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Original Research

Navigating the Knowledge Stream: Analyzing ChatGPT's Impact on Education Through Bibliometric

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Abstract

The use of ChatGPT technology in educational settings has sparked substantial discussion within the academic community. This innovation has instigated significant transformations in the landscape of educational systems. This article undertakes a bibliometric analysis of research on ChatGPT in Education spanning 2022 to 2023, covering the period from ChatGPT's inception to the present day. The primary aim of this study is to conduct both quantitative and qualitative analyses of research trends in the application of ChatGPT in the field of Education. This comprehensive investigation encompasses document types, subject areas, notable researchers, scientific collaboration, top countries and institutions, influential papers, prominent journals, and emerging topics. The results reveal that the most popular review articles and the highest paper counts were observed across document types. Within the subject area, ChatGPT emerged as the most prominent topic in education. Researchers from the UK and the Netherlands stood out prominently. Regarding the number of authors, articles authored by a single writer were the most abundant. Among the leading countries, the United States ranked first. The most prolific institute was in India, and the most impactful was in the UK. The leading journal was Nature, and the top article was also published there.

Keywords: Artificial Intelligence, Chatbot, ChatGPT, Education, Educational Technology.

Introduction

The release of ChatGPT by OpenAI has marked a turning point in public and academic discourse on artificial intelligence (AI), particularly in education. As an advanced generative language model, specifically, a variant of the GPT (Generative Pre-trained Transformer) architecture, ChatGPT is capable of generating coherent, human-like responses across a wide

range of tasks, including summarization, translation, programming assistance, and interactive learning (Adiguzel, Kaya & Cansu, 2023). Its capabilities have been notably extended in its latest version, ChatGPT-4, which supports multimodal inputs and enhanced reasoning capacity across disciplines. Within higher education, the widespread adoption of ChatGPT has triggered both enthusiasm and concern. On one hand, it offers a range of transformative applications such as personalized tutoring, rapid feedback, academic writing support, and multilingual translation (Atlas, 2023; D'Amico, White, Shah & Langer, 2023; Keykha, Behravesh & Ghaemi, 2024; Keykha, Imanipour, Shahrokhi & Amiri, 2025; Keykha, Mohammadi, Darabi & Hosseini, 2025).

On the other hand, there is increasing scrutiny around its limitations, including issues of factual inaccuracy, bias, opacity in reasoning, and concerns regarding academic integrity, job displacement, and ethical misuse (Kasneci et al., 2023; van Dis, Bollen, Zuidema, van Rooij & Bockting, 2023; Halaweh, 2023; Mhlanga, 2023; Jafari & Keykha, 2024). These dual perspectives have fueled an urgent need for evidence-based assessments of ChatGPT's role and trajectory in the educational domain. The growing relevance of ChatGPT has catalyzed scholarly interest in mapping its evolution and impact within academic contexts. As AI systems permeate teaching and learning environments, understanding the structure of research in this area becomes imperative. Bibliometric analysis, as a robust method for quantitatively evaluating scientific production, offers valuable insights into the intellectual landscape of emerging fields (Li & Lei, 2021; Zhang, Chen, & Zhang, 2021). Prior bibliometric investigations have been conducted on related educational technologies such as gamification and e-learning (Behl, Jayawardena, Pereira, Islam, Del Giudice & Choudrie, 2022), intelligent tutoring systems (Li & Wong, 2022; Keykha, 2022), adaptive learning (Chen, Zou, Xie & Wang, 2021), and innovative university frameworks (Rico-Bautista et al., 2022).

At the time this study was initially conceived and drafted, bibliometric literature on ChatGPT in education was in its infancy. However, several related studies have emerged in 2023 and 2024 (e.g., Polat, Topuz, Yildiz, Taslibeyaz & Kursun, 2024; Amarathunga, 2024; Zheltukhina, Sergeeva, Masalimova, Budkevich, Kosarenko & Nesterov, 2024; Nugroho, 2024), highlighting the growing scholarly interest in this domain. Acknowledging this evolving landscape, our study is not positioned as the first, but rather as a distinctive contribution that offers a comprehensive, multidimensional bibliometric review of ChatGPT's impact on education during its formative phase (2022–2023). In contrast, this study identifies a gap in the literature concerning the early-phase dynamics of ChatGPT's academic integration across interdisciplinary domains, especially within the education, medicine, and computer science triad. Moreover, previous studies rarely incorporate comparative insights from related educational technologies, nor do they offer policy recommendations grounded in regional disparities or development stages.

By capturing the evolution of research during ChatGPT's formative phase and synthesizing institutional, geographic, and disciplinary analyses, this study aims to fill a critical gap in understanding how emergent AI technologies reshape academic discourse at multiple levels. Our work differs from existing studies in several ways: it integrates both macro-level (e.g., country/institutional productivity) and micro-level (e.g., citation performance of individual authors, document types, and journals) analyses; it places findings in the context of broader trends in educational AI research; and it offers policy-level recommendations for developing regions. These combined elements position our work as a timely and holistic examination of a

rapidly evolving field 1. Introduction Focus: The introduction primarily focuses on ChatGPT's general use in education, making it better suited to a general review article than a focused bibliometric study.

Material and methods

This research, based on its objective, falls under the descriptive-exploratory research category and was conducted using bibliometric methods and analysis. The investigation's timing dictates that this study be longitudinal. It is a quantitative research study in terms of data. The research population comprises all scholarly papers on ChatGPT in higher education that have been indexed in the Web of Science databases by scholars worldwide. WoS is a high-quality database that covers top journals in basic sciences, social sciences, arts, and humanities (Fetscherin & Heinrich, 2015). To extract the records of this research, a search in the "Core Collection" section of the Web of Science database for the time period 2022-2023 was conducted. The keywords were chosen based on prior articles and ChatGPT's cognitive domain in education. To gather the articles, the following search formula was used:

TITLE-ABS-KEY (“ChatGPT in education" OR "ChatGPT in teaching" OR "ChatGPT opportunities in training" OR "ChatGPT opportunities in learning”)

We used the Bibexcel version 2008-08 (Persson, Danell & Schneider, 2009) to identify the most prevalent subjects and subject categories, the most prolific authors and their h-index, the most prolific journals, and the must-read papers. It is worth mentioning that citations from more influential publications were not treated equally with those from less influential ones. We used VOSviewer version 1.6.73 to identify the most prolific and influential institutions (van Eck & Waltman, 2010). Excel 2017 was used for various keyword analyses.

Results

Overall statistics and distributions

287 documents matched our search criteria. In total, these documents have been cited 674 times. The average number of citations per document is 2.35. The distribution of document kinds is seen in Table 1. Reviews had the highest average citations per paper, with 10.42 citations per paper.

