Navigating The Digital Shift: A Bibliometric Analysis of Chatbot Applications in Education

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Abstract **– In the ever-changing scenario of a technology-driven learning atmosphere, chatbots occupy a considerable role, taking up tasks in personalised learning and administrative support. This study uses a widespread bibliometric analysis of chatbots for educational purposes, engaging essential bibliographic data from Scopus and using the PRISMA flowchart approach for painstaking screening, exclusion and inclusion of studies in this field. Bibliometric tools like CiteSpace, VOSviewer, and Biblioshiny are utilised for this study to provide a multi-dimensional outlook on the effects and development of this field. The major findings of this study include an analysis of yearly scientific production about educational chatbots, identifying the most productive authors and synthesis of the most relevant sources and major cited documents globally. By analysing the influence of co-citation of cited authors and timezone views of cited journals, this study goes deep into the particulars of academic collaborations.**

This study analyzes the co-occurrence of keywords and those with the highest citation bursts to comprehend the intellectual structure of the topic's research field, giving an outlook into the focus areas and evolving trends. This study also undertakes to find practical implications and relevant research gaps. These insights identify the features of chatbot research and suggest future directions in practical application and scholarly inquiry. For effective incorporation and evolution of chatbots in the educational scenario, academicians, technologists, and educators can use this bibliometric analysis as an essential resource.

Keywords **– Chatbot, education, educational technology, bibliometric, biblioshiny, VOSviewer, Citespace.**

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1. Introduction

Chatbots are carving their own identity in the arena of technology-assisted learning [1]. They are used mainly in applications like administrative support and personalised learning. Educational chatbots boast of one of the advantages, which is personalised learning [2], [3]. These chatbots, using AI technology, cater to the learning experience of specific students by giving support and resources with regard to their progress and understanding of the subject. These tailor-made resources and other assistance ensure that learning is not too easy or too difficult for any specific student [4]. The use of educational chatbots also accentuates student motivation and engagement. These chatbots make learning more engaging and dynamic by integrating features like conversation interfaces and gamification aspects [5]. For students who feel the traditional learning style is dull, this feature keeps the student involved. Availability is another main feature that makes chatbots stand out in the crowd.

Chatbots can be accessed anywhere, anytime, unlike the traditional educator, who will be available only during class time or office hours, which is very beneficial for the students.

Students undergoing distance learning or candidates who have taken up adult education will benefit much more from chatbots since they do not have access to a real instructor [6]. Personalised learning is one of the major contributions of educational chatbots [7].

One helpful way of chatbots is learning a language, as they can simulate a setting to use natural conversations and provide the students with interactive and practical tools to enhance their language skills [8], engaging in administrative tasks like responding to FAQs, helping with the enrolment process, and giving out information regarding events and courses [9]. This would mean the educational staff can focus more on other tasks and enhance efficiency. Despite the positive outcomes of employing chatbots in academic roles, there are certain challenges that need to be tackled. It is crucial to guarantee the precision and dependability of the information shared by chatbots to do away with the confusion and hamper the learning process. Since chatbots might be used by students who are minors, the security and privacy of data is another major concern. Incorporating chatbots into the current educational system and curricula involves vigilant planning to ensure they supplement and augment traditional teaching methods [10], [11]. Another fact to be kept in mind is training students and teachers to make optimum use of this technology.

To optimise the use of chatbots, it is imperative to know their limitations and capabilities. Chatbots are sensitive to distinct languages, and cultural scenarios should be developed to guarantee inclusivity in education [12]. With the advanced use of AI technology, educational chatbots might become more technologically advanced and supportive in education [2]. Chatbots create custom-made learning experiences through the support given to students by analysing their learning styles, performances and preferences. A prototype of next-level chatbots, which work on par with human teachers, has also emerged, giving a more widespread educational experience [13]. Chatbots help the students deal with foundational subjects and more complex courses and even help with soft skill training. The development of chatbots, which use an emotional intelligence approach, is also heard in the technological sphere. These technologically sound chatbots can sense and adequately respond to the emotional state of students, provide emotional support, and provide personalised learning experiences.

Chatbots have a great future in the educational sector, with advancements in AI and machine learning ready to transform the landscape of the educational field [14], [15].

This bibliometric work intends to analyse the broad research on educational chatbots, tracing their evolution, present trends and expected development in this booming field [5], [16], [17], [18]. The study use mainstream bibliometric tools like BiblioShiny, CiteSpace, and VOSviewer, each with unique functionalities to carry out this study. With BiblioShiny as the interface for the ‘bibliometrix’ package in R, the data extraction and initial analysis processes become fast and efficient. It is also a tool for checking publications in terms of author details and citation matrices [19], [20], [21]. VOSviewer applies to the generation of visualisation of bibliometric networks [22], [23]. It allows the plotting of co-authorship, co-citation, citation, and keyword co-occurrence networks, showing a graphical depiction of the interrelationships across the research field [24], [25]. CiteSpace is celebrated for its ability to recognise and detect developing trends, pivotal points, and key authors and publications in the chatbot research field within educational contexts [26], [27], [28]. This analysis, try to show a profound understanding of chatbots' role in the educational sector, recognising meaningful research clusters, influential studies and potential gaps in the literature [29], [30]. This study serves as a source for practitioners and researchers in the educational sector and directs future studies on effectively incorporating chatbots in the educational atmosphere.

The following are the specific objectives of the study:

- Systematic mapping of the research on chatbots in education
- Analysis of trends and patterns in the literature, including the evolution of research themes over time.
- Effortlessly recognising the most important authors, articles, and influential works in the field with precision.
- Detecting emerging themes and identifying gaps in the existing literature.
- Providing recommendations for future research.

2. Materials and Methods

Scopus was chosen as this study's primary bibliographical data source because it covers a broader range of quality journals compared to other databases [31], [32], [33]. The publications were retrieved using the keywords "chatbot” and “education”.

There were no language restrictions; only journal articles, conference papers, and book chapters were considered. 870 documents were collected from 518 different sources from 2006 to 2024.

Figure 1 illustrates the PRISMA approach to selecting papers for bibliometric analysis. It is a three-phase procedure in which the study identifies and extracts the data for analysis initially from the databases.

The study excluded reviews, editorials, books, short notes, and surveys in the second phase. Documents included are articles, conference papers, and book chapters. The findings were stored as "CSV" and RIS files, and bibliometric analysis was performed on the data using CiteSpace version 6.2.R3 (Advanced) and Bibloshiny software. The main aspects of this investigation are summarised in Table 1.

