

Mapping Research Trends of Generative Artificial Intelligence in Education After ChatGPT: Conceptual Structure, Emerging Themes, and Future Research Directions

Ahmad Yusronil Wafi¹, Juwinda Lusi Apriliani², Albrian Fiky Prakoso^{3*}

^{1, 2, 3}Department of Economic Education, Universitas Negeri Surabaya, Jawa Timur, Surabaya

*Email: albrianprakoso@unesa.ac.id

ARTICLE INFO

Keywords:

Generative Artificial Intelligence
Bibliometric Analysis;
Higher Order Thinking Skills;
Cognitive Offloading;
Critical Thinking

ABSTRACT

Purpose – This study aims to map trends in publications, knowledge structure, conceptual developments, and future research directions for GenAI in education.

Methodology – This study employed a bibliometric analysis of 260 Scopus-indexed articles published between 2023 and 2025. The articles were selected based on predetermined inclusion and exclusion criteria and analyzed using Biblioshiny, which is integrated with RStudio.

Findings – The research findings indicate a substantial increase in GenAI publications following the emergence of ChatGPT and large language models (LLMs). An analysis of research collaborations shows that these contributions are largely driven by developed countries with stronger digital infrastructure. In addition, the conceptual and intellectual mapping suggests an increasing orientation toward a more human-centered learning perspective that extends beyond the initial focus on technology exploration, emphasizing higher-order thinking skills (HOTS), critical thinking, and cognitive transformation. However, this study also highlights challenges related to AI dependency and cognitive offloading.

Significance – This study contributes to the educational technology literature by providing a comprehensive overview of the development of GenAI research following the emergence of ChatGPT and explaining how it has evolved from technological exploration toward a human-centered learning perspective. These findings have implications for educators and educational institutions seeking to integrate GenAI by enhancing AI literacy, pedagogical readiness, and instructional design to maintain students' active cognitive engagement.

Received 12 August 2026; Received in revised form 21 August 2026; Accepted 27 September 2026

Jurnal Eduscience (JES) Volume 13 No. 5 (2026)

Available online 30 October 2026

©2026 The Author(s). Published by LPPM Universitas Labuhanbatu. This is an open-access article under the [Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License \(CC BY - NC - SA 4.0\)](https://creativecommons.org/licenses/by-nc-sa/4.0/)

INTRODUCTION

The development of generative artificial intelligence (GenAI) has ushered in a new paradigm in the transformation of education (Kasneci et al., 2023). Unlike previous technologies, which were designed to complement conventional learning methods (Zawacki-Richter et al., 2019). Consequently, the emergence of GenAI is beginning to expand the role of technology as a cognitive partner with the potential to support thinking, problem-solving, argumentation, and the provision of interactive feedback (Dwivedi et al., 2023; Ouyang & Jiao, 2021). That situation underwent a significant change after GenAI technologies based on large language models (LLMs), such as ChatGPT, were introduced in late 2022 (Kasneci et al., 2023); Tlili et al., (2023), by changing the way students interact with technology in the process of constructing knowledge and making decisions during learning (Salido et al., 2025).

The launch of ChatGPT has sparked a rapid increase in research into the capabilities of large language models (LLMs), marking a turning point in the development of artificial intelligence in the education sector (Lo, 2023). The emergence of LLMs represents a significant leap forward in AI development, owing to their ability to generate natural-language responses that resemble human communication (Z. Ji et al., 2023). However, there is still much debate regarding its accuracy, bias, and ethical implications (Bender et al., 2021). GenAI offers a variety of opportunities through personalized learning, instant feedback, and support for students' exploration of ideas and creativity (Bommasani et al., 2021). Findings (Baidoo-anu & Ansah (2023) predict that ChatGPT has great potential for creating learning designs, from developing questions to providing ongoing feedback.

One of the most critical issues arising from the integration of GenAI into education is how this technology affects the development of higher-order thinking skills (HOTS), including critical thinking, problem-solving, creativity, and decision-making (Chiu, 2024). The emergence of GenAI opens opportunities for students to explore ideas by providing access to diverse perspectives and fostering analytical skills that enrich divergent thinking (Lim et al., 2023; Olga Tzirides et al., 2023). On the contrary, the use of GenAI without critical evaluation can lead students to passively accept AI-generated answers (Mhlanga, 2023; Zhou et al., 2023a). This indicates the emergence of cognitive offloading, delegating part of the thinking process to external technology, thereby reducing students' active engagement in building their own understanding.

In general, the development of GenAI research in education is interdisciplinary, so its implications may vary in relevance across academic disciplines. For example, in the context of economics education, the implications of GenAI relate not only to access to information and problem-solving but also to the development of analytical skills, decision-making, and economic reasoning (Ratten & Jones, 2023). Thus, GenAI research generally maps out fundamental concepts in education to understand the opportunities and challenges across various disciplines, including economics education. However, this study does not specifically limit its analysis to economics education. However, this study does not specifically limit its analysis to economics education. Rather, economics education is used as an illustrative example to highlight this interdisciplinary nature and is not the focus of a separate analysis. Instead, this study broadly presents developments in GenAI research and their interdisciplinary implications.

Although research on GenAI in education has grown rapidly since the launch of ChatGPT, several gaps remain. Most studies still focus on the implementation of AI in higher education. At the same time, efforts to map the intellectual structure, thematic development, and evolutionary trajectory of GenAI research from a technological perspective toward cognitive transformation using a bibliometric approach remain limited. Furthermore, bibliometric studies that specifically map GenAI research in the post ChatGPT period of 2023–2025, including its relationship to higher-order thinking skills (HOTS), critical thinking, and cognitive offloading, have not yet been conducted systematically. These gaps are particularly evident in the context of economics education, which has not been extensively studied. This gap is also evident in its application across various interdisciplinary fields, including economics education, which, to date, has not been extensively studied from a bibliometric perspective.

The early adoption of GenAI in education can be understood through the Technology Acceptance Model (TAM) proposed by Davis (1989). This model explains that technology adoption is influenced by perceived usefulness and perceived ease of use. However, these two factors alone are insufficient to ensure pedagogical effectiveness in implementing GenAI (Davis, 1989; Venkatesh & Davis, 2000). Once adopted, the quality of the interaction between learners and GenAI determines whether the tool merely replaces effort or truly builds understanding. Drawing on Vygotsky (1997) and social constructivism, GenAI can serve as scaffolding; however, scaffolding is only effective when it is conditional and gradually reduced (Molenaar, 2022; Lin & Chang, 2023). This raises a crucial tension: if the features provided by GenAI are too easily accessible and are not gradually phased out, GenAI can shift from being a cognitive partner to a cognitive substitution mechanism (Risko & Gilbert, 2016). Consequently, the ease of use that drives technology adoption, as posited by TAM, paradoxically accelerates cognitive offloading and may increase technological dependence (Fan et al., 2025). Therefore, the ambivalence observed in recent literature (Fan et al., 2025) is not merely a simple contradiction but rather a continuum influenced by pedagogical processes. Thus, the effectiveness of GenAI's implications depends on pedagogical strategies that balance AI support with students' independent thinking.

