JTPED
Journal of Technological Pedagogy and Educational Development
Vol. 1, No.2, 2024, pp. 13-23
https://ejournal.jtped.org/ojs/index.php/jtped

Mapping the Rise of Generative AI in Teaching and Learning: A Bibliometric Analysis (2014–2024)

Nurfitri Ramadana [a,1,*], Patin Nabilla [b,2], Desy Dwi Putri [c,3], Rahmatul Ulya [d,4]

[a] Universitas Negeri Yogyakarta, Jalan Kolombo No.1, Yogyakarta 55281, Indonesia
[b] Universiti Kebangsaan Malaysia, Jalan Reko Bandar Baru Bangi, Selangor 43600, Malaysia
[c] Khon Kaen University, 123 Moo 16 Mittraphap Road, Mueang Khon Kaen, 40002, Thailand
[d.] Universitas Indonesia, Jalan Prof. Dr. R. Slamet Iman Santoso, Depok 16424, Indonesia
[1] nurfitriramadana.2022@student.uny.ac.id; [2] P160027@siswa.ukm.edu.my; [3] desy.p@kkumail.com,
[4] rahmatululya19@gmail.com
* Corresponding Author

ARTICLE INFO

Article history
Received June 07, 2025
Revised July 08, 2025
Accepted July 13, 2025

Keywords
Artificial intelligence techno;
Artificial intelligence;
Adversarial learning;
Federated learning;
Contrastive learning

ABSTRACT

This study aims to map the scholarly development of Artificial Intelligence (AI), particularly Generative AI (GenAI), in teaching and learning from 2014 to 2024. The research highlights key trends and the emergence of advanced approaches such as federated learning, contrastive learning, and adversarial learning. A bibliometric method based on PRISMA protocol was applied, using VOSviewer for keyword mapping. Data were extracted from the Scopus database, yielding 8,926 documents. After a systematic screening process, 157 eligible papers were selected for analysis. The findings indicate a significant rise in AI-related educational publications, especially following the emergence of GenAI tools like ChatGPT. Bibliometric visualizations reveal dominant research themes such as e-learning, personalized learning, and chatbots. Meanwhile, the rise of newer terms reflects an innovation shift toward safer, more adaptive, and personalized learning models. GenAI not only supports administrative tasks but also facilitates deeper and more meaningful learning interactions. The study underscores the strategic importance of integrating GenAI into curricula and fostering AI literacy among teachers and students to promote responsible and effective adoption. These insights pave the way for future research and practical implementation of intelligent learning systems in educational environments.

1. Introduction

Over the past decade, Artificial Intelligence (AI) has undergone rapid advancements and attracted growing interest across various sectors, particularly in education. This trend has stimulated efforts to integrate AI effectively into educational processes [1], [2], [3], [4], [5]. AI is regarded as one of the key drivers of transformation in the education sector, as well as a catalyst for economic growth, future workforce development, and global competitiveness [6], [7]. Innovations in Artificial Intelligence (AI) have opened new avenues for adaptive, personalized, and data driven teaching and learning. These advancements allow educators to design, implement, and evaluate instruction more effectively by enabling the identification of student needs, the delivery of immediate feedback, and the automation of assessment processes [8], [9].

https://doi.org/10.59247/jtped.v1i2.11

AI is utilized in education through instructional technologies such as intelligent tutoring chatbots and automated assessment systems [9], [10]. This technology also enables the implementation of instructional methods that are better aligned with individual learner needs, enhancing the learning experience through more adaptive and personalized approaches. One of the most significant developments in AI is the emergence of Generative AI [11].

Generative Artificial Intelligence (GenAI) takes a step further by creating new content such as text, images, and videos based on user-generated prompts or instructions [12], [13]. Unlike traditional AI, Generative AI leverages deep learning to produce human-like content and is now rapidly expanding across various domains, including education [14]. Examples of this technology, such as ChatGPT, DALL·E, Midjourney, and Bard, demonstrate the potential of Generative AI (GenAI) to revolutionize more personalized and adaptive learning, with the aim of improving educational outcomes [9], [16], [17].

The integration of Generative AI (GenAI) into teaching and learning processes offers numerous opportunities to enhance student engagement. GenAI can assist in developing instructional materials, providing feedback, supporting formative assessment, and can be applied in summative evaluation, student performance prediction, intelligent tutoring systems, and learning management [18]. However, despite the vast potential offered by Generative AI in education, its implementation also presents significant challenges. One major concern is related to ethics and privacy, as the use of student data to train AI models raises issues regarding the security of personal information [16]. In addition, another major challenge concerns the accessibility of this technology, as not all educational institutions possess the necessary resources to implement and utilize advanced systems such as GenAI. Algorithmic bias is also a critical issue, as AI models trained on non-representative data may produce biased outcomes that disadvantage certain segments of society particularly within the context of inclusive education [19].

The diagram in Fig. 1 illustrates the most relevant journal sources related to research on Artificial Intelligence (AI) in education. It shows that the majority of publications are found in the AIP Conference Proceedings and IOP Conference Series: Earth and Environmental Sciences, each contributing 7 documents, far surpassing other sources. This highlights the dominance of conference proceedings in the international publication of AI and Generative AI research. Other sources such as E3S Web of Conferences contribute 6 documents, while journals like APTISI Transactions on Technopreneurship, ASEAN Journal of Science and Engineering, and Cogent Education each contribute only 3 documents. These findings suggest that, despite significant publications in international journals, AI research in education is predominantly presented in conference forums rather than in academic journals, reflecting the ongoing dynamics and exploration of the emerging topic. The dominance of conference proceedings underscores the need for more publications in indexed journals that can have a broader impact and relevance for global educational practices.