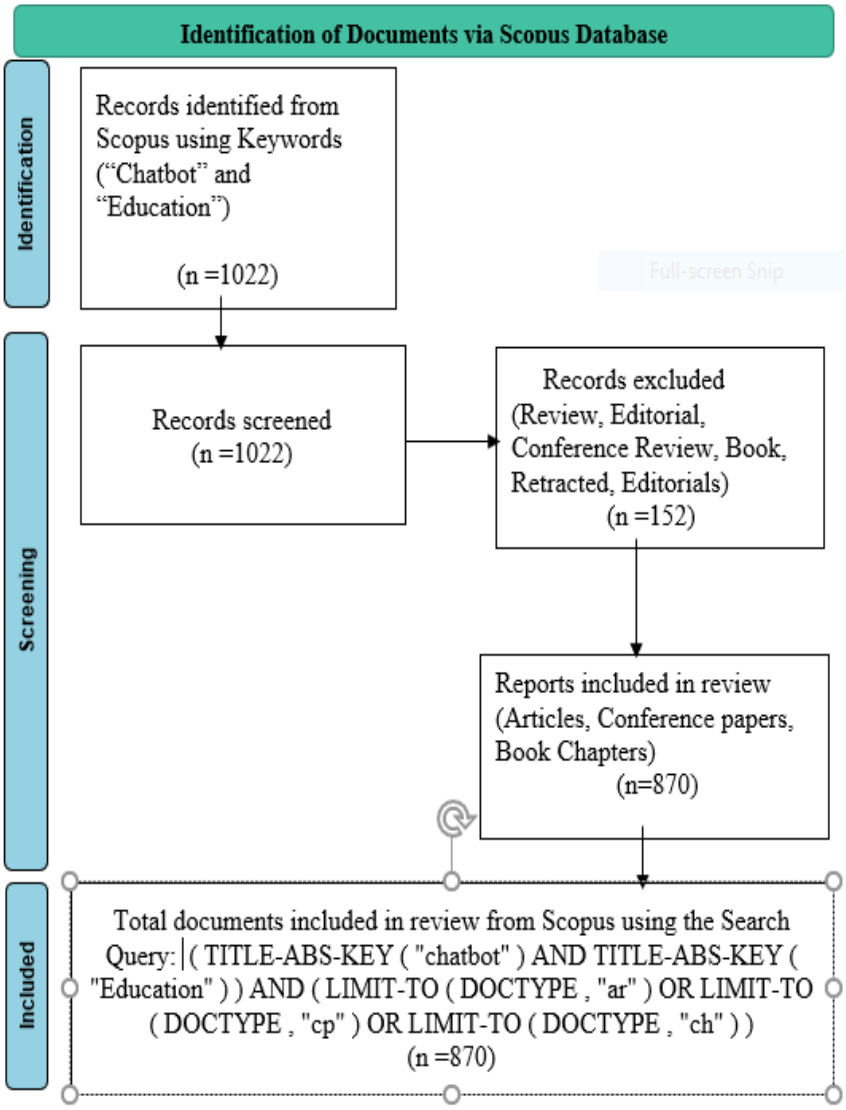

Figure 1. PRISMA Flow diagram used to identify, screen and include papers in the bibliometric analysis

Table 1. Key aspects of the investigation

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2006:2024
Sources (Journals, Books, etc.)	518
Documents	870
Annual Growth Rate %	12.98
Document Average Age	2.57
Average citations per doc	9.578
References	26697
DOCUMENT CONTENTS	
Keywords Plus (ID)	3796
Author's Keywords (DE)	2178
AUTHORS	
Authors	3152
Authors of single-authored docs	62
AUTHORS COLLABORATION	
Single-authored docs	66
Co-Authors per Doc	4.1
International co-authorships %	16.55
DOCUMENT TYPES	
Article	400
Book chapter	40
Conference paper	430

3. Findings

The results of the analysis, conducted using bibliometric tools, reveal key trends and patterns in chatbot research in education. Insights are provided into the evolution of scientific production, the most influential contributors, leading sources, and emerging topics in the field. Utilizing tools such as Biblioshiny, Citespace, and VOSviewer helped to map the scientific landscape and highlight critical areas of development. These tools enabled a comprehensive visualization of scholarly contributions, citation networks, and keyword co-occurrences, identifying key research areas and emerging themes shaping the field.

3.1. Annual Scientific Productions

Figure 2 depicts the number of documents published each year related to chatbot research in education. From 2006 until around 2017, there was a relatively stable and low volume of publications.

This suggests that while chatbots were a topic of academic interest, they had not yet become a major focus within educational research. Starting in 2018, there has been a noticeable increase in the number of documents, indicating a growing interest in the field.

This uptrend continues, becoming more pronounced in the years that follow.

The increase could be related to AI and machine learning advancements, making chatbots more capable and relevant for educational purposes.

The sharp peak observed in 2022 and 2023 represents a dramatic surge in publications, suggesting a significant spike in research activity related to chatbots in education. This could be due to several factors, such as the maturation of chatbot technology, increased funding and attention to EdTech due to the COVID-19 pandemic, the shift towards remote learning, or a combination of both.

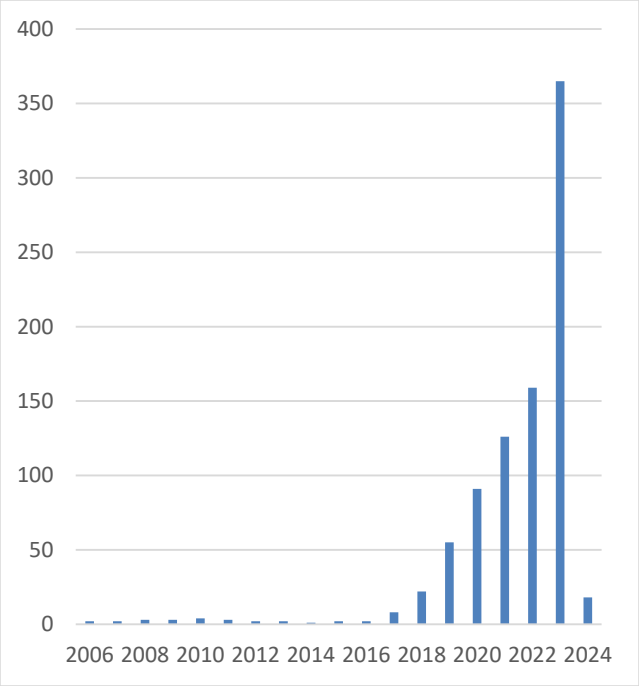

Figure 2. Annual scientific article production from 2006 to 2024

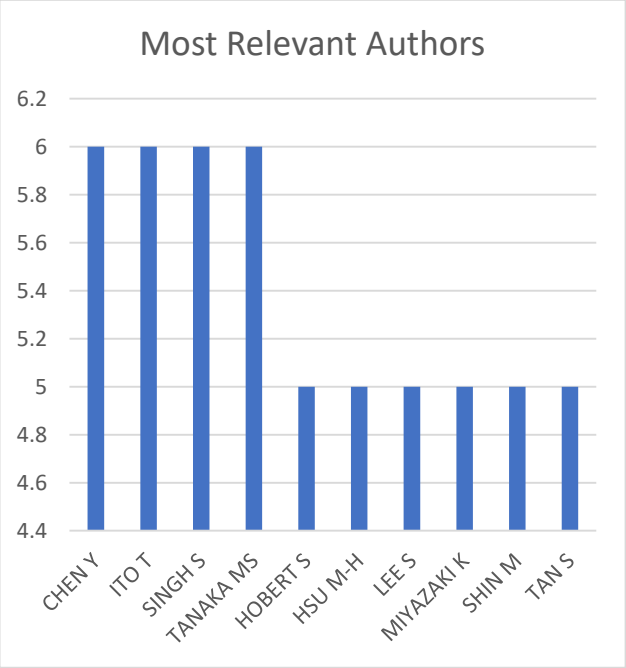

Figure 3. Most relevant authors

3.2. Most Contributed Author's

Figure 3 illustrates the landscape of scholarly contributions to chatbot research in education, highlighting the authors who lead the field in terms of publication volume. Chen Y, Ito T, Singh S, and Tanaka MS stand out with six publications each, signalling their prominence and active engagement in advancing this area of study. They are closely followed by Hobert S, Hsu M-H, Lee S, Miyazaki K, and Shin M, each with five contributions, underscoring their considerable influence on the development of educational chatbot technologies. Tan S also appears as a key figure, with five publications to their name, completing the picture of the most influential minds whose work is shaping the discourse on the integration of chatbots in educational settings.