The objectives of this study are to answer the following four questions: (1) What are the trends in publications, scientific productivity, and collaboration patterns in GenAI research in the field of education during the 2023–2025 period; (2) Which countries, journals, and authors have made the most significant contributions to the development of GenAI research in the field of education (3) How has the conceptual and intellectual structure of GenAI research in the field of education has evolved, and what research directions are beginning to emerge; and (4) How higher-order thinking skills (HOTS) and critical thinking are represented in the development of GenAI research themes in the field of education..

METHODOLOGY

Research Design

This study uses a bibliometric analysis (Donthu et al., 2021), a quantitative approach that uses metadata to explore and map research trends related to GenAI in the education sector. The research data were sourced from the Scopus database and underwent identification, screening, and selection based on specific criteria. Furthermore, the data analysis in this study utilizes Biblioshiny, a web-based tool from the Bibliometrix suite, to generate visualizations and knowledge maps of GenAI developments in the educational context for the 2023–2025 period, as well as the evolution of themes related to higher-order thinking skills (HOTS), critical thinking, and cognitive transformation.

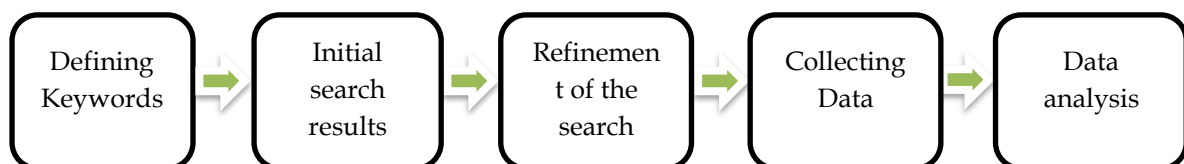


Figure 1. Workflow of the Bibliometric Analysis on Gen AI in Education

Figure 1 illustrates the stages of bibliometric analysis to map the development of GenAI research in the education sector. The analysis covers the performance, conceptual structure, intellectual structure, and social structure of the reviewed literature. This study will identify trends in publications, citation patterns, and the contributions of authors, journals, institutions, and even countries to these research trends. Using keyword mapping, thematic analysis, and co-citation analysis with the biblioshiny feature of the bibliometrix package in RStudio, the study will generate visualizations and knowledge maps (Aria & Cuccurullo, 2017; Sundkvist et al., 2025).

Data Collection

Bibliographic data was collected from the Scopus database, covering publications from 2023 to 2025. The literature search began by entering a combination of research keywords (“Generative AI” OR “ChatGPT” OR “large language models”) AND (“Critical Thinking” OR “Education” OR “Higher Order Thinking” OR “Learning”)—which are, of course, relevant to the topic of Generative Artificial Intelligence (GenAI) in the context of education and instructional design aimed at fostering higher-order thinking (HOTS), critical thinking, and cognitive transformation—into the title, abstract, and keyword fields. The initial search yielded 1,741 documents, which will subsequently undergo a selection process to ensure they meet the study's quality and inclusion criteria. The screening was conducted by filtering articles based on the publication range of 2023–2025, subject areas in the social sciences as well as Economics, Econometrics, and Finance, research type as journal articles, and English-language publications, resulting in 356 documents.

In the next stage, a manual screening was conducted to verify the data by reviewing the titles and abstracts in Microsoft Excel, carried out by the lead author due to the study's specific scope and the previously established inclusion and exclusion criteria. This process aimed to avoid potential subjectivity in identifying articles relevant to the main research topic by ensuring that titles and abstracts aligned to confirm the dataset's suitability for the research objectives. Articles were categorized as meeting the criteria if the research specifically discussed the application of GenAI, including ChatGPT, Large Language Models (LLMs), and various other GenAI technologies in an educational context. However, if a study only discusses the technical aspects of GenAI models without educational implementation, integrates AI into non-educational fields, is a conceptual article without a research dataset, or has no connection to educational objectives, it will be excluded. Thus, a study will be considered relevant if it discusses the integration of GenAI for the development of the education sector, including higher-order thinking skills (HOTS), critical thinking, and the transformation of learning practices. Consequently, after reviewing the titles and abstracts of 356 journals, 96 were excluded for conceptual or non-empirical framing, integration of GenAI outside the field of education, or lack of relevance to the study's inclusion criteria, resulting in 260 Scopus articles as of July 14, 2026.

The Searching Strategy Justification

The literature search for this study aligns with the recommendations of thematic bibliometric studies, focusing on search fields tailored to the research focus. This aims to minimize the inclusion of articles that only discuss the general implications of GenAI. The search formula was designed to identify GenAI-related publications by including the terms “Generative AI,” “ChatGPT,” and “Large Language Models.” Using the format TITLE-ABS-KEY (“Generative AI” OR “ChatGPT” OR “large language models”) AND (“Critical Thinking” OR “Education” OR “Higher-Order Thinking” OR “Learning”)) AND PUBYEAR > 2022 AND PUBYEAR < 2026, AND (LIMIT-TO (SUBJECT AREA, “Social Sciences and Economics, Econometrics and Finance”)), AND (LIMIT-TO (DOCTYPE, “ar”)), AND (LIMIT-TO (LANGUAGE, “English”)).

The documents that passed the initial selection were then exported in CSV format, containing bibliographic information such as author names, institutional affiliations, article titles, countries, publication sources, abstracts, and keywords. The dataset was re-screened to ensure it met the research criteria by reviewing titles and abstracts, resulting in a final selection of 260 articles. The data will then be analyzed using a bibliometric approach with the Biblioshiny software from the RStudio-based Bibliometrix package, as shown in Figure 2 below.

