Chatbots in education in Web of Science from 2016 to 2023: A bibliometric analysis

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Abstract: Despite the surge of publication of chatbots in the recent years in the field of education, we have little to know how this area has been researched so far, and the metrics of this type of research is still not known. To address such gap, this article offers a descriptive bibliometric study of chatbot research in education, aiming at presenting bibliometric analysis on articles on chatbots in education that were published in journals indexed in the Web of Science (WOS) database specifically Social Science Citation Index (SSCI) and Science Citation Index Expanded (SCIE) between 2016 and 2023. Descriptive bibliometric analysis was used to examine the data gathered from the chosen publications. including the annual number of articles and citations, the most productive author, countries with the highest publication output, productive affiliations, funding organizations, and publication sources. The bulk of the articles on chatbots in education, according to our dataset, were published between 2016 and 2023. The United States of America tops the list of countries regarding research productivity. The United Kingdom and China were ranked as most second and third productive countries, in terms of publication outputs. "Luke Kutszik Fryer emerged as the most productive author in this research domain in terms of the number of publications." The University of Hong Kong had the highest number of publications among affiliations, indicating their significant contribution to the field. Additionally, the journal "Computers in Human Behavior" stood out with the highest number of publications per year, highlighting its relevance in publishing research on chatbots in education. This research offers valuable insights and a roadmap for prospective researchers, pinpointing critical areas where success can be attained in the study of chatbots in education.

Keywords: chatbots; artificial intelligence; education; bibliometric analysis

1. Introduction

The use of chatbots in education has gained significant attention in recent years. They can be integrated into various educational settings to provide personalized learning experiences, support student engagement, and offer immediate feedback (Johnson, 2018).

Chatbots offer several potential benefits in the field of education. Firstly, they can provide personalized learning experiences by adapting to individual students' needs and preferences. Students' responses can be analyzed by chatbots, which can then modify their interactions to meet particular learning goals. This personalized approach can enhance students' engagement and motivation (Eduvos and Abejide, 2021; Smith and Brown, 2020). Additionally, chatbots can support students in their learning journey by offering additional resources and guidance. Moreover, chatbots have been shown to significantly enhance students' speaking and listening skills

(Anderson and Johnson, 2020; Lee and Park, 2019).

In addition to personalized learning and administrative support, chatbots can facilitate collaborative learning experiences. By integrating chatbots into online discussion forums or group projects, students can engage in interactive conversations with the chatbot and their peers. This interaction can foster critical thinking, problem-solving, and communication skills as students collaborate to solve complex problems or discuss course-related topics (Pradana and Syarifuddin, 2023; Sung et al., 2019).

Additionally, by customizing their learning to each student's requirements and tastes, chatbots may offer them a tailored educational experience. They can provide specialized information, tools, and direction, encouraging self-directed learning (Lee and Kim, 2019; Liaw and Chen, 2017; Li and Chen, 2017). Furthermore, chatbots can assist educators in automating routine administrative tasks, such as answering frequently asked questions, grading assignments, and providing timely reminders. This automation allows teachers to focus more on instructional activities and personalized interactions with students (Johnson, 2020; Li and Chen, 2017; Vaidya and Joshi, 2018).

Although there are a number of survey reviews on chatbots, they rarely give a general and descriptive overview of the direction of research, especially with the increase in technology in recent years. For example, Smith et al. (2018) investigated the use of chatbots in education through a comprehensive systematic review. The study examined the existing literature on the subject, analyzing the growth and trends in research related to chatbots in education. Similarly, Lin and Yu (2023) conducted a review of the existing literature on AI chatbots by presenting an expanded framework to facilitate the application of AI chatbots in education and finding out the challenges and factors influencing the effectiveness and acceptance of chatbots in education.

