





From Early Growth to Conceptual Formation: A Bibliometric Analysis of Generative AI Research in Higher Education

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Abstract

This study aimed to analyze the scientific output related to the use of generative artificial intelligence (GenAI) in higher education from a bibliometric perspective. The current analysis sought to uncover research growth trends, identify the most contributing publication sources, and identify the most prolific authors, as well as to examine the conceptual and intellectual framework and international collaboration networks. The study used a bibliometric analysis methodology on a sample of 959 studies extracted from the Web of Science database for the period 2021–2025, prepared by 2,881 researchers. The results revealed a research boom in the field, with an annual growth rate of 25.99% and an average of 10.28 citations per study, in spite of the relatively short lifespan of the documents. The journal of Education Sciences emerged as the most frequently published scientific source, while researcher Bozkurt A. was identified as the most productive author, reflecting the early stages of research development in this discipline. At the conceptual level, the analysis revealed that literature is centered around the axes of academic performance, motivation, technology acceptance, and modern teaching strategies. The shared citation map also showed that the field's intellectual framework is based on studies that combine applied educational dimensions with Technology Acceptance Models (TAM), extending to the technical foundations of these tools. Regarding international collaboration, the results demonstrated research leadership from the United States, China, and the United Kingdom, with notable contributions from Saudi Arabia, India, and Singapore. The study concludes that research in GenAI represents a dynamic and fast evolving field where educational and technological frameworks intersect, with a growing trend toward strengthening worldwide knowledge collaboration networks.

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Introduction

Today, the world is witnessing rapid and remarkable development. Thanks to technological advancements and the emergence of numerous artificial intelligence (AI) technologies, profoundly impacting all aspects of life (Chan & Hu, 2023). GenAI is one of the most important branches, trained to generate text, images, audio, video, and 3D models. Examples include ChatGPT, Copilot, and MidJourney (T. K. Chiu, 2024). Given its ability to mimic human skills and the rapid progress we are witnessing in this field, its use cannot be ignored, especially in higher education, despite some potential concerns (Michel-Villarreal et al., 2023).

The use of GenAI in higher education institutions offers a different learning experience. In addition to its ability to enhance the learning experience, improve the quality of educational performance, and support scientific research, it also contributes to improving the quality and efficiency of administrative processes related to admissions and review (Chan & Lee, 2023; Moorhouse et al., 2023). In these cases, GenAI can simulate human capabilities through a range of technologies based on neuronal networks, deep learning, and big data, contributing to the creation of innovative content (Yusuf et al., 2024). Consequently, universities should embrace this technology and encourage its integration into educational projects, given its potential to enhance the learning and research experiences of students, researchers, and even faculty members (van den Berg & du Plessis, 2023).

In light of this, many studies and research papers have addressed the uses of GenAI in higher education, indicating that it represents a significant turning point that will contribute to changing teaching and learning practices (Kurtz et al., 2024). This shift has led to its increased popularity among students and faculty members (O'Dea, 2024), due to the assistance it provides, such as helping them overcome the challenges of academic writing (Kim et al., 2025) and offering a stimulating and interactive experience that helps improve creativity and increase scholarly output (Chan & Hu, 2023; T. K. Chiu, 2024). Given this remarkable development, the need arises to study how to establish a collaborative interaction between GenAI and the human element in areas such as authorship, academic writing, critical analysis, educational content development, academic work evaluation, and all other related tasks in order to ensure ethical compliance and promote academic integrity (Bozkurt, 2024; Nguyen et al., 2024). GenAI is a relatively new digital tool, and despite the increasing research and studies on its applications in higher education, the research team believes that studies addressing bibliometric analysis remain limited. Previous studies have often focused on exploring opportunities, experiences, and how to address potential challenges (Almassaad et al., 2024; Michel-Villarreal et al., 2023; Wang et al., 2023), and the need for policies to regulate the use of smart digital tools in higher education (Chan, 2024; Moorhouse et al., 2023). This is especially relevant given that these are emerging technologies that may generate inaccurate content, in addition to the limitations of free access (Kyrpa et al., 2024). Moreover, more than a few educational studies have urged further research on practices and strategies related to the use of GenAI in education (T. K. Chiu, 2024), taking into account issues of academic integrity and maintaining ethical compliance (Farazouli et al., 2024).

Given the rapid development of GenAI applications in higher education, and the valuable outputs and important bibliometric maps that this type of research provides—information that helps identify future trends and frameworks (Donthu et al., 2021)—the need for this study is pressing, especially since another gap exists in

understanding how these fast evolving intelligent applications interact with theoretical frameworks (Bower et al., 2024). It is crucial to have a roadmap that clarifies the interaction and applications of this technology in higher education. Hence, this study aimed to identify and analyze the scientific literature on the use of GenAI in higher education through bibliometric analysis and systematic study. This involved reviewing articles in the scientific output indexed within the Web of Science database and analyzing emerging research trends in articles published between 2021 and 2025.

