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CHARTING THE GROWTH AND STRUCTURE OF EARLY CHATGPT-EDUCATION RESEARCH: A BIBLIOMETRIC STUDY

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ABSTRACT

Aim/Purpose	The purpose of this article is to provide an overview and analysis of the emerging research landscape surrounding the integration of ChatGPT into education. The main problem appears to be that this is a new, rapidly developing research area for which there is no comprehensive synthesis of the current literature. The aim of the article is to fill this gap by conducting a timely bibliometric study to map publication trends, influential works, themes, and opportunities, thus representing the growth and structure of ChatGPT educational research.
Background	This article addresses the issue of the lack of a comprehensive synthesis of the new research on ChatGPT in education by conducting a bibliometric analysis. Specifically, the authors use statistical and network analysis techniques to examine the patterns of publication, citation, and keywords and map the growth, contributions, themes, structure, and opportunities in this evolving field. The bibliometric approach provides a comprehensive, evidence-based overview of the current state of the literature to uncover trends and gaps and help researchers improve their understanding of appropriate and effective applications of ChatGPT in educational contexts.
Methodology	The authors used bibliometric analysis as the primary method to summarize the new research on ChatGPT in education. We searched the database of the Web of Science Core Collection to find 51 relevant documents from 2023 that included ChatGPT in the title and were classified as 'educational research.' The sample consisted of these 51 documents, including articles, early access articles,

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	editorials, reviews, and letters. Statistical techniques examined publication, citation, and keyword patterns. Network analysis visualized citation and co-occurrence networks to reveal intellectual structure. The multifaceted bibliometric approach allowed a comprehensive study of the sample from a productive, conceptual, and intellectual perspective.
Contribution	This article conducts comprehensive bibliometric analysis of this emerging research area and synthesizes publication, citation, and keyword data to map the growth and structure of the literature. The results reveal important trends, such as the rapid growth of publications since the release of ChatGPT, initial authorship patterns, the focus on higher education applications, and distinct research clusters around pedagogical, ethical, and assessment issues. Visualizing citation networks identifies seminal studies while mapping co-occurrence clarifies conceptual relationships between topics. The comparative analysis highlights the differences between document types, topics, and time periods. Knowledge mapping highlights gaps in the literature, such as lack of focus on K-12 contexts, and highlights opportunities for further research.
Findings	Key findings from this bibliometric analysis of the emerging research landscape surrounding ChatGPT integration in education include the following: • Since ChatGPT was released in late 2022, the number of releases has increased significantly, indicating rapid growth in this emerging space. • The most cited authors initially came primarily from Anthropic, but over time, the citations spread throughout the research community. • The topics focused primarily on higher education applications, with a clear focus on pedagogical strategies, ethical risks, and implications for assessment. • Citation networks visualized seminal studies, while the co-occurrence of keywords clarified conceptual connections. • Gaps such as applications in the K-12 context were uncovered, and opportunities for further research were highlighted. • The literature is rapidly evolving and requires ongoing monitoring of the development of this field. In general, the analysis presents the productivity, contributors, themes, structure, and opportunities in this emerging area around the integration of ChatGPT in education based on current scientific evidence. The key findings focus on the growing early interest, gaps and developments that can provide insight for researchers and educators.
Recommendations for Practitioners	Practitioners should carefully integrate ChatGPT into education based on new evidence, carefully assess contextual applicability, and proactively develop guidelines for ethical and equitable implementation. Ongoing advice, impact monitoring, and research partnerships are crucial to informing best practices. Educators must be vigilant for risks such as privacy, student well-being, and competence impairment while staying abreast of advances in knowledge to dynamically adapt integration strategies. The introduction should empower diverse learners through measured, integrative approaches based on continuous contextual analysis and ethical principles.

Recommendations for Researchers	This article recommends that researchers conduct more studies in under-researched contexts, use multiple methods to capture nuanced impacts, increase focus on responsible integration strategies, develop tailored assessments, conduct interdisciplinary collaborations, monitor long-term adoption, mix with interactive explain and publish open access technologies, help guide adoption pathways through actionable studies, and synthesize the exponentially growing literature through updated systematic reviews.
Impact on Society	The rapid publication growth and prevailing optimism suggest that the integration of ChatGPT into education will accelerate, increasing the need for rigorous research that guides ethical, responsible innovations that avoid risks and improve outcomes in all educational contexts. The findings have broader implications for guiding adoption trajectories through ongoing evidence synthesis and expanded investigations in under-researched areas to address knowledge gaps. Ultimately, continued monitoring and updated guidance are critical to ensure that ChatGPT's educational penetration progresses carefully by maximizing benefits and minimizing harms in rapidly evolving AI-powered learning ecosystems.
Future Research	Based on the basic mapping provided by this paper, recommended research directions include longitudinal impact studies, research tailored to under-researched contexts such as K-12, qualitative research to capture stakeholder perspectives, development and testing of AI-calibrated assessments as well as explorations that combine conversational and interactive learning technologies, updated systematic reviews, and co-designed implementation research that explain pedagogical strategies that ethically unlock learning potential while mitigating risks in diverse educational environments. Such multilayered tracking can provide critical insights to guide context-specific, responsible ChatGPT integration and monitor impact within rapidly evolving AI-powered education ecosystems.

Keywords artificial intelligence, bibliometric, ChatGPT, education

INTRODUCTION

Artificial intelligence (AI) strives to create intelligent machines that can perform tasks that typically require human cognition (Ekbia, 2010). A major area within AI is machine learning, which develops algorithms capable of learning from data to make predictions (Alzubi et al., 2018). Another key aspect of AI is natural language processing (NLP), which focuses on machine-human language interaction (Ali & Shandilya, 2021). NLP algorithms enable computers to understand, interpret, and generate human-like language. These algorithms examine text data, process it, extract meaning, and facilitate human-computer communication in natural language. NLP enables various applications, including chatbots, translation, sentiment analysis, and information retrieval systems (Galassi et al., 2021; Khurana et al., 2023).