3.3. Most Relevant Sources

The most relevant sources for chatbot research in education, as indicated by the number of articles published, showcase a range of academic forums and publications that have been central to disseminating research findings. Leading the chart is the "Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)" with a substantial 64 articles, highlighting its significance as a primary source for cutting-edge research in the intersection of computer science and education. Following are the "ACM International Conference Proceeding Series" and the "Lecture Notes in Networks and Systems", with 24 and 21 articles, respectively, reflecting their roles as important venues for presenting new research at international conferences. "Education and Information Technologies" stands out as a journal with 15 articles, emphasizing its relevance in the field of educational technology. Further important sources comprise "Communications in Computer and Information Science," and "CEUR Workshop Proceedings", and proceedings to particular conferences like "31st International Conference on Computers in Education", "Applied Sciences (Switzerland)", "Advances in Intelligent Systems and Computing", and the "IEEE Global Engineering Education Conference", with 8 articles each. These are some of the sources which embody scholarly communication and further thought processes in the use of chatbots in educational contexts.

Table 2. Most relevant sources

Sources	Articles
LECTURE NOTES IN COMPUTER SCIENCE (INCLUDING SUBSERIES LECTURE NOTES IN ARTIFICIAL INTELLIGENCE AND LECTURE NOTES IN BIOINFORMATICS)	64
ACM INTERNATIONAL CONFERENCE PROCEEDING SERIES	24
LECTURE NOTES IN NETWORKS AND SYSTEMS	21
EDUCATION AND INFORMATION TECHNOLOGIES	15
CEUR WORKSHOP PROCEEDINGS	12
COMMUNICATIONS IN COMPUTER AND INFORMATION SCIENCE	11
31ST INTERNATIONAL CONFERENCE ON COMPUTERS IN EDUCATION, ICCE 2023 - PROCEEDINGS	8
ADVANCES IN INTELLIGENT SYSTEMS AND COMPUTING	8
APPLIED SCIENCES (SWITZERLAND)	8
IEEE GLOBAL ENGINEERING EDUCATION CONFERENCE, EDUCON	8

3.4. Most Globally Cited Documents

The most globally cited documents in chatbot research within education cover a range of applications, highlighting the transformative potential of chatbots in enhancing learning across diverse fields. Gilson et al. and Lee et al. examine chatbots in medical education, focusing on improved learning outcomes and skill retention [34], [35], while Adamopoulou and Moussiades and Tlili et al. discuss the design and effectiveness of chatbots in smart learning environments, offering personalized support and adaptive feedback [36], [37].

Nadarzynski et al. and Palanica et al. explore chatbot applications in healthcare education, emphasizing accessibility and patient interaction training [38], [39]. Rudolph et al. highlight personalized learning and student engagement in higher education [40], whereas Fryer et al. examine the motivational impact of chatbots on student persistence [41]. Kerly et al. provide early insights into knowledge-based chatbots for interactive learning [42].

Table 3. Most globally cited documents

Paper	Total Citations	TC per Year	Normalised TC
GILSON A, 2023, JMIR MED EDUC	318	159	55.09
ADAMOPOULOU E, 2020, IFIP ADVANCES IN INFORMATION AND COMMUNICATION TECHNOLOGY	284	56.8	21.39
NADARZYNSKI T, 2019, DIGIT HEALTH	268	44.67	10.26
LEE P, 2023, NEW ENGL J MED	235	117.5	40.71
RUDOLPH J, 2023, J APPL LEARN TEACH-a	183	91.5	31.7
TLILI A, 2023, SMART LEARN ENVIRON	179	89.5	31.01
FRYER LK, 2017, COMPUT HUM BEHAV	172	21.5	3.37
PALANICA A, 2019, J MED INTERNET RES	159	26.5	6.09
CRUTZEN R, 2011, J ADOLESC HEALTH	143	10.21	2.96
KERLY A, 2007, KNOWL BASED SYST	139	7.72	1.82

3.5. Trend Topics

The trend topics in Figure 4 explicates the expansion and reputation of numerous terms across the scope of chatbot study in education over time. It showcases "artificial intelligence", "chatbots", "e-learning", and "conversational agents" as consistently prevalent topics, indicating a strong and ongoing focus on integrating AI into educational environments. User-centric terms like "human", "humans", "students", and "female" point to an interest in the demographic aspects of chatbot interaction and the personalisation of learning experiences.

Academic settings such as "higher education", "engineering education", and "computer programming" highlight the application of chatbots in specific domains. At the same time, "information use" and "knowledge-based systems" reflect concerns about the management of information and the foundational technology of chatbots. Less frequent but still significant, "ontology" and "computers" suggest research into the conceptual and technical infrastructure of chatbots, and the emergence of "online systems" towards the later years aligns with the growing shift to online learning platforms, underscoring the expanding role of chatbots in such environments.

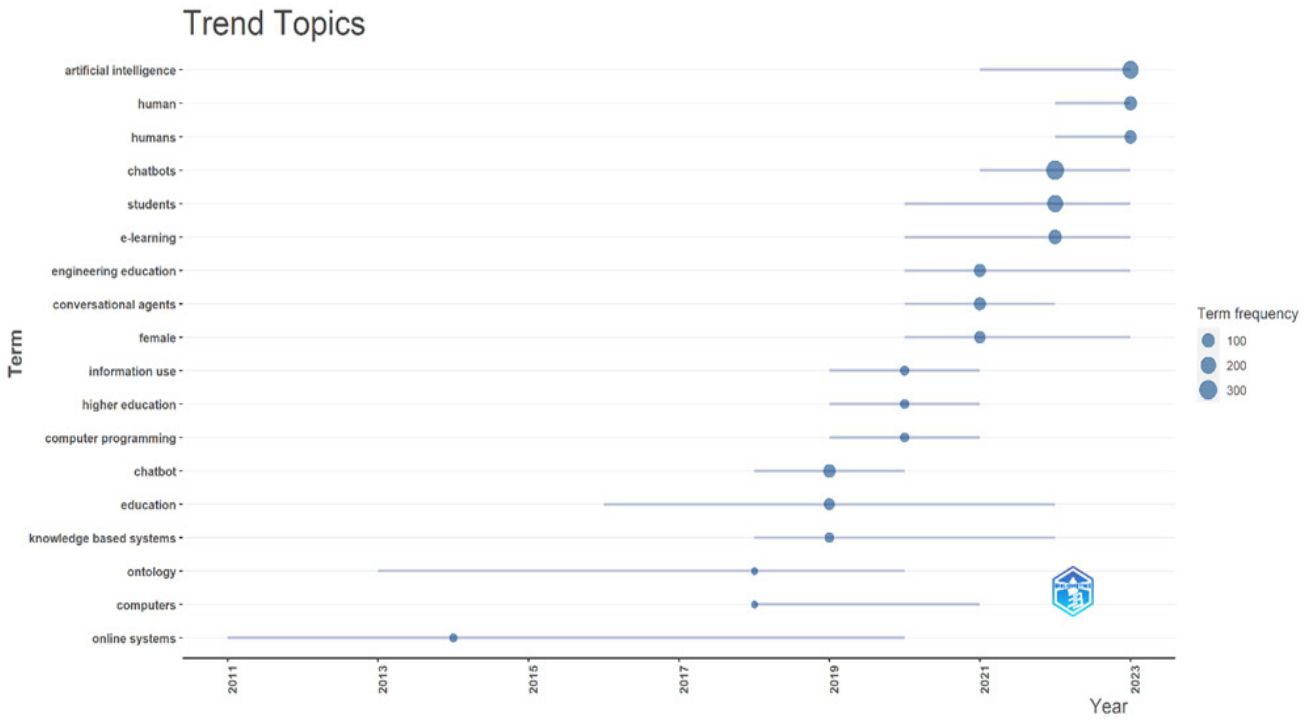

Figure 4. A visual representation of the popularity of various topics

3.6. Thematic Map of Author's Keywords

The thematic map in Figure 5 illustrates the distribution of research topics within the field of chatbot studies in education, mapped according to two dimensions: Centrality (relevance) and density (development).