The current research seeks to conduct a bibliometric analysis of scientific studies that addressed the use of GenAI in higher education during the period from 2021 to 2025. This can be achieved by answering the following questions:

- What are the overall scientific performance indicators for published studies on the use of GenAI in higher education during the period from 2021 to 2025?
- Which scientific journals and sources have contributed most to publishing studies related to the use of GenAI in higher education?
- Which scientific sources are most frequently cited in the literature related to the use of GenAI in higher education?
- Who are the most prolific authors in the field of using GenAI in higher education?
- What is the conceptual structure of scientific literature related to the use of GenAI in higher education, as reflected by the most frequently used keywords?
- What is the intellectual structure of literature related to the use of GenAI in higher education, as revealed by the shared citation network?
- Which studies are most frequently cited in the field of using GenAI in higher education?
- What are the patterns of international research collaboration between countries in published studies on GenAI in higher education?

Literature Review

In fact, GenAI is a collection of intelligent digital applications and tools derived from artificial intelligence (AI) that can generate creative multimedia content that mimics human style (Cooper, 2023; Kurtz et al., 2024). It operates by utilizing deep learning techniques and deep neural network models to process large amounts of input data, enabling it to learn patterns and structures and thus create coherent, contextually relevant outputs (Dwivedi et al., 2023; Tlili et al., 2023).

Recently, the importance of GenAI in higher education has become increasingly apparent due to rapid technological advancements. This led UNESCO to issue a guidance document on how to use these intelligent digital tools in education and research (UNESCO, 2024). In Saudi Arabia, the Saudi Data and Artificial Intelligence Authority (SDAIA) issued a guidance document on how to use GenAI positively in education as a supportive tool for students and faculty members (SDAIA, 2023). Many recent studies have also included the need to integrate GenAI into higher education due to the many advantages it provides, including, for example: automating administrative tasks (Tupper et al., 2024), personalized learning and increased interactivity,

developing and improving educational content, and supporting academic writing (Chan & Hu, 2023; Kim et al., 2025; van den Berg & du Plessis, 2023). Also, its use as a learning analytics model enhances engagement in digital learning environments (Al-Hafdi & Alhalafawy, 2026).

GenAI is considered as a cornerstone of educational development, offering intelligent alternatives to traditional methods. This directly contributes to deepening students' awareness and equipping them with creative and critical problem-solving skills (Javaid et al., 2022). The importance of these tools lies in personalizing education and tailoring resources to individual differences, making learning a more continuous and stimulating process (Hastuty et al., 2025). By tracking performance and understanding each learner's cognitive characteristics, these systems provide targeted educational support that improves learning outcomes (Yu et al., 2023). Additionally, GenAI's interactive digital environment offers ample opportunities for intelligent research and summarization, fostering a culture of self-directed learning (Kucukkuya et al., 2025). Within a collaborative learning framework, these technologies are effective in designing intelligent discussion spaces that encourage students to collaborate on addressing diverse issues. GenAI has reshaped higher education in various aspects, including teaching and learning (Alsayed et al., 2025), teacher roles (Alharbi et al., 2025), and scientific research (Alsulami et al., 2025). It has become a component of digital life in the educational environment (Ibrahim et al., 2024).

Theoretical Foundations of GenAI Integration in Higher Education

Regarding theoretical frameworks, the integration of GenAI into higher education and academic environments is an emerging and modern field (McGrath et al., 2025). The importance of understanding these smart digital tools and their impact lies in adhering to the principles of educational theories to fully leverage GenAI technologies in higher education (Francis et al., 2025). These technologies are based on learning theories such as social constructivism, a theoretical framework that emphasizes that education is not an isolated activity but rather one based on social interaction, where knowledge is constructed within contexts of collaboration and interaction (Zhou & Schofield, 2024). So, GenAI effectively contributes to enhancing collaborative learning by providing tools that support effective communication and the exchange of ideas (Francis et al., 2025).

Likewise, Personalized Learning theory refers to providing a different, more individualized learning model that departs from traditional models by designing learning that aligns with students' specific preferences and learning pace (Li & Wong, 2023). This contributes to meeting their educational needs and enhancing their learning experiences (Guo et al., 2024). Advanced applications can be used to control and modify educational content based on student learning analytics, helping them receive personalized support and enhancing their engagement in addressing academic challenges (Bhutoria, 2022). In this context, GenAI emerges as an essential tool for achieving this transformation. Its role extends beyond data analysis to include generating interactive and real-time learning content that adapts to each learner's unique characteristics. By formulating alternative activities and diverse interpretations that suit varying levels of understanding, GenAI embodies the practical application of Personalized Learning theory, transforming it from a theoretical framework into a flexible digital experience that supports cognitive independence and pushes the boundaries of self-directed learning to unprecedented levels.

Moreover, competency-based learning theory, which draws on some behavioral teaching principles, focuses on measuring student competence and assessing their abilities through reinforcement and feedback mechanisms in realistic learning environments, moving away from traditional rote memorization-based assessment (Tenakwah et al., 2023). GenAI aligns with this approach by offering adaptive assessment systems capable of simulating complex, realistic scenarios that test students' actual skills rather than their memorization of information. Thanks to its ability to generate immediate and detailed generative feedback. GenAI acts as a facilitator for the reinforcement process by precisely identifying skill gaps and proposing remedial learning pathways specifically designed to develop the student's lagging competence. This helps the student reach the required level of mastery before progressing to the next stage. While some principles of constructivist theories are drawn from GenAI's application to develop students' abilities and enhance their critical thinking and active learning skills (Padovano & Cardamone, 2024), integrating all technological capabilities, especially GenAI technologies, with learning theories contributes to a positive impact that improves educational outcomes in higher education (Francis et al., 2025).