Despite recognizing the potential benefits of integrating chatbots into education, there is a significant research gap regarding research trends related to chatbots in education (Lin and Yu, 2023; Liaw and Chen, 2017; Wang and Liu, 2017). Consequently, there is a crucial need for comprehensive research that explores the broader implications of chatbots in education and provides an overview of research trends, authors, producing countries, and publication sources. This will contribute to a better understanding of their potential and applicability in diverse educational settings. In light of this identified research gap, future research can focus on exploring the broader potential of integrating chatbots into various educational contexts. This may include studying the impact of chatbots on learning outcomes, student engagement, and teacher effectiveness in utilizing them (Bii and Too, 2022). Future research can also investigate the development of chatbot applications specifically designed for educational purposes, including the possibility of adapting and customizing them to individual student needs (Hobert and Solvie, 2020). These potential research areas will help provide valuable insights into how to maximize the benefits of using chatbots to enhance the educational experience and outcomes (Biswas and Bose, 2019).

Therefore, the objective of this comprehensive study is to analyze the current research landscape of chatbots in education through the application of bibliometric analysis. Bibliometric analysis is a statistical method used to quantify and assess trends in a specific field, and in this case, it will be employed to examine publications related to chatbots in education. The chosen time frame for this study, covering the period

from 2016 to 2023, is of particular significance due to the substantial increase in research on chatbots observed after 2016 (Liu and Duffy, 2023).

To achieve this aim, the researchers conducted a search of relevant database in Web of Science (WOS). Furthermore, a wide range of prestigious journals and chatbot resources were included in this research data. With the use of this data, we were able to track changes in the research interests about chatbots over time. We set out to address the following research questions only:

How has the distribution of chatbots in educational publications evolved between 2016 and 2023, and what are the most productive contributors, counties, and sources of publication in this domain?

2. Research methodology

Applying a bibliometric analysis approach, this study identified the characteristics of the research on chatbots in education carried out between 2016 and 2023. Tracking research on a particular subject and presenting the findings through various distinctive analyses of these studies forms the basis of bibliometric analysis. With the exception of conferences and proceedings, pertinent publications from the Web of Science database specifically in the major indexes (SSCI and SCIE) were incorporated into the analysis to get high-quality articles.

3. Data collection and analysis

Several criteria were taken into consideration in selecting the studies for analysis in this study. The first criterion involved including only articles in the current study, while excluding other types such as book chapters, editorials, and articles without abstracts. Conference presentations (papers) were also not included in the research. This decision was made because conference presentations can vary significantly in terms of quality, and often, qualified presentations are later published as journal articles (Hallinger and Chatpinyakoop, 2019).

The year 2016 was chosen as the starting point for the scan because there was a significant increase in the number of studies on chatbots in education during that year. A study by Hwang and Chang (2021) confirmed a notable rise in research related to chatbots in education starting from 2016, unlike previous years where the research in this area was very limited.

The scan that was carried out on 18 December 2023, we proposed conducting a search using the search string "chatbot" or "conversational agent" or "virtual assistant" or "ai chatbot" or "machine learning chatbot" or "intelligent chatbot" or "text-based chatbot" or "voice-based chatbot" or "chatbot development" or "chatbot applications" or "chatbot frameworks" or "chatbot platforms" or "chatbot design" or "chatbot user experience" or "chatbot integration" or "chatbot deployment" or "chatbot evaluation" or "chatbot performance" According to their relevance to our research questions, we evaluated the extracted articles using the inclusion and exclusion criteria provided in **Table 1**.

Table 1. The criteria for inclusion and exclusion in data screening.

Inclusion criteria	• Articles published in reputed international journals (indexed) by WOS. • Articles in English • Year of publication between 2016 and 2023 • Articles in Education
Exclusion criteria	• Conference papers, proceedings papers, and nonindexed publications. • Published in international non-WOS journals. • Published before 2019