Table 1
Documents types

Document	Count	Average citations per paper
Article	191	3.16
Editorial Material	41	8.39
Letter	8	4.23
Review	27	11.04

Based on the data presented in the table, review articles exhibit the highest average number of citations. It is noteworthy that review articles consistently receive the most citations, as

anticipated. This anticipation is supported by the observation that, in general, review articles tend to attract more citations than other article types (Keramatfar, Rafiee & Amirkhani, 2022). In terms of the number of documents, articles ranked first. This outcome aligns with expectations established through a review of relevant research literature. For instance, in higher education, articles emerged as the most prevalent document type (Yang, Sun, & Liu, 2017). Figure 1 shows the subject area with the most articles on ChatGPT.

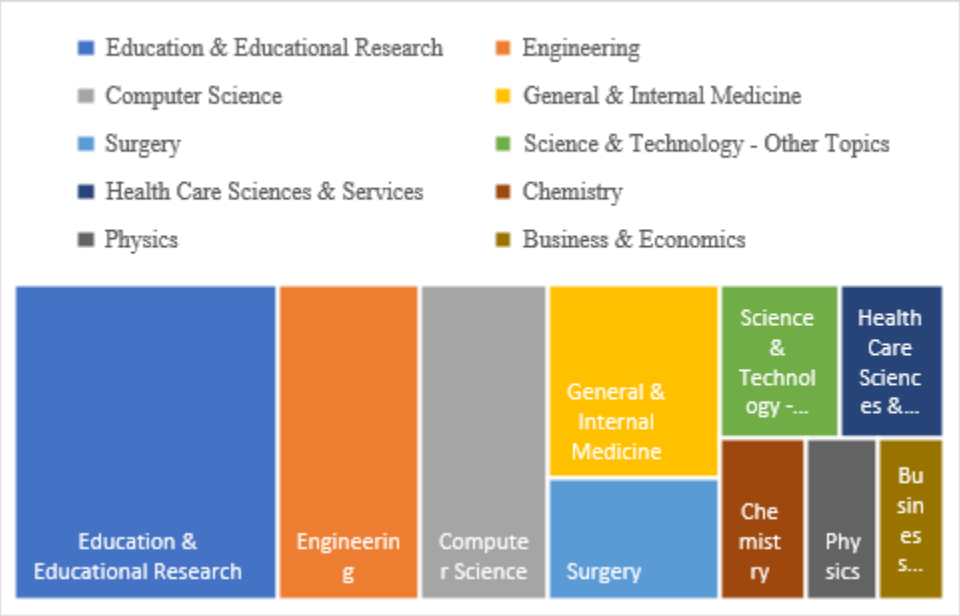

Figure 1: Shows the most frequent subject distribution of the papers in the 10 different categories (Source: Web of Science Analytics)

The graph above shows that the field of education has a larger share than the other areas of research. Following that, engineering and computer science had about equal shares. General and internal medicine is ranked third among all fields. The majority of articles focused on education, which was expected. However, contrary to these expectations, a study on the metaverse in education found that the most significant number of articles were in the natural sciences, mathematics, and engineering (Tlili et al., 2022).

Top authors

Table 2 lists the top 7 writers in terms of article citations. Siobhan O'Connor is the most productive and influential researcher in this topic, with an h-index of 2 and 109 citations. Conversational agent, Generative artificial intelligence, Generative AI, ChatGPT, and large language models are her most commonly used keywords, in descending order. She is a Senior Lecturer at the University of Manchester in the United Kingdom. She has a multidisciplinary background in nursing and information systems, and is currently pursuing a PhD in health informatics.

Table 2
Most prolific and impactful researchers

Author	All citations	Docs	Most used keywords
Siobhan O'Connor	109	2	Conversational agent; Generative artificial intelligence; Generative AI; ChatGPT; Large language models
Robert van Rooij	79	1	Computer science; Research management; Publishing; Machine learning
Eva AM van Dis	79	1	Computer science; Research management; Publishing; Machine learning
Johan Bollen	79	1	Computer science; Research management; Publishing; Machine learning
Claudi L Bockting	79	1	Computer science; Research management; Publishing; Machine learning
Willem Zuidema	79	1	Computer science; Research management; Publishing; Machine learning
Sascha Kraus	42	2	Conversational agent; Generative artificial intelligence; Generative AI; ChatGPT; Large language models

According to the table above, the author (O'Connor) from the University of Manchester has the most citations (109). The University of Amsterdam researchers are significantly behind. With a citation rating of 79, 5 researchers from the University of Amsterdam are ranked next. In addition, the top four keywords were computer science, research management, publishing, and machine learning. The statement, in short, outlines the key findings of a scientific study or publication. It highlights the author with the most citations, compares researchers from various institutions, and identifies the most frequently used keywords, all of which are critical components for understanding the research and its significance in the field.

Given the University of Amsterdam's robust scientific expertise in artificial intelligence, the outcomes detailed in this section were anticipated. However, it was also expected that additional results would emerge from substantial investments by countries such as the United States and China. Contrary to this expectation, diverse findings emerged in other studies in related fields. Notably, in the domain of gamification in education, the foremost author from China was Martí-Parreño, Méndez-Ibáñez, and Alonso-Arroyo (2016). In the context of flipped learning in higher education, the leading authors from Spain were Limaymanta, Apaza-Tapia, Vidal, and Gregorio-Chaviano (2021). Additionally, in the field of educational technology in physics education, the preeminent authors from Russia were Perdima, Suwarni, and Gazali (2022).

The prominent themes in the articles of top authors encompassed keywords such as "A Conversational Agent," "General Artificial Intelligence," "General AI," "ChatGPT," and "Large Language Models" within Siobhan O'Connor's piece. O'Connor emphasizes an interdisciplinary approach in his articles, advocating for the involvement of experts from diverse fields to

enhance ChatGPT's capabilities and boost productivity. Furthermore, he delves into the limitations of applying ChatGPT across various domains. Notably, there is considerable discord over the legalization of ChatGPT use.

Keywords used by researchers from the University of Amsterdam that delve into the realm of Computer Science, specifically focusing on Research Management and Publishing. The study, published in a journal, explores the connections between Machine Learning and its applications. The selected keywords align with the research's core themes. The authors focus on the benefits of incorporating ChatGPT into research activities, with particular emphasis on Research Management. The study underscores the central role of Research Management as a keyword, elucidating how ChatGPT can advance research and support monitoring objectives across various research management processes.

Scientific collaboration

According to the analysis of the conducted studies, the average number of authors per article is 3.95. Figure 2 depicts the percentage distribution of articles by author count.