The added value of integrating GenAI into higher education is highlighted by its fundamental connection with the principles of Self-Determination Theory. This integration acts as a catalyst for intrinsic motivation by fulfilling three basic psychological needs: autonomy, competence, and connection (T. K. F. Chiu, 2024). By empowering students to guide their learning paths and generate knowledge resources that align with their interests, GenAI fosters their sense of autonomy and control over the educational process. Furthermore, generative tools contribute to raising competency levels by providing immediate scaffolding support that helps students overcome complex cognitive obstacles, thus reducing the intensity of academic workloads (T. K. F. Chiu, 2024; Valle et al., 2022). This technological-educational interaction is directly reflected in the quality of learning outcomes, as the student transforms from a passive recipient to an active participant capable of employing smart solutions to address academic challenges with a spirit of innovation and high flexibility.

In conclusion, the transition of these educational frameworks from theory to effective field application via GenAI technologies remains fundamentally based on the parameters of the Technology Acceptance Model (TAM). The adoption of these innovations in the educational environment centers on users' understanding of the functional requirements that ensure technological acceptance. This acceptance is essentially based on two key factors: first, perceived useability, which refers to the extent to which the technology contributes to improving scientific outputs and enhancing academic performance; and second, perceived ease of use, which reflects the ease of interacting with these modern tools and overcoming technical complexities (Kelly et al., 2023; Xue et al., 2026).

Methodology

In this study, a selected dataset was analyzed using a quantitative exploration methodology, along with a bibliometric study of literature on the use of GenAI in higher education. The aim was to provide a relevant knowledge base that would enable researchers to identify gaps and monitor developments (Öztürk et al., 2024). The bibliometric analysis reveals a clear map of disciplines, sub-disciplines, and specialized scientific fields, as

well as information on the most contributing researchers and authors (Hernández-Torrano et al., 2022). This was achieved by utilizing the widely used Web of Science (WoS) database, whose impact factor for evaluating scientific journals is widely recognized (Koo, 2025). It also offers features such as reference tracking, citation reports, and research performance analysis (Huang et al., 2022).

Conducting the Search

This study employed a structured search protocol to examine the published literature on GenAI in the context of higher education. Initial data retrieval was performed from the Web of Science (WoS) database on March 29, 2025, encompassing intellectual output published between 2021 and 2025. A carefully designed search string was used, encompassing the most common large language models and generative tools. Table 1 outlines the initial search strategy and its technical limitations before the results were subjected to subsequent filtering, inclusion, and exclusion criteria.

Table 1. Search Protocol

Item	Description
Database	Web of Science
Search history	29/03/2025
Time period	2021-2025
Document type	Refereed Articles
Publishing language	English
Access	Open Access
Web of Science ranking	Education Educational Research
Analysis tool	within a Bibliometrix RStudio environment
Research series	("Generative AI" (Topic) OR ChatGPT (Topic) OR "Claude AI" (Topic) OR "MidJourney AI" (Topic) OR "Copilot AI" (Topic) OR "Gemini AI" (Topic) AND "Higher Education" (Topic) OR "University Education" (Topic) and 2021 or 2022 or 2023 or 2024 or 2025 (Publication Years) and Article (Document Types) and Education Educational Research (Web of Science Categories) and English (Languages) and Open Access)
Number of retrieved studies	25322

Inclusion and Exclusion Criteria

Following the completion of the extensive retrieval phase, a matrix of eligibility criteria was applied to narrow the search scope and select the studies most relevant to the topic of GenAI in education. Inclusion criteria included high-quality, publicly available English-language scholarly articles, while conference papers, book chapters, and reports were excluded to ensure uniformity in the types of documents selected for analysis. Table 2 summarizes these criteria, which resulted in a final sample of 959 scholarly studies.

Table 2. Inclusion and Exclusion Criteria

Standard	Description
Inclusion criteria	<ul style="list-style-type: none"> • Peer-reviewed articles • Published in English • Within the field of education and educational research • Published under open access • Focusing on GenAI
Exclusion criteria	<ul style="list-style-type: none"> • Conference and meeting papers • Book chapters • News reports • Non-educational studies • In languages other than English
The number after filtering	959 studies

Analysis of Included Studies

Following data purification, a list of studies included in the bibliometric analysis was compiled. Articles were categorized according to performance indicators such as the number of published articles, the number of citations, conceptual network analysis, and institutional and international collaboration, using the Bibliometrix tool within the RStudio environment. The studies were then ranked in descending order by the number of citations to identify the most influential articles in the field. This helps in constructing the intellectual framework of the research area, as the overall analysis helps in identifying the most prolific authors, leading journals, and frequently used keywords, in addition to representing thematic and collaborative relationships among the field's components. Consequently, the bibliometric analysis results will be presented according to the axes that reflect the study's findings, including: (1) indicators of the overall scientific performance of published studies on the use of GenAI in higher education; (2) journals with the highest publication output; (3) most cited scientific sources; (4) most prolific authors; (5) the conceptual structure of the field as reflected by keywords; (6) the intellectual structure as revealed by the shared citation network; (7) the most cited studies; and (8) a map of international collaboration between countries. These analyses were performed using the bibliometric analysis tools, network analysis, and graphical representation methods provided by the Bibliometrix package.