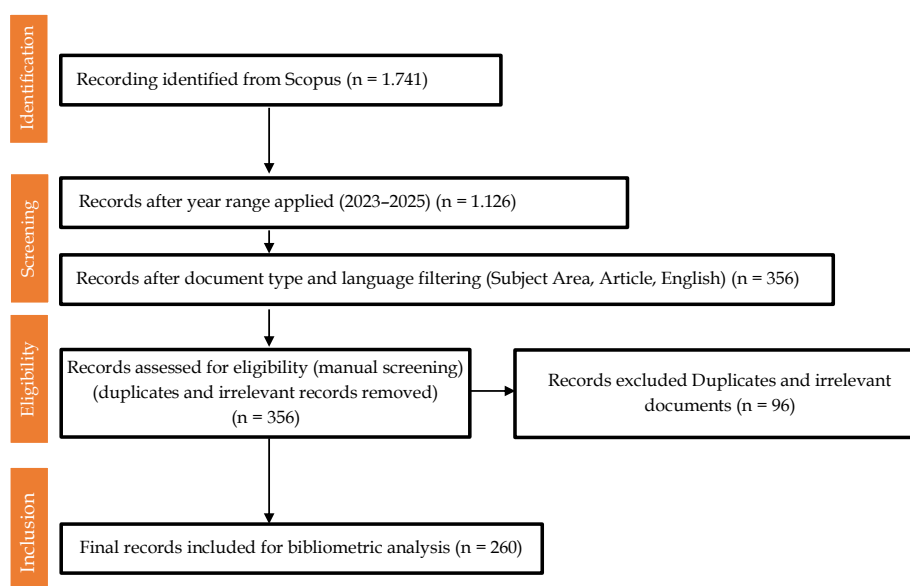


Figure 2. Bibliometric Article Selection Process

FINDINGS

Publication Trends and Scientific Productivity

The primary objective of this study is to analyze trends in scientific research publications focusing on the implications of GenAI in the education sector. An annual trend analysis was conducted to identify the dynamics of literature publications, the evolution of research, and the increasing focus on the implications of GenAI in the education ecosystem following the emergence of large language models (LLMs). Based on the results of the bibliometric analysis in Figure 3, GenAI research publications show a significant increase from 2023 to 2025. In 2023, there were only 9 GenAI research articles focused on the education sector. However, in 2024, research publications increased nearly sixfold, reaching 59 articles. In fact, research surged in 2025, reaching approximately 192 articles. This increase indicates that GenAI is currently one of the fastest-growing research topics in educational technology.

This increase reflects that research on GenAI in educational contexts can be a more complex area of study that supports the learning process. In the early stages, research was limited to LLM-based technologies used as learning aids. However, as this field has evolved, the academic community has shifted its focus toward pedagogical and cognitive aspects, including how GenAI can influence students' higher-order thinking (HOTS). In addition, recent research has examined critical issues such as the emergence of cognitive offloading resulting from AI dependency. Thus, the increase in research publications also broadens the scope of academic discussion regarding the impact of GenAI implementation on the learning process (UNESCO, 2023).

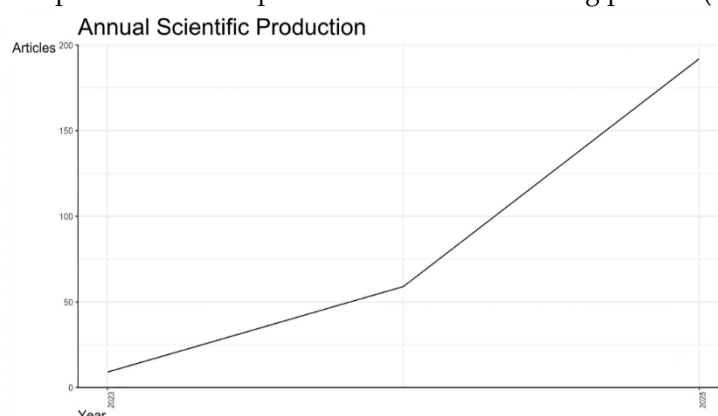


Figure 3. Annual Scientific Production of GenAI Research in Education (2023–2025)

The upward trend in publications shown in Figure 3 reflects changes in research patterns following the emergence of LLM-based GenAI. This trend is influenced by increased human access to AI, the ease of obtaining information instantly, and how students interact with technology during learning. Consequently, this development is also supported by a broadening of research focus on the impact of GenAI use on cognitive abilities, including the potential for cognitive offloading among students.

Table 1. The Most Productive and Influential Authors in Generative Artificial Intelligence Research in Education 2023–2025

Authors	Articles	Articles Fractionalized	H-Index	Total Citations
Lit T (Li et al., 2024)	5	1.18	5	183
Liu J (J. Liu et al., 2025)	5	1.11	3	51
Liu M (M. Liu et al., 2023)	3	0.70	3	238
Ji Y (Y. Ji et al., 2025)	3	0.78	3	153
Chang C-Y (Sui et al., 2025)	3	0.78	3	141

Table 1 lists the authors who have made the most productive and significantly influential contributions to the development of GenAI research in the context of education. The results of the bibliometric analysis show T. Li et al. (2024) rank as the author with the highest level of productivity, with five publications and an h-index of (h=5). This demonstrates the research's consistency in advancing GenAI development in education. Although Liu et al. (2023) have published fewer scientific papers, this author has had the strongest academic impact, with 238 citations. Thus, the scientific articles produced have significantly advanced knowledge in this field. In addition, J. Liu et al. (2025), Y. Ji et al. (2025), and Sui et al. (2025) highlight the importance of this field through a combination of publication productivity and citation metrics. Overall, these findings indicate that the development of the GenAI literature is influenced not only by the volume of publications produced but also by scientific contributions that impact academic progress.

Table 2 illustrates the publication sources that have played a significant role in the development of GenAI literature in the context of education. The analysis results show that “Education Sciences” ranks as the journal with the highest productivity, with 13 publications, followed by the journal “Education and Information Technologies”, which published 11 articles and has a greater scientific impact, with a total citation count (TC = 161) and an h-index (h = 9). On the other hand, the “Journal of Applied Learning and Teaching”, the “Australasian Journal of Educational Technology”, and “Educational Technology & Society” also serve as publication sources that support the advancement of research in the field of GenAI in education and illustrate that the literature continues to evolve through a multidisciplinary approach encompassing educational technology, pedagogy, and learning innovations.

Table 2. The Most Influential Publication Sources in Generative Artificial Intelligence Research in Education

Source Name	Citescore	N	H-Index	G-Index	M-Index	TC	TY-Start
Education Sciences	6.2	13	8	13	2.667	104	2023
Education and Information Technologies	15.5	11	9	11	4.500	161	2025
Journal of Applied Learning and Teaching	19.2	9	5	9	2.500	46	2023
Australasian Journal of Educational Technology	7.6	6	5	6	1.667	34	2023
Educational Technology and Society	12.0	6	4	6	1.333	28	2024

Note. N = number of publications; CiteScore = Scopus CiteScore indicating the average citations per document; HIndex = Hirsch index measuring the productivity and citation impact of a source; G-Index = index reflecting

citation distribution with greater weight to highly cited publications; M-Index = h-index normalized by the number of years since the first publication; TC = total citations; PY-Start = publication year of the first indexed document.

Geographical Distribution and Collaboration Network

With a total of 22 mentions, China holds the most dominant position in the international collaboration network, followed by the United States (USA) with 19, Australia (n=16), and the United Kingdom (n=16). The dominance of these countries indicates that nations with robust digital infrastructure and academic innovation remain the primary drivers of the GenAI transformation in education.

