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Trends in ChatGPT and Generative Artificial Intelligence in Education Research: A Scopus Based Analysis

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Abstract

The emergence of Generative Artificial Intelligence (GenAI) technologies such as ChatGPT has transformed the landscape of education research, reshaping how knowledge is created, accessed, and disseminated. This study aims to analyze global research trends on ChatGPT and GenAI in education through a bibliometric analysis of Scopus-indexed publications from 2023 to 2025. Using a quantitative bibliometric approach with data visualization tools such as VOSviewer and Bibliometrix (R package), this research examines publication growth, scientific collaboration, influential authors and journals, and keyword co-occurrence networks. The PRISMA 2020 protocol was applied to ensure systematic and transparent data selection. The results show an exponential increase in research output on GenAI in education, with the United States, China, and Australia leading contributions. Thematic mapping reveals three dominant clusters: (1) ChatGPT and generative AI applications in higher education; (2) human-centered and ethical AI in learning; and (3) large language models (LLMs) in educational innovation. This study identifies ChatGPT as both a learning tool and an epistemic partner that enhances personalization, creativity, and efficiency in teaching and research. The novelty of this research lies in its development of the "Generative Education Ecosystem (GEE)" framework, integrating socio-technical systems and constructivist theories to explain human-AI collaboration in learning. The findings contribute empirically and theoretically to understanding the global trajectory of GenAI in education and provide strategic insights for policymakers and educators to foster adaptive, ethical, and sustainable AI-based learning systems.

Keywords: *ChatGPT, Generative Artificial Intelligence, Education, Bibliometric Analysis, Human-AI Collaboration*

1. Introduction

The development of Generative Artificial Intelligence (GenAI), such as ChatGPT, Bard, and Claude, has brought significant changes to the way humans learn, think, and interact with digital information. In the field of education, this technology has become a key

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catalyst for digital transformation, enabling personalized learning, automated assistance, and greater efficiency in assessment processes (Pham et al., 2023). Based on an analysis of Scopus publications, research on GenAI in education has seen exponential growth since 2023, with a shift in focus from technical aspects to issues of ethics, institutional readiness, and learning quality (Nguyen et al., 2025). Studies also indicate that the use of ChatGPT in higher education enhances academic productivity and content creation efficiency (Lee & Palmer, 2025). This phenomenon marks a global paradigm shift toward more adaptive, collaborative, and dynamic AI-based learning.

The significance of this issue lies not only in its technological innovation but also in its contribution to the development of science and technology-based human resources (SDM Iptek), as outlined in the National Research Master Plan (RIRN) and the 4th Asta Cita of Prabowo, which emphasizes strengthening education, technology, and national research. In the context of the Sustainable Development Goals (SDG 4: Quality Education) and SDG 9: Innovation and Infrastructure, the utilization of generative AI plays a crucial role in expanding access to education and improving academic research efficiency (An et al., 2025). Moreover, mastering GenAI encourages an increase in the SDM Iptek ratio and supports the development of digital competencies for both teachers and students across various fields of study (Ahmed et al., 2025). Therefore, understanding the trends and directions of research on ChatGPT and GenAI in education is a strategic step toward achieving a globally competitive and sustainable educational transformation.

Recent research shows that ChatGPT has been widely used in learning activities, assessments, and academic writing, both in higher education and vocational contexts. Nguyen et al., (2025) examine how educational institutions are developing official guidelines for GenAI use, emphasizing the importance of regulations that align with the vision of digital educational organizations. A study by Lee & Palmer, (2025) identifies prompt engineering as an essential new skill for optimizing the use of ChatGPT to improve student learning outcomes and critical thinking. Other research highlights that while GenAI can expand creativity, it also presents challenges in maintaining the validity and originality of learning outcomes (Ahmed et al., 2025). Overall, the literature shows that ChatGPT has become an integral element in the evolution of modern, technology-based pedagogy.

Furthermore, recent studies show that the readiness of higher education institutions is a key factor in the effectiveness of ChatGPT and GenAI implementation (An et al., 2025). Tajsic et al., (2025) found that students in the fields of medicine and health tend to use ChatGPT and YouTube to reinforce their learning, although their trust in the accuracy of the content varies. This indicates that generative AI not only serves as a tool but also as an intellectual partner in the learning process. However, digital readiness, ethical use, and critical understanding of AI output remain major challenges in its application within education. Therefore, comprehensive bibliometric research is needed to systematically map the direction of research development in this field.

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Although various studies have examined the use of ChatGPT in classrooms, comprehensive bibliometric analyses based on Scopus that track publication trends, scientific collaboration, and thematic research focus are still very limited. Most previous studies have focused on practical implementation at the university level or on specific ethical issues (Nguyen et al., 2025). Additionally, there has been a lack of systematic analyses identifying the most influential authors, journals, and countries in shaping the research landscape of ChatGPT and GenAI in education (An et al., 2025). The absence of data on topic distribution and inter-theme relationships also hinders global understanding of the direction of AI-based education research. Therefore, this study is crucial in providing a comprehensive map of publication trends, collaboration networks, and the future development directions of research in this field.

The main issue in this research is the lack of a comprehensive global bibliometric mapping of research on ChatGPT and Generative AI in the context of education. The fragmentation of data has made it difficult to identify research developments in terms of productivity, collaboration, and scientific influence. This situation affects the limited development of AI-based curriculum strategies and evidence-based education research policies. As a result, the potential for academic collaboration across countries and disciplines has not been fully optimized. Therefore, this study aims to provide a quantitative analysis of the trends and patterns in research on ChatGPT and GenAI in education.

This study aims to analyse the research publication trends on ChatGPT and Generative Artificial Intelligence in the field of education, based on the number of publications per year, academic disciplines, country-level contributions, and patterns of scholarly collaboration. In addition, the study seeks to identify the most influential authors, journals, and articles in this field, based on productivity and the number of citations received. Furthermore, it aims to map the main topics and the relationships between research themes through keyword co-occurrence analysis, in order to understand the direction of knowledge development in this area. The study also focuses on identifying potential future research areas that are relevant to supporting the advancement of educational technology and innovative policy-making. Thus, this study is expected to provide an empirical overview of the AI research landscape in education and contribute to supporting national research strategies in the field of ICT and the development of science and technology-based human resources (HR-STI).

Academically, this study contributes to expanding the literature on the evolution of ChatGPT and GenAI research in education through a bibliometric network analysis approach. This study identifies the knowledge structure, key scientific actors, and thematic trends that shape the global AI education research ecosystem. Using the Scopus database, this research offers an empirical approach to understanding the dynamics of rapidly developing research. The findings are expected to serve as a methodological reference for other researchers examining the relationship between generative

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technology and pedagogy. Overall, this study adds academic value in the context of AI literacy and digital transformation in education.

Practically, the results of this study can serve as a foundation for education policymakers, research institutions, and universities to optimize the use of GenAI for effective and ethical learning. The research map produced helps in setting priorities for developing digital competencies and fostering cross-national collaborations. Additionally, the findings align with the 4th Asta Cita of Prabowo, which emphasizes strengthening human resources, science, and education as the foundation for national independence. This study also supports the implementation of the National Research Master Plan (RIRN) in the fields of ICT and education in the context of improving research productivity and digital literacy. Thus, this research contributes to the development of more inclusive and sustainable AI-based education policies.