Chatbots are interactive conversational agents that can engage in dialogue with human users (Hopkins et al., 2023). Natural language processing and machine learning algorithms allow chatbots to understand user input and formulate relevant responses (Aoki, 2020). Language models – AI algorithms trained on massive datasets to predict the next words in a sequence for coherent text – are integral to modern chatbots. As a large language model from OpenAI, ChatGPT demonstrates sophisticated natural language capabilities to understand context, generate human-like responses, and converse knowledgeably on various topics (Hopkins et al., 2023). Although earlier chatbots had limited conversation skills, ChatGPT represents a major advancement through its ability to produce high-quality, nuanced dialogue. ChatGPT's open-ended nature allows for more natural conversations compared to

previous rule-based chatbots. By fine-tuning Transformer-based models on dialogue data, ChatGPT has conversational capabilities far beyond previous chatbots (Tlili et al., 2023).

In education, artificial intelligence technologies, including machine learning and natural language processing (NLP), offer immense potential to improve learning and support decision-making (Cooper, 2023; Lo, 2023). AI-powered education systems can be tailored to individual learners, provide personalized content, offer intelligent feedback, and facilitate active, interactive learning (Ciolacu & Svasta, 2021). As an advanced language model from OpenAI, ChatGPT has major implications for education through its natural language processing capabilities. ChatGPT facilitates interactive, conversational human-machine experiences. This technology has tremendous potential to transform educational practices, including how students learn, educators teach, and institutions operate (Halaweh, 2023; Susnjak, 2022; Zhai, 2023a, 2023b).

ChatGPT has diverse applications in education as an interactive virtual assistant. Its conversational skills facilitate intuitive student interactions. ChatGPT encourages self-directed learning by allowing students to independently discover and expand knowledge through open dialogues (Karakose, 2023; Rahman & Watanobe, 2023). In addition, ChatGPT can help educators as an instructional support and lesson-planning tool and provide access to extensive educational resources, research, and teaching strategies to help design engaging and effective learning (Baidoo-Anu & Owusu Ansah, 2023; Nikolic et al., 2023). Educators can use ChatGPT to generate lesson plan ideas, receive activity suggestions, and gain insight into emerging education trends. However, careful consideration of ethical, privacy, and pedagogical factors is crucial to maximize benefits and mitigate potential challenges when implementing ChatGPT in educational settings (Cotton et al., 2023; Crawford et al., 2023).

ChatGPT shows potential for various educational uses. It can function as an intelligent tutoring system that tailors instruction to learners' needs and provides personalized explanations and practice. Students can get instant feedback by having ChatGPT review assignments or essays (Chinonso et al., 2023; Karakose, 2023). ChatGPT's conversational nature also enables it to act as a dialog partner, holding natural discussions with students to improve conceptual understanding. Initial experiments show that students asking ChatGPT questions leads to meaningful learning gains. These capabilities make ChatGPT well-suited for supplemental one-on-one tutoring and personalized learning (Fauzi et al., 2023; Shoufan, 2023).

A recent systematic review by Montenegro-Rueda et al. (2023) provides an overview of the existing literature on the use and impact of ChatGPT in education. The authors analyzed 12 studies published since ChatGPT was launched in late 2022. The main findings were that ChatGPT has a positive impact as an educational support and increases student motivation, performance, and collaboration. However, the results also highlighted the importance of training teachers to use ChatGPT properly. Although ChatGPT offers opportunities to improve the learning experience, successful implementation requires the development of appropriate skills and knowledge. The authors conclude that ChatGPT could open up new educational opportunities if used and monitored ethically, but further research is needed. This current review summarizes the initial findings and shows that more research is needed on the nuanced effects of ChatGPT in education.

Another recent review by Alhaidry et al. (2023) provides a comprehensive analysis of the use of ChatGPT in dentistry and healthcare. The authors reviewed 66 relevant articles published on ChatGPT from PubMed and Google Scholar. The review found that ChatGPT has shown promise in healthcare for diagnosis, decision support, data entry, and patient education. In dentistry, it is used in X-ray analysis, identification of dental restorations, and orthodontic evaluation. However, there are limitations, including privacy risks, unreliability, and lack of human empathy. The authors recommend the judicious use of ChatGPT in health care as a complementary tool under human supervision to minimize risks. Additionally, a review by Dempere et al. (2023) examines the impact of ChatGPT on higher education. The authors conducted a narrative review of the available literature

published since the release of ChatGPT in late 2022. Key findings show that ChatGPT has the potential to improve personalized learning, student participation, and accessibility in higher education. However, there are risks associated with plagiarism, decreased critical thinking, and devaluation of human knowledge. Recommendations include developing responsible use policies, reviewing reviews, and focusing on skill development rather than content memorization. This timely overview provides an initial summary of the opportunities and challenges as ChatGPT accelerates its adoption in higher education.

Although several previous studies have examined the impact of ChatGPT on education with systematic reviews, at the time of this research period, no bibliometric analysis was performed, specifically the literature in highly respected databases such as the Web of Science Core Collection (WOS-CC). For this reason, this bibliometric analysis was carried out. Bibliometric analysis is a powerful quantitative technique for comprehensively examining publication trends and patterns on a topic (McBurney & Novak, 2002; Ninkov et al., 2022; Watrianthos et al., 2022). When existing research is synthesized, key developments are revealed in a field to inform future directions. Specifically, this bibliometric study will provide new information on emerging research on the integration of ChatGPT in education. The findings will delineate the scope of current scholarship, uncovering core topics, influential works, gaps, and opportunities for further research. Mapping the knowledge structure around ChatGPT in education through this analysis can help scholars position their work and advance their understanding of appropriate and impactful applications.

This bibliometric analysis aims to address key questions about integrating ChatGPT into education:

1. What are the trends in publication over time?
2. Who are the most active journals, authors, and institutions?
3. What are the main topics and applications that are being researched?

Identifying publication patterns will elucidate the maturity, influence of the work/author, the extent of empirical evidence, and geographic clusters of this field. Analyzing keyword associations will reveal topic relationships. Examining the citations will reveal important publications and future opportunities. The findings will define research gaps to inform promising directions. It is hoped that mapping the knowledge structure around ChatGPT in education will help researchers position their work and avoid duplication. The results will also help educators identify evidence-based implementation strategies based on current scholarship.