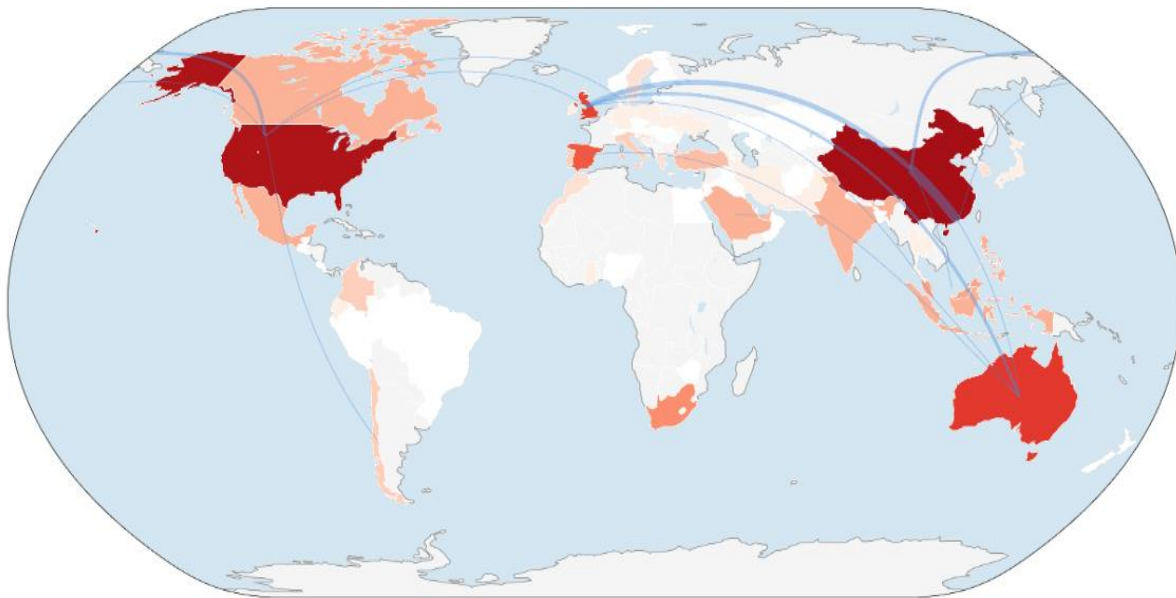


Figure 4. International Collaborations in Generative Artificial Intelligence Research in Education

Based on the results of this analysis, international collaboration plays a crucial role in advancing GenAI research by engaging diverse countries and global research centers. Hong Kong demonstrates strong ties to China, exhibiting the highest collaboration intensity with a total frequency of 14. Other Asian countries, such as Singapore and Malaysia, are also involved in the collaboration network, albeit with relatively lower intensity. Further analysis of the patterns of relationships between countries revealed that China and Hong Kong are the strongest collaborators, with a total frequency of 7. In addition, other pairings such as China–United Kingdom (4), China–United States (3), Australia–United Kingdom (3), and United States–United Kingdom (2) also make significant contributions to the development of GenAI research in education. These patterns indicate a combination of regional and transcontinental cooperation in connecting the world’s major research centers.

Nevertheless, the distribution of collaborative networks still exhibits geographical imbalance. Most research collaborations are concentrated in a few developed countries, such as China, the United States, the United Kingdom, and Australia. Meanwhile, the involvement of developing countries is still characterized by collaborative networks of relatively limited intensity. This situation presents an opportunity for developing countries to strengthen their broader academic contributions to GenAI research and the transformation of learning.

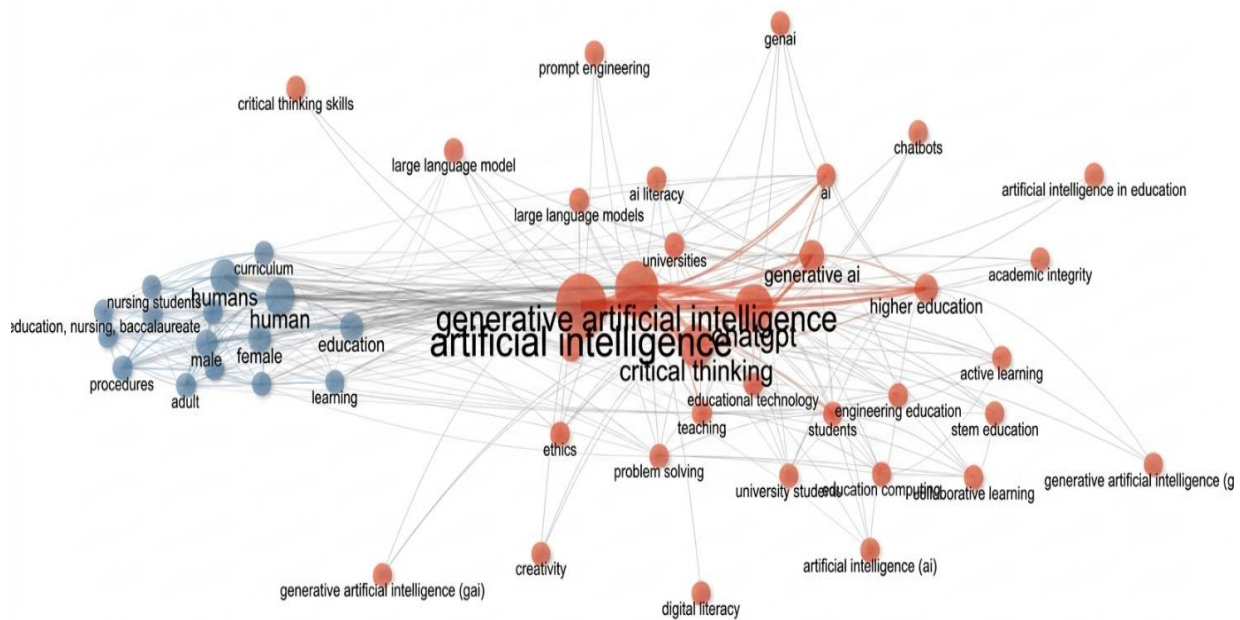


Figure 5. Keyword Co-occurrence Networks in Generative Artificial Intelligence Research in Education

Figure 5 depicts a keyword co-occurrence network that illustrates the conceptual structure of GenAI research developments in the education sector. The red cluster (technology integration and educational transformation dimension) is the largest cluster dominating the research network. It is characterized by the prevalence of keywords such as “generative artificial intelligence,” “artificial intelligence,” “ChatGPT,” “education,” “large language models (LLMs),” and “higher education.” This pattern indicates that most research focuses on integrating GenAI into the education sector, including the use of ChatGPT in educational innovation, the transformation of AI-based education systems, and instructional design that incorporates technology. Consequently, these keywords have become key drivers of the emergence of LLM-based technologies, propelling the digital transformation of education systems since 2022 and shifting the use of conventional AI toward generative AI that supports the learning process.

The blue cluster (Human Cognition and Learning Impact Dimension) focuses more on the impact of GenAI use on the learning process. Keywords such as “students,” “human,” “critical thinking,” and “learning” suggest that the research focus addresses human interactions with AI technology that influence thinking processes, learning engagement, and student competencies. This cluster demonstrates that the literature review continues to explore GenAI’s potential and the challenges that may arise during its integration into the learning process. This includes the importance of ensuring students play an active role in preventing GenAI from causing cognitive offloading. Thus, the conceptual framework of GenAI research in education reflects a shift from a technology-centered approach to a more human-centered learning approach, indicating a strong connection between the two clusters in supporting students’ critical thinking and independent learning.