The new approach integrating Generative AI in education includes the use of adaptive learning models and content personalization to support a more effective learning experience. This technology enables the development of learning materials that are responsive to the individual needs of students and provides timely and relevant feedback. Generative AI also enhances the effectiveness of assessments and facilitates more inclusive and accessible learning. These elements are interconnected in forming a flexible, adaptive, and responsive technology-based learning ecosystem. Overall, this ecosystem creates a more dynamic, data-driven educational environment that supports sustainable teaching innovation.

This study addresses the following research questions:

Q1: How has the use of Generative AI in education evolved from 2014 to 2024?
Q2: What are the key trends and innovations emerging in this field?"

This study contributes to mapping the development of research related to Generative AI in teaching and learning through a bibliometric approach. The research provides practical insights that are valuable for educators, educational institutions, and policymakers in designing sustainable

implementation strategies for Generative AI, aligned with the needs and challenges of the global education context. Recommended actions include enhancing teacher training on the use of AI in education, developing customizable AI-based learning content, and formulating policies that support the development of deep and sustainable educational technology infrastructure.

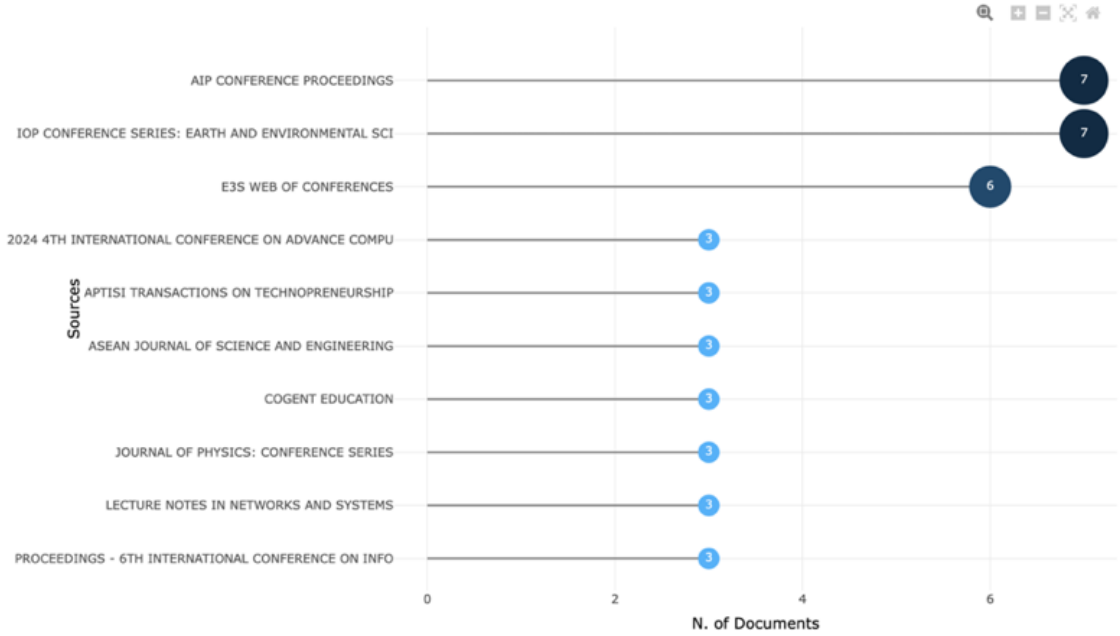

Fig. 1. Sources of Publications on Artificial Intelligence (AI)

2. Method

This study employs a bibliometric design to systematically analyze academic publications related to the application of Artificial Intelligence (AI) in the context of teaching and learning, with a particular focus on research concerning the development and implementation of Generative AI such as ChatGPT, Bard, and Claude in education [19], [20], [21], [22]. The objective is to analyze the development and trends in the use of Generative AI, particularly in the context of teaching and learning. Data were extracted from the Scopus database using a predefined set of keywords, covering the publication period from 2014 to 2024. The selection process applied inclusion and exclusion criteria to ensure the relevance of the publications, with a focus on articles discussing the application of Generative AI in education. The analysis was conducted on titles, abstracts, and keywords to trace the development of concepts and practical applications of Generative AI in education

Fig. 2 presents the PRISMA flow diagram, which illustrates the process of identifying and selecting documents for bibliometric analysis. The purpose of using the PRISMA flow is to ensure a systematic, transparent document selection process that aligns with the criteria in bibliometric research. This study focuses on the topic 'Artificial Intelligence in Indonesian Education', with data retrieved from the Scopus database covering the publication period from 2014 to 2024. The search keywords included terms such as 'Artificial Intelligence' and 'Education'. Data collection was conducted on July 3, 2025, resulting in a total of 8,926 non-duplicate documents. During the screening stage, documents were evaluated based on eligibility and topic relevance, narrowing the total from 8,926 publications. In the eligibility stage, titles and abstracts were reviewed to ensure alignment with the research topic, which yielded 157 documents meeting the criteria for bibliometric analysis. This flow diagram reflects a systematic and targeted selection process aimed at ensuring topic relevance and publication suitability for further analysis.