Several filters were applied to determine the scope of the study. The year 2016 was set as the starting point of the scan, and the end year was set as 2023. The initial scan yielded 5100 scientific publications. The first filtering step, which involved specifying the start and end years (2016–2023), resulted in 4483 scientific records. In the second step, only articles from scientific publications were selected, excluding conference papers, book chapters, and articles without abstracts. This narrowed down the number of scientific publications to 2142. Then, language selection was applied, and only English-language publications were chosen, resulting in a set of 2102 articles for review. A further scan was conducted by selecting high-quality SSCI & ESSCI publications, and the number of articles for review was set at 1524. Finally, additional filtering was performed by selecting the categories "education and educational research" and "education scientific disciplines," which reduced the number of scientific publications to 263. **Figure 1** depicts the analytic research framework.
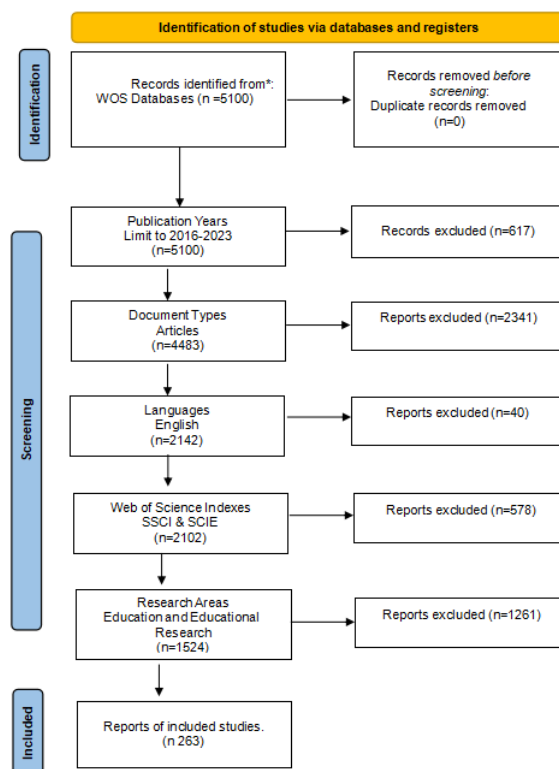

Figure 1. Study's analytical framework.

4. Findings

The purpose of the study is to identify the profile of conversations in education

from 2016 to 2023. The research questions guided the discussion of this review's results.

4.1. Research question 1

How will chatbots be distributed in educational publications between 2016 and 2023? In order to address the first question, the publication years of the published documents between 2016 and 2023 were analyzed. Our findings indicate that the number of publications on chatbot research in education has steadily increased over the years. In 2016, only three publications were found in this area. The number of publications then increased to nine in 2017, indicating a growing interest in chatbot research in education.

In 2018, the number of publications further increased to 11, reflecting a continuous upward trend. The subsequent years witnessed a significant rise in the number of publications. In 2019, the number of publications more than doubled to 16, indicating a substantial increase in research activity in this field.

The year 2020 marked a significant milestone in chatbot research in education, with the number of publications reaching 26. This was a considerable increase compared to the previous years, suggesting a growing recognition of the potential of chatbots in educational settings.

The trend continued to rise in 2021, with the number of publications reaching 51. This substantial increase indicates a growing interest and investment in chatbot research in education. The year 2022 witnessed a further surge in research activity, with 63 publications on chatbot research in education.

The most recent data available for this analysis is from 2023, when the number of publications reached 84. This is the highest number of publications recorded during the analyzed period, indicating a continued upward trend in chatbot research in education.

The upward trend observed in the number of publications indicates that chatbot research in education is an active and evolving field. Researchers are increasingly exploring the use of chatbots to enhance teaching and learning experiences, improve student engagement and support, and address various educational challenges. The cumulative growth of publications from 2016 to 2023 can be visualized in **Figure 2**.
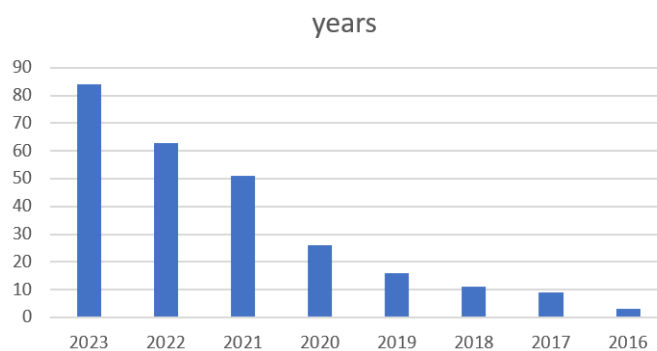

Figure 2. Distribution of publications by years (2016–2023).