Strategic Theme Development from Thematic Mapping

The thematic mapping in Figure 6 was analyzed for centrality and thematic trends, illustrating the positions and development of the main themes of GenAI research in the education sector. Several key themes in this study fall into the “motor themes,” “basic themes,” and “emerging or declining themes” quadrants, indicating that the adoption of GenAI in education has grown following the emergence of LLMs, particularly ChatGPT.

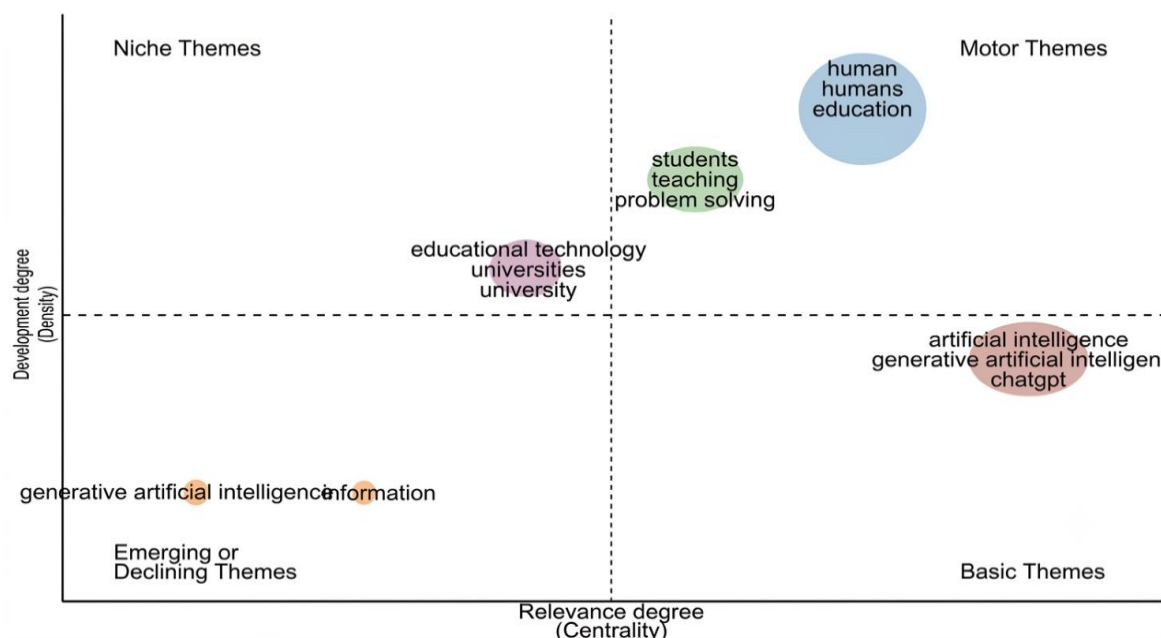


Figure 6. Thematic Map of Generative Artificial Intelligence Research in Education

Intellectual Structure and Emerging Research Themes

The third objective of this study is to interpret the results of the bibliometric analysis to understand the intellectual development, conceptual structure, and evolutionary direction of GenAI research in the education sector. Research patterns based on the results of thematic mapping and keyword networks visualize the shift in the focus of GenAI research toward more complex studies of human-technology interactions that influence human cognitive abilities.

The basic themes of “artificial intelligence,” “generative artificial intelligence,” and “ChatGPT” form the three pillars of a research framework focused on understanding the potential for GenAI integration into the educational ecosystem. The themes “human,” “humans,” and “education” fall within the “motor themes” quadrant, indicating that the primary driving forces behind GenAI research are humans and the educational context. This positioning suggests that the GenAI literature addresses not only technical capabilities but also the technology’s contribution to the evolution of educational systems.

Furthermore, the shift in the focus of GenAI research is beginning to evolve toward a human-centered approach, that is, how technology can support students’ competencies, including critical thinking, problem-solving, creativity, and 21st-century skills. This shift is reflected in the emergence of the themes “students,” “teaching,” and “problem solving,” which are in high-growth areas of research. Nevertheless, most studies still focus on the experiences of students and higher education institutions in adopting AI technology to support academic activities, as evidenced by the dominance of the themes “educational technology,” “universities,” and “university.”

Meanwhile, the theme “generative artificial intelligence transformation,” which falls under the category of emerging or declining themes, signals a new research direction examining how GenAI can serve as a transformative technology to shift the learning paradigm. Overall, the results of the bibliometric analysis of GenAI research call for further exploration to better balance GenAI adoption with the preservation of human cognitive capacity. Therefore, GenAI’s role as a cognitive partner is the primary direction for learning transformation, supporting the thinking process rather than replacing human cognitive abilities.

Intellectual Foundations of GenAI, HOTS, and Critical Thinking

To understand the intellectual foundations of the development of GenAI research in education, this study conducted a reference co-citation analysis. Unlike keyword analysis, which describes the evolution of research

themes, co-citation analysis provides insight into the foundational literature that underpins the development of a field of study.

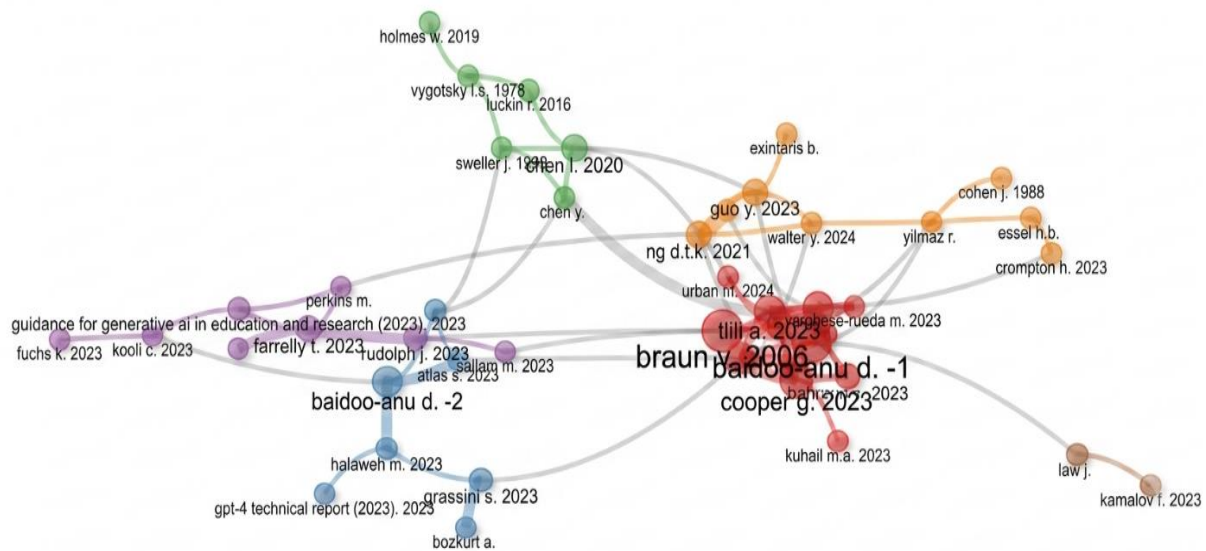


Figure 7 Reference Co-Citation Network of Generative Artificial Intelligence Research in Education