METHOD

The purpose of this bibliometric analysis is to identify and examine the scientific literature on ChatGPT in educational research. The goal is to gain a comprehensive overview of the research landscape. This analysis will investigate trends across multiple dimensions using descriptive statistics, visualizations, and network analytics. Authorship patterns, including productivity, collaboration, and institutional affiliation, will be analyzed using summary metrics. The prominence and contributions of the journal will be evaluated using performance indicators such as the number of publications and citations and the h-index. Institutional and country productivity will be mapped to determine geographic publishing hotspots.

The WOS-CC was purposefully selected as the sole database for this bibliometric analysis due to its prestigious reputation and stringent inclusion criteria that ensure comprehensive coverage of only high-quality peer-reviewed publications across disciplines (Bar-Ilan, 2008). WOS-CC indexes journals selectively based on impact and scope, providing a focused corpus of reputable academic literature. This distinguishes WOS-CC from more expansive databases, such as Google Scholar, which contain a wider mix of sources. Additionally, a key advantage of WOS-CC is that it categorizes indexed journals by subject area. We strategically limited our search to articles classified under "educational research" in the WOS-CC. This eliminated the need for further filtering and improved the precision of the analyzed literature, as all documents were published in established education-focused journals.

Searching the exclusive WOS-CC database and leveraging its educational research categorization streamlined the retrieval of pertinent and valid literature on ChatGPT's applications in education.

Using documents published since 2023, this study analyzes up-to-date research reflecting the rapidly evolving state of knowledge on this emerging topic. The WOS-CC encompasses more than 250 research areas, including "educational research," enabling the selection of relevant datasets that match the research objectives and enhance the reliability and quality of the findings. The analysis was performed in June 2023, using specific search queries to retrieve pertinent documents. The search query "(TI=("ChatGPT")) AND (SJ=("EDUCATIONAL RESEARCH"))" targeted documents with "ChatGPT" in the title categorized under "Educational Research." We confirmed through a preliminary search that no substantive, relevant articles were published before 2023, as expected, given ChatGPT's late 2022 release.

Figure 1 shows the PRISMA flowchart that illustrates the process for identifying, reviewing, and assessing suitability, including documents in this bibliometric analysis. The initial search of the WOS-CC returned 129 records with ChatGPT in the title. After narrowing the topic to educational research, 51 articles remained. These 51 eligible articles were published in 2023 and included in the qualitative and quantitative analysis. The PRISMA diagram summarizes the systematic process followed to retrieve the relevant literature on ChatGPT in educational research for this study.

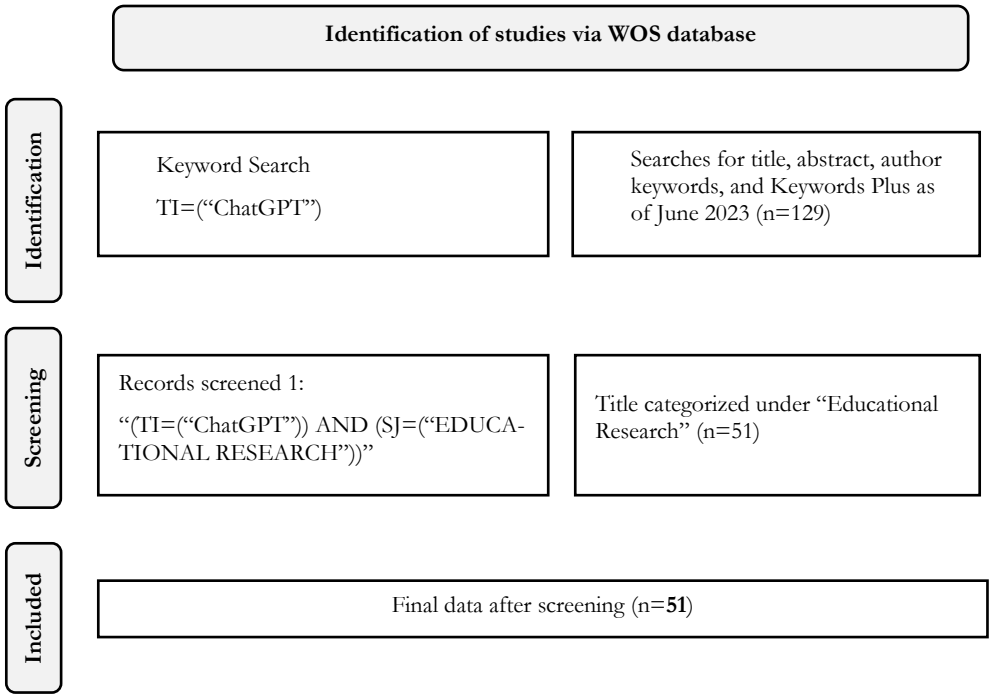

Figure 1. Screening data using the PRISMA method (Samala et al., 2023)

Citation analysis and co-citation mapping will identify landmark studies and intellectual connections between key publications. Co-occurrence analysis of author keywords using network mapping will reveal the conceptual structure and hotspots. Overlay visualization will integrate citation and co-occurrence networks to illustrate topic evolution. Comparison and contrast analysis between document types, subjects, and time will elucidate differences (Ahmad et al., 2023; Watrianthos & Yuhefizar, 2023).

Advanced techniques, such as multidimensional scaling and clustering, will determine the network clusters. Using this multifaceted methodology, the complex landscape and knowledge structure will

be rigorously analyzed from multiple perspectives. Triangulation of these diverse techniques will generate robust insights that address the purpose of the study. Although bibliometrics provides a useful lens, findings are inherently bounded by the assembled corpus. To maximize data quality, the search strategy was systematically executed across databases by two independent researchers and was refined iteratively. Deduplication ensured that the analyzed sample contained only unique documents.

The search in June 2023 yielded 51 documents published in 2023, indicating that this is an emerging research area. The types of documents included 22 articles, 14 early access articles, 5 editorials, 3 early access editorials, 1 review, and 5 early access letters. This distribution shows that preliminary findings are rapidly disseminated through early-access publications. The documents represented 34 different sources, demonstrating contributions in various journals and conferences rather than concentration in a few venues.

On average, the documents had 2.86 authorships per article and 13.73% international collaboration, reflecting the nascent teamwork. With an average of 1.7 citations per document and references ranging from 0-20, most documents had few citations given the recent timeline but were grounded in broader educational technology and AI literature through their references. These documents will be further examined and analyzed to elucidate trends, themes, and contributions related to ChatGPT in education. This research uses Biblioshiny to visualize and analyze descriptive and conceptual data (Aria & Cuccurullo, 2017; Radha & Arumugam, 2021).