2. Research Method

This study employs a bibliometric approach based on Scopus data to explore the trends, patterns, and developments of scientific studies related to the use of ChatGPT and Generative Artificial Intelligence (GAI) in the context of education. This approach was chosen for its ability to measure scientific impact and to map the intellectual structure and evolution of specific topics within academic literature (Lendvai, 2025). Given the growing attention toward generative AI technologies in education since the emergence of ChatGPT in late 2022, this study aims to provide a comprehensive, data-driven overview of the development of scholarly discourse in this field (Dwivedi et al., 2023).

Data were collected exclusively from the Scopus database due to its extensive coverage, inclusion of reputable journals, and relevance for bibliometric studies (Kelly et al., 2023). The search process was conducted in November 2025 using the Boolean string: (TITLE-ABS-KEY(ChatGPT) AND TITLE-ABS-KEY(Generative Artificial Intelligence) AND TITLE-ABS-KEY(Education)) AND PUBYEAR > 2022 AND PUBYEAR < 2026 AND (LIMIT-TO(SUBJAREA, "SOCI")) AND (LIMIT-TO(DOCTYPE, "ar")) AND (LIMIT-TO(LANGUAGE, "English")) AND (LIMIT-TO(EXACTKEYWORD, "Chatgpt") OR LIMIT-TO(EXACTKEYWORD, "Generative Artificial Intelligence") OR LIMIT-TO(EXACTKEYWORD, "Education")). These criteria specifically targeted English-language articles within the social sciences discipline that discuss ChatGPT and GAI in the educational context, with a publication time frame from 2023 to 2025. In this way, the study focuses on contemporary scholarly works that are both topically and temporally relevant (Kumar, 2025).

The data selection process followed the systematic guidelines of the PRISMA 2020 protocol (Jacinto et al., 2024). The selection procedure consisted of four main stages: identification, screening, eligibility assessment, and inclusion. In the identification stage, all search results were exported into a comma-separated values (CSV) format. Next, during the screening stage, duplicate and irrelevant articles based on their titles and abstracts were eliminated. The eligibility assessment stage involved reading the full text

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of each article to ensure its relevance to the main topic of the study. Finally, only articles meeting all inclusion criteria were incorporated into the final analysis. The application of PRISMA ensured that the entire process was transparent, systematic, and replicable (Parmar et al., 2025).

Data analysis was conducted using the software tools VOSviewer and Bibliometrix on the R platform. VOSviewer was employed to visualise collaboration networks among authors and institutions, as well as keyword co-occurrences within the analysed publications (Zhang et al., 2025; Qin & Zhang, 2025) . Meanwhile, Bibliometrix was used to extract key bibliometric indicators such as the number of annual publications, leading journal sources, the most productive authors, and the geographical distribution of contributors (Bozkurt, 2023). This combined approach enabled a comprehensive mapping of the scientific structure, collaboration dynamics, and conceptual trends within the literature on ChatGPT and GAI in the field of education.

3. Result

3.1 Publication Trends and Research Collaboration on ChatGPT and GenAI in Education

The analysis of publication trends and research collaboration is essential for understanding the direction of development and the intensity of studies on ChatGPT and Generative Artificial Intelligence (GenAI) in the field of education. The following graph presents the growth pattern of the number of publications per year, along with the level of international collaboration, reflecting the increasing global interest and cooperation in this area.

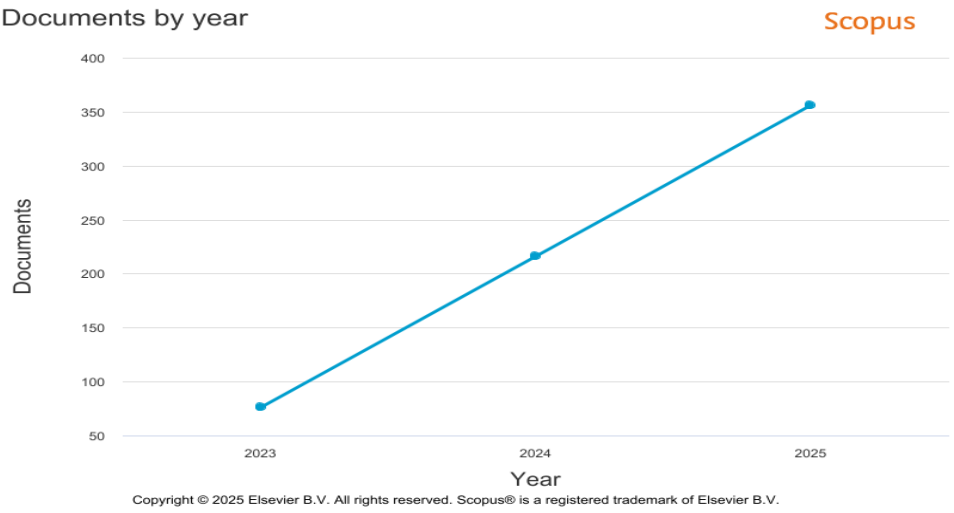

Figure 1. Documents by year. Source: Scopus database.

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The graph above illustrates the trend in the number of publications indexed in Scopus concerning ChatGPT and Generative Artificial Intelligence (GenAI) in the field of education during the period from 2023 to 2025. Overall, the data indicates a significant increase in the number of publications each year, with clear growth observed between 2023 and 2025. In 2023, the number of publications was recorded at around 75 documents, which then almost doubled in 2024 to more than 215 documents, and rose again to exceed 350 documents in 2025.

This pattern reflects a growing interest in research on the use of generative AI in education, which can be attributed to rapid technological advancements and the increasing adoption of AI in the global academic context. This growth also indicates that ChatGPT and similar technologies are becoming increasingly relevant and urgent research topics, in line with the digital transformation of the education sector.