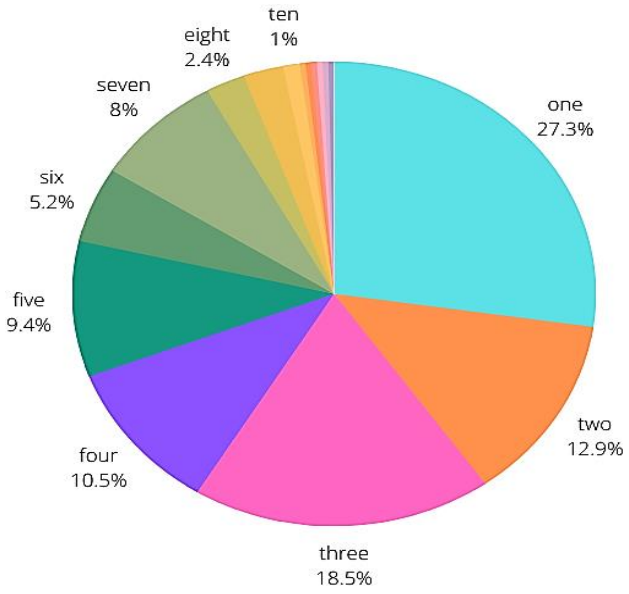

Figure 2: Articles by number of authors

This graph provides valuable information on the distribution of authorship within a particular dataset or field. It demonstrates that single-authored papers are the most common, accounting for 27.3 percent, followed by three-author articles at 18.5 percent and, finally, two-author articles at 12.9 percent. Understanding authorship patterns can be helpful to researchers, publishers, and anyone interested in collaboration patterns within a particular academic or professional environment. As anticipated, articles authored by a single individual accounted for the highest number in the study. A parallel investigation in the realm of artificial intelligence in higher education also found that articles written by a single author exhibited the highest frequency (Maphosa and Maphosa, 2023). A total of 989 authors were involved in the study of ChatGPT in education, and the author network was constructed using VOSviewer software based on a collection of articles assembled in 2023. In this section, the minimum number of citations per author was set at 3, resulting in the identification of 14 authors who met this criterion (as shown in Figure 3).

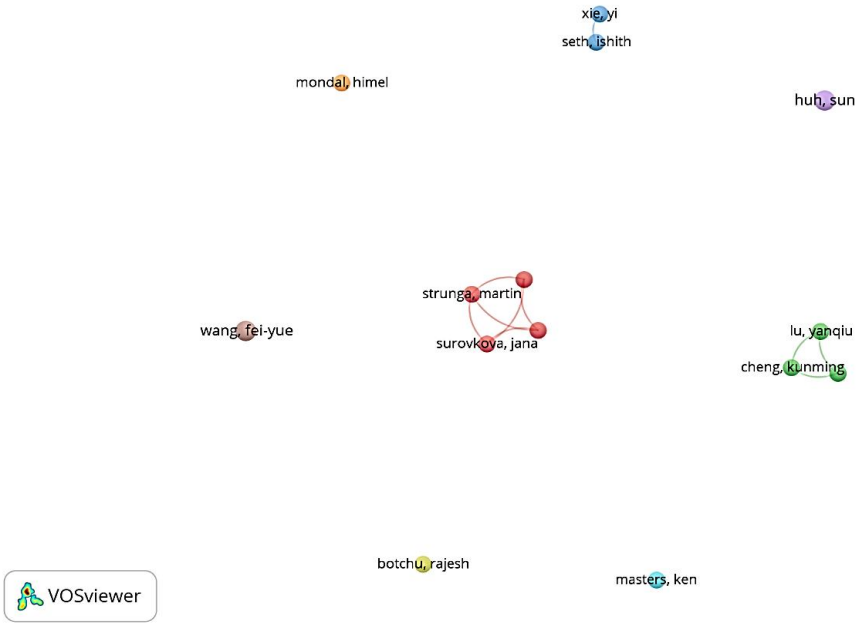

Figure 3: Co-network of Co-authored by the authors

Given the prevalence of single-author articles, the above figure was expected. The remarkable point in the cooperation clusters formed is the presence of a colleague at the university. In the red cluster, four researchers were from Comenius University, Bratislava, Slovakia. Slovakia is one of the most active countries in Eastern Europe in the field of artificial intelligence, so we can already expect this result.

Top countries and institutions

As shown in Table 3, the United States published the most documents in this field, totaling 95. Following closely were England and China, each contributing 31 papers. Figure 5 depicts the map of collaboration among the most productive countries. The size of the graph's nodes corresponds to the number of documents published by each country. The edges of the graph denote co-authorship connections, while the node colors indicate unique node clusters. The VOS algorithm (van Eck & Waltman, 2007) was used to cluster the data, which relies on co-citation data to identify these clusters. The presence of three clusters can be partially attributed to geographical distribution. Cluster one comprises European countries and one Asian country, including England, Germany, Switzerland, Italy, and India. Cluster two is more diverse, with a country from Oceania and one from Asia, namely the United Arab Emirates and Australia. The third cluster includes the United States, China, and South Korea.

Table 3
Distribution of co-authored papers by the countries

Country	Documents	Citations	Total Link Strength
United States	95	225	53
England	31	158	33
Italy	17	106	13
China	31	93	28

Country	Documents	Citations	Total Link Strength
Australia	30	91	25
Germany	20	76	19
India	29	73	18
Switzerland	11	63	15
South Korea	10	30	4
United Arab Emirates	11	12	6

*Citations sort this table

As mentioned before, the United States has the most documents, with a total of 95. It also has the most citations, with 225. Following the United States are England and China, each with 31 documents. Australia and India are particularly notable, with 30 and 29, respectively. The information in the table is valuable for understanding the distribution of research documents and citations across countries. It can be used to compare the research production and effect of several countries in a given field or academic discipline. Researchers, governments, and institutions frequently use such data to assess the global research environment and identify areas for collaboration and potential research partnerships.

As anticipated, the study revealed that the United States has emerged as the foremost country in the field. This outcome is credited to the significant investments the United States has made in artificial intelligence in recent years, which have notably influenced the education sector. The United States has consistently performed exceptionally well in various related areas, including gamification in education (Swacha, 2021), e-learning (Das, 2021), Metaverse in education (Tlili et al., 2022), Flipped classroom in education (Yang et al., 2017), and artificial intelligence in higher education (Caldevilla-Domínguez, Martínez-Sala & Barrientos-Báez, 2021). Contrary to expectations, China did not achieve the ranking anticipated in this research, despite substantial investments in artificial intelligence, similar to those of the United States. In previous studies focusing on virtual reality in education and blockchain technology in higher education, China had claimed the top position (Rojas-Sánchez, Palos-Sánchez & Folgado-Fernández, 2023; Reis-Marques, Figueiredo & de Castro Neto, 2021). Another unexpected finding was Spain's ranking, given its extensive involvement in artificial intelligence. Spain, for instance, has excelled as the leading country in e-learning in higher education (Djeki, Bondiombouy & Alhassan, 2022).