RESULTS

This bibliometric analysis aimed to map the emerging research landscape surrounding the integration of ChatGPT in education. Using the WOS-CC, 51 relevant documents from 2023 were analyzed. The methodology involved statistical analysis of publication trends, classification and visualization of productive contributors, topic modeling using keyword analysis, and network mapping for intellectual structure. The scope covered peer-reviewed academic literature in document types, subject areas, and regions. Through a multidimensional bibliometric approach, this study synthesized findings across productivity, conceptual, and intellectual dimensions to elucidate patterns, impact, and research fronts in this nascent domain. The results provide an evidence-based overview of the current state and evolution of the literature to inform scholars, educators, and policymakers interested in ChatGPT's educational applications.

Key findings reveal rapid growth in educational research related to ChatGPT since its late 2022 launch. The results of prolific authors show early contributions concentrated among anthropic researchers as the first movers. Keyword and topic analysis point to a focus on higher education applications. Citation and co-citation networks visualize distinct clusters around pedagogical implications, ethical concerns, and assessment challenges. Additional major findings covered include the emergence of practitioner-oriented literature complementing academic publications, comparisons of geographic research foci, and opportunities to integrate ChatGPT with interactive simulations and intelligent tutoring systems.

The results are structured to provide an overview of the productivity, influence, collaboration trends, and thematic focus of the study. First, productivity patterns are examined based on the analysis of prolific authors, institutions, and locations. Influential works are then identified through citation counts and network analysis. The collaborative authorship trends are then explored. Finally, the conceptual structure is mapped to reveal the core topics and foci. Cluster analysis elucidates the relationships between concepts. This section outlines each key analysis sequentially to guide the reader through the multifaceted ChatGPT knowledge landscape within education research. By presenting a structured overview, this section aims to orient the reader and improve the clarity of the bibliometric findings. The sequence moves from descriptive productivity statistics to relational citation and co-occurrence networks that provide deeper insight into the nature of research and knowledge structures in this emerging field.

Publication Trends

Research on ChatGPT documented in the WOS-CC has seen a large surge, with a total of 420 articles published in mid-2023. These data are based on ChatGPT appearing in article titles, underscoring the growing academic interest and focus on this advanced language model. The 420 articles published in mid-2023 indicate a robust and rapidly evolving research landscape. This reflects the dynamism and rapid pace of research in the field of artificial intelligence and natural language processing. The scope of the articles also suggests very different perspectives, methodologies, and insights, providing a comprehensive understanding of the role and impact of ChatGPT.

The Web of Science covers around 250 different research fields from various disciplines, including natural sciences, social sciences, and educational research. In this study, we strategically focused on the field of educational research (Singh et al., 2021). This ensured that the articles analyzed were exclusively educational and maintained their relevance and specificity for our bibliometric investigation. By focusing on educational research, our aim is to examine the complex interplay between ChatGPT and education and how this advanced language model shapes pedagogical practices and paradigms. Thus, 51 articles in the field of educational research were found during the research period.

Table 1 provides an in-depth overview of ChatGPT's associated research areas. Notably, "Others" at 21.43% indicates a wide scope of topics, underscoring ChatGPT's cross-disciplinary adaptability. "Engineering" and "Computer Science" emerge as leading areas at 19.05% and 12.86% respectively. This prominence suggests a foundational emphasis on the technical and computational aspects of ChatGPT. The depth of research in these domains probably encompasses the advances, applications, and mechanisms of technology. Unexpectedly, yet intriguingly, "General Internal Medicine" and "Surgery" are also notably represented at 18.57% and 15.95%, respectively. This indicates a growing trend for the use of ChatGPT in medical settings, which could include diagnostics, patient interactions, or complex surgical procedures. Finally, a significant 12.14% is attributed to "education and educational research." Although substantial, it occupies the sixth position in prominence within this data set.

The representation of "education and educational research" in the dataset, while substantial, is not the most dominant, suggesting several underlying factors influencing this distribution. Educational institutions often adopt a phased approach to new technologies. Furthermore, ChatGPT's applications span domains, distributing the research focus. Although significant, education occupies the sixth position in prominence here.

Table 1. ChatGPT research on ChatGPT (mid-2023)

Research areas	Record count	% of the total
Others	90	21.43
Engineering	80	19.05
General Internal Medicine	78	18.57
Survey	67	15.95
Computer Science	54	12.86
Education and Education Research	51	12.14

Figure 2 shows the increasing number of monthly publications in 2023 until the mid-2023 production of this manuscript. It is important to clarify that a few of the analyzed articles had publication dates beyond June 2023 because they were initially made available as early access publications in Web of Science, which accounts for those dates falling outside the formal search window.