Results

General Scientific Performance

The bibliometric analysis revealed that the scientific output related to the use of GenAI in higher education during the period from 2021 to 2025 reached 959 studies published in 264 scientific journals, reflecting the growing interest in this topic in recent years. The annual growth rate of scientific output was 25.99%, a high rate indicating rapid development in this field of research. A total of 2,881 authors contributed to these studies, averaging 3.24 citations per study, while 164 articles were individually authored. This demonstrates the prevalence of collaborative publishing in this field. The percentage of international co-authors was 20.86%, a positive indicator of international collaboration and knowledge exchange among researchers.

Concerning impact, the average number of citations per study was 10.28, a relatively high figure considering the relatively recent publication, with the average age of the documents being only 1.44 years. The number of references cited in the total number of studies obtained, which is (959) studies, amounted to (36,629) references, while the authors used (2,645) keywords, as this reflects the diversity of interests among researchers and the difference in their research visions and approaches through this emerging field. Figure 1 illustrates the general scientific performance of the studies included in the bibliometric analysis.

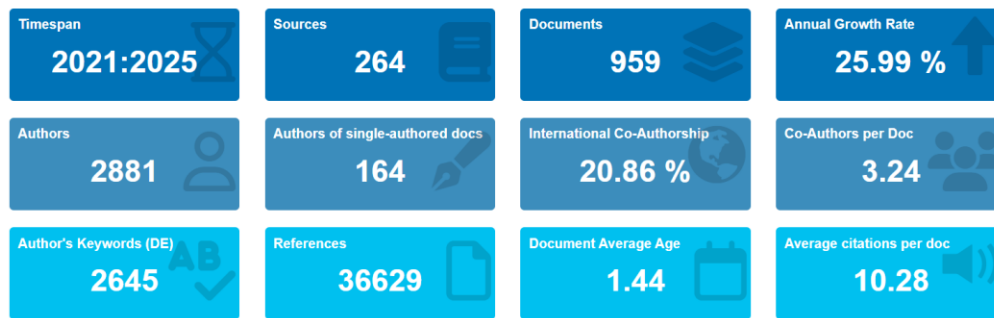


Figure 1. General Scientific Performance Indicators for Studies

Most Published Journals

The analysis, as shown in Figure 2, revealed that the journals with the highest number of published studies were Education Sciences (103 studies), Frontiers in Education (51 studies), and BMC Medical Education (36 studies).

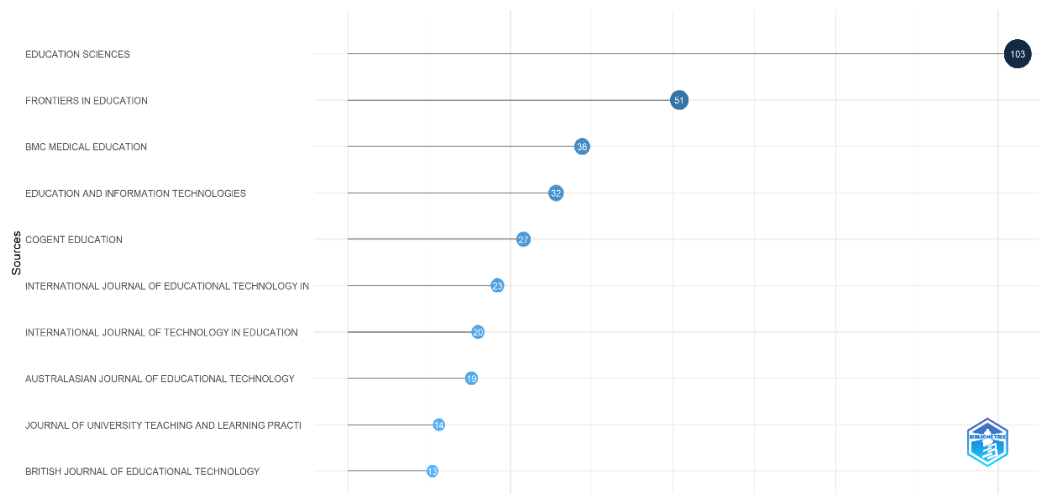


Figure 2. Most Published Journals in GenAI

Education and Information Technologies ranked fourth with 32 studies. Other journals, such as Cogent Education, International Journal of Educational Technology in Higher Education, International Journal of Technology in Education, and Australasian Journal of Educational Technology, also demonstrated significant interest and activity, although the number of published studies varied compared to the other journals.

Most Cited Sources

arXiv topped the list of most frequently cited sources with 569 citations from the studies included in this study. Given its open-access, pre-peer-reviewed nature, this reflects the significant interest of researchers in this field and its rapid development and novelty. This was followed by the journal Education and Information Technologies with 507 citations, and then the journal Computer & Education, both of which specialize in the intersection of education and technology. The list also included journals focused on educational practices and teaching, such as Educational Sciences, Sustainability, Computers in Human Behavior, and the British Journal of Educational Technology, as illustrated in Figure 3 of the most frequently cited sources.

