behavior and AI Literacy [35]	260
17	The influence of ChatGPT on student engagement: A systematic review and future research agenda [36]	243
18	Exploring students' perspectives on Generative AI-assisted academic writing [37]	241
19	Empowering student self-regulated learning and science education through ChatGPT: A pioneering pilot study [38]	229
20	Recommender Systems in the Era of Large Language Models (LLMs) [39]	227

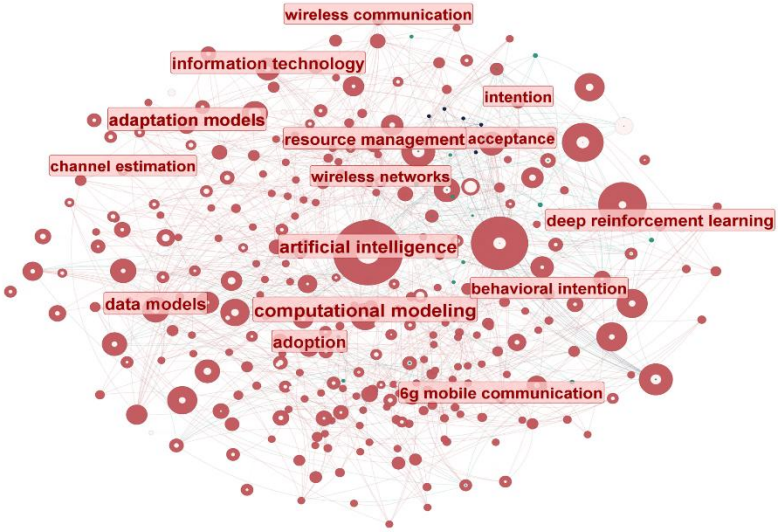
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3.2 Research Hotspots and Thematic Clustering Analysis

3.2.1 Keyword Co-occurrence Analysis

Keywords are not only the main problems in the literature but also the popular research directions at a certain time. Keyword Co-occurrence Analysis (KCA) is used to find popular research topics based on frequent keywords.[40].

Figure 8: Keyword co-occurrence network map



As shown in the keyword co-occurrence network (Figure 8), node size represents keyword frequency, and the connections between nodes represent the strength of co-occurrence association among terms. According to the map, “artificial intelligence”, “generative AI”, “generative artificial intelligence”, “large language model” and “education” are the main nodes in the network and serve as the basic concepts of the entire research field. Based on the above core nodes, all high-frequency keywords can be organised into three levels. The three levels are as follows: First, there is the technology-ontology layer, which includes terms such as “deep learning”, “machine learning” and “neural networks”, and focuses on the basic technical foundation of artificial intelligence; Second, there is the educational-scenario layer, which covers terms like “higher education”, “university students”, “medical education” and “massive open online course”, and details all kinds of educational environments where AIGC is used; Third, there is the outcomes-and-theory layer, which contains terms such as “learning outcome”, “critical thinking”, “student engagement” and “technology acceptance model”, and focuses on the effects of applying technology on learners and related theoretical support.

At the same time, some secondary nodes have recently formed sub-research communities such as “prompt engineering”, “task analysis”, “academic writing” and “AI literacy”, and have carried out related research on prompt design, academic-writing training and teachers' and students' AI literacy. The keywords are close to each other; thus, it can be seen that the three topics of technology research, scenario-based practice and learning-outcome evaluation are closely related, and no fully independent or isolated research paths have been established in this field yet.

3.2.2 Keyword Clustering and Research Theme Classification

Automatic clustering of keywords is carried out based on the Log-Likelihood Ratio algorithm, and Figure 9 shows the results of clustering. The overall network modularity is Q = 0.8269, and the weighted mean silhouette value is S = 0.962; both meet the ideal threshold and indicate that the clustering result is relatively good. Table 5 presents the details of the 11 stable clusters.

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Figure 9: Keyword cluster analysis map