Figure 7 presents a co-citation network that shows that research on GenAI in education is organized into several interconnected clusters of literature. The network structure reveals connections between research on artificial intelligence, educational technology, pedagogical innovation, and the implications of AI use for learners' cognitive processes. Several references located at the center of the network, in particular Baidoo-anu & Ansah (2023) and Tlili et al. (2023), indicate that this literature has had a significant influence on the intellectual development of research on GenAI. The red cluster indicates the early development of ChatGPT in its application in the field of education, as evidenced by the emergence of a cluster of literature focused on the development of GenAI, ChatGPT, and Large Language Models (LLMs), supported by research (Cooper, 2023; Tlili et al., 2023). The blue cluster represents the research foundations of GenAI and the integration of technology into learning, as illustrated in early research on opportunities and challenges (Atlas & Atlas, 2023; Halaweh, 2023; Zhou et al., 2023). This indicates that the development of GenAI is a continuation of previous research on the use of intelligent technology in education. Meanwhile, the green cluster illustrates the relationship between AI and the learning process, as well as students' cognitive abilities, indicating an increasing research orientation toward a human-centered learning approach, in which GenAI supports thinking processes and knowledge construction. This cluster is supported by fundamental learning theories, including social constructivism (Vygotsky, 1997) and Sweller's cognitive load theory, as well as the foundations of AI in education (Luckin & Holmes, 2016).

Meanwhile, other groups have highlighted areas of research that are still evolving, particularly those related to AI-based instructional design, AI literacy, and critical thinking, for example (Crompton & Burke, 2023; Ng et al., 2022), as well as academic integrity and ethical guidelines for the use of GenAI—for example, guidelines (UNESCO, 2023), which reflects the implications of GenAI for 21st-century competencies. However, it should be noted that clusters of critical thinking and HOTS theories cited independently have not yet been identified. Instead, these clusters appear at the keyword level within the conceptual structure rather than as a consolidated body of foundational literature. This indicates that the relationship between critical thinking and HOTS in RQ4 is emerging as a thematic focus rather than a theoretically consolidated research stream. Thus, the results of the co-citation analysis reinforce previous findings—namely, the progression from technology adoption to pedagogy and human cognitive transformation—and reveal that the theoretical foundations specifically addressing GenAI in relation to critical thinking and HOTS have not yet been consolidated into an identifiable intellectual lineage.

DISCUSSION

This bibliometric study aims to map developments, uncover the structure of knowledge, and interpret the direction of research evolution regarding GenAI in the education sector during the 2023–2025 period. A turning point in research technology development occurred following the launch of ChatGPT in late 2022, which is a key finding of this study. These developments are reflected in increased publication output, the expansion of international collaboration networks, and the emergence of new research themes. Thus, the current transformation of GenAI has shifted the paradigm of technology use; technology is no longer viewed merely as a tool to support learning but is evolving into a cognitive partner that plays a role in accelerating access to information, supporting problem-solving, and shaping the interaction patterns of learners in educational settings (Crompton & Burke, 2023).

The emergence of large language models (LLMs) opened new avenues for research in late 2022. This increase in productivity has broadened the scope of research to include various pedagogical implications. Contributions from various developed countries indicate that research on GenAI has become a global phenomenon, influenced by research capacity, digital infrastructure, and educational institutions' readiness to adopt new technologies. However, the distribution of research still reveals a gap between countries with strong technology ecosystems and contributions from developing countries, which continue to face limitations in digital infrastructure, AI regulations, and human resource readiness. Thus, enhancing research capacity in developing countries presents a critical opportunity to broaden geographic representation in the advancement of GenAI studies.

An analysis of the intellectual structure based on keyword co-occurrence networks and thematic mapping of GenAI research in education reveals two main orientations: the transformation of educational technology and its impact on human cognition. The thematic configuration comprising “generative artificial intelligence,” “ChatGPT,” “artificial intelligence,” and “education” indicates that early-stage GenAI research remains focused on exploring technologies that support learning. However, there has been an increasing orientation toward a more human-centered focus, as evidenced by the emergence of themes such as “students,” “teaching,” “problem solving,” and “human,” which indicate that technology is increasingly being positioned as a mediator in the process of knowledge construction rather than as the sole focus of learning. These findings reinforce the social constructivist perspective, which holds that learning depends not only on the transfer of information but also on how learners actively construct meaning through interaction with their learning environment. Furthermore, this encourages the emergence of a new paradigm regarding how GenAI will influence human higher-order thinking skills (HOTS) and its potential to expand processes of reflection, idea exploration, and knowledge construction (Marx et al., 2023).

The evolution of GenAI literature reveals two complementary aspects: GenAI as a potential cognitive partner and GenAI as a source of risk associated with cognitive offloading (Lin & Chang, 2023). The educational value of GenAI is determined not only by the technology's capabilities but also by how it is used in the learning process. Therefore, the development of GenAI should be guided by the principle that technology serves as a tool to enhance cognitive abilities, not as a substitute for human cognition. The evolution of GenAI continues to present opportunities for further research, as reflected in the theme “generative artificial intelligence transformation,” which remains evolving and offers avenues to explore how GenAI can contribute to the long-term development of students' competencies.

The practical implications of this study suggest that developing AI literacy is crucial for understanding the limitations of GenAI and for using the technology ethically and reflectively. Educational institutions need to design learning strategies that foster collaboration between humans and technology, thereby strengthening human critical thinking skills, which is the primary goal of GenAI's use. Thus, future research should no longer merely question whether GenAI is effective in education but rather focus on how to design and implement this technology to create a learning ecosystem that optimizes AI's benefits while preserving learners' ability to think independently (Ng et al., 2022). These implications also open opportunities for the application of GenAI

in specific academic disciplines, including economics education. Although the Scopus subject fields applied in this study, Social Sciences and Economics, Econometrics and Finance, allow for articles with an economic focus to be included in the dataset, the bibliometric analysis does not isolate or interpret word clusters or co-citation patterns specifically related to economics education. Therefore, this discussion remains conceptual rather than based on empirical evidence. The characteristics of economics education, which involve the analysis of economic phenomena, reasoning, information evaluation, and decision-making, provide a framework for exploring how integrating GenAI can support the learning process without replacing students' cognitive abilities. Thus, the researchers identify economics education as a direction for future research to empirically examine how GenAI influences students' economic reasoning, analytical skills, and decision-making.

This study has several limitations that affect the interpretation of the results. First, the bibliometric analysis drew exclusively on the Scopus database and excluded research from other sources. Second, the study was limited to English-language articles, so it does not fully represent articles from various countries and other publication languages. Third, the study was limited to the period 2023–2025. Fourth, the distribution of publications and collaboration networks among developing countries remains relatively limited. Therefore, further observation is needed regarding the broader paradigm of GenAI use in education, including a specific examination of GenAI applications across various academic disciplines, such as economics education.