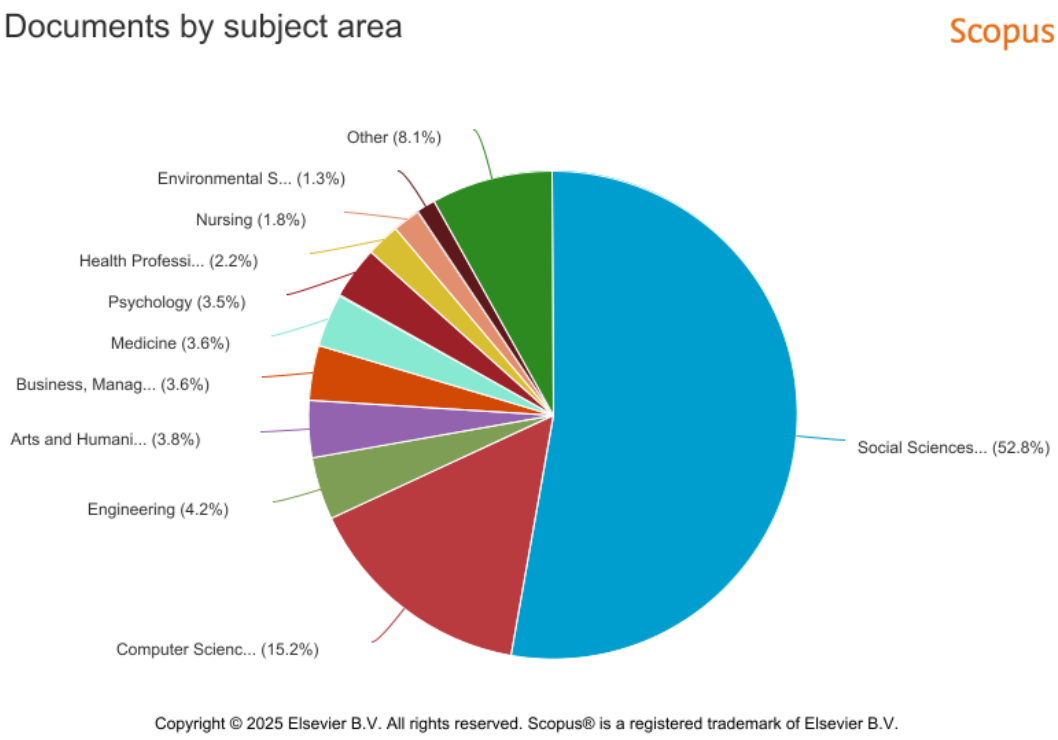

Figure 2. Documents by subject area. Source: Scopus database.

The graph above illustrates the distribution of subject areas of Scopus-indexed publications on ChatGPT and Generative Artificial Intelligence (GenAI) in the field of education. Among all the recorded documents, the Social Sciences dominate with the largest contribution of 52.8%, indicating that the application of generative AI is most

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widely explored within social, psychological, and educational contexts, encompassing disciplines such as sociology, psychology, and higher education.

In addition, Computer Science represents the second-largest subject area, accounting for 15.2% of the total publications, highlighting the crucial role of technology in the development and application of AI. The Engineering field also contributes significantly with 4.2%, reflecting the close relationship between AI technology development and engineering disciplines. Meanwhile, other areas such as Health (3.5%), Business and Management (3.6%), and Arts and Humanities (3.8%) demonstrate more niche yet important applications of AI within specific contexts. The Other category accounts for 8.1% of the total, encompassing various other subjects that remain relevant to generative AI research.

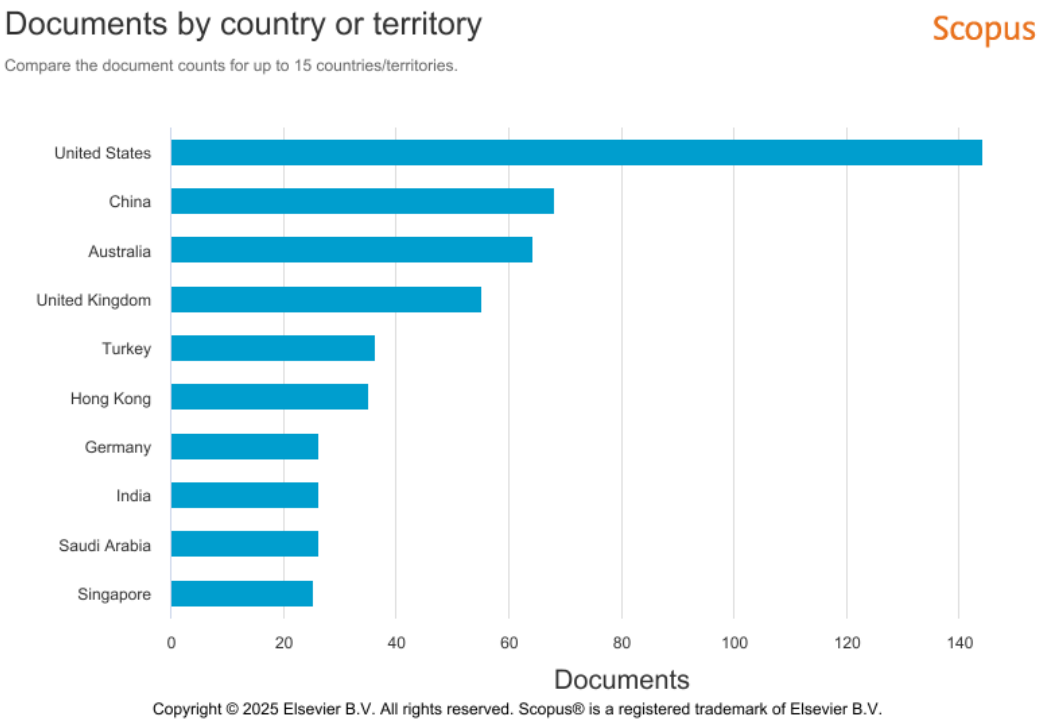

Figure 3. Documents by country. Source: Scopus database.

The graph above shows the distribution of the number of publications related to ChatGPT and Generative Artificial Intelligence (GenAI) in education by country or region on the Scopus platform. According to the data presented, the United States leads with the highest number of publications, reaching around 150 documents, followed by China and Australia, with approximately 70 documents each. These countries represent significant centres of research and innovation in AI technology, with both nations playing leading roles in the development and implementation of AI in education.

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The United Kingdom follows with a substantial contribution, with a publication count of nearly 55 documents. This is followed by countries such as Turkey, Hong Kong, Germany, India, Saudi Arabia, and Singapore, which demonstrate active engagement in generative AI research, albeit with lower publication numbers.

This pattern indicates that, although the United States dominates GenAI research in education, emerging economies such as China, India, and Saudi Arabia are increasingly showing significant interest in this topic. This reflects the global dynamics in the development and adoption of AI technologies, which have now become a focus of research across different parts of the world.

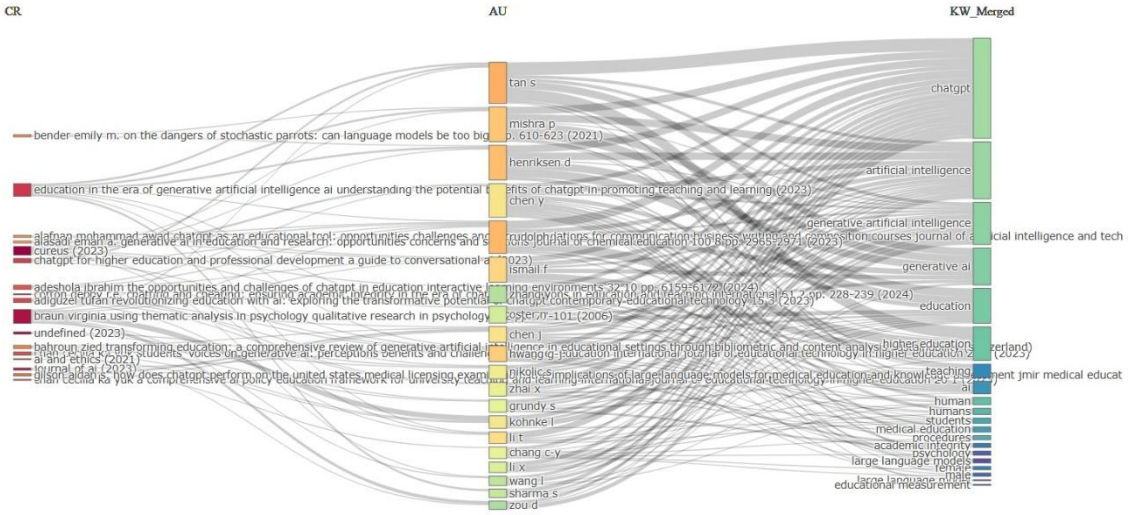

Figure 4. Collaboration. Source: Scopus database.