Journal of Technological Pedagogy and Educational Development
Vol. 1, No. 2, 2024, pp. 13-23

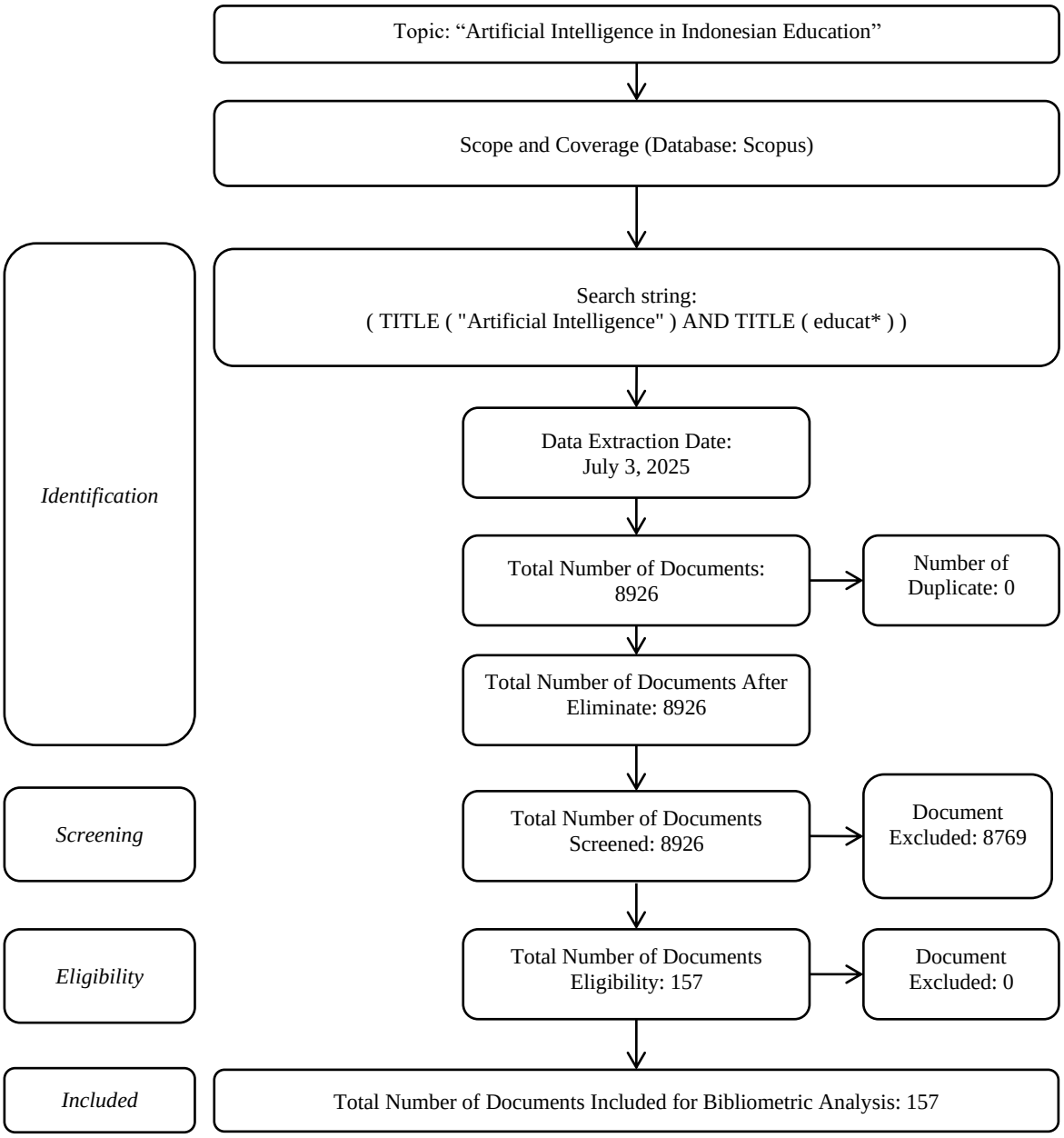

Fig. 2. PRISMA Method for Document Selection

The inclusion and exclusion process was conducted systematically to ensure that only relevant documents were selected for analysis. The inclusion criteria focused on publications specifically discussing the use of Artificial Intelligence in teaching and learning, with an emphasis on Generative AI in the context of education, published between 2014 and 2024. Meanwhile, the exclusion criteria included publications not directly related to the research topic, such as those discussing the technical aspects of AI without relevance to education, as well as documents not available in English.

Inclusion criteria applied: (1) Publications discussing the use of Artificial Intelligence (AI) in teaching and learning. (2) Focus on Generative AI in education. (3) Publications published between 2014 and 2024. (4) Documents relevant to AI-based educational practices.

Exclusion criteria: (1) Publications that do not discuss education or focus solely on the technical aspects of AI. (2) Documents not available in English.

Data analysis in this study was conducted using two tools: VOSviewer was employed to analyze the research focus and the emergence of keywords in the data collection. This analysis focused on mapping the occurrence of frequently used keywords in titles and abstracts, as well as visualizing their network relationships [23]. Through VOSviewer, dominant research themes and emerging concepts were identified, reflecting shifts and expansions in educational AI research. This approach enables the identification of evolving research trends and provides a clear overview of the direction of Generative AI research in teaching and learning.

3. Results and Discussion

3.1. Trends and Growth of Publications

Fig. 3 illustrates the dynamics of the average citation per publication related to Artificial Intelligence in education from 2018 to 2024. A sharp increase in 2019 indicates the presence of significant publications that had a high impact in shaping the early discourse on AI in education. The drastic decline in 2020 can be attributed to the shift in research focus due to the pandemic or a lack of significant publications during that year. The resurgence in 2023 reflects the growing attention to Generative AI following the emergence of models like ChatGPT. The decrease in 2024 is due to the relatively recent publications, which have not yet accumulated many citations, indicating that citation impact requires an accumulative time frame.