The map is divided into four quadrants:
Basic Themes: Positioned in the lower right quadrant, topics like "artificial intelligence", "chatbots", and "artificial intelligence chatbots" indicate foundational areas of the field that have both high centrality and development. These well-established topics have spawned extensive research and are central to scholarly dialogue.

Niche Themes: In the upper left quadrant, terms such as "ontology" and "knowledge base" reflect specialised, emerging, or less developed themes with lower centrality. These may represent highly specialised or new areas, and while they are essential, they have not yet gained widespread attention within the field.

Motor Themes: Located in the upper right quadrant, terms like "conversational agent", "COVID-19", and "patient education" show high centrality and development, suggesting that they are both well-developed and currently driving research within the field.

These pivotal themes likely influence the current research's direction and are well-integrated into the broader discussion.

Emerging or Declining Themes: The lower left quadrant includes topics like "python", which may represent emerging or declining themes with low centrality and development in the field context. If emerging, these could be areas that are gaining traction but are not yet prominent in the literature; if declining, they might be areas that are losing scholarly interest or have been largely explored.

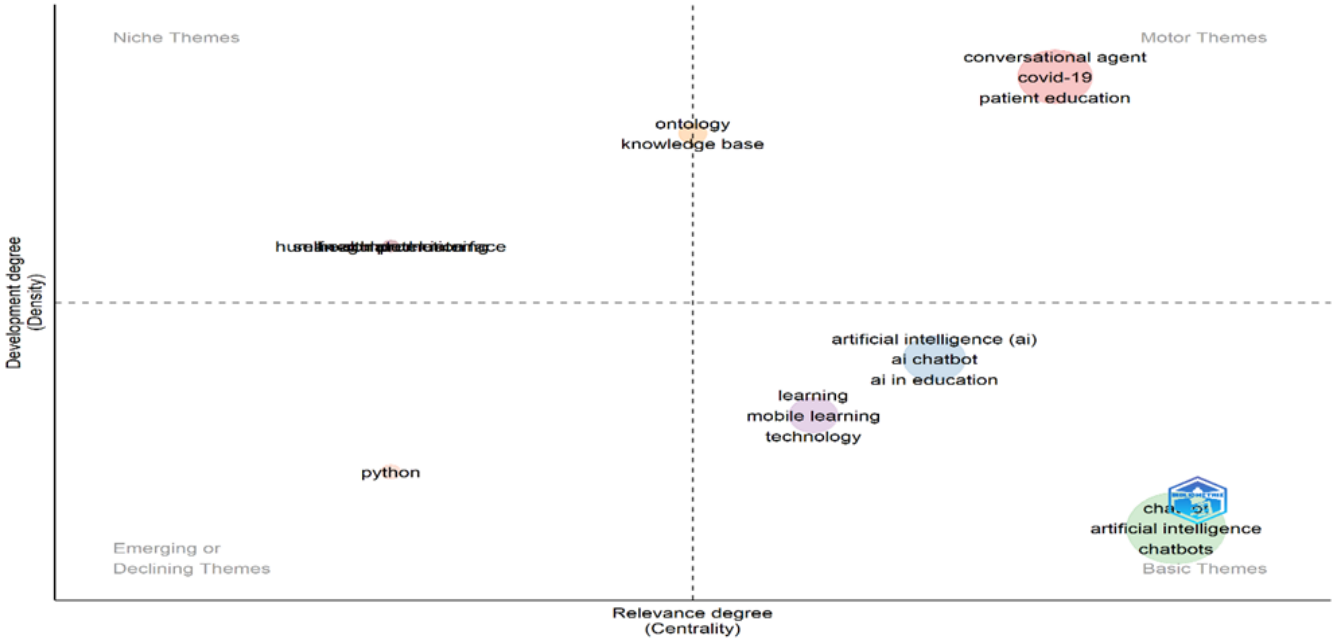

Figure 5. Thematic map

3.7. Conceptual Structure Map using Multiple Correspondence Analysis

The conceptual structure map using multiple correspondence analysis (MCA) depicted in Figure 6 visualises the relationship between different research themes in chatbots, as depicted in the uploaded image. The map is colour-coded to distinguish between clusters of related themes:

Green Cluster: This includes terms such as "language processing," "learning algorithms", "natural language processing," and "machine learning systems". It indicates a strong focus on chatbot development's technical and computational aspects, particularly those involving language processing and learning capabilities.

Purple Cluster: It contains "language," "computing practices", and "education", suggesting an intersection between educational practices, the use of language, and computing technologies. This cluster may represent research on the practical application of chatbots in educational settings, encompassing both the development and deployment of these technologies.

Red Cluster: This cluster features "human-computer interaction", "chatbot", and "distance education", focusing on the user experience and the delivery of education through chatbots. The presence of "human-computer interaction" alongside "chatbot" strongly emphasises how users engage with chatbot technology in learning environments, particularly at a distance.

Blue Cluster: Terms like "software", "medical education", and "mobile" are grouped here, implying a specialised application of chatbots in the healthcare education sector and the use of mobile platforms for delivery. This could reflect a trend towards mobile learning (m-learning) applications and the increasing importance of chatbots in medical training.

Each cluster represents a different conceptual domain within the broader field of chatbot research.

The first dimension (Dim 1) on the horizontal axis, which explains a significant proportion of the variance (77.03%), could represent the technological complexity or focus of the research, ranging from basic software and mobile applications to advanced natural language processing systems. The second dimension (Dim 2) on the vertical axis, although explaining less variance (21.56%), might differentiate between the contexts of application, such as healthcare and distance education, versus general education and computing practices.

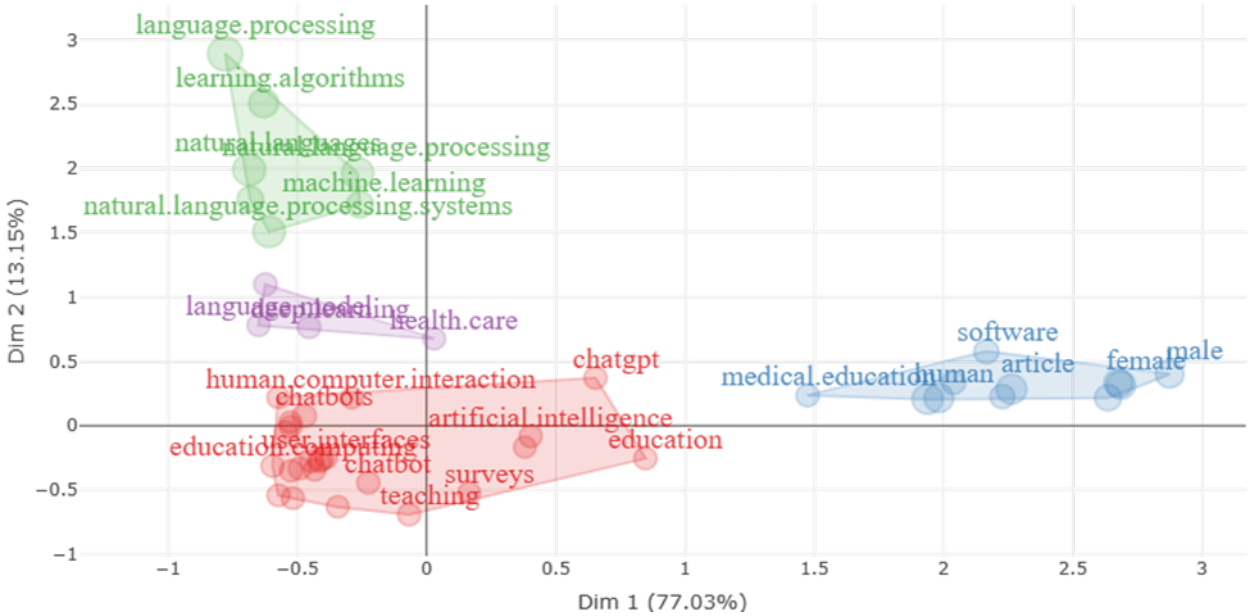

Figure 6. Conceptual arrangement of the subject area

3.8. Co-Citation of Cited Authors

The co-citation of cited authors refers to a situation where two authors are cited together in other research papers. It is a method used to establish a relationship between authors in a particular field of study, helping to map scholarly communication and to identify influential authors, thought leaders, and collaborative networks. Figure 7 depicts the graphical representation of scholarly connections between authors based on the frequency of their co-citation in other works.