4.2. Research question 2

Which authors and sources of publications are most pertinent to chatbot and

education research? A bibliometric analysis was conducted to examine the research output and impact of chatbots in education in various academic journals. The analysis focused on the number of articles published, total citations received, citations per research, and the publishers of these journals. The outcomes are shown in **Table 2** below.

Table 2. The top 10 highly productive journals on chat bot in the years (2016–2023).

Journal	Number of articles	Number of citations	Number of citations per research	Publisher
Computers in Human Behavior	40	341	42.5	Pergamon-Elsevier Science Ltd
Education and Information Technologies	19	18	2.25	Springer
Frontiers in Psychology	19	67	8.375	Frontiers Media Sa
International Journal of Human Computer Studies	16	156	19.5	Academic Press Ltd- Elsevier Science Ltd
Psychology Marketing	13	53	6.625	Wiley
Cyberpsychology Behavior and Social Networking	7	136	17	Mary Ann Liebert
Interactive Learning Environments	7	14	1.75	Routledge Journals, Taylor & Francis Ltd
British Journal of Educational Technology	6	38	4.75	Wiley
Computers Education	6	35	6.625	Pergamon-Elsevier Science Ltd
Educational Technology and Society	6	41	5.12	Int Forum Educational Technology & Soc, Natl Taiwan Normal Univ

The analysis revealed that the journal with the highest number of articles on chatbots in education was Computers in Human Behavior, with a total of 40 articles. This journal also had the highest number of citations, with a total of 341 citations, resulting in an average of 42.5 citations per research article.

On the other hand, Education and Information Technologies had the lowest number of articles (19) and the lowest number of citations (18), resulting in an average of 2.25 citations per research article.

Frontiers in Psychology and International Journal of Human Computer Studies also had a significant number of articles (19 and 16, respectively) and received a considerable number of citations (67 and 156, respectively). These journals had average citations per article of 8.375 and 19.5, respectively.

Psychology Marketing, Cyberpsychology, Behavior, and Social Networking, and Computers & Education were other notable journals in terms of the number of articles and citations received. Psychology Marketing had 13 articles and 53 citations, resulting in an average of 6.625 citations per research article. Cyberpsychology, Behavior, and Social Networking had 7 articles and 136 citations, with an average of 17 citations per research article. Computers & Education had 6 articles and 35 citations, with an average of 6.625 citations per research article.

Interactive Learning Environments, British Journal of Educational Technology, and Educational Technology & Society had a relatively lower number of articles and citations. Interactive Learning Environments had 7 articles and 14 citations, resulting in an average of 1.75 citations per research article. The British Journal of Educational Technology had 6 articles and 38 citations, with an average of 4.75 citations per

research article. Educational Technology & Society had 6 articles and 41 citations, with an average of 5.12 citations per research article.

Table 3 provides a summary of authors in the field of chatbots in education research. According to the WOS database, the most productive author was Ben Luke Kutszik Fryer from China, who had his first publication in this area in 2006. he had a total of 47 publications and 1041 citations. The second most productive author was Jaeho Jeon from the United States, with a total of 12 publications and 83 citations. Following Jeon is Lee, Seo Young from South Korea, with a total of 71 publications and 487 citations. The table presents a list of the most productive authors in education chatbots research.

Table 3. List of the 15 most prolific authors in the chatbots in education research area.