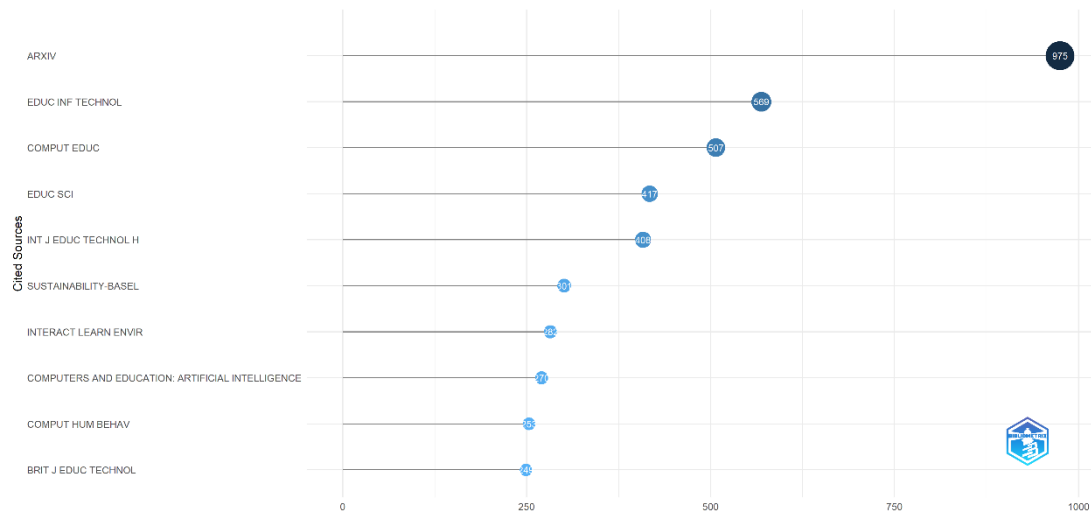


Figure 3. Most Cited Sources in GenAI

Most Published Authors

The analysis revealed that a limited number of researchers topped the list of scientific output in the field of GenAI in higher education during the period (2021-2025) (see Figure 4).

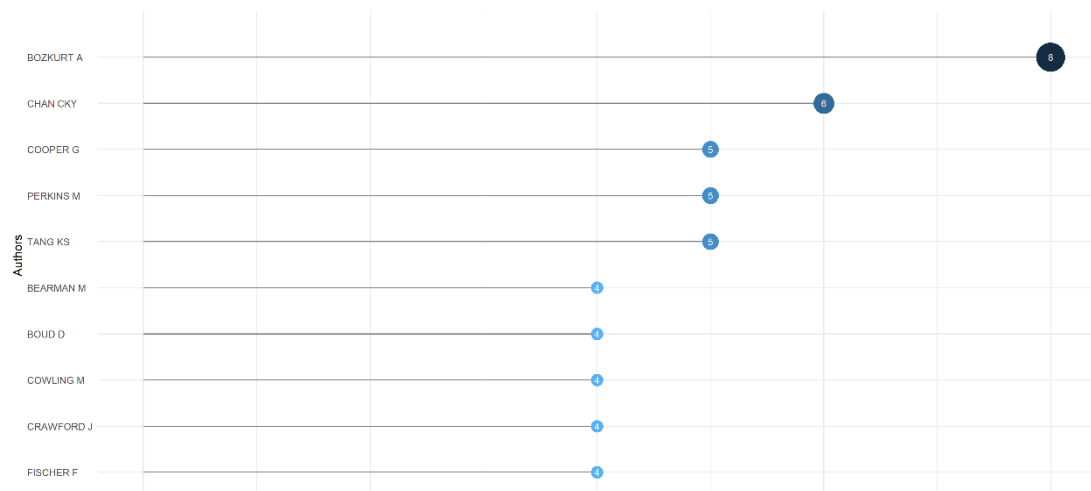


Figure 4. Most Published Authors

As shown in Figure 4, Bozkurt A ranked first with 6 publications, followed by Tong KS, Bearman M, Boud D,

Cowling M, Fischer F, and Crawford J, each with 5 publications. These results reflect the novelty of this field, which is still in its early stages, thus highlighting the promising research opportunities for researchers to further enrich scientific and educational contributions in this area.

Conceptual Structure for GenAI

The results of the conceptual network analysis of the studied sample showed a clear concentration of keywords in the fields of education such as: students, performance, artificial intelligence, and technologies, reflecting the growing interest in the educational impact of using these technologies in higher education. As illustrated in Figure 5, several interconnected conceptual groups emerged, most notably:

- The red group, which included keywords such as education, artificial intelligence, technology, ChatGPT, and outcomes;
- The blue group, which included keywords such as students, performance, impact, and motivation;
- The purple group, which included keywords such as acceptance, adoption, and perceived ease;
- The orange and green groups, which included keywords such as instruction, teachers, strategies, and engagement.