The graph above illustrates the complex relationships among references (CR), authors (AU), and keywords (KW) that frequently appear in research on ChatGPT and Generative Artificial Intelligence (GenAI) within the educational context. Each interconnected element in this graph represents the collaborative network between published references, contributing authors, and the most frequently used terms in the literature.

For instance, references such as *"Education in the Era of Generative Artificial Intelligence"* and *"ChatGPT for Higher Education"* are directly associated with authors such as Tan S, Mishra P, and Henriksen D, who often cite key terms including *ChatGPT*, *artificial intelligence*, *generative AI*, and *education*. This reflects the central focus of research in this field, which revolves around the application and impact of generative AI technologies in education.

Moreover, keywords that consistently appear such as *"generative artificial intelligence"* and *"large language models"* highlight research trends that strongly

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concentrate on applying these advanced technologies for learning, teaching, and assessment in higher education. The graph also demonstrates how research in this area has evolved through interdisciplinary contributions, with an emphasis on the influence of AI on various aspects of education, including psychology, higher education, and educational evaluation.

3.2 Most Influential Authors, Journals, and Articles

To gain a deeper understanding of the main contributions in research on ChatGPT and Generative Artificial Intelligence (GenAI) in the field of education, an analysis of the most influential authors, journals, and articles is essential. The following graph presents the identification of leading authors, prominent journals, and the most highly cited articles that have made a significant impact on the development of research in this field.

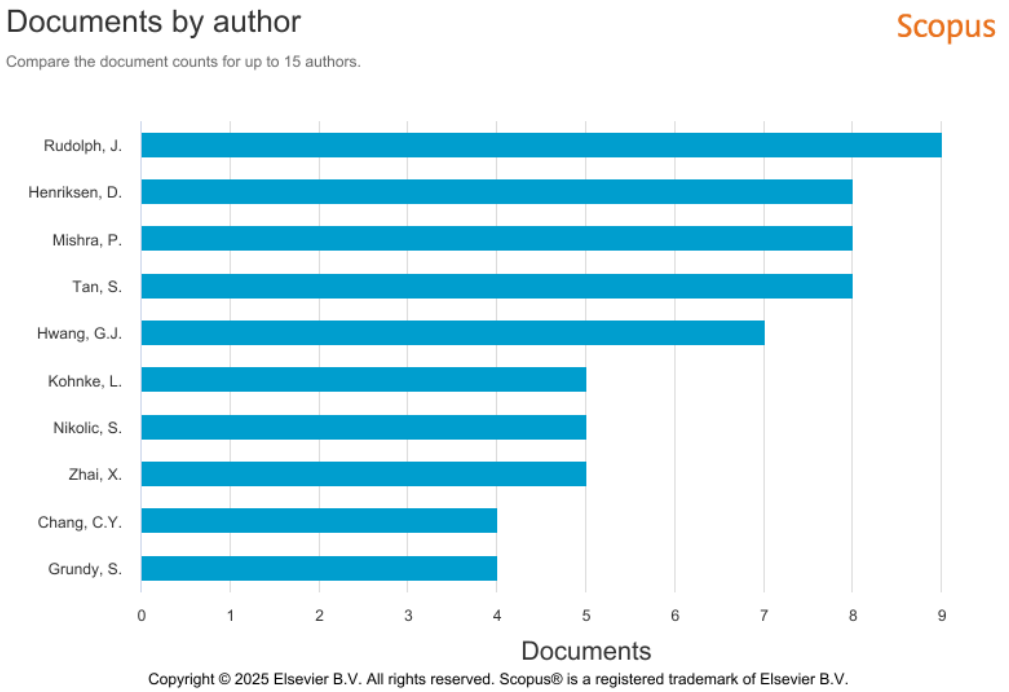

Figure 5. Documents by author. Source: Scopus database.

From the graph, it can be seen that Rudolph, J. ranks at the top with a total of 9 documents, indicating the highest level of productivity among the authors analysed. Next are Henriksen, D., Mishra, P., and Tan, S., each with 8 publications, signifying significant and consistent contributions in the relevant research field. Hwang, G.J. follows with 7 documents, further confirming his strong involvement in research activities, particularly in the domain of educational technology and digital learning.

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Other authors, such as Kohnke, L., Nikolic, S., and Zhai, X., each have 5 publications, demonstrating active engagement, albeit on a more moderate scale. Meanwhile, Chang, C.Y. and Grundy, S. are recorded with 4 documents, still representing important contributions within a broader network of scholarly collaboration.

Overall, the graph highlights a concentration of scientific productivity among several key researchers, with most highly-published authors likely serving as central figures in the relevant academic community. This distribution pattern reflects a typical hierarchy of scholarly contribution within the global research ecosystem, where certain academics act as primary drivers of innovation and the dissemination of scientific knowledge in their respective fields.

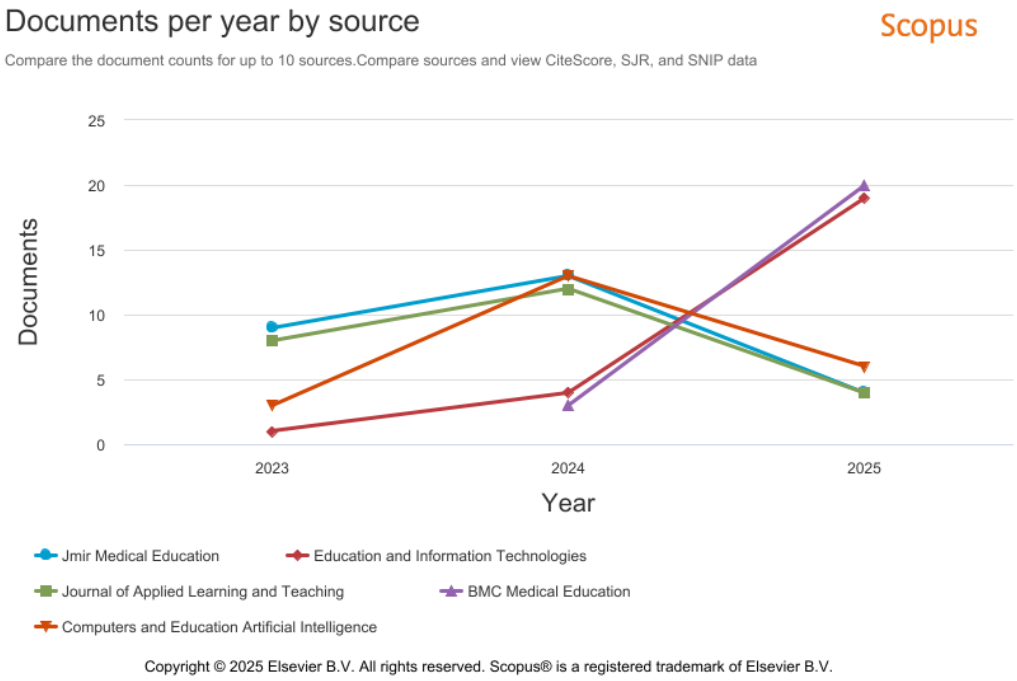

Figure 6. Documents per year by source. Source: Scopus database.