CONCLUSION

This bibliometric study shows that research on GenAI in education has grown rapidly following the emergence of ChatGPT in late 2022, with a shift in focus from the adoption of GenAI as a learning aid to more complex studies of the relationship between technology and human cognitive abilities. The study's findings reveal two coexisting perspectives: the potential of GenAI as a cognitive partner and the emergence of various challenges, including dependence on AI, cognitive offloading, academic integrity, and the need to strengthen AI literacy. Theoretically, this study contributes to expanding our understanding of the evolution of GenAI research from a technology-oriented focus to one that places greater emphasis on cognitive abilities and human engagement. In practice, these findings underscore the importance of pedagogical readiness and instructional design that position GenAI as a tool to augment, rather than replace, students' thinking abilities. However, this study has limitations because it relies solely on the Scopus database, is restricted to English-language publications, and covers a relatively short observation period (2023–2025), meaning that geographical representation and long-term research trends cannot yet be fully characterized.

ACKNOWLEDGMENT

The author would like to express appreciation to all parties who provided support during the research process. Special thanks are extended to the academic advisor and academic colleagues who provided feedback, guidance, and intellectual support throughout the research process. The author also appreciates access to the Scopus database, which served as a source for collecting and analyzing bibliometric data on GenAI research in education.

REFERENCES

- Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R Tool for Comprehensive Science Mapping Analysis. *Journal Of Informetrics*, 11(4), 959–975. <https://doi.org/10.1016/J.Joi.2017.08.007>
- Atlas, S., & Atlas, S. (2023). Chatgpt For Higher Education and Professional Development: A Guide To Conversational Ai. *College Of Business Faculty Publications*. https://digitalcommons.uri.edu/Cba_Facpubs/548
- Baidoo-Anu, D., & Ansah, L. O. (2023). Education In the Era of Generative Artificial Intelligence (AI): Understanding The Potential Benefits of ChatGPT in Promoting Teaching and Learning. *Journal Of Ai*, 7(1), 52–62. <https://doi.org/10.61969/Jai.1337500>

- Bender, E. M., Gebru, T., Mcmillan-Major, A., & Shmitchell, S. (2021). On The Dangers of Stochastic Parrots: Can Language Models Be Too Big? *Facct 2021 - Proceedings of the 2021 ACM Conference on Fairness, Accountability, And Transparency*, 610–623. <https://doi.org/10.1145/3442188.3445922>
- Bommasani, R., Hudson, D. A., Adeli, E., Altman, R., Arora, S., Von Arx, S., Bernstein, M. S., Bohg, J., Bosselut, A., Brunskill, E., Brynjolfsson, E., Buch, S., Card, D., Castellon, R., Chatterji, N., Chen, A., Creel, K., Davis, J. Q., Demszky, D., ... Liang, P. (2021). *On The Opportunities and Risks of Foundation Models*. <https://arxiv.org/pdf/2108.07258>
- Chiu, T. K. F. (2024). The Impact of Generative AI (GenAI) On Practices, Policies, And Research Directions In Education: A Case of ChatGPT and Midjourney. *Interactive Learning Environments*, 32(10), 6187–6203. <https://doi.org/10.1080/10494820.2023.2253861>
- Cooper, G. (2023). Examining Science Education in ChatGPT: An Exploratory Study of Generative Artificial Intelligence. *Journal Of Science Education and Technology* 2023 32:3, 32(3), 444–452. <https://doi.org/10.1007/S10956-023-10039-Y>
- Crompton, H., & Burke, D. (2023). Artificial Intelligence in Higher Education: The State of The Field. *International Journal of Educational Technology in Higher Education*, 20(1). <https://doi.org/10.1186/S41239-023-00392-8>
- Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, And User Acceptance of Information Technology. *Management Information Systems Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How To Conduct A Bibliometric Analysis: An Overview and Guidelines. *Journal Of Business Research*, 133, 285–296. <https://doi.org/10.1016/J.Jbusres.2021.04.070>
- Dwivedi, Y. K., Kshetri, N., Hughes, L., Slade, E. L., Jeyaraj, A., Kar, A. K., Baabdullah, A. M., Koohang, A., Raghavan, V., Ahuja, M., Albanna, H., Albashrawi, M. A., Al-Busaidi, A. S., Balakrishnan, J., Barlette, Y., Basu, S., Bose, I., Brooks, L., Buhalis, D., ... Wright, R. (2023). Opinion Paper: “So What If ChatGPT Wrote It?” Multidisciplinary Perspectives on Opportunities, Challenges, And Implications of Generative Conversational AI For Research, Practice, And Policy. *International Journal of Information Management*, 71, 102642. <https://doi.org/10.1016/J.Ijinfomgt.2023.102642>
- Fan, Y., Tang, L., Le, H., Shen, K., Tan, S., Zhao, Y., Shen, Y., Li, X., & Gašević, D. (2025). Beware Of Metacognitive Laziness: Effects of Generative Artificial Intelligence on Learning Motivation, Processes, And Performance. *British Journal of Educational Technology*, 56(2), 489–530. <https://doi.org/10.1111/Bjet.13544;Page:String:Article/Chapter>
- Halaweh, M. (2023). ChatGPT in Education: Strategies for Responsible Implementation. *Contemporary Educational Technology*, 15(2). <https://doi.org/10.30935/Cedtech/13036>
- Ji, Y., Zhan, Z., Li, T., Zou, X., & Lyu, S. (2025). Human-Machine Co-Creation: The Effects of ChatGPT on Students’ Learning Performance, AI Awareness, Critical Thinking, And Cognitive Load in a STEM Course Toward Entrepreneurship. *IEEE Transactions on Learning Technologies*, 18, 402–415. <https://doi.org/10.1109/Tlt.2025.3554584>
- Ji, Z., Lee, N., Frieske, R., Yu, T., Su, D., Xu, Y., Ishii, E., Bang, Y. J., Madotto, A., & Fung, P. (2023). Survey Of Hallucination in Natural Language Generation. *ACM Computing Surveys*, 55(12). <https://doi.org/10.1145/3571730;Wgroup:String:Acme>
- Kasneci, E., Sessler, K., Küchemann, S., Bannert, M., Dementieva, D., Fischer, F., Gasser, U., Groh, G., Günnemann, S., Hüllermeier, E., Krusche, S., Kutyniok, G., Michaeli, T., Nerdel, C., Pfeffer, J., Poquet, O., Sailer, M., Schmidt, A., Seidel, T., ... Kasneci, G. (2023). ChatGPT for Good? On Opportunities and Challenges of Large Language Models for Education. *Learning And Individual Differences*, 103, 102274. <https://doi.org/10.1016/J.Lindif.2023.102274>
- Li, T., Ji, Y., & Zhan, Z. (2024). Expert Or Machine? Comparing The Effect of Pairing Student-Teacher with In-Service Teacher and ChatGPT on Their Critical Thinking, Learning Performance, And Cognitive Load in an Integrated STEM Course. *Asia Pacific Journal of Education*, 44(1), 45–60. <https://doi.org/10.1080/02188791.2024.2305163>