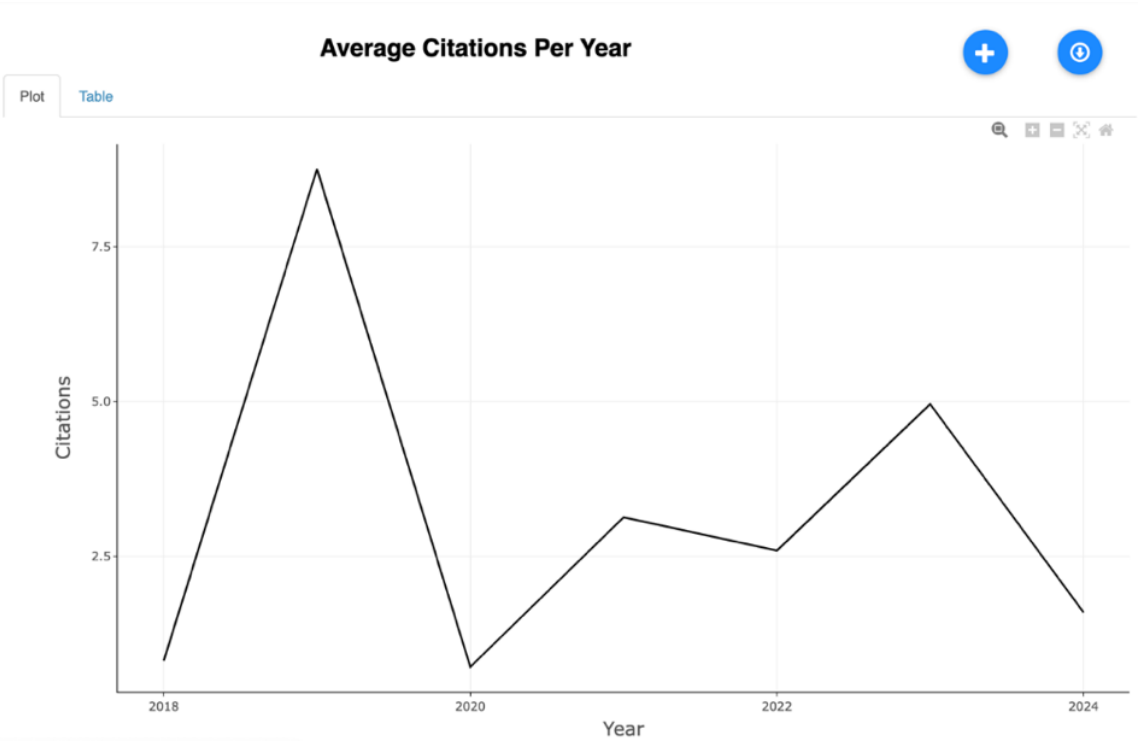

Fig. 3. Average Citations per Year

The results are supported by detailed quantitative data, offering robust insights into publication trends, research focus, and the novelty of emerging keywords in the domain of Artificial Intelligence (AI) in education. From a total of 8,926 documents retrieved from the Scopus database (2014–2024), 157 eligible publications were analyzed. The most prominent source was the AIP Conference Proceedings and IOP Conference Series: Earth and Environmental Science, each contributing 7 documents, followed by E3S Web of Conferences with 6 documents. These findings suggest a strong tendency for researchers to disseminate AI-related educational studies in conference proceedings rather than peer-reviewed journals.

Country-wise distribution revealed that the majority of publications originated from the United States, China, and the United Kingdom, which collectively contributed more than 45% of the total eligible documents, indicating their leadership in the AI-in-education research domain. Citation analysis shows a peak in 2019, corresponding with early impactful studies, and another increase in 2023 aligned with the rise of Generative AI tools such as ChatGPT. The average number of citations per article in 2019 exceeded 25, while more recent publications (2023–2024) have yet to accumulate significant citations due to their recency.

The VOSviewer-based keyword co-occurrence analysis identified core themes such as "e-learning," "personalized learning," "chatbots," and "machine learning." Notably, new keywords such as "federated learning," "contrastive learning," and "adversarial machine learning" emerged, signifying a shift toward research that emphasizes data security, robust model training, and personalized AI applications in education. These novel terms highlight a progressive transition from basic AI implementations to more complex, ethical, and context-aware applications. Collectively, these findings provide a comprehensive map of current and emerging research directions, offering valuable guidance for future scholarly and practical developments in AI-enhanced education.

3.2. Research Focus Analysis

Analysis using VOSviewer identified the main themes in the literature on Artificial Intelligence (AI) in global education through keyword relationship mapping [20], [21]. The bibliometric visualization (Fig. 4) shows that 'artificiantelligence' is a central theme closely related to terms such as 'machine learning', 'deep learning', 'e-learning', 'personalized learning', and 'students'. These associations reflect the research focus on the utilization of AI for more adaptive, personalized, and data-driven learning, in line with the direction of digital transformation in education.