The image presents a line graph titled “Documents per Year by Source”, sourced from Scopus, illustrating the dynamics of the number of scholarly publications from various sources (journals) over the period 2023-2025. *JMIR Medical Education* shows a relatively stable trend with a slight increase from around 9 documents in 2023 to 13 in 2024, before declining again in 2025. *Education and Information Technologies* displays significant and continuous growth, rising sharply from around 3 publications in 2023 to 13 in 2024, and reaching approximately 19 documents in 2025, making it one of the most consistently growing sources.

The *Journal of Applied Learning and Teaching* shows a rising pattern, peaking in 2024 with around 12 publications, before experiencing a sharp drop to around 4 publications

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in 2025. *BMC Medical Education* initially shows relatively low activity during 2023-2024, but undergoes a substantial surge in 2025, reaching around 20 documents, indicating increased researcher interest in the topics published by this journal.

Meanwhile, *Computers and Education: Artificial Intelligence* shows consistent growth from 2023, peaking in 2024, before slightly declining in the following year. Overall, the graph depicts varied dynamics in scientific publication across journals, with certain sources such as *BMC Medical Education* and *Education and Information Technologies* experiencing exponential growth, indicating increasing scientific relevance and research intensity in the field of technology-based education and digital learning. This phenomenon reflects a shift in global research focus towards the integration of technology in education and pedagogical innovation in the digital era.

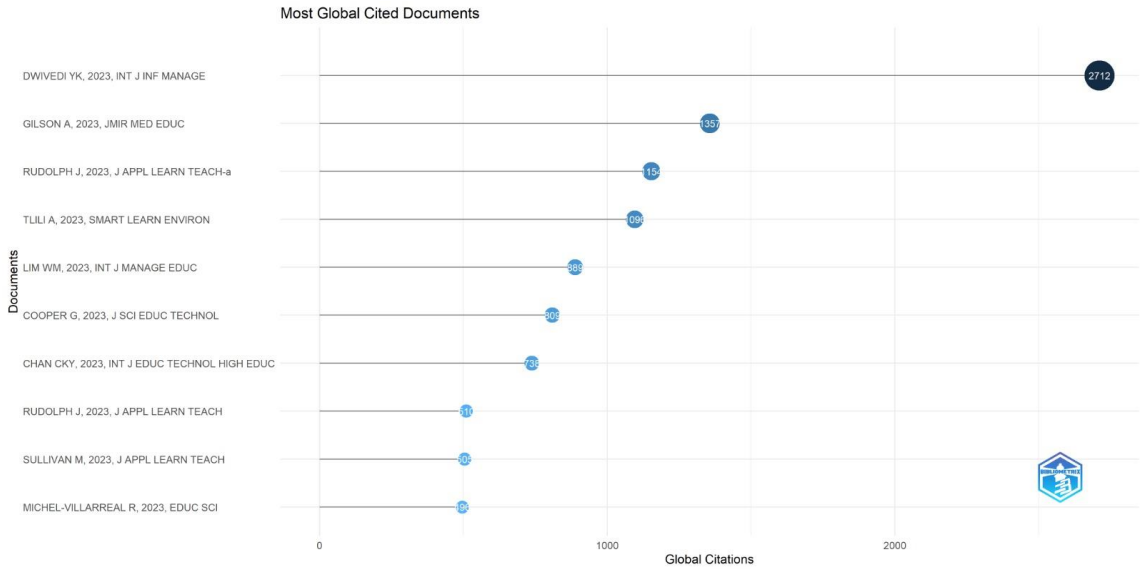

Figure 7. Most Global Cited Document. Source: Scopus database.

This graph illustrates the documents with the highest global citation counts related to ChatGPT and Generative Artificial Intelligence (GenAI) in the field of education, based on data from various sources. From the graph, it is evident that the document authored by Dwivedi YK (2023) in the *International Journal of Information Management* has received 2,712 citations, making it the most cited publication in this category.

Other documents, such as those written by Gilson A (2023) in *JMIR Medical Education* and Rudolph J (2023) in the *Journal of Applied Learning and Teaching*, also show substantial citation numbers, each exceeding 300 citations. This indicates that these publications have played a key role in shaping the understanding of generative AI applications in education.

Overall, the graph demonstrates how several leading articles in this field have gained wide recognition within the academic community, reflecting their significant influence on

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the development of AI research in education and the relevance of the themes explored in these publications.

3.3 Mapping of Main Research Topics and Inter-Theme Relationship

The following figures illustrate the mapping of main research topics and inter-theme relationships related to *ChatGPT*, *artificial intelligence*, and *large language models* within the educational context. These visualizations highlight the central themes, their level of development, and how different research areas are interconnected in the current body of literature.

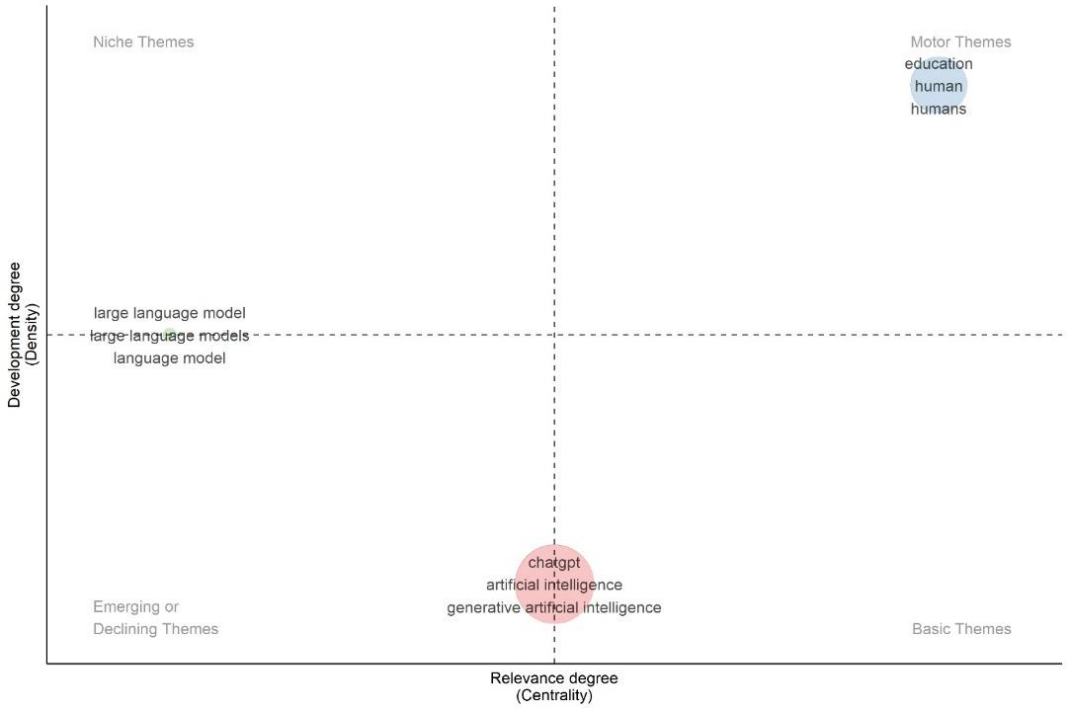

Figure 8. Mapping of main topics. Source: Scopus database.