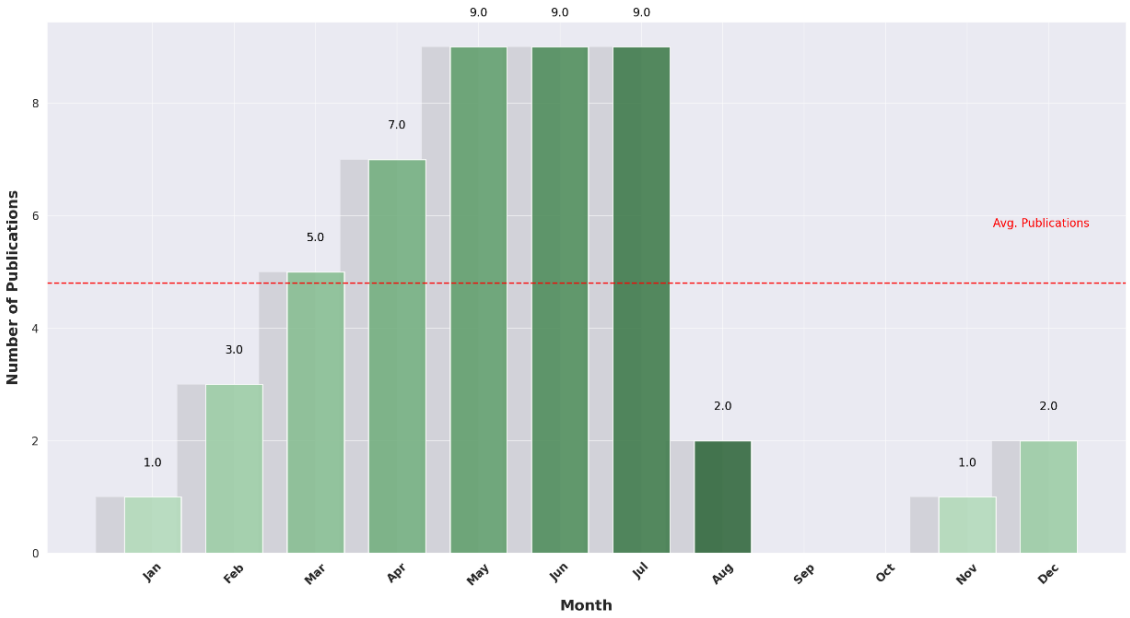

Figure 2. Number of publications by month in mid-2023

The first article, authored by Ricky Tsang of the University of British Columbia, Canada (Tsang, 2023), discusses potential applications of OpenAI's ChatGPT in undergraduate medical education. It outlines how ChatGPT could assist medical students during preclinical and clinical training. Tsang) stated that ChatGPT has tremendous potential to improve undergraduate medical education, but its popularity requires explicit usage guidelines. The key contributions are spotlighting ChatGPT's possible undergraduate medical education uses and the necessity of formal policies and training for safe and effective adoption.

Influence Source

Examining individual authors' total citation counts provides valuable initial insights into influence within an emerging research area. Highly cited authors successfully advance science through work that attracts ongoing attention, as evidenced by accumulating citations over time. Total citations indicate research impact since frequent citations reflect the authors' ideas and findings that shaped subsequent work or inspired follow-up inquiries. Authors with more total citations have disseminated influential insights, methods, or perspectives that resonate in the literature. Tracking total citations can identify pioneers who shaped the research direction through groundbreaking contributions (Aksnes et al., 2019). However, the citation analysis has limitations that require a balanced interpretation since the citation behavior is complex. Although not definitive, total citations provide a useful quantitative starting point for assessing the evolving influence of emerging literature.

Among the authors most cited, Huh (2023) has the highest h-index of 2, indicating two highly cited articles with at least two citations each. However, the low h-index values for all authors point to the nascent state of this research field, where most articles have yet to acquire substantial citations due to recency. Along with Tlili et al. (2023), they have promising emerging influence with 10 citations each for their single published article on ChatGPT in education (Tlili et al., 2023). As the field evolves, expanding the analysis to additional metrics, such as the g-index and contemporary citation counts, will further identify influential authors. These preliminary citation data provide a baseline for ongoing monitoring of intellectual influence based on the accrual of citations.

The authors' patterns of influence showed that researchers played a prominent role early on due to their position as the original developers of ChatGPT. However, the number of citations is increasing,

suggesting that as the field develops, it is worthwhile to attract a growing number of contributors from all institutions. South Korea, China, and the United Kingdom are actively publishing educational applications in ChatGPTs tailored to their AI strengths. Their continued focus on this area should be monitored in the future.

Regarding thematic contributions, the *Journal of Educational Evaluation for Health Professionals* published a highly cited article (Huh, 2023) that evaluated ChatGPT's medical knowledge and highlighted Korea's pursuit of AI applications in specific educational contexts. Since the education of health professionals represents an important area of application, it is worth keeping an eye on the continued productivity of this journal. Although no single author or institution has achieved sustained dominance in this nascent stage, the patterns suggest that multiple pioneers have made contributions that deserve further treatment.

When mapping influence sources in an emerging research landscape through bibliometrics, examining the most highly cited contributions is essential. As discussed above, identifying impactful and prolific authors by total citations provides valuable initial insights. Building on the author-level analysis, this section focuses specifically on quantifying influence at the document level. Highly cited publications reflect findings, methods, and perspectives that successfully resonated through the literature, inspiring follow-up work, opening new directions, and marking pivotal milestones shaping the field's evolution. When characterizing this developing domain that integrates ChatGPT in education, assessing contributions with significant citations offers crucial insights into the foundational work and the trajectories that define the landscape.

Huh's (2023) descriptive study published in the *Journal of Educational Evaluation for Health Professionals* has the highest total citations, 16 times in WOS-CC until mid-2023. This suggests that it has been the most impactful and influential paper to date on ChatGPT in education, setting the stage for further work. Three other highly cited articles are the papers by Cotton et al. (2023) in *Innovations in Education and Teaching International* (12 citations), Tlili et al. (2023) in *Smart Learning Environments* (10 citations), and Arif et al. (2023) in *Medical Education Online*, focusing on higher education applications, pointing to this as an area of early research activity. The prominence of these specific articles highlights the value of citation analysis in identifying particularly impactful work. However, tracking citations over longer time periods will further reveal an enduring influence as this nascent area evolves. These preliminary data provide helpful baseline evidence on the most cited contributions at the early stage of ChatGPT education research.

The article by Huh (2023) constitutes one of the very first empirical investigations published examining ChatGPT's capabilities by testing it on an actual medical school examination. The novel insights from directly assessing ChatGPT's competency on authentic subject material likely attracted substantial interest. By providing some of the earliest evidence on ChatGPT's examination performance, this timely study gained visibility and influence as an early mover on a rapidly emerging topic. In addition, the paper makes a well-timed contribution, capitalizing on surging interest regarding ChatGPT's implications for education after its public release in late 2022. The highly relevant topical focus aligned well with the research of many authors exploring artificial intelligence in education, helping drive citations.

The practical approach of evaluating ChatGPT's knowledge on a real medical exam provides more tangible insights versus theoretical analyses. Direct testing of competencies in the parasitology subject matter itself proved to be impactful. It can be inferred that this article addresses a relevant issue or introduces a novel approach in the area of education evaluation specifically tailored for health professionals. The high citation count further underscores its influence and the academic community's recognition of its value. Researchers and educators in the field of health education may be using the insights of this article to inform their practices, methodologies, or further research.