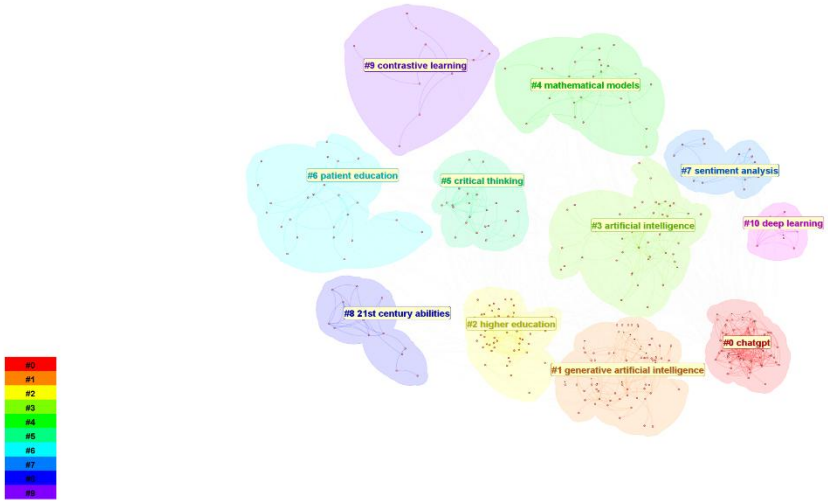


Table 5: Statistical summary of keyword clustering results

Cluster	Size	Silh.	Mean Yr.	Cluster Name	LLR Label Core Content
#0	58	0.687	2024	ChatGPT computational optimization	ChatGPT, computational modeling, resource management, diffusion models
#1	56	0.558	2024	Generative artificial intelligence education	Generative artificial intelligence (GenAI), self-determination theory, student engagement
#2	54	0.580	2024	Higher education technology acceptance	Higher education, technology acceptance model, UTAUT2
#3	46	0.627	2023	Large language model sentiment analysis	Generative art, text analysis, emotional reactions, large language models
#4	30	0.620	2024	Mathematical models in medical education	Mathematical models, fault diagnosis, hedonic-motivation adoption model
#5	27	0.730	2024	Critical thinking & collaborative learning	Critical thinking, cognitive load, lesson planning, collaborative model
#6	26	0.727	2024	Patient education & AI medical teaching	Patient education, clinical reasoning, nursing education, AI-assisted medical instruction
#7	17	0.824	2024	Sentiment analysis & educational prediction model	Sentiment analysis, analytical models, predictive models, classroom teaching
#8	14	0.899	2025	21st century abilities & human-computer collaborative teaching	21st century abilities, learning strategies, human-computer interaction
#9	13	0.832	2024	Contrastive learning & generative adversarial network	Contrastive learning, generative adversarial network, training data
#10	8	0.993	2022	Deep learning & generative art image classification	Deep learning, image classification, generative art, virtual screening

The Silhouette coefficient is a typical measure of the internal cohesion of keywords in a cluster; it is closer to 1 the more thematically unified the cluster is and the clearer its boundaries. All clusters in this study have a silhouette coefficient greater than 0.5 and are considered to be good clusters [15]. Among them, #10 had the highest silhouette coefficient of 0.993 and only carried out research on early deep learning image algorithms in one line. Clusters #8, #9, #5 and #6 all have silhouette coefficients greater than 0.7, so they have good internal consistency in their sub-domain themes. The three main clusters, #0, #1 and #2, cover a large number of research areas and have overlapping keywords; they also have a low silhouette coefficient and are in line with the general trend of bibliometric mapping.

The mean year of publication for a cluster is when that field developed. Cluster #10 has a mean year of 2022, and it was the foundation for pre-ChatGPT research on image generation and its underlying deep-learning algorithms; thus, it provided a technical basis for the later applications of AIGC in education. Cluster #3 has an average year of 2023, and it is one of the early research directions in the initial popularisation of

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large models, focusing on lightweight text-sentiment analysis. Clusters #0–#7 and #9 all have an average year of 2024; thus, 2024 was a period of full-scale boom in China's international AIGC-in-education research, and many research directions have been developed in parallel, such as technology optimisation, higher education teaching, medical education and critical thinking cultivation. Cluster #8 has an average year of 2025 and is the latest research front focusing on human-AI collaboration and the cultivation of holistic competence; this will be the future direction of this field.

According to the semantics of the cluster labels, the 11 clusters can be grouped into five main research directions. Clusters #0, #1 and #2 constitute the main threads of this field, and they respectively focus on the optimisation of the underlying ChatGPT model, general empirical research on GenAI in education, and university technology-acceptance behaviour based on self-determination theory and UTAUT2 to produce a large body of empirical literature. Cluster #3 and Cluster #7 are in the branch of quantitative teaching and analysis, so a large-model text-sentiment recognition method will be used to build predictive tools for classroom learning and achieve digital assessment of learning conditions. Cluster #4 and Cluster #6 are the medical-education crossover tracks; they include mathematical modelling in medical education and AI-assisted clinical or nursing training. Cluster #5 investigates the teaching value of instructional design and studies the dual effects of artificial intelligence on critical thinking and cognitive load. Clusters #9 and #10 are the basic algorithm clusters that provide technical support for the image and text generation models, and cluster #8 is the new frontier for 2025, exploring human-AI collaboration models and all-round student competency cultivation.