The graph above illustrates a thematic map showing the relationship between the degree of relevance (centrality) and the degree of development (density) of the main topics in research related to ChatGPT and Generative Artificial Intelligence (GenAI). Based on the positioning of the themes in the graph, ChatGPT, Artificial Intelligence, and Generative Artificial Intelligence occupy the most central and rapidly developing area, marked by large red nodes. This position indicates that these topics represent the core and most relevant themes in current research and are evolving rapidly within the technology-based education literature.

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Conversely, Large Language Models (LLMs) appear as a more niche theme, with lower relevance and slower development, as reflected by its position further from the centre of the graph. This suggests that although LLMs are an essential component of AI development, research on their application in education remains in its early stages.

In addition, themes such as Education, Humans, and Human are located in the *motor themes* quadrant, indicating that these topics are both highly relevant and rapidly developing, with a focus on the impact of AI within human and educational contexts. This reflects a growing trend toward the application of AI to support teaching, learning, and educational management. Overall, the map illustrates the dynamics of research in the field of generative AI, with ChatGPT and AI emerging as the most influential and rapidly advancing themes, while human and education related topics are increasingly shaping the future direction of research.

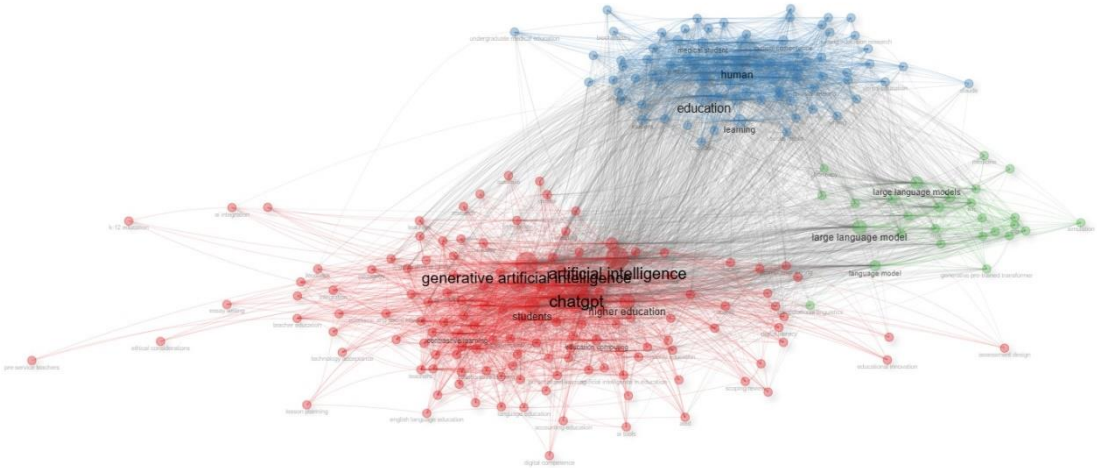

Figure 9. Interconnections between topics. Source: Scopus database.

The graph above presents a keyword network map illustrating the interconnections among the main topics that frequently appear in research related to ChatGPT and Generative Artificial Intelligence (GenAI) in the field of education. The map is divided into several thematic clusters, each representing a distinct yet interconnected area of research focus.

The red cluster includes topics that are more specifically related to Generative Artificial Intelligence and ChatGPT, featuring central keywords such as *students*, *higher education*, *continuous learning*, and *language model*. This indicates that research within this cluster primarily focuses on the use of AI in higher education, particularly in the context of learning and the development of technology-based skills.

The blue cluster, which is more closely associated with education and human-centred themes, includes keywords such as *education*, *learning*, and *medical students*. This reflects

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the importance of research exploring the application of AI in education more broadly, with an emphasis on enhancing learning experiences and adapting AI-based curricula, particularly in medical and professional education.

The green cluster encompasses topics focused on Large Language Models (LLMs) and their applications in education, featuring keywords such as *large language model*, *educational innovation*, and *assessment design*. This highlights the significant influence of LLM technology in the digital transformation of education, including AI-based curriculum development and assessment design.

Overall, the graph provides a clear overview of how generative AI, particularly ChatGPT, has become a central research topic across various educational disciplines, and how these topics have evolved into interrelated thematic clusters that collectively shape the technology-driven transformation of education.

3.4 Opportunities and Future Research Directions in AI-Based Education

The analysis of the research landscape on Artificial Intelligence (AI) in education reveals a progressive conceptual evolution towards multidisciplinary integration. Based on the thematic strategic map, themes such as education, human, and humans occupy the position of *motor themes* with high levels of relevance and density, indicating the dominance of research oriented towards the relationship between humans and learning technologies. Meanwhile, ChatGPT, artificial intelligence, and generative artificial intelligence serve as *basic themes* that form the core foundation of AI development in education, although they still require deeper theoretical and pedagogical exploration. In contrast, *niche themes* such as large language model and language models represent more technical and specialised research directions, particularly in the context of adaptive learning, automated assessment, and the development of intelligent tutoring systems.

The visualisation of the keyword network reveals three major interacting clusters: the red cluster, focused on *generative artificial intelligence* and *ChatGPT*, which emphasises the application of generative AI in learning contexts; the blue cluster, centred on *education* and *human*, which highlights the humanistic and socio-cognitive aspects of human–AI interaction; and the green cluster, encompassing *large language models* and *simulation*, which illustrates the integration of language technologies and simulation within experiential learning environments. Together, these clusters form a knowledge structure that demonstrates the synergy between technological innovation and pedagogical principles, indicating that AI in education is not merely viewed as an assistive tool but as a catalyst for epistemological and methodological transformation in the teaching and learning process.

These findings indicate that future research directions in AI-based education will move towards a deeper integration of technological, pedagogical, and ethical dimensions. The main focus should be directed towards the development of adaptive learning that personalises the learning experience without undermining human values; the

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strengthening of AI literacy and ethics to address challenges related to authenticity, algorithmic bias, and data protection; and the utilisation of AI as a collaborative partner in the creation and evaluation of knowledge.

Furthermore, the integration of AI into simulation and experiential learning presents opportunities to design a more reflective, inclusive, and sustainable educational ecosystem. Thus, future AI-based education is expected not only to enhance learning efficiency but also to emphasise the humanistic dimension positioning AI as a supporter rather than a replacement of human intellectual capacity.

4. Discussion

4.1 Publication Trends and Research Collaboration on ChatGPT and GenAI in Education

Based on bibliometric results and Scopus trends from 2023-2025, research on Generative Artificial Intelligence (GAI) in education demonstrates significant acceleration and a paradigm shift towards sociotechnical learning systems. The most relevant grand theory to explain this phenomenon is the Sociotechnical Systems Theory (Trist & Emery, 1951), which emphasises the importance of balancing the technological and social subsystems to achieve sustainable innovation (Flavin et al., 2025) .