A literature mapping analysis reveals that the second most cited article in this study period by Cotton et al. (2023) is likely to gain increasing attention beginning in mid-2023. The literature map in Figure

3 illustrates that Cotton et al.'s article slowly accrues more citations throughout the year. This pattern indicates that the significant issues examined by the authors are beginning to be examined and discussed by other researchers in the field. The gradual escalation of citations over 2023 suggests that Cotton et al.'s work is making an emergent impact on the scholarly discourse as researchers build on its novel contributions over time.

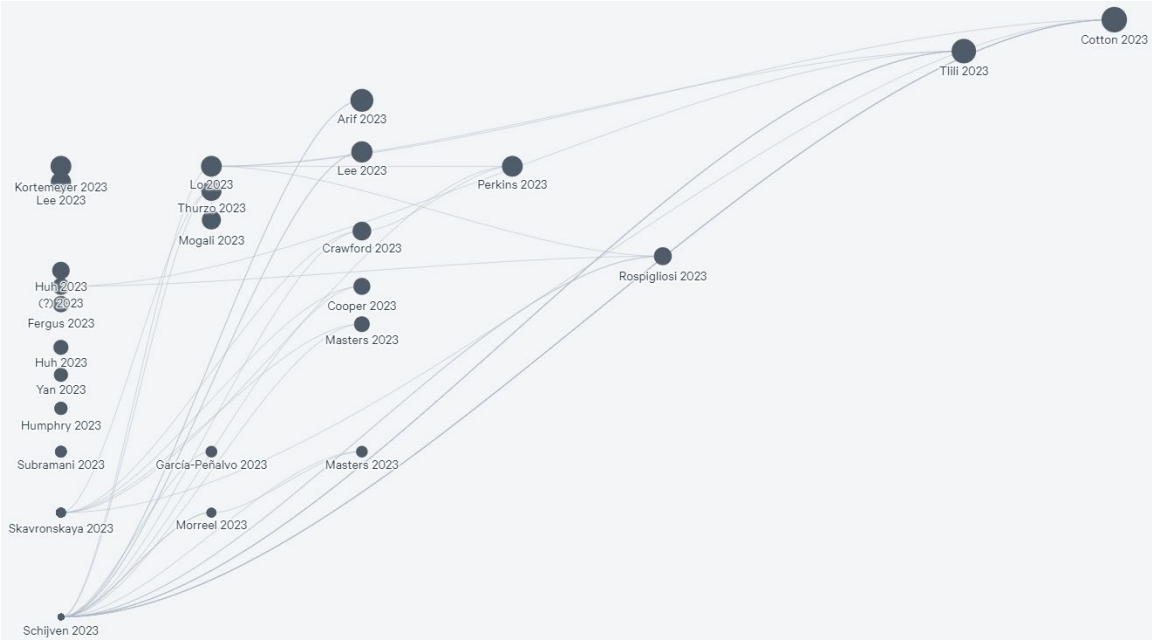

Figure 3. **Most cited articles using Litmaps**

Cotton et al.'s (2023) work critically analyzed ChatGPT's implications for assessment and integrity. The innovative approach demonstrated capabilities while catalyzing discussion. The examination of risks of plagiarism and cheating by Cotton et al. has been highly popular as researchers address ethical risks. This influential article shaped the dialogue on strategies for detecting and addressing academic dishonesty with AI.

Although published very recently, Cotton et al.'s (2023) article has accrued 12 citations within a year, reflecting rapid uptake and attention from the academic community. The increasing number of citations throughout 2023 highlights its emerging influence as more scholars engage directly and build on the insights and issues raised. Given the timeliness and relevance of its focus on the implications of academic integrity, Cotton et al.'s work seems poised to remain highly impactful as an early landmark in shaping the pedagogical and policy responses to the adoption of ChatGPT in educational institutions. The literature mapping provides evidence that Cotton et al.'s study, currently the second most cited article, is gaining influence based on its citation trajectory. This reveals Cotton et al.'s work as an important foundational publication catalyzing advances in understanding ChatGPT's multifaceted implications for education through its timely insights that have resonated among scholars.

The *Journal of Educational Evaluation for Health Professionals* has emerged as the most influential source with 19 total citations and an h-index of 2, which is attributed to the publication of the highly impactful article by Huh (2023) on ChatGPT for medical education applications. *Innovations in Education and Teaching International* ranks second with 14 total citations, also due to a single highly cited article, Cotton et al.'s (2023) timely article examining the implications of academic integrity of ChatGPT. The prominence of these two journals highlights their significant contributions as early publishers of seminal studies that catalyzed follow-up investigations despite their recency.

Regarding the countries, South Korea leads with 22 total citations and a high 5.5 average citations per article, indicating that Korean scholars were quick to explore and analyze the educational applications of ChatGPT. The UK, China, and Australia also feature as active countries, aligned with their AI research strength. Given the nascence of this field, continued monitoring is required to determine whether these initial influencers maintain impact over time. However, preliminary evidence suggests that certain journals, such as *Journal of Educational Evaluation for Health Professions* and *Innovations in Education and Teaching International*, served as crucial hubs for sharing early research, while countries such as Korea, China and the United Kingdom drove a high level of engagement with ChatGPT's education applications through timely contributions from their scholars.

Main Topics

Identifying the predominant topics provides critical insight into the evolution of a research domain. By elucidating the core topics and knowledge clusters, keyword analysis reveals the conceptual structure of the literature. Examining relationships between topics shows how the focus has shifted, and new directions have arisen as the field progresses. Analyzing trends in topical prevalence delineates the maturity of different research areas, the influence of discoveries, and promising frontiers. Thus, mapping the topical landscape is essential in bibliometric analysis to understand historical development patterns and forecast future trajectories based on the growth of specific subjects.

For this study on the integration of ChatGPT into education, keyword analysis will identify key topics and group related terms into themes. Visualizing the network and comparing the prevalence of keywords in different phases will chart the progression of the main topics. This uncovers how research has expanded from initial focus areas as new applications and implications emerge surrounding the use of ChatGPT in academic contexts. The elucidation of the main topics and trends provides key evidence to interpret the current state, progression, and future horizons of this rapidly developing literature.