The minimum citation threshold of 20 for an author to be included in the network ensures that the visualised connections represent significant and influential scholarly relationships.

With 278 authors out of 39,369 meeting this criterion, the network highlights the most prominent and influential authors within the chatbot research community. The size of each cluster and the density of connections within them suggest how prolific or interconnected the authors are in each thematic area.

Cluster 1 (Red), the most extensive with 89 authors, and Cluster 2 (Green), close in size with 81 authors, likely represent core research themes fundamental to chatbot technology and its applications. Cluster 3 (Blue), with 58 authors, suggests a well-established area of focus, potentially encompassing specific chatbot functionalities or educational contexts.

The more modestly sized Cluster 4 (Yellow), including 34 authors, and the smaller Cluster 5 (Light Blue), with 14 authors, could reflect niche subjects or emerging trends in chatbot research. Finally, Cluster 6 (Purple), the smallest group with six authors, indicates highly specialised or cutting-edge areas within the field.

Table 4. List of most cited authors

Author	Citations	Total link strength
FRYER L.K.	122	385
ATWELL E.	115	249
FOLSTAD A.	97	216
LOMBARDI M.	95	666
COLACE F.	87	617
WINKLER R.	85	236
WEIZENBAUM J.	84	228
PASCALE F.	83	610
THOMPSON A.	81	306
SINGH S.	80	133

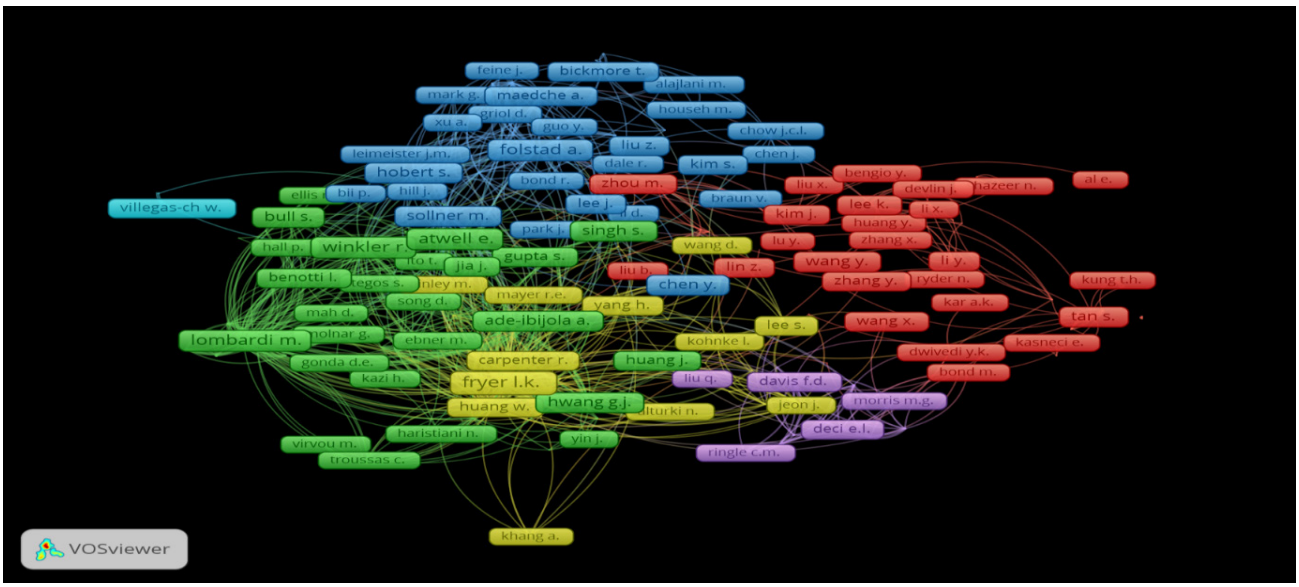

Figure 7. Co-citation of cited authors

3.9. Co-occurrence of all Keywords

The co-occurrence network visualised in Figure 8 represents the interrelation of keywords in the domain of chatbot research in education. The network, based on a minimum occurrence threshold of five, includes 326 keywords out of 5102, categorised into four distinct clusters:

Cluster 1 (Red), with 112 items, appears to focus on the human aspect of chatbot interaction and education, featuring keywords like "human", "female", "patient education", and "psychology". This cluster suggests a research emphasis on the user experience, demographic-specific studies, and the psychological impact of chatbot interaction.Cluster 2 (Green), comprising 92 items, is centred around "chatbot", "students", and "education", indicating a core emphasis on chatbot applications for student learning and educational processes.

This cluster likely reflects chatbot integration's technological and pedagogical perspectives in educational settings.

Cluster 3 (Blue), with 64 items, includes "natural language processing", "machine learning", and "deep learning", pointing to the technical underpinnings and advancements in chatbot functionalities.

Research in this cluster may focus on developing and improving chatbot capabilities through advanced computational techniques.

Cluster 4 (Yellow), containing 58 items, encompasses terms like "software", "mobile learning", and "eHealth", indicating an application-oriented approach, possibly looking at the delivery platforms for chatbots and their role in health education.

Table 5. Most occurring keywords in the research realm

Keyword	Occurrences	Total link strength
chatbot	450	751
chatbots	356	684
artificial intelligence	282	561
e-learning	119	297
chatgpt	110	207
education	109	250
human	104	169
natural language processing systems	97	238
learning systems	94	255