Authors	Affiliation	Country	Year of 1st publication	Number of articles	Number of citations
Luke Kutszik Fryer	University of Hong Kong	China	2006	47	1041
Jaeho Jeon	Indiana University Bloomington	United States	2021	12	83
Lee Seo Young	Yonsei University	South Korea	2008	71	487
Gain PARK	New Mexico State University	United States	2022	5	8
Ching Sing Chai	Hong Kong University	China	2002	178	5530
Thomas K. F. Chiu	Hong Kong University	China	2014	44	972
Samuel Kai Wah Chu	University of Hong Kong	China	2005	86	1498
Chung Jiyun	Sungkyunkwan University	South Korea	1999	24	595
Folstad Asbjorn	New Mexico State University	United States	2007	46	1235
Kai Guo	University of Hong Kong	China	2021	11	32
Gwo-Jen Hwang	National Taiwan University of Science & Technology	Taiwan	1990	449	15,149
Kowatsch Tobias	Swiss Federal Institutes of Technology Domain	Switzerland	2008	120	2179
Lee Sangyoon	Connecticut College	United States	2015	5	61
Maedche Alexander	Karlsruhe Institute of Technology	Germany	2000	129	3609
Don Shin	Sungkyunkwan University	South Korea	1990	260	8285

4.3. Research question 3

Which country produces the most chatbots used in education research? **Table 4** and **Figure 3** illustrate the selection of "country," "total publications," and "most productive academic institution" as the analytical criteria in the content analysis conducted for the most productive nations in the chatbots in the education research domain.

The top 15 nations in terms of productivity when it comes to chatbots in the field of education research are displayed in **Table 4** and **Figure 3**, which also indicate the subject distributions of the most productive nations, regions, and institutions. From a national perspective, the majority of the specified nations and areas showed consistent interest in all study topics pertaining to chatbots in education. On the other hand, different nations, areas, and demonstrated a particular interest in particular developments. For instance, the United States was the most productive nation, with 77 articles overall at Western Illinois University. They were followed by "China" at the University of Hong Kong, with 36 articles overall, and "Germany" at the Karlsruhe

Institute of Technology (KIT), with 24 publications overall. Additionally, **Table 4** showed statistics from other industrious and prolific nations in the chatbots in education study sector.

Table 4. Top 15 countries and institutions.

| Rank	Country	Institutions	TP	Rank	Country	Institutions	TP
1	Usa	Western Illinois University	77	9	France	TBS Business School	10
2	China	University of Hong Kong	36	10	Australia	University of Sydney	9
3	Germany	Karlsruhe Institute of Technology (KIT)	24	11	Japan	University of Sydney	8
4	South Korea	Yonsei University	24	12	Canada	University of Quebec	7
5	Taiwan	National Taiwan University of Science & Technology	21	13	Norway	University of Oslo	7
6	Netherlands	University of Amsterdam	14	14	Sweden	Linkoping University	6
7	England	University of Amsterdam	12	15	India	Microsoft Corporation	5
8	Spain	National Centre of Excellence in Youth Mental Health	12				

Note: TP = Total publications.
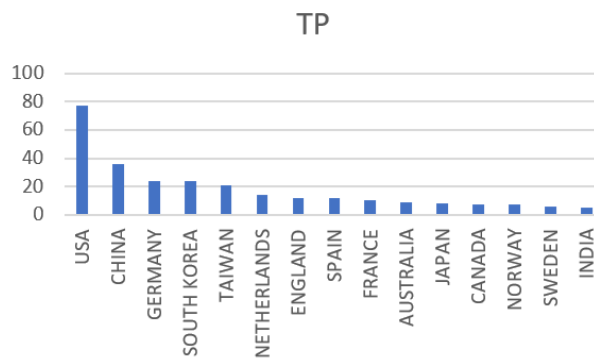
Figure 3. Number of publications on chatbot research in education.

4.4. Research question 4

Which terms have been most often used in chatbot and education research over the past ten years? As seen in **Figure 4**, "co-occurrence" was chosen as the analysis type and "authors keywords" was designated as the unit for the bibliometric study of the most popular keywords.