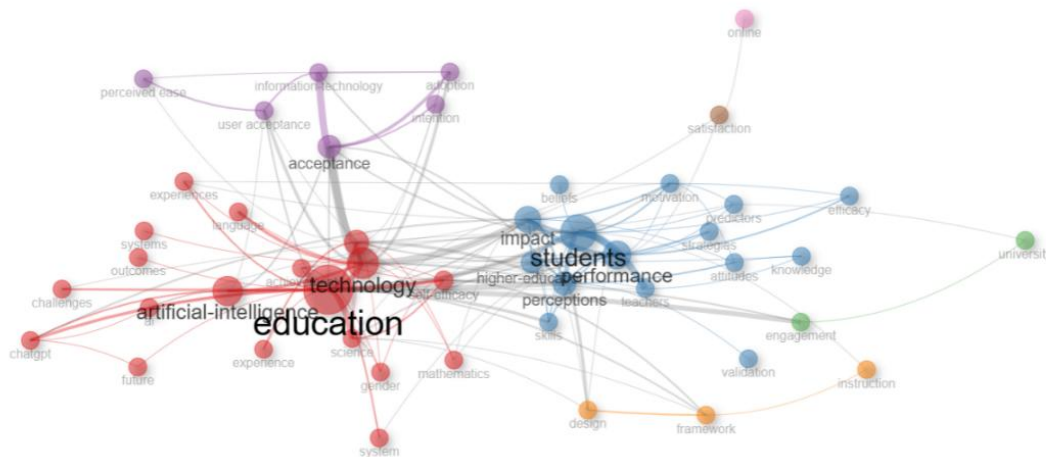


Figure 5. The Conceptual Structure of the Keywords Most Associated with the Use of GenAI in Higher Education

Based on these findings, it can be said that the literature presented in this field within the framework of higher education has focused on key themes, such as:

- The first theme relates to the impact of these smart digital tools on the educational process within higher education institutions, where keywords such as performance, motivation, and adoption were frequently used, reflecting researchers' interest in the use of these tools within classrooms and academic platforms.
- The second axis relates to the attitudes and perceptions of students and faculty members regarding the use of these smart digital tools. Keywords such as chat, acceptance, perceived ease, and strategies were frequently used, indicating a focus on how to use and interact within an ethical and educational framework.

- The third axis reflects the interest in employing GenAI in the educational process, from design to development. Keywords such as instruction, teachers, and engagement were frequently used, indicating the adoption of these smart technologies in higher education and the development of a model that aligns with the rapid evolution of higher education environments thanks to these tools.

Intellectual Structure for GenAI

The Co-citation Network analysis map showed clusters of published studies, clearly demonstrating that the studies under investigation played a significant role in shaping the field of GenAI applications in higher education. Figure 6 illustrates knowledge clusters comprised of studies and scholarly references that enriched both the theoretical and practical aspects of GenAI use in higher education. These references and studies focused on the educational aspects and the impact of these smart digital tools on academic environments. Moreover, the network also demonstrated a group of recent studies that focused on employing generative artificial intelligence tools, such as ChatGPT, with an emphasis on the educational opportunities and ethical considerations associated with the use of artificial intelligence, as well as the challenges accompanying its implementation in educational environments. Furthermore, the studies illustrated in the network indicated the growing interest in the impact of generative artificial intelligence on the development of educational practices and instructional design. Prominent examples of these studies include (Baidoo-Anu & Ansah, 2023; Dwivedi et al., 2023; Kasneci et al., 2023; Tlili et al., 2023).



Figure 6. Common Citation Map of Literature related to the Use of GenAI

Most Cited Papers

Analysis of the overall citations of the studies showed that some studies received high citation rates, indicating their important influence and extensive adoption in the field of GenAI in higher education. As shown in Figure 7, the study by (Cotton et al., 2024) topped the list with 597 citations. This study addressed the challenges of academic assessment using GenAI tools. It was followed by the study by (Tlili et al., 2023) with 503 citations, which discussed the opportunities and challenges of integrating these intelligent technologies into higher education settings. The study by (Cooper, 2023) also stood out with 387 citations, focusing on GenAI's ability to improve academic performance. Finally, the study by (Lim et al., 2023) with 368 citations, which examined the effects of GenAI on learning practices, also featured prominently.

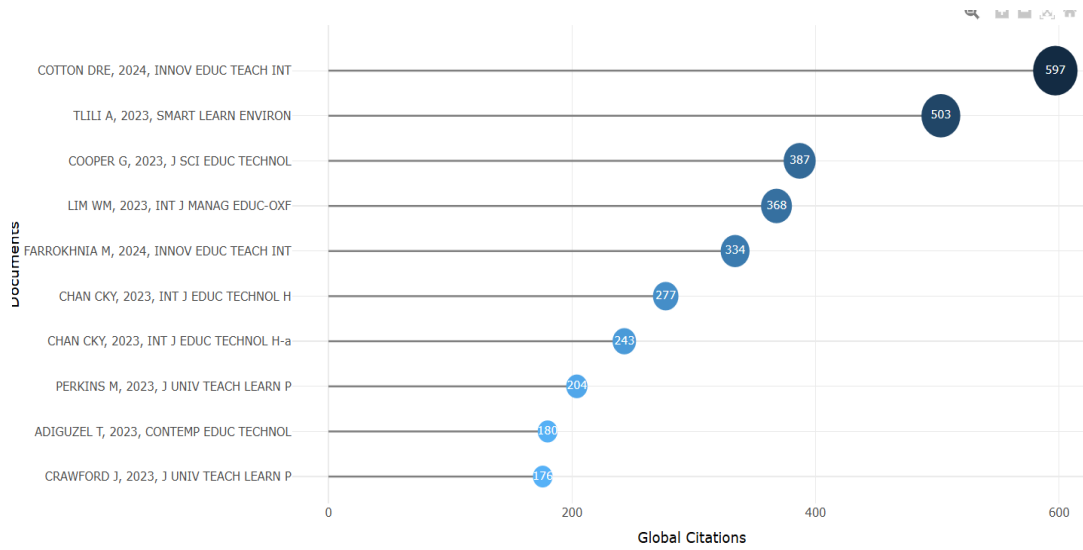


Figure 7. Most Cited Studies

Collaboration Map

The Country Collaboration Map, as shown in Figure 8, shows significant research collaboration in GenAI and its applications in higher education.