The spatial-association features of the cluster map show clear divisions among the different knowledge communities, and there are very few cross-cluster links. The four research circles of algorithmic technology, general education, medical teaching and humanistic reflection are still separate, and there is a general lack of integration between STEM model-based research and real classroom teaching in the current interdisciplinary field of AIGC in education. In short, there have been general developments in 2024, and the scale of the #8 human-AI collaboration cluster is still relatively small; more empirical evidence needs to be collected.

3.2.3 Keyword Burst Detection

Figure 10: Keyword burst-detection map

Top 10 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2022 - 2026
deep learning	2022	2.24	**2022**	2023	
task analysis	2023	12.3	**2023**	2024	
natural language processing	2023	6.97	**2023**	2024	
artificial intelligence	2023	5.38	**2023**	2023	
neural networks	2023	2.4	**2023**	2024	
language model	2023	2.35	**2023**	2024	
medical education	2024	6.58	**2024**	2024	
management	2024	3.6	**2024**	2024	
prompt engineering	2024	2.22	**2024**	2024	
biological system modeling	2024	1.99	**2024**	2024	

Keyword burst analysis is used to find words that have increased in frequency in recent years and study the progress of new research. Figure 10 is the top 10 keywords with the highest citation bursts from 2022 to 2026. Based on the start year of each term, there are three periods of development.

The first stage started in 2022, was only deep learning at that time, and had a score of 2.24 in 2022-2023; this was the earliest technological foundation for the field before ChatGPT spread widely. The second stage started in 2023 and is now producing most of the strong surges. Task analysis has a strength of 12.3 in 2023-2024; natural language processing has a strength of 6.97 in 2023-2024; artificial intelligence has only been at a strength of 5.38 in 2023; neural networks have had a strength of 2.4 in 2023-2024; and language models have had a strength of 2.35 in 2023-2024. Task analysis has the highest burst strength among the ten keywords, and

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this value is more than five times that of the second-ranked natural language processing. Based on the above data, after the initial popularisation of large language models in 2023, the focus of attention in research has moved from the general development of AI and NLP to the design and analysis of specific teaching problems. The third stage will start in 2024, and it will cover medical education with a strength of 6.58, management with a strength of 3.6, prompt engineering with a strength of 2.22, and biological system modelling with a strength of 1.99. All the above terms started and ended in 2024, and since then, the focus of research has moved away from vertical, domain-specific applications in medical education and biological modelling towards practical implementation skills in prompt engineering and management.

According to the timeline of burst detection, research on AIGC-empowered education in China has developed in stages; first, in 2022, the foundation of deep learning technology was studied, and then, by 2023, attention moved to large language models and natural language processing. Task-oriented instructional design has drawn the attention of many researchers, and by 2024, research has been conducted in many specialised areas and practical applications. Therefore, the direction of research is no longer just technology; rather, it is applications in particular problems and educational situations.

4. Conclusion

4.1 Main Research Conclusions

Accurately grasping the overall developmental trajectory, core research forces, and hotspot-evolution patterns of the AIGC-empowered education field is an important foundation for clarifying the international research landscape of Chinese academia and advancing the digital practice of localized smart education. Over the past three years, Chinese scholars have produced a substantial body of international English-language output on the integration of generative AI and education, but existing reviews are mostly qualitative and lack a panoramic, quantitative analysis of the large-scale English-language literature. Drawing on 1,505 “Article”-type documents authored by Chinese institutions in the Web of Science Core Collection from 2022 to 2025, this study integrates tools such as Origin, CiteSpace, and VOSviewer, applying multidimensional scientometric and content-analysis methods—including annual-output statistics, collaboration-network analysis, journal co-citation, keyword co-occurrence, LLR clustering, burst detection, and timezone mapping—to complete a panoramic analysis of the field systematically. The main conclusions are as follows:

First, publication output in the field shows exponential growth, with a clear three-stage evolutionary pattern. The year 2022 was the nascent stage, with only one article produced, dominated by introductory discussion of basic generative-AI theory; 2023–2024 marked an explosive stage, with a batch of interdisciplinary empirical output accompanying the popularization of ChatGPT and the implementation of domestic education-digitalization policies; 2025 entered a stage of rational deepening, with annual output reaching 1,058 articles and accounting for 70.3% of the total sample, as research shifted from shallow tool testing toward deeper issues such as educational ethics, stage-specific adaptation, and teaching-evaluation reform, with the research system gradually maturing.