Another interesting comparison, presented in the context of the outcomes in this section, is shown in Figure 4, which illustrates science production statistics across various countries. As of the 2024 ranking, the United States leads in scientific production, having been a pioneering force in this domain. A noteworthy observation is the shift in China's science ranking to second place, contrary to expectations of securing a higher position beyond the fourth spot, as the research suggested. England, ranked third globally in science, was expected to be among the leading nations in this study. Italy's unexpected third-place finish, despite being ranked eighth globally in scientific output, adds another intriguing dimension to the findings. Figure 3 further unveils an intriguing aspect-the position of Switzerland. Despite being 16th globally in production, it ranks 8th in this context. This revelation underscores the importance of investing in artificial intelligence in education within the country. A surprising and unexpected discovery highlighted in the table is the United Arab Emirates' position, reflecting the country's substantial

investment in artificial intelligence, particularly in the educational sector.

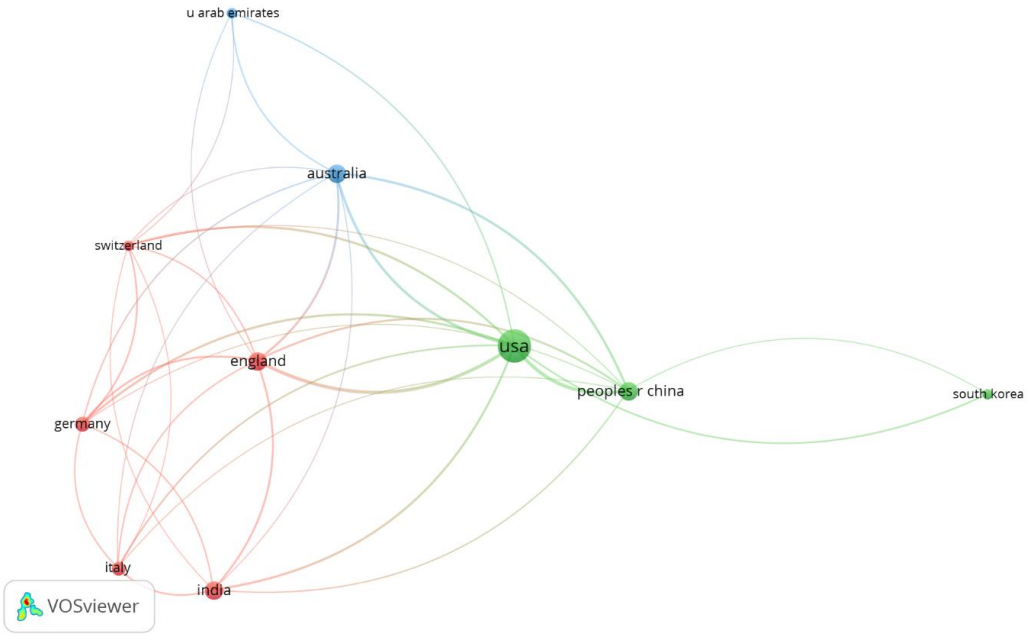

Figure 4: Network of co-authorship by the countries

China published the most documents in this field (593), followed by the United States (377), and Canada (82).

The significant feature of this illustration lies in the formation of a cooperative alliance among European nations (excluding India) within the red cluster—the predominant connections within this cluster trace back to England. The second cluster, denoted in blue, includes Australia and the United Arab Emirates. England and Australia have a well-established scientific partnership. Notably, the presence of the United Arab Emirates in this cluster and the connection between the United States of America and the United Arab Emirates is unexpected. This can be explained by the advancements in international relations in higher education and the exchange of professors to the United Arab Emirates.

In the third cluster, which is characterized by its green color, the grouping includes the United States, China, and South Korea. The anticipated association between China and the United States is attributed to their strong scientific collaborations. It is noteworthy that South Korea, another Asian country, is also part of this cluster, possibly influenced by the geographic proximity of China and South Korea. A notable observation is that the flow of scientific production does not originate directly in Europe and reach South Korea; instead, it passes through intermediaries such as the United States and China.

Table 4 lists the top ten most productive and influential institutions in this discipline. Out of a total of 569 organizations, only 10 organizations met the criterion of having a minimum of 4 citations to be retained. Due to China's population and scientific activity, Chinese institutions have published a large number of documents. Five Indian colleges are among the top ten most productive. On the other hand, Asia and Oceania institutions dominate the top-cited list. The most cited institution is the University of Hallym.

Table 4

Top institutions

Most prolific			Most impactful		
Institution	Country	Docs	Institution	Country	Citations
All India Institute of Medical Sciences	India	5	The University of Manchester	The United Kingdom	109
Monash University	Australia	5	Hallym University	South Korea	23
The University of Queensland	Australia	5	University of Wollongong	Australia	19
Hallym University	South Korea	4	Indiana University	US	13
University of Wollongong	Australia	4	All India Institute of Medical Sciences	India	10
Hospital for Special Surgery	US	4	Hospital for Special Surgery	US	10
Chinese Academy of Sciences	China	4	Monash University	Australia	10
The University of Hong Kong	Hong Kong	4	Chinese Academy of Sciences	China	8
The University of Queensland	Australia	4	The University of Hong Kong	Hong Kong	2
The University of Sydney	Australia	4	The University of Queensland	Australia	1

The outcomes of this section were surprising. Firstly, institutions from India were ranked at the top. Interestingly, a study in a related field found that gamification was most effective in institutional education in Taiwan (Martí-Parreño et al., 2016). But the other result was expected in the most impactful section, and Manchester University in the UK was ranked first. In the same field, these institutions have previously been recognized as leaders in distance education in the United Kingdom (Amoozegar, Khodabandelou & Ale Ebrahim, 2018). It is in second place among institutions from South Korea, which was unexpected. The fourth rank of an institution in the United States was far-fetched. Due to previous investments and studies, a higher rank was expected from this country In analogous research, U.S. institutions have consistently claimed the top spot, as seen in studies on technology and higher education (Rodríguez Jiménez, Sanz Prieto & Alonso García, 2019), e-learning (Djeki et al., 2022; Das, 2021), technology in higher education (Rodríguez Jiménez et al, 2019), and the flipped classroom in education (Yang et al, 2017). The information in the table helps determine the productivity and influence of various institutions in a given topic or research field. Understanding which institutions are actively producing and influencing research in a specific field can help academics, policymakers, and institutions drive cooperation and future research paths.