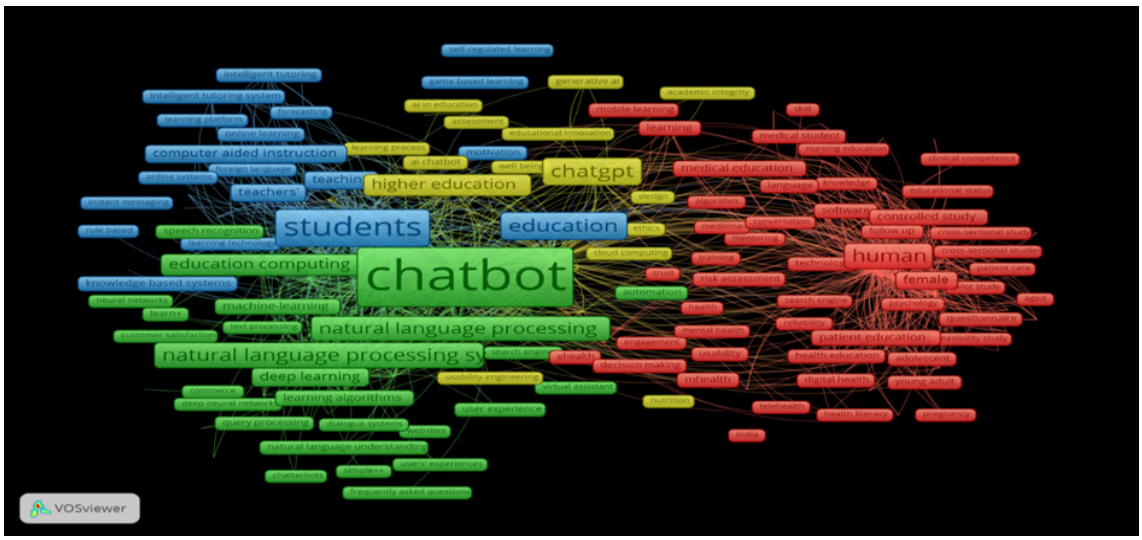

Figure 8. Co-occurrence network map of all keywords

3.10. Keywords with the Strongest Citation Bursts

Figure 8 illustrates the top 20 keywords with the strongest citation bursts, delineating a narrative of chatbot research's evolving landscape from 2014 to 2024. The term "chatbot" led the charge between 2015 and 2020, marking a vibrant period of burgeoning interest and seminal work in the field, closely paralleled by "education", indicating a significant exploration of chatbots in learning contexts.

Brief yet impactful, the focus on "curricula" integration in 2017-2018 and on "information use" from 2018 to 2021 underscores a shift towards chatbots as pedagogical aids and information processors.

The technical aspects of chatbot construction were underlined by "computer programming" and "knowledge-based systems" at their respective peaks, while "educational technology" and "engineering education" reflect the expanding application of chatbots in specialised fields.

"User interfaces" and "decision making" signal an interest in the user-centric design and cognitive aspects of chatbot interactions. The simultaneous bursts in "information systems" "procedures" and "intelligent systems" from 2019 to 2021 suggest a collective focus on the structural and intelligent operations of chatbots. "Teaching and learning" and "surveys" hint at evaluative research on chatbot efficacy and educational impact. The culmination of this period saw a diverse expansion into "education systems" "mobile applications" "neural networks", and "online education", highlighting the multifaceted implementation of chatbots in contemporary education settings and closing with an acute focus on "university students", reflecting the targeted study of chatbot impacts on higher education learners. This research aims to learn more about the dynamic nature of educational chatbots to cater to the growing needs of societal needs, academic scrutiny, and educational technology.

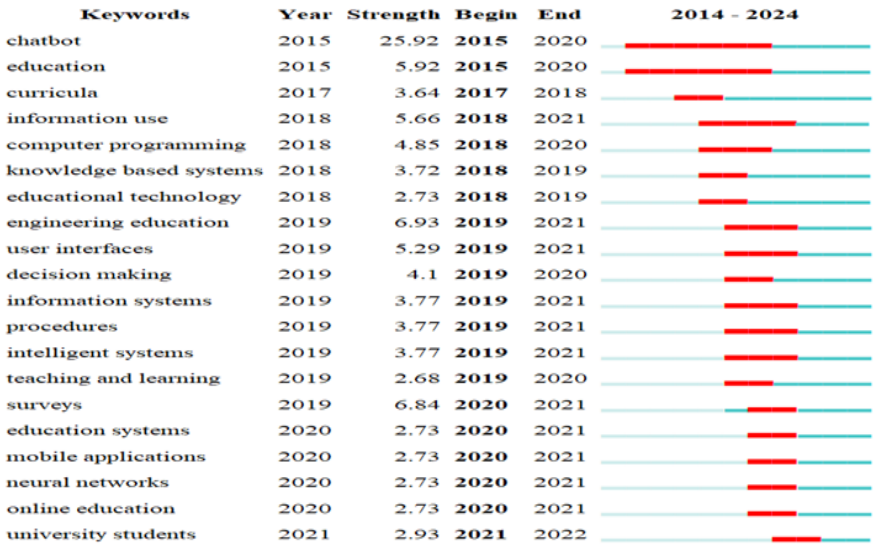

Figure 9. The keywords that have the strongest citation burst

3.11. Timezone View of Co-Citation of Journals

The timezone view of co-citation among scientific journals gives a dynamic image of the academic discourse and development across a research community. By plotting the journals in a timeline based on the frequency of their citation, this image clarifies the development of erudite relationships and thematic concentrations over the period of time. Groups of recurrently co-cited journals underscore collaborative networks and common subject matters. Coming up with new groups or the development of currently existing ones shows the shift in research paradigms or the upcoming trend of innovative topics.

Journals with several connections often appear as central nodes within the network, imitating their crucial role in circulating influential research. The network consists of 15 clusters, and the prominent clusters are as follows: Cluster #0, Learning Experience, has 97 members and a silhouette value of 0.602. The major citing article of the cluster is Foroughi, B. The most cited members in this cluster are Computers in Human Behavior and Computers & Education. Cluster #1, Learning Algorithm, has 83 members and a silhouette value of 0.889. The major citing article of the cluster is Foroughi,. Cluster #2, Learning Algorithm, has 76 members and a silhouette value of 0.755. The major citing article of the cluster is Cerny, M.

The most cited members in this cluster are IEEE Access and Procedia Computer Science. Cluster #3, Japanese Medical Resident, has 71 members and a silhouette value of 0.713. The major citing article of the cluster is Foroughi, B.

The most cited member in this cluster is Med Internet Res. Cluster #4 Comparative Analysis has 65 members and a silhouette value of 0.939. The major citing article of the cluster is Rudolph, J. The most cited members in this cluster are Nature. Cluster #6 Chatbot-Based Digital Tutor has 24 members and a silhouette value of 0.858. The major citing article of the cluster is Kuhail, Ma. The most cited members in this cluster are Unleashing the Potential of Chatbots in Education: A State-of-the-Art and Hum.

Behav Cluster #7 Goal Setting Feedback has 14 members and a silhouette value of 0.971. The major citing article of the cluster is Chang, Dh. The most cited members in this cluster are Arxiv and Comput. Educ and Procedia Comput. Sci. Cluster #8, Spanish Speaking User, has 9 members and a silhouette value of 0.983. The major citing article of the cluster is Bender, A. The most cited members in this cluster are Int. J. Approx. Reasoning, Sigkdd Explorations and Correlation-Based Feature Subset Selection for Machine Learning. Cluster #5 Artificial Intelligence has 2 members and a silhouette value of 0.833.

The major citing article of the cluster is Hasanein, Am (2023.0-JAN). The most cited members in this cluster are Performance of Chatgpt on Usmle: Potential for Ai-Assisted Medical Education Using Large Language Models, Business Intelligence: Data Mining and Optimization For Decision Making.