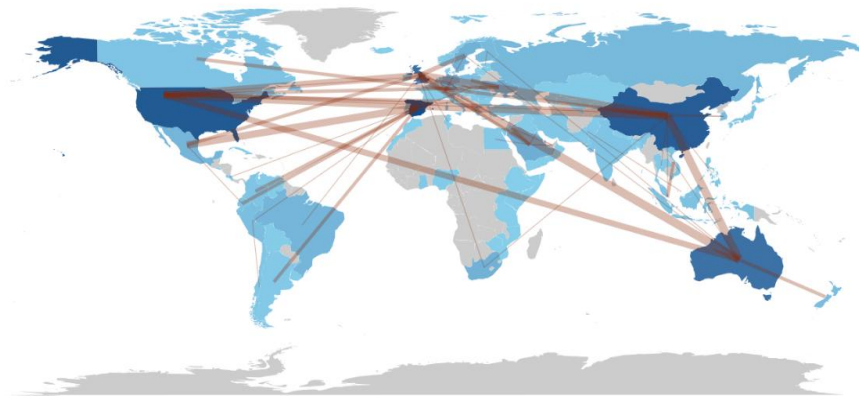


Figure 8. Map of International Cooperation between Countries

International co-authorship within the included studies reached 20.86%, reflecting a collaborative approach among researchers that fosters knowledge exchange, particularly in this field. The United States led in research collaborations, followed by China, the United Kingdom, and Australia, indicating these countries as key research hubs in this area. The map also reveals active participation from other countries such as Saudi Arabia, India, Singapore, and South Korea, demonstrating the growing interest in this field and its applications in higher education. Besides, research contributions emerged from European countries like Portugal, Spain, Slovenia, and France, as well as from Latin American and African nations, highlighting the formation of unconventional international research networks and collaborations.

Discussion

The results of the bibliometric analysis showed a remarkable growth in the scientific output of studies that dealt with the use of GenAI in higher education from the year (2021) until (2025), as the sample of studies that were conducted on this study amounted to (959) studies, and the annual growth amounted to (25.99%), which reflects the increasing interest of researchers in this field. The growth is a response to the digital transformations that the world is witnessing today, and is in line with the recommendations of UNESCO calling for the responsible use of GenAI tools in research and education (UNESCO, 2024), as well as the guidance document issued by the Saudi Data and Artificial Intelligence Authority (SDAIA), which is an encouraging document for faculty members and students, and reflects the official supportive trends regarding the integration of these smart digital technologies in higher education (SDAIA, 2023). Some recent studies support this growth, indicating that integrating GenAI tools into higher education contributes to enhancing scientific research and provides promising new opportunities for academic development (Cooper, 2023; Dwivedi et al., 2023; Tlili et al., 2023). It also reflects higher education's trend toward digital transformation in response to rapid changes and the adoption of these smart digital tools in academic environments (Kurtz et al., 2024).

Knowing the identities of the authors and journals most frequently contributing to GenAI is crucial for understanding the field's knowledge structure. This helps identify trends related to influence and scientific output, as these authors participate in shaping future paths and formulating theoretical frameworks for the field (Donthu et al., 2021). In this context, the results of the bibliometric analysis revealed the contributions of a number of authors to the quick growth witnessed in the field. Several researchers stood out for their research activity during the study period, most notably Bozkurt A, who is the most productive researcher, followed by researchers such as Tong KS, Bearman M, Boud D, Cowling M, Fischer F, and Crawford J. As for scientific journals and publications, journals such as *Education and Information Technologies*, *Computer & Education*, and the *British Journal of Educational Technology* stood out. These are among the most prominent academic publishing platforms that are increasingly interested in publishing studies related to the field of GenAI and its uses in higher education. This reflects a growing interest among journals in focusing on exploring the educational aspects and ethical challenges associated with the use of these technologies, as evidenced by studies published in these journals (Chen et al., 2025; Herath et al., 2025; Záková et al., 2025; Zheng et al., 2024).

Conceptual analysis of the structure is one of the most important axes for understanding the research trends of the field, as it allows for the identification of the most frequently occurring topics and keywords, and reveals the thought patterns upon which the cognitive structure is based (Donthu et al., 2021). The conceptual structure in this study revealed prominent cognitive clusters that reflected the researchers' interests, which can be divided into three main axes.

- The first axis: The impact of GenAI on the educational process: This was evident in keywords such as adoption and motivation. This axis is supported by recent studies focusing on academic interaction and the impact of these smart digital technologies in academic environments (Chiu, 2022; Valle et al., 2022).
- The second axis: Student and faculty perceptions and acceptance of these technologies: This was evident in keywords such as acceptance and perceived ease. This axis is supported and explained by

the focus on the technology acceptance model, which emerged in several studies indicating student and faculty attitudes ranging from optimism to hesitation regarding the support and reliability of these smart digital tools (Evmenova et al., 2024).

- The third axis focuses on content design and best teaching methods, as evidenced by keywords such as engagement, teachers, and instruction. This is further supported by studies that view GenAI as an effective educational tool that contributes significantly to the learning process through academic content design and mapping (Choi et al., 2024), and its ability to provide feedback and improve academic performance (Jauhiainen & Guerra, 2024).