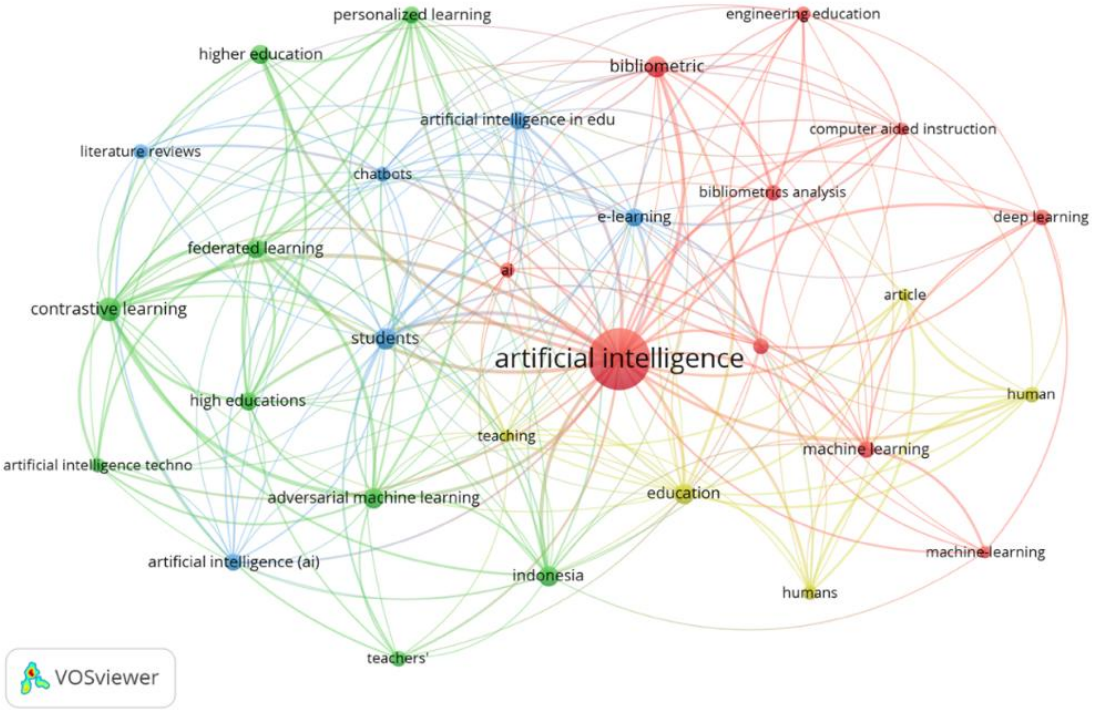

Fig. 4. Research Focus Analysis

Additionally, this network illustrates the strong relationship between Artificial Intelligence (AI) and teaching and learning processes, highlighting its connection with various emerging concepts that support technology-based learning. Keywords such as e-learning, personalized learning, chatbots, and federated learning indicate that AI, particularly in the form of Generative AI, contributes to the development of more adaptive, responsive, and data-driven learning models

The connection of AI with terms such as teachers, students, and teaching also indicates that the utilization of Generative AI is not only focused on system development but also on enhancing the quality of interactions between educators and learners. This reinforces the finding that, over the past decade (2014–2024), Generative AI has increasingly occupied a strategic position in the global discourse on innovations in digital teaching and learning [24], and has become a key driver in the transformation of pedagogical approaches across various levels of education

This network illustrates the strong relationship between Artificial Intelligence (AI) and the teaching and learning processes. This relationship is evident in how AI is increasingly integrated into various technology-based learning approaches aimed at enhancing educational effectiveness. Keywords such as e-learning, personalized learning, chatbots, and federated learning highlight the important role of AI, particularly in the form of Generative AI, in developing more adaptive, responsive, and data-driven learning models. This opens up opportunities for learners to experience more personalized learning tailored to their individual needs

The connection of AI with terms such as teachers, students, and teaching indicates that the application of Generative AI is not solely focused on the development of learning systems or software. AI also plays a crucial role in enhancing the quality of interactions between educators and learners, assisting teachers in facilitating more meaningful learning processes. These findings strengthen the evidence that, over the past decade (2014–2024), Generative AI has increasingly occupied a strategic position in the global discourse on innovations in digital teaching and learning. AI has become a key driver influencing the transformation of pedagogical approaches across various educational levels, steering education towards a more intelligent and adaptive system that meets the needs of the times

3.3. Keyword Novelty

Keyword novelty analysis aims to identify the latest terms emerging in the field of Artificial Intelligence (AI) for teaching and learning. These findings provide an overview of the current trends in research development and highlight topics that are beginning to receive greater academic attention (Fig. 5).

In the VOSviewer visualization, keywords highlighted in yellow represent relatively new themes within the research focus on Generative AI for teaching and learning. The yellow color indicates that these terms have only begun to emerge in recent years and have not been extensively explored in existing literature. This layer of analysis allows researchers and policymakers to recognize emerging areas of interest and identify opportunities for further research in areas that are still underexplored but have the potential to make a significant impact.

The keyword novelty analysis aims to identify emerging terms in the field of AI for global education. These findings provide insights into how research over the past decade particularly from 2022 to 2024 has begun to shift from the basic utilization of AI toward the implementation of Generative AI in digital learning (Fig. 5). Terms such as “federated learning”, “contrastive learning”, and “adversarial machine learning” have started to emerge prominently as new topics gaining widespread scientific attention.

The models and learning approaches depicted in the visualization also highlight topics such as personalized learning, chatbots, and artificial intelligence techno as integral components of a more adaptive and contextual digital education transformation. Notably, the emergence of the keyword higher education indicates that research is not only concentrated on learning technologies but also on their implementation at the institutional and higher education policy levels. This emphasis suggests that AI is no longer viewed merely as a technical support tool but is increasingly positioned as a strategic element in instructional design.