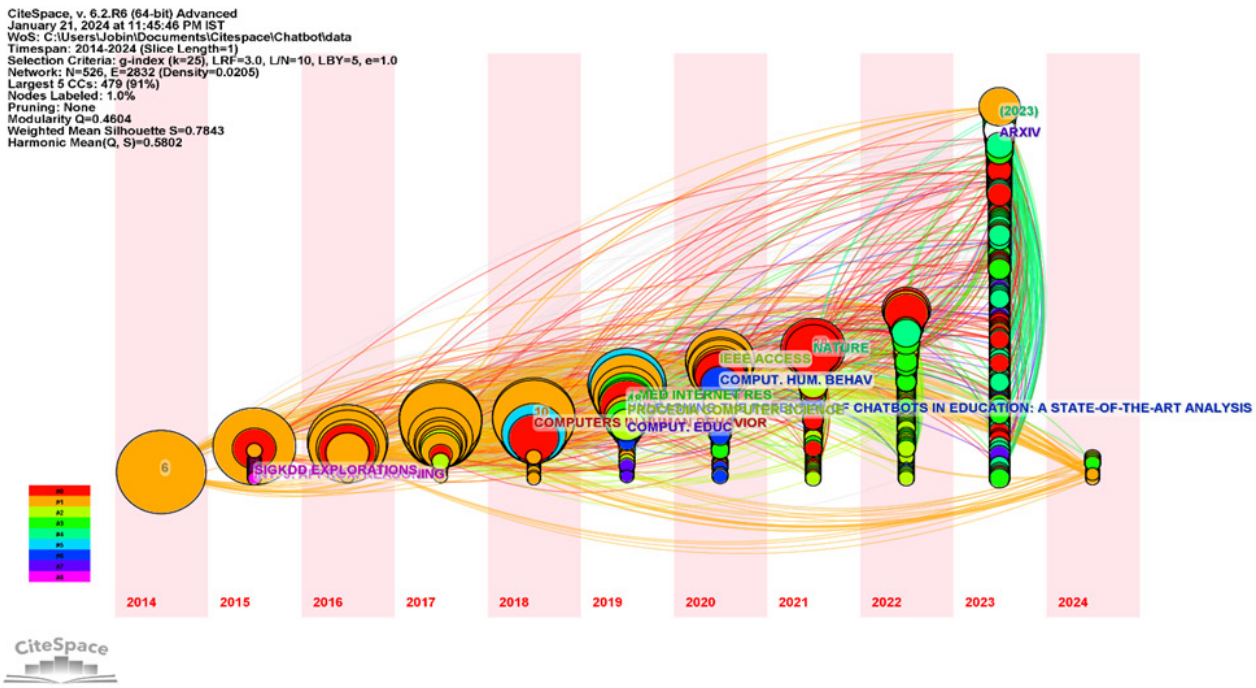

Figure 10. Visualization of the time zone network of the cited journals

3.12. Timeline View of Countries' Collaborations

The timeline view of countries' collaborations in chatbot research indicates an extensive and dynamic scholarly network, with significant interactions among various nations over the years, as revealed by the clustering of co-citations. The clusters represent thematic focal points within the research domain and the countries most engaged in these areas: Cluster #0 - SYSTEMATIC REVIEW: Dominated by the United States and India, with Spain also contributing significantly, this cluster reflects a concerted effort in conducting comprehensive reviews of the literature, possibly synthesizing the current knowledge on AI chatbots and their applications.

Cluster #1 - POTENTIAL THREAT: Led by Germany, Italy, and France, the research in this cluster seems to delve into the implications of AI, particularly the potential risks or disadvantages that chatbots might pose, perhaps in administrative services or other operational contexts.

Cluster #2 - USING CHATBOT: The United Kingdom, Australia, and China are prominent in this cluster, which focuses on the practical application of chatbots in education, possibly exploring the transformative effects of AI chatbots on modern education and remote teaching.

Cluster #3 - USING MACHINE: With Taiwan, Malaysia, and Indonesia as key contributors, this cluster suggests an interest in the use of machine learning within chatbots for educational purposes, examining factors influencing the intention to use chatbots and their determinants.

Cluster #4 - DESIGN DEVELOPMENT: Thailand, Switzerland, and Sweden lead this cluster, indicating a focus on the design and development process of educational AI chatbots, including their usability and user experience, as evidenced by research like the design and usability of an educational AI chatbot for individuals with haemophilia in Senegal.

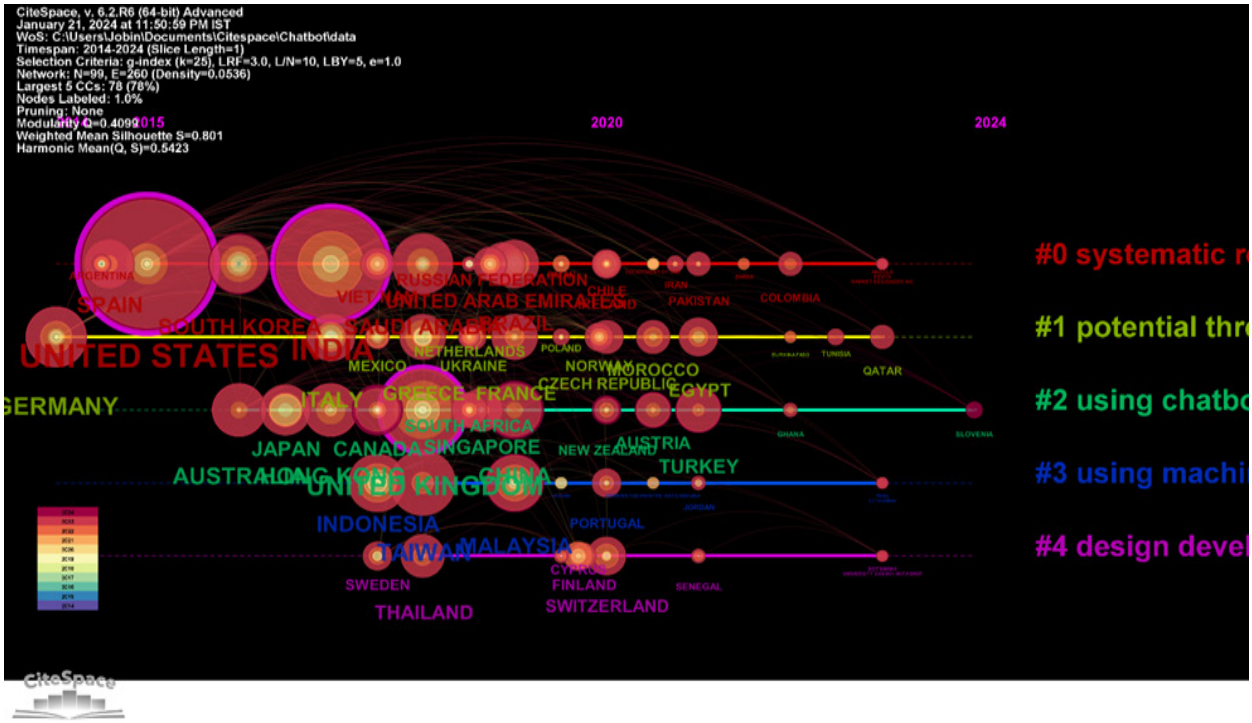

Figure 11. Timeline network visualization of countries collaborations

4. Discussions

The overview of chatbot research in education from 2006 to 2024 reveals a burgeoning academic field with a steady annual growth rate of 12.98%. The dataset encompasses 870 documents across 518 sources, including journals, books, and other scholarly materials. Despite the relative youth of the documents, with an average age of 2.57 years, they have achieved an average of 9.578 citations each, underscoring the impactful nature of research in this area. The analysis of document contents shows a wealth of keywords, with 3796 'Keywords Plus' indicating a broad scope of study and 2178 'Author's Keywords' reflecting the diverse focuses of researchers. When 3152 authors contribute to this field, it is open to say that the field is very collaborative, though a slight number (62) of these authors have gone for single-author publication. Since the number of single-authored documents is 66, it is very suggestive that collaborative writing is more common, with an average of 4.1 co-authors per document.

About 16.55% of co-authorship is of international collaboration, which stresses the global interest and cross-border academic engagement in chatbot research. Regarding types of documents, conference papers come top with 430 entries, followed closely by articles and book chapters with 400 and 40, respectively.