Table 2 illustrates a robust association between the keywords "artificial intelligence" and "chatgpt," making it the pair that occurs most frequently. This preeminence underscores ChatGPT's significance within the broader artificial intelligence domain. Research on this topic likely explores ChatGPT's AI capabilities, comparisons to other AI technologies, and its representation as an advancement in the field. Furthermore, pairing "chatgpt" with "chatbot" illuminates ChatGPT's potential role in developing or enhancing chatbot functionalities. Discussions around this topic likely examine ChatGPT's conversational strengths, differentiation from traditional chatbots, and applications in sectors like customer service. Moreover, pairing "artificial intelligence" and "chatbot" suggests broader investigations of AI's role in empowering chatbot technologies, from the efficacy of AI algorithms to implementation challenges.

Table 2. Top 20 co-occurrence keyword pairs

Rank	Keyword pair	Frequency
1	(artificial intelligence, chatgpt)	18
2	(chatbot, chatgpt)	6
3	(artificial intelligence, chatbot)	5
4	(academic integrity, artificial intelligence	5
5	(academic integrity, chatgpt)	5
6	(chatgpt, education)	4
7	(artificial intelligence, education)	4
8	(artificial intelligence (ai), chatgpt)	3
9	(chatgpt, large language model)	3
10	(artificial intelligence, large language mode)	3

Ethical considerations prominently emerge when "academic integrity" is paired with both "artificial intelligence" and "chatgpt." These associations probably encompass discussions of the ethical implications of AI technologies, especially ChatGPT, in academic contexts. The discourse potentially centers on AI misuse threats to academic integrity, such as essay generation and broader contemplation of AI's intersection with academic values. Additionally, juxtaposing "chatgpt" and "education" illuminates the surging interest in elucidating ChatGPT's role in education. Such discussions may span ChatGPT's potential as an educational tool, integration into learning platforms, and nuanced implications for educational settings.

Similarly, co-occurring "artificial intelligence" and "education" provide insight into AI's transformative role in education, touching on personalized learning, AI tutors, and ethical integration. Interestingly, chatgpt, paired with the "large language model," highlights technical discussions of the foundations, training, and capabilities of ChatGPT compared to other models. Similarly, "artificial intelligence" with a "large language model" reflects broader dialogues on positioning these models within AI, including training challenges, applications, and trajectories. In essence, the co-occurring keyword pairs in the dataset provide a panoramic view of the multifaceted discussions surrounding ChatGPT. Collectively, they offer insights into ChatGPT's technological foundations, diverse applications, ethical considerations, and pivotal role within both the AI and educational domains. Tracking these associations gives perspective on the breadth of issues and relationships elucidated through the conceptual structure of this developing literature.

Identifying emerging trends requires disentangling the temporal dynamics within a corpus to reveal a shifting focus over time. Non-negative matrix factorization (NMF) is an advanced technique that is well-suited for this purpose (Huang et al., 2012). NMF decomposes the data into latent semantic factors that represent the underlying topics and their evolution. Applied to text, NMF reveals co-occurring term clusters constituting coherent topics. Tracking changes in these topic groups over time periods visualizes the trajectories of research themes. Therefore, the NMF elucidates conceptual changes and new directions by altering vocabulary patterns (Liu et al., 2018).

Table 3 shows five dominant topics extracted from the abstract corpus that provide valuable information on key focus areas of research that examine the integration of ChatGPT into educational contexts. A predominant theme in several topics is the potential applications of ChatGPT and AI technologies to transform and enhance various aspects of pedagogy and learning. From Topic 1's emphasis on the infusion of AI tools into education to Topics 2 and 4 centering on ChatGPT's roles in assessment, writing support, and comprehension across subjects, including medicine and language learning, the discourse clearly coalesces around harnessing ChatGPT to reimagine educational practices. Likewise, Topic 5's examination of learning tasks and assessments points to practical implementations of ChatGPT.

Table 3. Top 20 co-occurrence keyword pairs

Topic	Term
1	AI, tools, education, educators, use, science, generative, potential, academic, research.
2	medical, knowledge, progress, examination, students, test, performance, response, questions, level
3	behavioral, intention, learning, learners, study, use, model, EFL, self, usefulness
4	writing, l2, language, tool, academic, classrooms, expressed, pedagogy, natural, learning
5	learning, tasks, assessment, education, responses, practice, chatbot, lack, complex, chemistry

In addition, the focus areas also reveal a dual emphasis on the learner-instructor experience. For example, Topic 3 highlights the potential of ChatGPT in modeling and responding to student behaviors to promote self-directed learning, whereas Topic 1 focuses more holistically on transformations

in academic research and the educational landscape. This indicates that attention is paid to how ChatGPT empowers and empowers both the learners themselves and the broader institutional structures. In summary, analysis of the prevailing topics demonstrates the significant focus on and optimism for ChatGPT's capacity to enhance multiple facets of teaching and learning through innovative applications leveraging its AI capabilities. However, the discussions also critically examine the broader implications for educational paradigms and research. This highlights the nuanced, multifaceted lens applied to studying ChatGPT's integration in education.

DISCUSSION

The exponential growth in publications on the integration of ChatGPT in education in the past year indicates substantial early-stage interest as researchers rapidly investigate the implications of this potentially disruptive AI. The volume suggests enthusiasm and optimism about ChatGPT's ability to transform learning (Zhai, 2023a). However, the recency of most publications means limited accrued citations at present, constraining the understanding of the lasting impact in this nascent stage. Continued temporal citation analysis will be critical in tracking whether this initial productivity converts to influence over time as the field develops.

The concentration of highly cited authors from Anthropic as initial first movers is understandable, given their position as ChatGPT's original developers. However, the beginning of citations to diffuse across the broader research community in this preliminary analysis demonstrates the widening of the engagement. As discoveries and issues related to ChatGPT are disseminated, citations are distributing rather than remaining siloed (Aksnes et al., 2019). This suggests that the domain is expanding beyond corporate insiders to include various scholars. Sustained citation networks and co-authorship analyzes in longitudinal studies will reveal whether anthropic authors maintain enduring influence or become superseded as external researchers gain prominence through novel contributions, such as innovating ChatGPT assessment methods. Comparison of author citation and collaboration patterns over time can quantify the diffusion of influence as this literature grows.

The predominant focus on ChatGPT applications in higher education contexts likely reflects rapid experimentation by professors and adult learners given academic freedom. However, the lack of focus on K-12 settings is concerning (Fransson et al., 2020), as this segment deserves equal research to develop appropriate integrations that account for the needs of young users. Examining the factors that influence this imbalanced attention could inform strategies to address this crucial research gap. Dedicated studies tailored to K-12 are essential as schools adopt AI technologies to realize benefits while protecting student well-being.