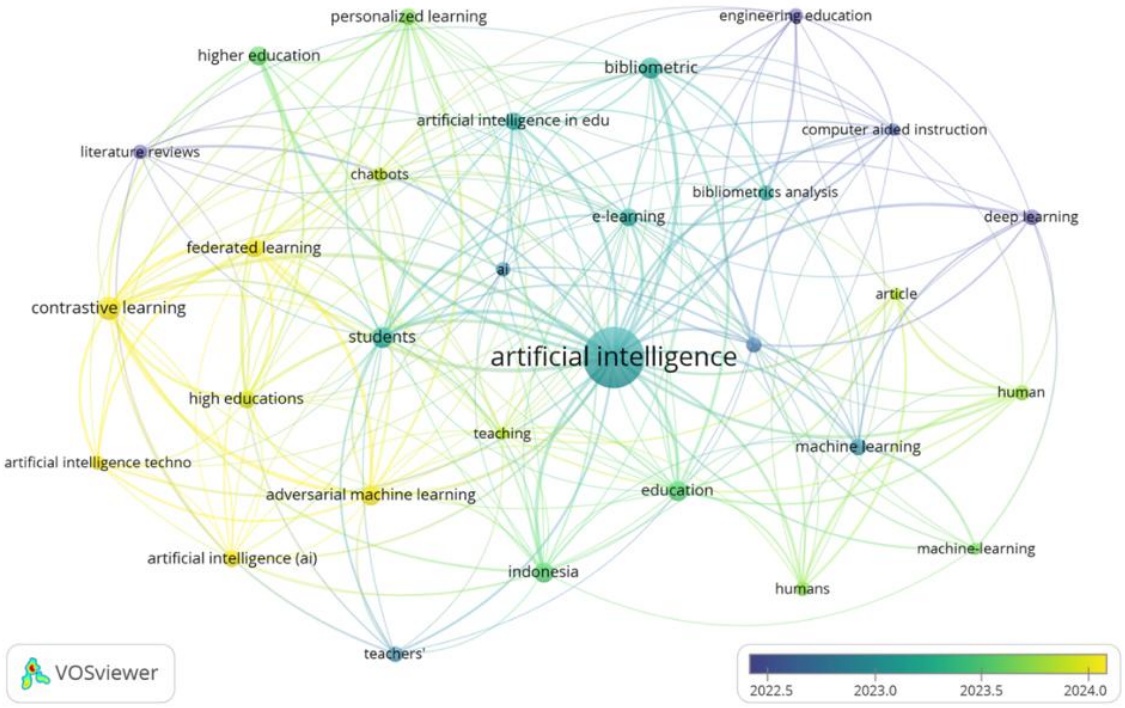

Fig. 5. New Keywords

The emergence of the keyword federated learning underscores the growing recognition of Artificial Intelligence (AI) approaches that enable collaborative and distributed model training without data sharing, thereby highlighting data privacy as a critical factor in the successful implementation of AI in education [25], [26]. This indicates a shift in research focus toward AI applications that prioritize data privacy, enabling collaboration without the need to centralize data. This shift reflects a growing drive to develop more personalized and data-driven learning systems without compromising the security of learners' personal information [27].

The emergence of contrastive learning highlights the growing efforts to link AI with deeper data understanding and more accurate representation [28]. Meanwhile, the keyword adversarial machine learning indicates a trend toward the integration of more robust and secure learning techniques aimed at enhancing model resilience against attacks and data perturbations [29]. The emergence of these keywords indicates a movement toward strengthening AI to better address real-world challenges. This development enables AI to provide more effective solutions within educational contexts. Moreover, this trend opens opportunities to design safer learning systems and implement trustworthy technologies in global education

This study demonstrates that the development of research on Artificial Intelligence (AI) in education has progressed beyond the application of basic instructional technologies toward more complex and adaptive models. The emergence of the term artificial intelligence techno reflects the expansion of the AI domain, which integrates intelligent technologies into educational systems. This underscores that AI is no longer merely a tool for automated assessment or instructional chatbots, but has become a core element in the design of digital learning [30], [31], [32], [33]. This novelty is evident in the emergence of new keywords in the literature, indicating that recent research has begun to explore AI implementation through more sophisticated approaches aimed at creating personalized, adaptive, and contextual learning experiences.

The emergence of terms such as adversarial learning, federated learning, and contrastive learning marks a significant phase in the transformation of AI research in the field of education.

Federated learning stands out for offering a collaborative approach to training AI models without centralizing data, thereby supporting the protection of learner privacy. Meanwhile, contrastive learning is being adopted to enhance data representation understanding, enabling AI to detect subtler patterns for personalized learning. Adversarial learning, on the other hand, has gained attention as a novel strategy for strengthening AI model resilience against data attacks, which is essential for building trustworthy digital learning systems. These findings suggest that the focus of AI research in education is shifting toward innovations that not only improve learning effectiveness but also prioritize security, transparency, and privacy. Furthermore, while generative AI can assist in teaching, the majority of respondents believe that human teachers, with qualities such as critical thinking and emotion, remain irreplaceable. They also assert that generative AI should be effectively integrated to enhance learning without replacing the role of teachers [13].

4. Conclusion

The results of the study indicate that, over the past decade, the application of Artificial Intelligence (AI), particularly Generative AI (GenAI), in education has developed rapidly. From being used for standard tasks such as automated assessments and adaptive learning, Generative AI has evolved towards more advanced approaches. The emergence of keywords such as artificial intelligence techno, federated learning, contrastive learning, and adversarial learning reflects a significant shift in research focus, emphasizing improvements in learning quality, personalization, data security, and system resilience. These findings confirm that AI, particularly Generative AI, has become a major driver of pedagogical innovation and a key pillar in the future of digital learning.