Upon closer inspection of **Figure 4**, the study's keyword list appears as "chatbot" (occurrences "Oc" = 92), This indicates the significant focus on research related to chatbots in education, "artificial intelligence" (Oc = 53), highlighting the substantial interest in utilizing AI technologies in the development of chatbots in educational contexts. "Conversational agent" (Oc =41), indicating the use of conversational agents as a means of interaction in online learning environments; "Chatbots" (Oc = 34); "Technology" (Oc = 25); "Self-disclosure" (Oc = 16); and "Anthropomorphism" (Oc = 14). These were followed by students, machines, education, and design. When the keywords of the publications are examined, these results demonstrate the diverse aspects and research directions within the field of chatbots in education, encompassing technological, pedagogical, and design perspectives.
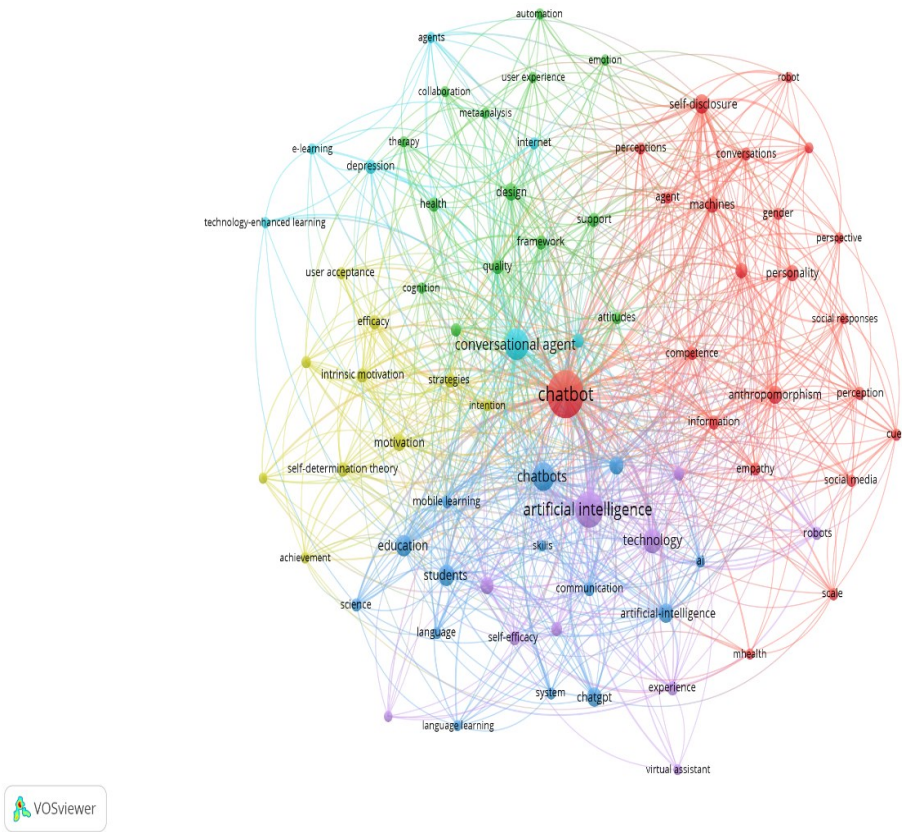
Figure 4. Analysis results of productive countries in chatbots in education research.

The existing studies have extensively documented the widespread use of natural in the field of chatbots in education include natural language processing (NLP), which involves the processing and analysis of human language and is the dominant approach. Machine learning techniques have emerged as another commonly utilized approach, as they enable systems to learn and improve from data without explicit programming. Furthermore, the existing studies have identified learning analytics involving the measurement and analysis of learning data, as another commonly applied technique in AI-based systems in education.

5. Discussion

This study employs bibliometric analysis to provide a comprehensive overview of the role of chatbots in education, drawing from a dataset of 263 research papers obtained from the Web of Science. The analysis of literature trends reveals a growing popularity of chatbots as a viable area of study in education research. The dataset indicates a noticeable increase in the number of publications focusing on chatbot research in education between 2016 and 2023, which indicates active growth and development in this field. This was confirmed by Lin and Yu (2023), and this growth can be attributed to technological progress and its integration into educational contexts. Arouse interest among researchers and lead to a greater number of studies exploring their potential in education.

Leading countries in the field of chatbot research in education, including the United States of America, China, Germany, and South Korea, show a strong commitment from researchers to investigate the potential of chatbots in education, as

evidenced by the study conducted by Hwang and Chang (2021).