This conceptual framework can help researchers understand the conceptual structure of the field and guide them toward other areas that will further enhance and enrich it. For example, future research could focus on studying the educational implications of using these digital tools in designing interactive educational content, or on exploring cultural differences in the adoption and acceptance of these tools within academic settings (Evmenova et al., 2024).

The bibliometric analysis results revealed that the social structure of research in the field of GenAI in higher education is highly collaborative, particularly at the international level. Collaboration accounted for 20.86% of the total, with the United States, China, the United Kingdom, and Australia leading the list of countries most actively involved in research collaboration networks. This distinction stems from the advanced capabilities these countries possess, including robust infrastructure and strategic support for their research centers, compared to less engaged nations. This aligns with the findings of (Dwivedi et al., 2023) regarding the digital divide and its impact on international research collaboration, especially in emerging technologies such as GenAI in higher education. These results support recent studies indicating that international research collaboration offers promising opportunities to enhance the effective application and use of these tools in higher education (Nguyen et al., 2024) through knowledge sharing and research expansion, thereby fostering innovation and research leadership (McGrath et al., 2024).

The scientific structure of the GenAI field reveals the emergence of a group of researchers who have played significant roles in shaping this emerging research area. Analysis also shows that scientific output remains concentrated around a limited number of them, reflecting the nature of the field's early stages and its relatively short lifespan. Typically, a small group of pioneers and researchers emerge to lead innovation in the early stages of a field, a characteristic of emerging fields (Donthu et al., 2021; Dwivedi et al., 2023). Research in emerging and somewhat complex fields like GenAI often requires a combination of technical expertise and pedagogical considerations (Nguyen et al., 2024), which contributes to a limited pool of contributors and influencers. However, growing interest, geographical diversity, and the increasing number of institutions suggest that the field is poised for expansion and growth in the near future (McGrath et al., 2024).

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On the other hand, studies with high citation rates clearly focused on core issues such as academic integrity, educational opportunities, and challenges. This indicates that the debate surrounding GenAI and its applications in higher education extends beyond simply adopting the tools; it also encompasses ethical and epistemic dimensions (T. K. F. Chiu, 2024; Cotton et al., 2024; Francis et al., 2025; Tlili et al., 2023). This focus underscores the importance of building a knowledge base that connects technological capabilities with a pedagogical framework (Li & Wong, 2023; Nguyen et al., 2024). This points to the need for a future research agenda that broadens participation and promotes the integration of the pedagogical and technological dimensions of this field (Kurtz et al., 2024; Noroozi et al., 2024).

Limitations and Future Directions

Despite the demanding methodology used to ensure the accuracy and comprehensiveness of this study, it encountered some limitations that must be considered. The research was limited exclusively to the Web of Science database and to English-language sources only, which may result in the omission of some studies published in other databases or in different languages, reflecting diverse cultural and regional perspectives. Moreover, relying on a specific set of keywords, given the rapidly evolving and dynamic nature of GenAI concepts, may lead to the exclusion of some newly coined terms that appear daily in educational and technical literature. Still, these findings still provide an important initial roadmap for understanding scientific research trends and establishing a strong knowledge base for the field.

Based on these limitations, the current study suggests several paths for future research. It recommends conducting bibliometric studies that integrate data from multiple databases, such as Scopus and Google Scholar, to ensure more comprehensive coverage. It also emphasizes the need to expand the analysis of scientific output in various languages to explore digital gaps and different local contexts. The study also recommends moving from quantitative analysis of intellectual output to field and qualitative studies that investigate the actual impact of GenAI tools on learning outcomes and the development of practical skills among students, in addition to researching the ethical frameworks and university policies regulating this use, in order to ensure the sustainability of the digital transformation in higher education.

Conclusions

The results of the current bibliometric study reveal a clear increase in scholarly interest in the use of GenAI applications in higher education during the period 2021–2025. This is reflected in the high annual growth rates

of scholarly output, the diversification of publication sources, and the increasing patterns of research collaboration among researchers, institutions, and countries. The results also indicate that this field is still experiencing rapid growth, which explains the diversity of topics and issues addressed in scientific literature in recent years. The analysis shows that research interest in this field has focused primarily on several key areas, including the impact of GenAI applications on academic performance, motivation, and engagement in learning. It also addresses the perceived acceptance, adoption, and ease of use among students and faculty, as well as the integration of these applications into the design of educational practices and teaching strategies within higher education institutions. Additionally, the analysis of the intellectual framework and shared citations shows that the current literature is based on studies that address the educational and applied dimensions of using these tools, in addition to studies related to theoretical models of technology acceptance and studies that establish the technological development upon which GenAI applications are built. The findings also revealed significant international research collaboration in this field, led by the United States, China, the United Kingdom, and Australia, with research contributions from other countries such as Saudi Arabia, India, Singapore, and South Korea. This reflects the growing global interest in the use of GenAI in higher education. Furthermore, the results showed that some studies and scientific publications had a high impact in terms of citation rates, particularly those addressing the challenges and opportunities associated with integrating GenAI applications into academic settings. Overall, the study's findings indicate that scientific research related to the use of GenAI in higher education is experiencing rapid growth and expanding research interests, with a clear focus on the educational and technical aspects of using these applications within university environments.

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