Future research should incorporate other databases such as Google Scholar, Garuda, DOAJ, and other relevant databases. Qualitative or mixed methods could be employed to explore the implementation of Generative AI in classrooms. Additionally, it is crucial to explore regional differences related to infrastructure, teacher readiness, and educational policies in adopting this technology. Longitudinal studies are needed to assess the long-term impact of AI, particularly federated learning and contrastive learning, on learning outcomes. This research is also important to understand the long-term effects of AI on teaching practices across various educational institutions.

Declaration

Supplementary Materials: Supplementary materials of this study include the full dataset retrieved from Scopus and visualizations generated using VOSviewer and Program R.

Author Contribution: NF: Conceptualization, Writing - Initial Draft, Editing and Visualization, Methodology and Review & Editing, MFFA & NGAAR: Conceptualization, Formal analysis, Methodology and Review & Editing; SR: Validation and Monitoring. All authors have read and approved the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgment: The authors would like to thank Yogyakarta State University for the support and facilities provided during the research process. In particular, we appreciate the access provided to conduct a comprehensive data analysis.

Conflicts of Interest: The authors declare no conflict of interest.

References

[1] I. H. Y. Yim and J. Su, "Artificial intelligence (AI) learning tools in K-12 education: A scoping review," *J. Comput. Educ.*, vol. 12, no. 1, pp. 93-131, 2025, https://doi.org/10.1007/s40692-023-00304-9.

[2] A. O. (Olnancy) Tzirides *et al.*, "Combining human and artificial intelligence for enhanced AI literacy in higher education," *Comput. Educ. Open*, vol. 6, p. 100184, 2024, https://doi.org/10.1016/j.caeo.2024.100184.

[3] A. Nguyen, H. N. Ngo, Y. Hong, B. Dang, and B. P. T. Nguyen, "Ethical principles for artificial intelligence in education," *Educ. Inf. Technol.*, vol. 28, no. 4, pp. 4221–4241, 2023, https://doi.org/10.1007/s10639-022-11316-w.

[4] I. Stepin, J. M. Alonso, A. Catala, and M. Pereira-Farina, "A Survey of Contrastive and Counterfactual Explanation Generation Methods for Explainable Artificial Intelligence," *IEEE Access*, vol. 9, pp. 11974–12001, 2021, https://doi.org/10.1109/ACCESS.2021.3051315.

[5] A. Al Darayseh, "Acceptance of artificial intelligence in teaching science: Science teachers' perspective," *Comput. Educ. Artif. Intell.*, vol. 4, p. 100132, 2023, https://doi.org/10.1016/j.caeai.2023.100132.

[6] R. Sahar and M. Munawaroh, "Artificial intelligence in higher education with bibliometric and content analysis for future research agenda," *Discov. Sustain.*, vol. 6, no. 1, p. 401, 2025, https://doi.org/10.1007/s43621-025-01086-z.

[7] S. C. Kong, W. M. Y. Cheung, and G. Zhang, "Evaluating artificial intelligence literacy courses for fostering conceptual learning, literacy and empowerment in university students: Refocusing to conceptual building," *Comput. Hum. Behav. Reports*, vol. 7, p. 100223, 2022, https://doi.org/10.1016/j.chbr.2022.100223.

[8] Y. M. Wang, C. L. Wei, H. H. Lin, S. C. Wang, and Y. S. Wang, "What drives students' AI learning behavior: a perspective of AI anxiety," *Interact. Learn. Environ.*, vol. 32, no. 6, pp. 2584–2600, 2024, https://doi.org/10.1080/10494820.2022.2153147.

[9] I. Celik, M. Dindar, H. Muukkonen, and S. Järvelä, "The Promises and Challenges of Artificial Intelligence for Teachers: a Systematic Review of Research," *TechTrends*, vol. 66, no. 4, pp. 616–630, 2022, https://doi.org/10.1007/s11528-022-00715-y.

[10] V. Maphosa and M. Maphosa, "Artificial intelligence in higher education: a bibliometric analysis and topic modeling approach," *Appl. Artif. Intell.*, vol. 37, no. 1, 2023, https://doi.org/10.1080/08839514.2023.2261730.

[11] F. Almasri, "Exploring the Impact of Artificial Intelligence in Teaching and Learning of Science: A Systematic Review of Empirical Research," *Res. Sci. Educ.*, vol. 54, no. 5, pp. 977–997, 2024, https://doi.org/10.1007/s11165-024-10176-3.

[12] W. M. Lim, A. Gunasekara, J. L. Pallant, J. I. Pallant, and E. Pechenkina, "Generative AI and the future of education: Ragnarök or reformation? A paradoxical perspective from management educators," *Int. J. Manag. Educ.*, vol. 21, no. 2, p. 100790, 2023, https://doi.org/10.1016/j.ijme.2023.100790.

[13] C. K. Y. Chan and L. H. Y. Tsi, "Will generative AI replace teachers in higher education? A study of teacher and student perceptions," *Stud. Educ. Eval.*, vol. 83, p. 101395, 2024, https://doi.org/10.1016/j.stueduc.2024.101395.

[14] H. K. Aladsani, "Developing postgraduate students' competencies in generative artificial intelligence for ethical integration into academic practices: a participatory action research," *Interact. Learn. Environ.*, vol. 4820, pp. 1–19, 2025, https://doi.org/10.1080/10494820.2025.2487517.