These findings emphasize the global interest in chatbots in education research and highlight the collaborative efforts and knowledge exchange within the field. Researchers worldwide recognize the transformative potential of chatbots in education and actively contribute to their development. Further analysis of subject distributions within each nation, region, and institution can offer additional insights into specific areas of interest and potential research gaps.

The results of this study indicate that Computers in Human Behavior Journal has emerged as the leading outlet in terms of both the number of articles and citations, interest in the topic of chatbots in education within the field of human-computer interaction. Frontiers in Psychology and International Journal of Human-Computer Studies also made substantial contributions to the research on chatbots in education, receiving a considerable number of citations and indicating their influence within the field. Other notable journals include Psychology Marketing, Cyberpsychology, Behavior, and Social Networking, and Computers & Education, although to a lesser extent compared to the leading journals. The distribution of articles and citations across different journals reflects the varying levels of interest, impact, and recognition that research on chatbots in education has received.

The identification of the most productive authors in this area reveals the significant contributions of Ben Luke Kutszik Fryer from China, indicating widespread recognition and influence. Jaeho Jeon from the United States and Lee, Seo Young from South Korea also emerged as highly productive authors, suggesting consistent and sustained contributions to the research on chatbots in education.

Keyword analysis highlights a significant focus on the utilization of chatbots in educational contexts, with "chatbot" being the most frequently occurring keyword, indicating a growing interest in exploring their potential as educational tools. The prominence of the keyword "artificial intelligence" suggests a substantial interest in incorporating AI technologies into the development of chatbots in education, aligning with the recognition of AI's potential to enhance learning experiences. The keyword "conversational agent" underscores the use of chatbots as virtual conversational partners in online learning environments, aiming to create more engaging and interactive learning experiences for students. Other keywords such as "students," "machines," "education," and "design" also appeared in the analysis, albeit with lower frequencies. the dominant algorithms leveraged in the existing AI research, in order of prevalence, are natural language processing, machine learning (including deep neural networks), and learning analytics.

6. Conclusion

The utilization of bibliometric analysis in this study offers valuable insights into the field of chatbots in education, contributing to both emerging and ongoing research efforts by examining publication trends, citation patterns, researchers can gain a comprehensive understanding of the current state of research and identify key areas for further exploration. Furthermore, it provides a comprehensive overview of the role of chatbots in education based on bibliometric analysis. The findings highlight the growing popularity of chatbots as a viable area of research in education, with a

noticeable increase in publications focusing on this topic. Leading countries such as the United States, China, Germany, and South Korea demonstrate a strong commitment from researchers to explore the potential of chatbots in education. The identified publication outlets, such as Computers in Human Behavior, Frontiers in Psychology, and International Journal of Human-Computer Studies, indicate the high level of interest and impact within the field. Productive authors, including Ben Luke Kutszik Fryer, Jaeho Jeon, and Lee Seo Young, have made significant contributions to advancing knowledge in this area. Keyword analysis reveals a focus on the utilization of chatbots in educational contexts, with an emphasis on artificial intelligence and conversational agents. The most widely used algorithms natural language processing, machine learning (including deep neural networks), and learning analytics.

These findings contribute to the understanding of chatbots in education research and provide valuable insights for researchers to identify publication outlets and stay updated with the latest developments. Furthermore, this study serves as a foundation for future research, enabling further examination of trends and advancements in the field of chatbots in education.

7. Limitation and suggestions for future research

This research has several limitations. The WOS database was initially limited to data collection, so not all scholarly journals are included. It is possible that journals indexed in other databases, such as Scopus, were not included in our dataset. Future studies should consider expanding their datasets by including other databases, such as Scopus or Dimensions. There may also be limitations in terms of the keywords used in our sources, as technology is constantly advancing, and new terms related to chatbots may emerge that are not covered in our dataset. It is recommended that future projects identify comprehensive terms that encompass studies examining chatbots in educational settings. Since our study has a general focus on investigating the use of chatbots in educational settings, future studies could explore how different chatbots can enhance students' learning outcomes, as the ultimate goal of utilizing cutting-edge technology is to improve learning outcomes.

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