In the context of education, the technological dimension encompasses the emergence of ChatGPT, large language models (LLMs), and adaptive learning systems, which act as catalysts for change. The social dimension includes teachers, students, and ethical as well as institutional policies that influence the acceptance and use of AI. The interaction between these dimensions gives rise to pedagogical innovations such as AI-integrated learning design, personalised feedback systems, and autonomous learning environments (Nguyen et al., 2025; Henriksen et al., 2024).

The final outcome is an ethical, adaptive, and human-centred educational result, marking the transition from the paradigm of “technology as a tool” to “AI as an epistemic partner” (Chen et al., 2023; Nikolic et al., 2025). Accordingly, the conceptual model in the figure below illustrates a Generative AI-based learning ecosystem governed by the reciprocal relationship between technological innovation and social structures.

This model can serve as a conceptual framework for further research related to the design of ethical AI policies in education and the effectiveness of GAI implementation in enhancing the quality of learning interactions.

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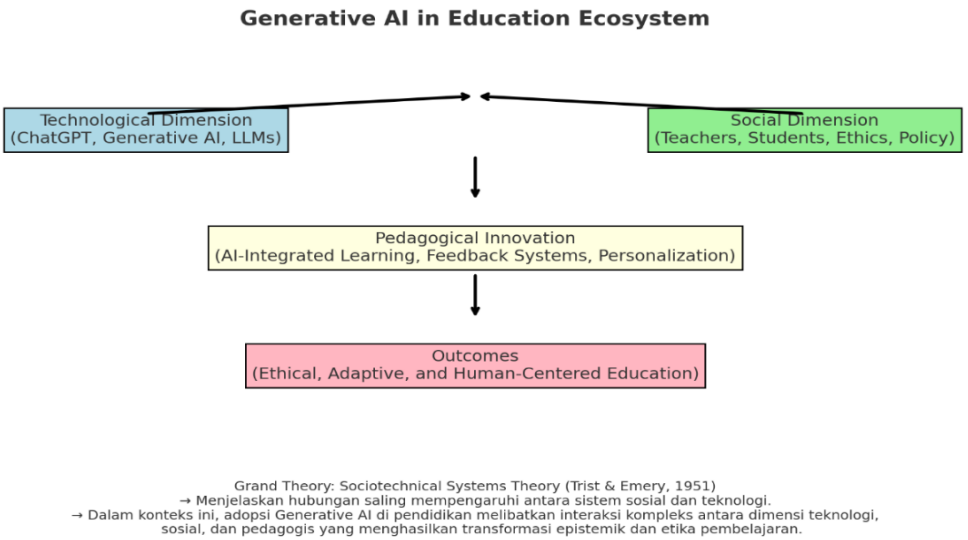

Figure 10. Conceptual Framework

4.2 Most Influential Authors, Journals, and Articles

The results of the bibliometric analysis covering publications, authors, journal sources, and the most highly cited documents reveal a significant transformation in the knowledge dynamics of Generative Artificial Intelligence (GAI) research in the field of education. Based on the Sociotechnical Systems Theory (Trist & Emery, 1951), this development can be understood as the outcome of a reciprocal interaction between technological systems and social systems. In this context, technological advancements such as ChatGPT and Large Language Models (LLMs) act as the main catalysts of change, while social factors such as ethics, pedagogy, and educational policy serve as balancing forces that ensure technological innovation remains grounded in human values and sustainability (Dwivedi et al., 2023; Gilson et al., 2023).

Leading authors such as Rudolph, Henriksen, Mishra, and Tan have made major contributions in shaping the new direction of this research. Their studies have expanded beyond the technical aspects of AI towards a more holistic and humanistic approach. Rudolph et al., (2023) highlights the importance of AI literacy in enhancing educators' digital competence, whereas Henriksen et al., (2024) and Mishra et al., (2024) explore the role of AI in fostering creativity and embedding ethical values within learning design. The prominence of their research indicates that AI-integrated pedagogical approaches have become a global focal point, aligning with the sociotechnical perspective that innovation is most effective when a balance between social and technological dimensions is achieved (Henriksen et al., 2024; Nikolic et al., 2025).

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In terms of publications, trends observed in journals such as JMIR Medical Education, Education and Information Technologies, and Computers and Education: Artificial Intelligence indicate a growing diversification of themes and cross-disciplinary collaboration. The significant increase in medical journals such as BMC Medical Education in 2025 signifies the expanding adoption of GAI in professional education, particularly in health and medical fields. These findings support the views of Lim et al., (2023) and Gilson et al., (2023), who argue that GAI can enhance clinical training and diagnostic decision-making through AI-based simulations. Theoretically, this demonstrates how technological and social systems evolve together (*coevolution*), generating innovations that are responsive to real-world needs within educational settings.

Furthermore, the analysis of the most highly cited documents reveals that the works of Dwivedi et al., (2023), Gilson et al., (2023), and Rudolph et al., (2023) serve as the main theoretical foundations of the global discourse on GAI. These studies introduce new conceptual frameworks that emphasise the importance of integrating artificial intelligence, ethics, and human learning. Within the framework of Sociotechnical Systems Theory, this phenomenon illustrates a process of mutual adaptation, in which humans learn to utilise AI as a cognitive partner, while AI systems are designed to align with educational values and goals (Cooper, 2023; Chan, 2023; Tlili et al., 2023). These findings form the basis for the Ethical-AI Pedagogical Framework, a new approach that combines AI literacy, academic integrity, and responsible innovation.

In synthesis, these findings illustrate the evolution of a paradigm towards a conceptual model of AI-Empowered Humanistic Education, in which AI functions not merely as a learning tool but as an epistemic and ethical partner that plays an active role in the process of knowledge creation (Almasri et al., 2024) . This model emphasises the integration of three key dimensions: the technological dimension (the capability of AI systems to personalise learning and provide adaptive feedback), the social dimension (the roles of teachers, students, and ethical policies), and the pedagogical dimension (creative and reflective learning strategies). Thus, recent research reinforces the view that the future of education is no longer limited to the digitalisation of learning, but rather involves the formation of a sociotechnical ecosystem that positions humans and AI in a collaborative relationship aimed at creating an educational environment that is adaptive, inclusive, and sustainable (Nguyen et al., 2025; Henriksen et al., 2024; Nikolic et al., 2024).

4.3 Mapping of Main Research Topics and Inter-Theme Relationship

Based on the theme map and network visualization illustrates the thematic relationships among *ChatGPT*, *artificial intelligence*, and *education* as the main clusters that are closely interconnected. According to the mapping results, topics such as ChatGPT, artificial intelligence, and generative artificial intelligence emerge as basic themes with high relevance but low density, indicating that these themes are still developing and serve

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as the core foundation of the current academic discourse. Meanwhile, themes such as education, human, and humans occupy the motor themes area, reflecting both high relevance and high development. This suggests that the integration of AI into educational contexts and human-AI interaction has become the central focus of contemporary research. In contrast, large language models lie in an area of moderate relevance and low development, indicating that this topic is currently in a phase of specialization or is beginning to mature in its applications.