[15] S. Akgun and C. Greenhow, "Artificial intelligence in education: addressing ethical challenges in K-12 settings.," *AI Ethics*, vol. 2, no. 3, pp. 431–440, 2021, https://doi.org/10.1007/s43681-021-00096-7.

[16] M. M. A. Parambil *et al.*, "Integrating AI-based and conventional cybersecurity measures into online higher education settings: Challenges, opportunities, and prospects," *Comput. Educ. Artif. Intell.*, vol. 7, p. 100327, 2024, https://doi.org/10.1016/j.caeai.2024.100327.

[17] Z. Bahroun, C. Anane, V. Ahmed, and A. Zacca, "Transforming Education: A Comprehensive Review of Generative Artificial Intelligence in Educational Settings through Bibliometric and Content Analysis," *Sustain.*, vol. 15, no. 17, 2023, https://doi.org/10.3390/su151712983.

[18] H. Crompton and D. Burke, "Artificial intelligence in higher education: the state of the field," *Int. J. Educ. Technol. High. Educ.*, vol. 20, no. 1, 2023, https://doi.org/10.1186/s41239-023-00392-8.

[19] B. Ogunleye, K. I. Zakariyyah, O. Ajao, O. Olayinka, and H. Sharma, "A Systematic Review of Generative AI for Teaching and Learning Practice," *Educ. Sci.*, vol. 14, no. 6, 2024, https://doi.org/10.3390/educsci14060636.

[20] M. Ivanova, G. Grosseck, and C. Holotescu, "Unveiling Insights: A Bibliometric Analysis of Artificial Intelligence in Teaching," *Informatics*, vol. 11, no. 1, 2024, https://doi.org/10.3390/informatics11010010.

[21] R. Dwivedi and L. Elluri, "Exploring Generative Artificial Intelligence Research: A Bibliometric Analysis Approach," *IEEE Access*, vol. 12, pp. 119884–119902, 2024, https://doi.org/10.1109/ACCESS.2024.3450629.

[22] Q. Liu, N. L. Ali, and H. Y. Lee, "Applying VOSviewer in a bibliometric review on English language teacher education research: an analysis of narratives, networks and numbers," *Cogent Educ.*, vol. 12, no. 1, p., 2025, https://doi.org/10.1080/2331186X.2025.2449728.

[23] K. Yang and A. C. Thoo, "Visualising the Knowledge Domain of Reverse Logistics and Sustainability Performance: Scientometric Mapping Based on VOSviewer and CiteSpace," *Sustain.*, vol. 15, no. 2, 2023, https://doi.org/10.3390/su15021105.

[24] N. L. Rane, "ChatGPT and similar generative artificial intelligence (AI) for smart industry: role, challenges, and opportunities for Industry 4.0, Industry 5.0, and Society 5.0," *Innov. Bus. Strateg. Manag.*, vol. 2, no. 1, pp. 10–17, 2024, https://doi.org/10.61577/ibsm.2024.100002.

[25] G. K. Jagarlamudi, A. Yazdinejad, R. M. Parizi, and S. Pouriyeh, "Exploring privacy measurement in federated learning," *J. Supercomput.*, vol. 80, pp. 10511–10551, 2023, https://doi.org/10.1007/s11227-023-05846-4.

[26] H. Li *et al.*, "Review on security of federated learning and its application in healthcare," *Futur. Gener. Comput. Syst.*, vol. 144, pp. 271–290, 2023, https://doi.org/10.1016/j.future.2023.02.021.

[27] A. Z. Tan, H. Yu, L. Cui, and Q. Yang, "Towards Personalized Federated Learning," *IEEE Trans. Neural Networks Learn. Syst.*, vol. 34, no. 12, 2022, https://doi.org/10.1109/TNNLS.2022.3160699.

[28] L. Y. Li *et al.*, "A knowledge graph completion model based on contrastive learning and relation enhancement method," *Knowledge-Based Syst.*, vol. 256, p. 109889, 2022, https://doi.org/10.1016/j.knosys.2022.109889.

[29] S. Pelekis *et al.*, "Adversarial machine learning: a review of methods, tools, and critical industry sectors," *Artif. Intell. Rev.*, vol. 58, no. 8, 2025, https://doi.org/10.1007/s10462-025-11147-4.

[30] B. Prosenjak and E. Jakupčević, "Attitudes of Primary and Secondary EFL Teachers in Croatia Towards the Use of AI in Classroom Settings," *ELOPE English Lang. Overseas Perspect. Enq.*, vol. 22, no. 1, pp. 133–150, 2025, https://doi.org/10.4312/elope.22.1.133-150.

[31] E. A. Morrison, *Design Futures Literacies*, vol. 2. FUEL4DESIGN Project /Oslo: Oslo School of Architecture and Design (AHO), 2023.

[32] H. Munir, B. Vogel, and A. Jacobsson, "Enfoques de inteligencia artificial y aprendizaje automático en la educación digital: Una revisión sistemática," *Information*, vol. 13, no. 4, p. 203, 2022, https://doi.org/10.3390/info13040203.

[33] E. Y. Barakina, A. V. Popova, S. S. Gorokhova, and A. S. Voskovskaya, "Digital Technologies and Artificial Intelligence Technologies in Education," *Eur. J. Contemp. Educ.*, vol. 10, no. 2, pp. 285–296, 2021, https://doi.org/10.13187/ejced.2021.2.285.