Top publication sources

Table 5 shows the bibliographic relationships among journals on ChatGPT in education. 9 publications were chosen after discovering at least four citations from a total of 184 journals. In fact, Table 5 lists the top 10 publication sources that have published the most publications in this particular field. Additionally, to evaluate these sources, we included their SJR and impact factor in the table. It's worth noting that Nature has the highest impact factor among them. Following that are the Journals of Public Health and Medical Teacher. In the sixth column, we offered the most commonly used terms to demonstrate the focus regions of various sources. Following is a brief review of the most influential papers from these journals based on the most frequently used keywords.

Table 5
Top sources

Sources	Docs	Citations	SJR	IF	Most used keywords
Nature	5	84	20.957	64.8	Computer science, Research management, Publishing, Machine learning, Communication, Scientific community, Information technology
The Cureus Journal of Medical Science	20	41	-	1.2	Artificial Intelligence, ChatGPT, Medical Education, , Machine Learning, Ethical Considerations
Annals of Biomedical Engineering	11	15	0.848	3.8	ChatGPT, Artificial Intelligence, Deep Learning, Natural Language Processing, Chabot
Sustainability	6	13	0.664	3.9	Education, Artificial Intelligence, ChatGPT, Safety Education, Sustainability
Aesthetic Plastic Surgery	4	7	-	0.3	ChatGPT; Artificial intelligence; Chatbot; Rhinoplasty, Breast reconstruction
Medical Teacher	5	7	1.217	4.7	Ethics; artificial intelligence; medical education; health professions education; ChatGPT
Journal of Chemical Education	6	4	0.555	3	Internet, General, First-Year Undergraduate, Web-Based Learning, Communication
Applied Sciences-Basel	4	2	-	2.838	ChatGPT, Artificial Intelligence, Educational Technology, Dentistry, Telemedicine
Journal of Public Health	5	2	1.187	4.4	Education, Artificial Intelligence, Advantages, Disadvantages, Ethical Use

Table 5 displays the most common keywords associated with the subject derived from the journals. Identifying and comprehending these critical research keywords is essential for facilitating efficient and effective scholarly communication, conducting literature reviews, and investigating field research. It is a fundamental phase in the research process as it enables them to navigate the extensive landscape of academic literature and make a meaningful contribution to their field. The following sections discuss the most significant keywords. It was expected that Nature would emerge as the primary journal in this domain. What is remarkable — and as predicted — is the considerable influence that artificial intelligence has exerted on the field of medicine, as reflected in medical journals in recent years. The engineering journal's third-place finish was also anticipated. Nevertheless, the unforeseen aspect is the heightened prominence of computer journals, evident in studies on E-learning (Djeki et al., 2022) and distance education (Amoozegar et al., 2018).

Artificial intelligence

Artificial intelligence (AI) has grown significantly and has become increasingly entrenched in the twenty-first century. There has been ongoing research into the precise nature of AI as a concept in this period of interdisciplinary study, which includes computer science, cybernetics, automation, mathematical logic, and linguistics. In fact, the exploration of artificial intelligence dates back to as early as the 1940s and 1950s, when researchers in the fields of mathematics, engineering, and computer science began delving into the prospects of creating artificial brains and sought to define the concept of machine intelligence. In 1950, Alan Turing established the renowned "Turing Test," which played a crucial role in shaping the idea of "Machine Intelligence." The roots of AI can be traced back to a workshop held at Dartmouth College in 1965, where John McCarthy urged participants to adopt the concept of "Artificial Intelligence." This marked the start of the initial "Golden Age" of AI (Liu et al., 2018). The growth of computing and information processing technology has led to the extensive application of artificial intelligence (AI) in education settings, often referred to as Artificial Intelligence in Education (AIED). This includes the development and use of intelligent tutoring systems, teaching robots, learning analytics dashboards, adaptive learning systems, and many other forms of human-computer interaction (Chen et al., 2021). Here are several of the most sophisticated keywords utilized in academic journals.

ChatGPT

ChatGPT is indeed a prominent example of a Large Language Model (LLM), capable of generating human-like text responses to user inquiries by drawing on vast datasets. It has piqued the interest of researchers across a wide range of fields, thanks to its remarkable proficiency in complex text-generation tasks such as document writing, code debugging, question answering, and knowledge acquisition. ChatGPT recently completed professional tests for law, business, and medical licenses by answering prepared questions. This breakthrough has ignited people’s interest. Some people believe that ChatGPT will increase human creativity and productivity, while others are concerned about its potential impact on the labor market. This debate highlights the need to reconsider the relationship between humans and AI in our rapidly changing society (Wang, Anwer, Dai & Liu, 2023). In the dynamic field of online education, AI has emerged as a significant game-changer. Tools such as ChatGPT have brought about major transformations across areas ranging from assessment development to language acquisition. AI is used by many

e-learning platforms, including Coursera, to detect common assignment errors (Steenbergen-Hu & Cooper, 2014). AI chatbots can enhance students' text comprehension by offering tailored questions and feedback on their answers. The tool can also be used to enhance an individual's critical thinking and analytical abilities. Another crucial element of ChatGPT is that it enables students to modify sentences, practice accurate pronunciation and terminologies, understand sentence structure, and provide real-time interpretations (Zhai, 2022).

Chatbot

Chatbots play a crucial role in enhancing interpersonal communication and supporting education. They provide a wide range of knowledge and expertise through interactive approaches and user-friendly interfaces, and can even be used for one-on-one consultations (Muniasamy & Alasiry, 2020; Poncette, Rojas, Hofferbert, Sosa, Balzer & Braune, 2020). Lately, chatbots have been widely used in education. Chatbots have become more popular in e-learning platforms to enhance student learning (D'Aniello, Gaeta, Gaeta, & Tomasiello, 2018). Chatbot technology is one of the most crucial tools for e-learning as it effectively bridges the gap between technology and education. The use of chatbots provides students with an interactive learning environment, similar to one-on-one teacher interactions (Clarizia, Colace, Lombardi, Pascal, & Santaniello, 2018).

Education

Education is a necessary and rigorous process of transmitting knowledge, values, attitudes, abilities, and senses that lead to learning acquisition (Westerhoff, 1987).

Natural language processing

Natural Language Generation (NLG) systems are computer programs that generate text in various human languages, including English, typically based on non-linguistic input data. These programs, like many AI systems, require vast amounts of data that are challenging to acquire. Overall, these challenges arose from the complexity and novelty of the tasks computers performed and were exacerbated by the variability of human writing (Reiter, Sripada & Robertson, 2003). NLP uses natural language processing to develop effective techniques for bringing about change in educational settings. The focus of NLP is to create educational software and practices that support the use of natural language in education, including tools such as e-rater and Text Adaptor. Software systems equipped with NLP can identify language-learning processes in natural contexts (Alhawiti, 2014).

Machine learning

Artificial intelligence (AI) includes a subset known as machine learning. Fundamentally, it involves providing a machine or model with access to data and allowing it to learn autonomously. In 1959, Samuel suggested that computers could acquire knowledge on their own, without any explicit programming. The phrase "machine learning" was coined by him and has since become the standard definition of computers' self-directed learning.