Different topical groups focused on pedagogical implications, ethical concerns, and assessment challenges align with expected scholarly responses that critically analyze this potentially disruptive AI. Such multifaceted examinations of technical, social, and educational lenses are prudent when assessing complex innovations such as ChatGPT. Tracking conceptual shifts through dynamic topic modeling will illuminate whether current skepticism gives way to embracing transformational opportunities as research coalesces around long-term, ethical integrations (Wiranto & Uswatunnisa, 2022; Yi et al., 2020).

With the emergence of ChatGPT research in education, sustained evidence synthesis is critical as more literature accumulates to reveal more sophisticated findings. No single study provides a definitive understanding of the balance between the potential and risks of this AI. Because this analysis represents an early snapshot, continued follow-up through updated bibliometric reviews is essential. This statement emerges from our analysis of current early research on ChatGPT integration in education. Our sample included only 51 articles published in 2023, suggesting that this is still an emerging field. Furthermore, these initial studies tended to focus specifically on applications in the context of higher education. The emergence and limited scope of the analyzed literature explain the lack of definitive conclusions on the balance of potentials and risks in this first wave.

As ChatGPT research expands rapidly across all levels of education, continued synthesis will be critical to developing nuanced understanding. Our assertion reflects the preliminary results of this bibliometric study and highlights the need for continued evidence monitoring as this dynamic field evolves. Additionally, qualitative studies that capture the perspectives of students, faculty, and administrators can complement this quantitative knowledge mapping to elucidate the nuances. Previous literature reviews have provided a valuable early synthesis of the emerging impacts of ChatGPT in educational and healthcare settings. The systematic analysis by Montenegro-Rueda et al. (2023) summarized early evidence that, while ChatGPT shows promise as an educational aid, successful implementation requires the development of risk management skills and knowledge. The report by Alhaidry et al. (2023) emphasized applications in medical decision-making but cautioned that reliability issues require human oversight. Furthermore, Dempere et al. (2023) mapped opportunities to improve learning through ChatGPT while warning about critical thinking and ethical concerns.

Our unique contribution is a timely and in-depth bibliometric analysis to characterize the knowledge structure as the research on ChatGPT in education increases. Although existing overviews summarize thematic findings, our methodology clarifies network patterns and trends in citations, collaborations, and topics. This diverse data mapping uncovers productivity hotspots, intellectual pillars, and research frontiers that demonstrate maturity and shape development trajectories. For example, by mapping citation streams, new groundbreaking publications can be visually differentiated from the insularity of the company. Comparing the co-occurrence of keywords shows connections between technical, social, and learning dimensions. Cluster analysis is used to delineate research priorities that require a special focus, for example, on the privacy of learners. In general, our findings provide empirical evidence and mapping to inform research and practice in ways that differ from previous thematic summaries. This research includes quantitative analyzes of networks and temporal trends that were not considered in the initial reviews. It represents one of the first bibliometric knowledge mappings in a rapidly evolving field and identifies priorities and opportunities for stakeholders. The knowledge structures described using rigorous data science techniques build on the content of these overviews to reveal deeper structures and connections within the emerging literature.

In particular, the themes uncovered in this bibliometric analysis highlight several focus areas that illustrate the different considerations for integrating ChatGPT into education. For example, the emphasis on AI tools and generative models suggests optimism about leveraging ChatGPT's capabilities to transform practices (Hacker et al., 2023). Thematic clusters also critically address ethical risks, such as threats to scientific integrity (Crawford et al., 2023; Rosa et al., 2020). This shows a nuanced attention to the balance of benefits and challenges. The importance of topics in assessment, writing, and comprehension underscores the practical applications explored using the strengths of ChatGPT. But it also shows that the student behavior is modeled, which reflects the interest in interactive learning partnerships. Overall, the themes and their relationships presented in this study illustrate the range of issues, applications, and implications examined in the context of ChatGPT-supported education.

CONCLUSIONS

This bibliometric analysis provides timely information on the emerging research landscape surrounding the integration of ChatGPT in education. The findings reveal an increasing level of early activity, with publications increasing since ChatGPT's late 2022 release. Citation patterns exhibit an influence that spreads from initial anthropic reports to the broader community. The topics focus prominently on higher education, with clusters around pedagogical strategies, ethical risks, and assessment implications. However, focus areas also signal gaps, such as K-12 applications. Our analysis of the conclusion sections across the sample indicates a prudent and balanced perspective. Although the authors note benefits such as personalized learning and interactive dialogues, they consistently emphasize ethical risks and the need for careful, evidence-based integration.

In general, the conclusions reflect optimism about the potential of ChatGPT if implemented responsibly but caution against uncritical adoption. This nuanced, optimistic, yet vigilant expert tone

aligns with the aim of harnessing benefits through ethical approaches while monitoring long-term impacts across educational contexts. Limitations of this analysis provide interpretive limits, including the sole use of the WOS-CC and the lack of contextual richness of qualitative studies that capture student, educator, and institutional perspectives. Looking ahead, interests will likely expand across educational levels as integration advances, necessitating rigorous contextual investigations. Contributions that integrate learning analytics, personalization, simulations, and intelligent tutors appear promising if developed through a critical lens. This early knowledge mapping provides a foundation, as continued evidence monitoring is critical to guide thoughtful ChatGPT assimilation in education's evolving ecosystem.

In particular, this timely bibliometric analysis makes valuable contributions by providing one of the first comprehensive empirical mappings to elucidate the emerging research landscape at the intersection of ChatGPT and education. The rigorous methodology synthesizes multifaceted data patterns to reveal productivity, influence, structure, and gaps in this rapidly developing literature. Visual mapping of citation and co-occurrence networks gives novel insight into relationships between impactful contributions and core topics. Comparing research focuses over time and across document types enables unique temporal and categorical analysis to elucidate patterns in this nascent field. The findings inform ethical integration and guide adoption strategies based on current evidence. In general, this study significantly advances understanding by characterizing the state of scholarship and opportunities to steer future directions as ChatGPT is integrated into diverse educational contexts.

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