- Lim, W. M., Gunasekara, A., Pallant, J. L., Pallant, J. I., & Pechenkina, E. (2023). Generative AI And the Future of Education: Ragnarök or Reformation? A Paradoxical Perspective from Management Educators. *The International Journal of Management Education*, 21(2), 100790. <https://doi.org/10.1016/j.ijme.2023.100790>
- Lin, M. P. C., & Chang, D. (2023). Chat-Acts: A Pedagogical Framework for A Personalized Chatbot to Enhance Active Learning and Self-Regulated Learning. *Computers And Education: Artificial Intelligence*, 5, 100167. <https://doi.org/10.1016/j.caeai.2023.100167>
- Liu, J., Sun, D., Sun, J., Wang, J., & Yu, P. L. H. (2025). Designing A Generative AI-Enabled Learning Environment for Mathematics Word Problem Solving in Primary Schools: Learning Performance, Attitudes, And Interaction. *Computers And Education: Artificial Intelligence*, 9, 100438. <https://doi.org/10.1016/j.caeai.2025.100438>
- Liu, M., Ren, Y., Nyagoga, L. M., Stonier, F., Wu, Z., & Yu, L. (2023). Future of Education in the Era of Generative Artificial Intelligence: Consensus Among Chinese Scholars on Applications of ChatGPT in Schools. *Future In Educational Research*, 1(1), 72–101. <https://doi.org/10.1002/Fer3.10>; Website: [Website:Pericles](https://www.periclesjournal.com); Journal: [Journal:28359402](https://www.periclesjournal.com); Wgroup: String: Publication
- Lo, C. K. (2023). What Is the Impact of ChatGPT on Education? A Rapid Review of The Literature. *Education Sciences*, 13(4), 410. <https://doi.org/10.3390/Educsci13040410/S1>
- Luckin, R., & Holmes, W. (2016). Intelligence Unleashed: An Argument for AI in Education. Ucl Knowledge Lab: London, UK, 849–851. <https://www.pearson.com/content/dam/corporate/global/pearson-dot-com/files/innovation/intelligence-unleashed-publication.pdf>
- Marx, E., Leonhardt, T., & Bergner, N. (2023). Secondary School Students' Mental Models and Attitudes Regarding Artificial Intelligence - A Scoping Review. *Computers And Education: Artificial Intelligence*, 5, 100169. <https://doi.org/10.1016/j.caeai.2023.100169>
- Mhlanga, D. (2023). Open AI in Education: The Responsible and Ethical Use of ChatGPT Towards Lifelong Learning. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4354422>
- Molenaar, I. (2022). Towards Hybrid Human-AI Learning Technologies. *European Journal of Education*, 57(4), 632–645. <https://doi.org/10.1111/Ejed.12527>; Wgroup: String: Publication
- Ng, D. T. K., Lee, M., Tan, R. J. Y., Hu, X., Downie, J. S., & Chu, S. K. W. (2022). A Review of AI Teaching and Learning From 2000 To 2020. *Education And Information Technologies* 2022 28:7, 28(7), 8445–8501. <https://doi.org/10.1007/S10639-022-11491-W>
- Olga Tzirides, A., Saini, A., Zapata, G., Searsmith, D., Cope, B., Kalantzis, M., Castro, V., Kourkoulou, T., Jones, J., Abrantes Da Silva, R., Whiting, J., Polyxeni Kastania, N., & Olga, A. (2023). Generative AI: Implications And Applications for Education. 2023. <https://doi.org/10.48550/Arxiv.2305.07605>
- Ouyang, F., & Jiao, P. (2021). Artificial Intelligence in Education: The Three Paradigms. *Computers And Education: Artificial Intelligence*, 2, 100020. <https://doi.org/10.1016/j.caeai.2021.100020>
- Ratten, V., & Jones, P. (2023). Generative Artificial Intelligence (ChatGPT): Implications for Management Educators. *The International Journal of Management Education*, 21(3), 100857. <https://doi.org/10.1016/j.ijme.2023.100857>
- Risko, E. F., & Gilbert, S. J. (2016). Cognitive Offloading. *Trends In Cognitive Sciences*, 20(9), 676–688. <https://doi.org/10.1016/j.tics.2016.07.002>
- Salido, A., Syarif, I., Sitepu, M. S., Suparjan, Wana, P. R., Taufika, R., & Melisa, R. (2025). Integrating Critical Thinking and Artificial Intelligence in Higher Education: A Bibliometric and Systematic Review of Skills and Strategies. *Social Sciences & Humanities Open*, 12, 101924. <https://doi.org/10.1016/j.ssaho.2025.101924>
- Sui, C. J., Chang, C. Y., & Yen, M. H. (2025). Stem-5e Socio-Scientific Argumentation with Generative AI-Driven Scaffolding: Exploring the Interplay Between Epistemic Beliefs and Learning Outcomes. *Journal Of Science Education and Technology* 2025 35:2, 35(2), 429–447. <https://doi.org/10.1007/S10956-025-10257-6>

- Sundkvist, C. H., Madsen, D. Ø., Munim, Z. H., & Stenheim, T. (2025). Three Decades of Research on Earnings Management - A Bibliometric Literature Review. *International Journal of Procurement Management*, 23(1), 38–64. <https://doi.org/10.1504/Ijpm.2025.145559>
- Tlili, A., Shehata, B., Adarkwah, M. A., Bozkurt, A., Hickey, D. T., Huang, R., & Agyemang, B. (2023). What If the Devil Is My Guardian Angel: ChatGPT as a Case Study of Using Chatbots in Education. *Smart Learning Environments* 2023 10:1, 10(1), 15-. <https://doi.org/10.1186/S40561-023-00237-X>
- Unesco. (2023). Guidance For Generative AI in Education and Research. In *Guidance for Generative AI in Education and Research*. Unesco. <https://doi.org/10.54675/Ewzm9535>
- Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. <https://doi.org/10.1287/Mnsc.46.2.186.11926>, 46(2), 186–204. <https://doi.org/10.1287/Mnsc.46.2.186.11926>
- Vygotsky, L. S. (1997). *Readings on the Development of Children*. Harvard University Press, 79–91. <https://www.hup.harvard.edu/books/9780674576292>
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic Review of Research on Artificial Intelligence Applications in Higher Education – Where Are the Educators? *International Journal of Educational Technology in Higher Education* 2019 16:1, 16(1), 39-. <https://doi.org/10.1186/S41239-019-0171-0>
- Zhou, D., Liu, S., & Grassini, S. (2023). Shaping The Future of Education: Exploring the Potential And Consequences of AI and Chatgpt in Educational Settings. *Education Sciences* 2023, Vol. 13, Page 692, 13(7), 692. <https://doi.org/10.3390/Educsci13070692>