Machine learning (ML) is profoundly revolutionizing teaching, learning, and research in education. Educators are using machine learning (ML) to detect early signs of academic struggles in students and take action to improve retention and student success. Researchers are using machine learning to accelerate their investigations and uncover new discoveries and

insights. Machine learning is amplifying the scope and influence of online learning materials through localization, transcription, text-to-speech, and personalization (Kučak, Juričić & Đambić, 2018).

Must-read papers

The number of citations is regarded as an effective metric for determining the significance of a research work (Singh, Uddin & Pinto, 2015). In this section, we will examine papers with high citation rates. Additionally, we will compile current review articles and offer suggestions for potential research areas. Table 6 presents the ten papers with the most citations. Surprisingly, more than half of these articles have been published in medical journals, demonstrating the importance of this topic in the medical world.

Table 6
Top ten cited papers

Title	Citation	Authors	Document Type	Source
ChatGPT: five priorities for research	79	Bockting CL; van Dis EAM; Bollen J; van Rooij R; Zuidema W	Editorial Material	Nature
Open artificial intelligence platforms in nursing education: Tools for academic progress or abuse?	69	O'Connor S	Editorial Material	Nurse Education in Practice
"So, what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges, and implications of generative conversational AI for research, practice, and policy	40	Dwivedi YK; Kshetri N; Hughes L; Slade EL; Jeyaraj A; Kar AK; Baabdullah AM; Koohang A; Raghavan V; Ahuja M; Albanna H; Albashrawi MA; Al-Busaidi AS; Balakrishnan J; Barlette Y; Basu S; Bose I; Brooks L; Buhalis D; Carter L; Chowdhury S; Crick T; Cunningham SW; Davies GH; Davison RM; De RH; Dennehy D; Duan YQ; Dubey R; Dwivedi R; Edwards JS; Flavian C; Gauld R; Grover V; Hu MC; Janssen M; Jones P; Junglas I; Khorana S; Kraus S; Larsen KR; Latreille P; Laumer S; Malik FT; Mardani A; Mariani M; Mithas S; Mogaji E; Nord JH; O'Connor S; Okumus F; Pagani M; Pandey N; Papagiannidis S; Pappas IO; Pathak N; Pries-Heje J; Raman R; Rana NP; Rehm SV; Ribeiro-Navarrete S; Richter A; Rowe F; Sarker S; Stahl BC; Tiwari MK; Aalst WV; Venkatesh V; Viglia	Article	International Journal of Information Management

Title	Citation	Authors	Document Type	Source
		G; Wade M; Walton P; Wirtz J; Wright R		
Can artificial intelligence help for scientific writing?	31	Salvagno M; Taccone FS; Gerli AG	Article	Critical Care
ChatGPT Utility in Healthcare Education, Research, and Practice: Systematic Review on the Promising Perspectives and Valid Concerns	23	Sallam M	Review	Healthcare
ChatGPT for good? On opportunities and challenges of large language models for education	23	Kasneci E; Sessler K; Kuchemann S; Bannert M; Dementieva D; Fischer F; Gasser U; Groh G; Gunnemann S; Hullermeier E; Krusche S; Kutyniok G; Michaeli T; Nerdel C; Pfeffer J; Poquet O; Sailer M; Schmidt A; Seidel T; Stadler M; Weller J; Kuhn J; Kasneci G	Editorial Material	Learning and Individual Differences
Artificial Hallucinations in ChatGPT: Implications in Scientific Writing	21	Alkaissi H; McFarlane SI	Article	Cureus Journal of Medical Science
Evaluating the Feasibility of ChatGPT in Healthcare: An Analysis of Multiple Clinical and Research Scenarios	19	Cascella M; Montomoli J; Bellini V; Bignami E	Article	Journal of Medical Systems
Are ChatGPT's knowledge and interpretive abilities comparable to those of medical students in Korea when taking a parasitology examination? a descriptive study	18	Huh S	Article	Journal of Educational Evaluation for Health Professions
Chatting and cheating: Ensuring academic integrity in the era of ChatGPT	15	Cotton DRE; Cotton PA; Shipway JR	Article: Early access	Innovations In Education and Teaching International

The most impactful article has been "ChatGPT: Five Priorities for Research." This article

has an Impact Factor (IF) of 64.8 and was published in the journal Nature. Van Dis et al. (2023) listed five advantages of ChatGPT for research in this work. These five benefits are as follows: (1) Hold on to human verification; (2) Develop rules for accountability; (3) Invest in truly open LLMs; (4) Adopt Artificial Intelligence Benefits; and (5) Widen the debate.

O'Connor (2023) delves into the effects of artificial intelligence on nursing education, examining its advantages and challenges. Some of these benefits include personalizing learning, answering questions, assisting with activities, and comprehending complex topics. The author argues that significant obstacles must be overcome to integrate artificial intelligence into nursing education. Scientific misconduct, failure to name sources in responses to queries, a decline in assessment quality, and other issues are among these concerns. In their study, Dwivedi et al. (2023) address the advantages, disadvantages, and implications of adopting ChatGPT. The authors examined the opportunities and challenges posed by ChatGPT through an interdisciplinary approach involving 43 specialists. According to experts, there is broad agreement that ChatGPT increases productivity and provides considerable benefits. However, ethical concerns must be addressed. Furthermore, the authors underline three crucial areas for managing artificial intelligence: transparency, ethics, and organizational and social changes.

Salvagno, Taccone & Gerli (2023) investigated whether artificial intelligence can help with scientific writing. They found that ChatGPT is a highly beneficial writing tool that can help researchers in a variety of subjects. Their research innovation lies in the emphasis that no publications in the field of specialized medical care have used this approach. Nonetheless, they expect more publications in this field in the future. Sallam (2023) carried out a systematic review of the prospective applications of ChatGPT in education, research, and special care. They examined 60 studies in this review and concluded that ChatGPT will transform educational, research, and special care practices. In addition, it is essential to exercise caution when implementing ChatGPT due to its issues with acceptability. They also recommended establishing an ethical code to guide the use of ChatGPT in healthcare. Kasneci et al. (2023) examined the opportunities and challenges of large language models in education. They investigated educators' and students' viewpoints. They stated that by emphasizing the most critical opportunities, these language models drive educators and learners to build a set of competencies and the necessary literacy skills.