This indicates a huge preference for presenting new findings in the research field in conference settings, which are probably arenas for innovative discussions and peer feedback. Regarding document types, the field is dominated by conference papers, with 430 entries, 400 articles, and 40 book chapters. This distribution indicates a strong preference for presenting new research findings in conference settings, typically venues for cutting-edge discussions and immediate peer feedback, followed by more detailed explorations in journal articles and book chapters. The prevalence of conference papers may also reflect the rapid development cycle of technology-related fields like chatbot research, where sharing and promptly disseminating the latest findings is crucial. A publication trend for chatbot research in education can be observed in the Annual Scientific Productions for chatbot research in education, with a steady increase in the number of publications from 2006 to 2017 and a sharp peak in 2022 and 2023, which is likely to be a result of rising AI advancements, increased EdTech funding, and the shift towards remote learning during the COVID-19 pandemic.

The most contributed authors in the research realm include Chen Y, Ito T, Singh S, and Tanaka MS, each with six publications, followed by Hobert S, Hsu M-H, Lee S, Miyazaki K, and Shin M with five. This reflects a landscape of influential researchers shaping the field. The most relevant sources in chatbot research in education are diverse, led by "Lecture Notes in Computer Science" (64 articles), followed by "ACM International

Conference Proceeding Series" (24 articles), "Lecture Notes in Networks and Systems" (21 articles), and "Education and Information Technologies" (15 articles), with several other notable forums and conferences contributing significantly to the field. Key global citations in chatbot research within education feature diverse influential works, notably Gilson A.'s 2023 "JMIR Medical Education" article leading in impact, followed by significant contributions from Adamopoulou E., Nadarzynski T., Lee P., Rudolph J., Tlili A., Fryer L.K., Palanica A., Crutzen R., and Kerly A., representing a mix of recent and longstanding influential studies in the field.

The trend topics reveal a strong focus on integrating AI, as evidenced by the prevalence of terms like "artificial intelligence", "chatbots", "e-learning", and "conversational agents". Additionally, user-centric terms such as "human," "students", and "female", alongside academic contexts like "higher education" and "computer programming", reflect a growing emphasis on personalisation and application in specific educational domains. In contrast, "ontology" and "online systems" highlight evolving research interests in the field's infrastructure and online learning platforms. The thematic map of the author's keywords categorises topics into four quadrants based on centrality and density: Basic themes like "artificial intelligence" and "chatbots" in the lower right quadrant are foundational and well-developed; Niche themes such as "ontology" in the upper left represent specialised, emerging areas with lower centrality; Motor themes in the upper right like "conversational agent" and "COVID-19" are central and highly developed, driving current research; and the lower left quadrant includes emerging or declining themes like "python", indicating either nascent or waning research interests. Researched themes are presented as a conceptual structure map using multiple correspondence analysis (MCA), which shows the relationships between themes and groups them into different clusters. The green cluster is concerned with technical issues such as “language processing” and “machine learning systems”, suggesting an emphasis on the technological evolution of chatbots.

Scholarly references like “language” and “education” in the purple cluster indicate work at the crossroads of educational methodologies and the system of computing technologies. At the forefront of the red cluster, human-computer interaction and chatbots discuss user experience in distance education. The blue cluster, including "software" and "medical education," implies a focus on chatbots in healthcare education and mobile learning. The map's dimensions suggest a spectrum from technological complexity to varied application contexts.

The co-citation network of cited authors in chatbot research, with a minimum citation threshold of 20, visually represents significant scholarly relationships among 278 influential authors from a pool of 39,369. This network, segmented into six clusters, indicates varying levels of author prominence and thematic interconnectivity: Cluster 1 (Red) and Cluster 2 (Green) are the largest, likely representing core chatbot research themes, followed by well-established Cluster 3 (Blue), with niche or emerging topics in the smaller Clusters 4 (Yellow) and 5 (Light Blue), and highly specialised or cutting-edge areas in the smallest Cluster 6 (Purple). The keywords "chatbot" (450 occurrences) and "chatbots" (356 occurrences) are the most prominent in chatbot research, indicating a strong focus on this technology. Other key areas highlighted by the data include "artificial intelligence" (282 occurrences), "e-learning" (119), "chatbot" (110), and aspects related to "education" (109), "human" interaction (104), "natural language processing systems" (97), and "learning systems" (94), reflecting a diverse interest in the integration of chatbots with AI, online education, and advanced learning technologies. The top 20 keywords with the strongest citation bursts in chatbot research from 2014 to 2024 illustrate an evolving focus, starting with "chatbot" from 2015 to 2020, signalling burgeoning interest and paralleled by "education", highlighting their application in learning. This progression includes shifts to "curricula" integration (2017-2018) and "information use" (2018-2021), technical aspects with "computer programming" and "knowledge-based systems", and expanding applications in "educational technology" and "engineering education". The emphasis on "user interfaces" and "decision making" reflects a user-centric approach, while bursts in "information systems", "procedures", and "intelligent systems" (2019-2021) indicate a focus on structural and intelligent operations. The period concludes with diverse expansion into "education systems", "mobile applications", "neural networks", and "online education", culminating with a focus on "university students", showcasing the dynamic response of chatbot research to changing educational technology and academic needs.

The timeline view of countries' collaborations in chatbot research reveals a dynamic scholarly network with distinct thematic clusters: the United States and India in systematic reviews, Germany-led research on AI risks, the UK's practical chatbot applications in education, Southeast Asian focus on machine learning in chatbots for education, and Thailand's leadership in the design and development of educational AI chatbots.

5. Research Gap and Practical Implications

Several research gaps emerge based on the bibliometric analysis of chatbots in education. First, there is a noticeable lack of exploration into the specific needs and experiences of diverse demographic groups, such as differences in age, gender, cultural, and linguistic backgrounds. This highlights a need for more inclusive and diverse research to understand how chatbots can be tailored to a wider range of learners. Secondly, the analysis points to an underexplored intersection between chatbots and emerging technologies like neural networks and mobile applications, suggesting a potential area for innovative educational tool development. Moreover, there seems to be a lack of long-term studies examining chatbots' lasting effects on learning outcomes and student engagement. Additionally, a dearth of research addresses the privacy considerations associated with using chatbots in educational settings. Furthermore, there is a gap in the understanding of how to customise and personalize chatbot interactions to cater to learning paths.

From a perspective, these findings have implications for incorporating chatbots into education. The prominence of terms related to domains like "engineering education" and "computer programming" suggests that chatbots can serve as effective specialised teaching aids. This becomes particularly relevant in education and remote learning, as indicated by the mention of " education" and its connection to "COVID-19". The potential for chatbots to enhance student engagement in virtual learning environments during crises presents an opportunity for educational institutions. Moreover, emphasising "user interfaces" and "decision making" underscores the importance of developing user-intuitive interfaces for chatbots to facilitate better learning interactions. Finally, this analysis highlights the importance of incorporating chatbots in education to implement data-driven teaching methods. By utilising "information use" and "knowledge-based systems", chatbots can personalise learning experiences and contribute to skill education.

These findings indicate that chatbots have the potential to significantly enhance practices by adapting to the changing needs and dynamics of the field.

6. Conclusion

This bibliometric analysis of chatbots provides insightful trends and highlights further areas for research and application in the field of education.

The study highlights the need for a more in-depth study that discusses diverse learner needs, therefore suggesting a possible change to a more tailored and flexible chatbot interaction. Integrating chatbots with emerging technologies, including neural networks and mobile applications, might result in more intelligent and interactive learning tools. Chatbots should also be considered to explore how they affect the long-term learning outcomes and student engagement, which indicates the potential impacts of the chatbots over time. As discussion continues to gain center stage in the ever-changing field of chatbots within the scope of educational systems, the need to ensure ethical conduct as well as address the privacy issue in maintaining user trustworthiness and the effectiveness of the chatbots still stands. Through this analysis, the increasing importance of chatbots in education is emphasised in the investigation process, with further research and development of the educational field being set in a direction.

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