Within the context of recent studies, a number of works confirm these patterns. For example, research by Mahrishi et al., (2024) demonstrates that ChatGPT has revolutionized higher education through more interactive and efficient AI-driven learning, while simultaneously highlighting the need for strong ethical frameworks and regulatory oversight. This finding is reinforced by Cherif et al., (2024), who emphasize ChatGPT's potential to enhance personalized learning in medical education, yet also caution against risks related to academic integrity and data accuracy. Similarly, Twinomurinzi & Gumbo, (2025) note increased student productivity through the use of ChatGPT but stress the necessity of developing clear policies and ethical frameworks to support sustainable implementation. Collectively, these findings indicate that the topic ChatGPT in education is transitioning from mere conceptual exploration to concrete pedagogical practice, reflecting the high level of relevance visualized in the thematic diagram.

From the perspective of grand theory, this phenomenon can be explained using the Technological Pedagogical Content Knowledge (TPACK) framework and Constructivist Learning Theory. According to TPACK, the adoption of ChatGPT in educational contexts represents a synergy between technology, pedagogy, and content, where AI functions as a mediator that supports adaptive and reflective learning. This is evident in the study by Hassoulas et al., (2023), which shows that medical students and lecturers perceive ChatGPT as a tool capable of accelerating cognitive processes, while still requiring critical supervision to maintain scientific validity. Based on Constructivist Learning Theory, ChatGPT serves as a *scaffolding agent* that helps learners construct understanding autonomously through reflective and iterative dialogue, as demonstrated in (Su et al., 2025). However, the limitations of large language models (LLMs) in grasping deep contextual meaning remain a major obstacle to achieving meaningful learning.

The novelty emerging from research within this thematic cluster (as reflected in the placement of ChatGPT and generative AI in the lower-right quadrant of the first diagram) is the shift from purely conceptual inquiries toward more empirical approaches that examine both the cognitive effectiveness of LLMs and the ethics of their use. For instance, the meta-analysis by Vargas Bernuy et al., (2025) shows that ChatGPT-4 has surpassed passing thresholds on various medical and pharmaceutical licensure exams, indicating increasingly human-like reasoning capabilities. Thus, the integration of ChatGPT into higher education is no longer merely experimental it has become a systemic phenomenon

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requiring a reframing of learning epistemology from human-centered pedagogy toward an AI-augmented learning ecosystem.

Accordingly, the combination of empirical findings and thematic visualizations demonstrates that current research is moving toward interdisciplinary inquiry that bridges large language technologies with human learning contexts. Grand theories such as constructivism and sociotechnical systems theory provide crucial conceptual foundations for understanding the dynamics of human-AI interaction in education. This confirms that the primary novelty of this research lies not only in ChatGPT's technical capabilities as a tool, but in the paradigm shift toward an epistemologically and pedagogically complementary human-AI collaboration.

4.4 Opportunities and Future Research Directions in AI-Based Education

Based on the visualizations and bibliometric results, the analysis indicates the presence of three major clusters in the current research landscape: (1) *ChatGPT and generative artificial intelligence*, (2) *education and human-centered AI*, and (3) *large language models (LLMs)*. The thematic map shows that the "ChatGPT" theme has high centrality but low density, suggesting that this topic serves as a foundational concept that is still developing toward stronger theoretical depth. In contrast, the "education-human" cluster has the highest density, indicating that AI-driven education research has reached a level of methodological and theoretical maturity. Meanwhile, the "large language model" cluster occupies a niche position, reflecting a shift toward more specific and technical research developments.

In this context, the most promising direction for future research lies in the development of Human-AI Collaborative Cognition. This shift marks a transition from using AI merely as a tool to viewing it as a cognitive partner in human-machine reasoning. Based on Activity Theory and Socio-Technical Systems Theory, AI is no longer regarded solely as an instrument but as a social actor within learning systems one that co-shapes thinking and knowledge processes. Studies such as Gonsalves, (2024) demonstrate that ChatGPT is increasingly used as a *thinking partner* that supports reflective and critical reasoning. Thus, the potential novelty emerging from this trend is the development of the concept of AI Cognitive Apprenticeship a learning model in which AI functions as a dialogic partner that helps students build reasoning, creativity, and higher-order thinking.

Furthermore, the dimensions of ethics, autonomy, and epistemic justice will become crucial new research territories for understanding the relationship between humans and artificial intelligence. Drawing on Critical Theory Sánchez Muñoz et al., (2025) and Actor-Network Theory (ANT), the relationship between humans and AI can be viewed as an ongoing negotiation of power between human agency and algorithmic agency. Recent studies such as Su et al., (2025) and Mahrishi et al., (2024) highlight the importance of ethical AI use, particularly in relation to knowledge justice and

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representation. A significant future research direction lies in exploring AI epistemic justice that is, how algorithms influence access to knowledge, the validity of information, and the distribution of epistemic resources in increasingly digitalized educational environments.

Additionally, the large language model (LLM) cluster points to an emerging research direction: understanding how AI might become a *learner entity* itself (Teckwani et al., 2024). According to Connectivism Theory (Siemens, 2005), knowledge no longer resides solely within individuals but is distributed across networks of humans and technologies. From this perspective, future research may investigate machine pedagogy, examining how LLMs learn from human interactions and adapt contextually. This opens opportunities for developing the concept of AI metacognition the capacity of language models to reflect on errors, refine their responses, and autonomously contribute to meaningful learning dialogues.

The integration of these three clusters points toward the potential formation of a new Grand Theory: the Generative Education Ecosystem (GEE). Drawing on Complex Adaptive Systems Theory (Holland, 1995), this ecosystem is dynamic, in which humans, AI, and data interact and co-evolve adaptively. Meta-analytic studies such as Zhu et al., (2025); Jackaria et al., (2024) demonstrate that ChatGPT-4 has approached human professional performance in medical examinations, indicating that AI now has the potential to become a valid and collaborative knowledge agent. Within this context, learning systems are no longer one-directional but evolve into generative ecosystems that continuously develop through simultaneous human-AI feedback loops (Kostas et al., 2025)

The thematic and bibliometric mappings reinforce the idea that future research will not simply examine the effectiveness of AI in education but will advance toward a new ontology of learning one that is generative, collaborative, and co-evolutionary. The strongest future research potential lies in developing interdisciplinary theories that merge constructivism, socio-technical systems theory, connectivism, and critical theory to construct a paradigm of an AI-driven co-learning society. Thus, the central focus of future studies will shift from how humans use AI to learn to how humans and AI learn together to create new knowledge.

5. Conclusion

The findings of this study affirm that research on ChatGPT and Generative Artificial Intelligence (GenAI) in the context of education has entered a phase of paradigmatic transformation, leading to a sociotechnical integration between humans and educational technology. The surge in global publications since 2023 reflects the scientific enthusiasm surrounding GenAI's potential to revolutionise pedagogical practices, expand access to education, and enhance both the effectiveness and personalisation of learning. Bibliometric analysis indicates that central themes such as ChatGPT, education, and

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human-centred AI serve as key conceptual foundations that are evolving towards a multidisciplinary synthesis encompassing technology, ethics, and pedagogy. Drawing on Sociotechnical Systems Theory and Constructivist Learning Theory, human-AI collaboration is no longer viewed merely as instructional interaction, but as an epistemic partnership that positions AI as a reflective partner in the creation of knowledge. Thus, the direction of future research is moving towards the development of a (Generative Education Ecosystem) one that is adaptive, ethical, and sustainable where humans and AI co-evolve in a learning process that is mutually enriching, both cognitively and socially.

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