Furthermore, a clear plan, with a critical attitude, is required to assess the facts of integrating and using language models in education. If obstacles are addressed in a reasonable and responsible manner, educational opportunities can be expanded. Alkaissi and McFarlane (2023) investigated the effects of artificial intelligence illusions in scientific writing. This study presents two medical scenarios and evaluates the chatbot's performance in generating content for these situations. The study examines both the positive and negative aspects of ChatGPT's performance in academic writing. They suggest that although ChatGPT is capable of producing scientific content, the data it generates is a combination of factual and fictitious information. This blend of truth and fiction raises concerns about the reliability and accuracy of utilizing AI models for academic writing, especially in fields like medicine.

Cascella, Montomoli, Bellini, and Bignami (2023) investigated the viability of ChatGPT in healthcare. They emphasized the advantages and disadvantages of adopting ChatGPT. While acknowledging ChatGPT's enormous impact in education, they feel its benefits in real-world settings remain unknown, especially in fields like medicine, where a higher level of critical thinking is required. It is essential to promote the appropriate use of ChatGPT, educate users

on its use, and address its issues effectively in the medical field. Huh (2023) conducted a comparative study to assess ChatGPT's cognitive capacity and interpretive ability in parasitology examinations for Korean medical students. Huh claimed that ChatGPT performed worse than medical students and that its accuracy did not correlate with the level of the topics in question. Although it provided some general explanations, it performed worse than the students as a whole. Cotton, Cotton, and Shipway (2023) explored academic dishonesty and ChatGPT's impact on education. They discussed the advantages of ChatGPT in education and concerns regarding academic integrity. They suggested strategies for universities to appropriately use ChatGPT, including adopting processes and policies and providing appropriate training and assistance. They also offered several methods for identifying and preventing cheating. Overall, they concluded that these concerns could be effectively mitigated by implementing proactive, ethical practices.

Keyword analysis

We analyzed the most commonly used terms between 2020 and 2021. Figure 5 displays word clouds depicting these timeframes. Texts are visually summarized using word clouds (Heimerl, Lohmann, Lange & Ertl, 2014). The size of the terms in the word clouds corresponds to how often they appear during the relevant time period. ChatGPT, artificial intelligence, chatbot, education, medical, and learning are all terms used to describe ChatGPT.

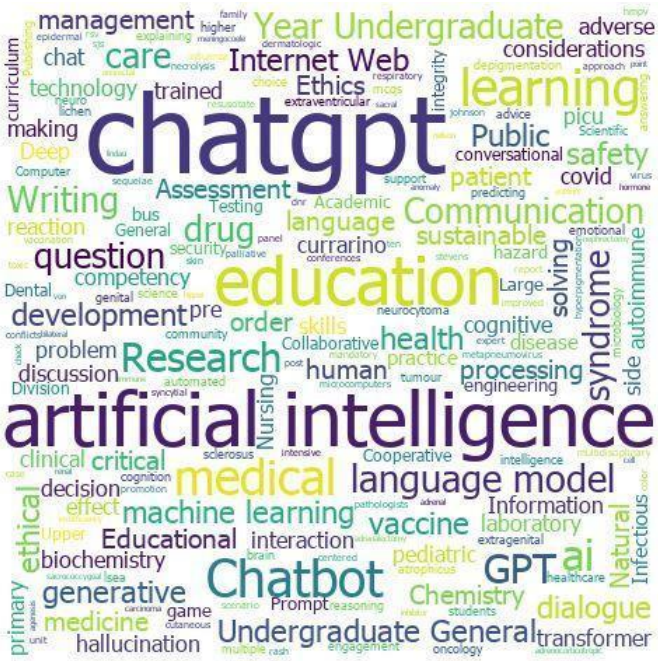

Figure 5: Word clouds of the keywords used in the research papers (http://rank.sid.ir/cloud)

Discussion

The integration of ChatGPT technology into educational settings has sparked extensive debate among academics, marking a significant shift in the educational landscape. In this study, the researchers conducted a bibliometric review of ChatGPT research in Education from 2022 to 2023, capturing the evolution of this technology in the educational domain. What distinguishes this work is the pioneering use of bibliometric analysis in this specific field, a

methodology that can provide valuable insights into the emerging trends and key players. One of the primary goals of this research is to offer a dual perspective by combining quantitative and qualitative analyses of research trends in the application of ChatGPT in education. This comprehensive approach encompasses a wide range of facets, including research highlights, prevalent thematic categories, influential researchers, affiliated institutions, seminal papers, distinguished journals, and emerging topics. The identification of predominant subject categories, such as education and educational research, engineering, and computer science, sheds light on the field's interdisciplinary nature and its potential to bridge various academic domains. Furthermore, the geographical distribution of research output underscores the global reach of this technology, with the United States, England, and China leading the way in terms of contributions.

The outcomes from the segment on nations are consistent with research on artificial intelligence in education. For example, in investigations conducted by Baek and Doleck (2020), Song and Wang (2020), Akhmadieva, Udina, Kosheleva, Zhdanov, Timofeeva, and Budkevich (2023), Fatimah, Sarwi, and Haryani (2024), and Moreno-Guerrero, López-Belmonte, Marín-Marín, and Soler-Costa (2020), the United States of America consistently emerged as the primary country. Intriguingly, our study contradicts these conclusions, as different nations claimed the highest ranking in relation to artificial intelligence in education. Hinojo-Lucena, Aznar-Díaz, Cáceres-Rech, and Romero-Rodríguez (2019) pinpointed Australia and Canada as the leading nations, while Maphosa and Maphosa (2023), López-Chila, Llerena-Izquierdo, Sumba-Nacipucha, and Cueva-Estrada (2023), and Romero-Carazas et al. (2023) determined that China held the foremost position. According to an investigation by Bicen, Bogdan, and Petruc (2023), Germany ranked first, followed by India.

Australia's prominence as the most prolific institution in this field is a noteworthy finding, as it suggests a concentrated effort in this region towards exploring ChatGPT's potential in education. Additionally, the United States, being home to the most influential institution, signifies its central role in shaping the discourse on ChatGPT in education. Results from similar research in the field of artificial intelligence in education support the findings presented in this section. Taking Fatimah et al. (2024) as an example, the leading institution was initially in the United States of America and later in Italy. It is worth noting that some studies contradicted the results of this section. For instance, in the survey by Hinojo-Lucena et al. (2019), the top organization was located in Spain. Perhaps even more surprising, in a study on artificial intelligence in education (Romero-Carazas et al., 2023), the best-performing institution was in Bahrain. Another research (Moreno-Guerrero et al., 2020) ranked the top institution in England. In this segment, the research results align with Manchester University's top position in England.