Second, through dual institutional and author collaboration networks and multidimensional bibliometric indicators, this paper clarifies the global distribution pattern of research forces in the field. In terms of institutional output scale, the University of Hong Kong ranks first in total publications, and Hong Kong/Macau universities show a marked advantage in overall English-language output; Zhejiang University, Tsinghua University, and Beijing Normal University, together with other mainland “Double First-Class” comprehensive universities, teacher-training universities, and the Chinese Academy of Sciences, constitute the core mainland research body, with Nanyang Technological University as a frequent overseas collaborating institution; spatially, three research clusters have formed in the Guangdong–Hong Kong–Macao Greater Bay Area, the Yangtze River Delta, and Beijing–Tianjin–Hebei. Based on frequency and betweenness-centrality indicators, the Chinese Academy of Sciences, the Chinese University of Hong Kong, and Nanyang Technological University are identified as key hubs for cross-regional and transnational collaboration, but most research activity remains confined within single-institution research groups, with relatively little cross-regional, industry–academia–research, or teacher-training/AI-institution collaborative output. The author collaboration network similarly shows a fragmented, small-cluster pattern: Niyato, Dusit, Kang, Jiawen, and Du, Hongyang form the field's largest and most productive collaborative team, while Chan, Cecilia Ka Yuk stands out for

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disproportionately high per-article citation impact despite a comparatively modest output. Most leading authors show clear barriers to cross-team academic exchange, indicating tight internal collaboration within individual research circles.

Third, the field displays a pronounced interdisciplinary character and high international academic recognition. WoS subject-category statistics show that education forms the core layer, and electrical engineering, computer science, and linguistics form a supporting technical layer. The total volume of STEM-related literature exceeds that of education-related literature, and this reflects a disconnect between technology-oriented research and real teaching scenarios. The journal co-citation network divides into three clusters for general education, language teaching, and medical education, and Education and Information Technologies serves as the most productive venue while high-impact SSCI journals like Computers and Education and the International Journal of Educational Technology in Higher Education include domestic output to confirm that China's related research has gained international academic recognition. Document co-citation results show that Dwivedi (2023) is the core foundational document, and ethics-related literature emerged late without forming a unified, mature theoretical consensus.

Fourth, the research themes display a complete layered structure, with hotspots iterating systematically over time. The keyword co-occurrence network forms a three-layer structure of underlying technology, teaching scenarios, and learning outcomes; the LLR algorithm identifies 11 stable clusters, which can be consolidated into five major strands—large-model educational applications, university technology acceptance, medical-education crossover research, critical-thinking-oriented teaching, and underlying algorithms—with the 2025 clusters on human–AI collaboration and 21st-century competencies representing the latest frontier. The keyword burst timeline clearly traces the evolutionary path: 2022 was marked by a single foundational burst around deep learning; 2023 saw the field's most intense surge, led by task analysis together with natural language processing, artificial intelligence, neural networks, and language model, as research pivoted decisively toward concrete large-model applications and task-level instructional design; by 2024, burst terms had narrowed further into vertical, domain-specific applications and practical implementation skills—medical education, management, prompt engineering, and biological system modeling—with the research focus moving progressively away from a purely technical perspective and returning to the foundation of educational practice.At the same time, all the various cluster circles are still separate, and there is little communication between STEM algorithmic research and educational empirical research—this is a typical problem of this interdisciplinary field.

4.2 Limitations

This paper also has some shortcomings. Only English-language papers from the Web of Science Core Collection are used in this paper, and Chinese-language publications in CNKI and Scopus databases have been excluded to limit the scope of the sample. East Asian author names are likely to have irregular spellings in foreign-language databases, and even after cross-referencing, there may be small differences in frequency statistics. This paper has only conducted a shallow content analysis of the highly cited works and has not carried out large-scale text mining or qualitative analysis of the theme clusters; therefore, the specific practical disagreements in the sub-fields cannot be revealed.

4.3 Suggestions for Future Research

Based on the shortcomings and research frontiers of the bibliometric maps in this study, future research should build long-term, cross-regional and cross-industry cooperation networks to overcome geographical and disciplinary barriers, and strengthen joint efforts among universities in mainland China, Hong Kong, Macao and overseas. Localised, long-term tracking studies in basic education, vocational education and lifelong learning can be added to the empirical research to reduce the dependency on single-university samples. Organised studies on the educational ethics of AIGC can establish a quantitative risk assessment system and practical campus-level governance norms. Research on Multimodal Generative Technology and Regional Educational Equity in Non-Textual Large Models can be carried out. In accordance with the national education digitalisation plan, research on the local adaptation of personalised smart-education ecosystems and reform of educational assessment can provide rich theoretical and practical support for the development of our country.

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