The active involvement of reputable publications such as Nature, the Journal of Public Health, and Medical Teacher underscores the importance of this research domain and its capacity to influence not only the educational field but also the wider academic community. The outcomes of this study differ notably from those of research in artificial intelligence in education, mainly because the selected journals are medical-focused. A noteworthy development is the growing interest in using ChatGPT in medical education, a trend that has gained traction in recent years. ChatGPT can serve as a valuable aid in medical education, research, and clinical administration. Nevertheless, it should not be viewed as a substitute for human expertise and understanding, given AI's inherent limitations. Despite these constraints, there is a notable advancement in information technology, machine learning, and AI, suggesting

a rapid transformation in how we approach medical education and clinical management. Embracing these changes with an open mind is essential for leveraging their potential to enhance medical education and clinical administration (Khan, Jawaid, Khan & Sajjad, 2023). Certainly, ChatGPT presents both opportunities and challenges in education, much like any other phenomenon. The various opportunities and challenges arising from ChatGPT in the field of education (Kasneci et al, 2023; AlAfnan, Dishari, Jovic & Lomidze, 2023; Rahman & Watanobe, 2023; Islam & Islam, 2023; Qureshi, 2023; Baidoo-Anu & Owusu Ansah, 2023; Kılınç, 2023; Bahrini et al, 2023; Javaid, Haleem, Singh, Khan & Khan, 2023; Sok & Heng, 2023). In contrast, this research found that journals from various fields were most influential in education. For example, in the study by Hwang and Tu (2021), the top journal in educational technology was identified; in studies by Romero-Carazas et al. (2023), López-Chila et al. (2023), and Akhmadieva et al. (2023), the best computer science journal was highlighted. In the research by Moreno-Guerrero et al. (2020), the top education journal was identified.

In this research, the primary author was affiliated with the University of Manchester, England. Following closely were researchers from the University of Amsterdam in the Netherlands. These findings align with a prior study by Fitriani, Rosidah, and Zafrullah (2023), in which the lead author in the field of artificial intelligence in education was affiliated with the University of Sussex, England. Similarly, a corroborating result was found in the research by Moreno-Guerrero et al. (2020), indicating that the field's foremost author in artificial intelligence in education hailed from England. Simultaneously, there are studies with results that contradict this research's findings. In the study by Hwang and Tu (2021), the top researcher, with 30 citations, was from the United States of America. In the research by Hinojo-Lucena et al. (2019) and Bicen et al. (2023), the most accomplished researcher was from Spain. Baek and Doleck's study (2020) identified the top author as from New Zealand, while Romero-Carazas et al. (2023) found the leading author to be from China. However, a shocking discovery emerged in a study that found a researcher at a university in South Africa had been trained by six top researchers in the field of artificial intelligence (López-Chila et al., 2023).

In this research, the most prevalent document type was "Article," with 191 instances. However, review articles garnered more citations, totaling 27. The conclusions drawn in this section align with the outcomes of Baek and Doleck's 2020 research on artificial intelligence in education. Interestingly, these results differ from those of the 2020 study by Moreno-Guerrero et al., in which the most abundant document type was "Proceedings Paper." The key terms identified in this research comprise: Artificial Intelligence, ChatGPT, Chatbot, Education, Natural Language Processing, and Machine Learning. The results in this section align closely with those of studies conducted in artificial intelligence in education. For instance, in the survey by López-Chila et al. (2023), the prominent keywords were artificial intelligence, higher education, machine learning, GPT chat, and education. Similarly, the study by Bicen et al. (2023) yielded related keywords such as AI, Artificial Intelligence, Education, and Machine Learning.

Conclusion

Overall, this bibliometric review offers a comprehensive understanding of the evolving landscape of ChatGPT in education and its implications for future research and practice. It is essential to recognize that ChatGPT's integration into education has brought about a transformative shift, sparking debates and discussions within the academic community. This

article provides a pioneering bibliometric review of research conducted on ChatGPT in Education from 2022 to 2023, marking a significant milestone in the field's scholarly exploration. The study's primary aim is to provide a comprehensive analysis of research trends, both in quantity and quality, related to the application of ChatGPT in education.

This study's inclusive approach covers a wide array of aspects, including research highlights, prevalent thematic categories, notable researchers, affiliated institutions, influential papers, prominent journals, and emerging topics. It is particularly noteworthy that the analysis reveals the interdisciplinary nature of this field, with predominant subject categories spanning education and educational research, engineering, and computer science. Furthermore, the geographical distribution of research output underscores the global nature of this technology's adoption, with the United States, England, and China leading the way in research contributions. Australia's prominence as the most prolific institution in this field indicates a concentrated effort in exploring the potential of ChatGPT in education. At the same time, the United States is identified as the home of the most influential institution, underlining its central role in shaping the discourse in this area. The active contributions of leading journals such as Nature, Journal of Public Health, and Medical Teacher underscore the significance of this research domain and its potential to influence not only education but also broader academic discourse. Overall, this bibliometric review offers a comprehensive overview of the evolving landscape of ChatGPT in education, providing valuable insights for researchers, educators, and policymakers as they navigate the future of educational technology.

In recent years, the use of ChatGPT technology in educational settings has sparked extensive debate within the academic community. This study takes a pioneering step by conducting a bibliometric review of research conducted on ChatGPT in Education from 2022 to 2023. This period encompasses the technology's inception to the present day. This approach represents a novel way to explore ChatGPT's dynamics in the educational field. The central objective of this research is to conduct a comprehensive analysis of research trends on the application of ChatGPT in education. The study spans a broad spectrum of elements, including research highlights, thematic categories, prominent researchers, affiliated institutions, influential papers, noteworthy journals, and emerging topics. The analysis reveals the field's interdisciplinarity, with education and educational research, engineering, and computer science as predominant subject areas. Moreover, the geographical distribution of research output highlights the contributions from the United States, England, and China, underlining the global significance of this technology. Australia's position as the most prolific institution in this area underscores its active exploration of ChatGPT's potential in education. At the same time, the United States emerges as the hub of the most influential institutions, underscoring its pivotal role in shaping the discourse surrounding ChatGPT in education. The active involvement of renowned journals such as Nature, Journal of Public Health, and Medical Teacher underscores the importance of this research domain and its capacity to influence both educational practices and broader academic conversations. In conclusion, this bibliometric review offers a comprehensive and pioneering exploration of ChatGPT in education, providing valuable insights for researchers, educators, and policymakers as they navigate the field of educational technology.

At the conclusion, implementation recommendations are provided based on the research findings. Given the significance of the ChatGPT domain in education and the increasing prevalence of artificial intelligence in the educational realm, it is advisable to enhance schools'

and universities' infrastructure for AI use. This will ensure that the educational system remains aligned with technological advancements. Given the research excellence of European scholars in this domain, it is proposed to establish an international research network, particularly with European countries, to advance this field. Additionally, recognizing India as the most productive institute and highlighting the country's investments in artificial intelligence in education, it is recommended that scientific exchanges be facilitated. Drawing on India's experience can be particularly valuable for countries at a similar developmental stage, such as Iran, seeking to leverage artificial intelligence effectively in education.

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