

Educational Technology For Digital Learning : A Bibliometric Analysis

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ABSTRACT:

This study aims to analyze the evolution of research in the field of educational technology using a bibliometric approach based on Scopus data. From an initial dataset of 9,783 articles, a systematic selection process using the PRISMA protocol narrowed the focus to 29 relevant articles for in-depth analysis. Utilizing VOSviewer software, the study explores keyword trends, co-authorship networks, and institutional as well as national affiliations involved in the field. The analysis reveals a growing interest in topics such as artificial intelligence, virtual reality, e-learning, and bibliometric methods within educational technology. In addition, the study identifies leading contributing countries, prominent research institutions, and highly cited papers. These findings provide a comprehensive overview of the recent developments in educational technology research. The implications of this study are expected to offer valuable insights for researchers and stakeholders in identifying research gaps and designing future research agendas that are more aligned with current technological and educational advancements.

ABSTRAK:

Penelitian ini bertujuan untuk menganalisis evolusi penelitian dalam bidang teknologi pendidikan menggunakan pendekatan bibliometrik berbasis data dari Scopus. Dari 9.783 artikel yang diperoleh, proses seleksi sistematis menggunakan protokol PRISMA menghasilkan 29 artikel yang relevan untuk dianalisis lebih lanjut. Dengan bantuan perangkat lunak VOSviewer, studi ini mengeksplorasi tren

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kata kunci, jaringan kolaborasi antar-penulis, serta afiliasi institusi dan negara yang terlibat. Hasil analisis menunjukkan meningkatnya perhatian terhadap topik seperti kecerdasan buatan, realitas virtual, e-learning, dan bibliometrik dalam konteks teknologi pendidikan. Selain itu, penelitian ini mengidentifikasi negara-negara kontributor utama, lembaga penelitian terkemuka, serta artikel yang paling banyak dikutip. Temuan ini memberikan gambaran yang komprehensif mengenai arah perkembangan studi teknologi pendidikan dalam beberapa tahun terakhir. Implikasi dari studi ini diharapkan dapat memberikan panduan bagi peneliti dan pemangku kepentingan dalam mengidentifikasi celah penelitian dan merancang agenda penelitian masa depan yang lebih relevan dengan perkembangan zaman.

Kata kunci: Bibliometrik, Kecerdasan Buatan, Pembelajaran Digital, Realitas Virtual, Gamifikasi

INTRODUCTION

The rapid advancement of educational technology has led to significant transformations in teaching and learning methodologies across various educational levels (Ravichandran et al., 2024). Various instructional models, such as blended learning, flipped classroom, and personalized learning, have emerged as a response to technological integration in the classroom (Daniel et al., 2024). Moreover, several teaching methods—such as problem-based learning, project-based learning, and collaborative learning—now increasingly rely on technological tools to facilitate access to digital content, student engagement, motivate students and interactive learning environments (Eswaran, 2024). However, with the continuous increase in the number of publications each year, a systematic mapping of educational technology research trends is essential to provide a deeper understanding of the field's development.

The integration of online learning on artificial intelligence (Stracqualursi & Agati, 2024), virtual reality (Han & Lorenzo Najord, 2024), and gamification (Miroshnyk et al., 2023) has expanded access to education while enhancing learning experiences. As reliance on technology in education grows, research in this field has increased substantially, reflecting both academic and practical interest in evaluating its effectiveness, adaptability, and long-term impact on educational outcomes (Khan et al., 2025). X users have a majority of positive opinions about improving the learning experience in using AI, VR and



gamification in learning, although some are concerned about the potential negative impacts of AI on ethics and society (Han & Lorenzo Najord, 2024). Learners' behavioral intentions, actual behavior, and academic performance are also factors in the realization of AI technology transformation (Ashraf et al., 2025).

Despite this growing body of research, there is still a lack of comprehensive bibliometric mapping that systematically explores how educational technology research has evolved over time—particularly in identifying dominant themes, collaboration patterns, and emerging topics such as AI and ChatGPT in learning contexts. Previous studies have typically examined isolated technologies or pedagogical approaches but have not offered a holistic overview of the entire research landscape in educational technology. To address this gap, the present study contributes by conducting a bibliometric analysis of educational technology research indexed in the Scopus database. This analysis identifies trends in publication growth, keyword evolution, and collaboration networks using VOSviewer visualization tools. By doing so, this study provides a structured overview of research development in educational technology and offers insights for academics, practitioners, and policymakers to understand existing patterns and identify future research directions.

This approach enables researchers to analyze the evolution of a field based on bibliographic data from academic databases, revealing key aspects such as publication trends over time, geographic distribution of research, contributions from leading institutions, and patterns of collaboration among researchers. Additionally, keyword analysis helps to identify emerging themes and provides insights into future research directions. By analyzing publication trends, researcher collaborations, and dominant research themes, this study seeks to offer valuable insights for academics, practitioners, and policymakers in understanding the development of educational technology and potential future research directions. Furthermore, the findings may help identify research gaps that have yet to be explored, serving as a reference for future studies in this field.

METHODS

This study employs a bibliometric approach to analyze the evolution of educational technology research based on data from Scopus, one of the largest

and most credible academic databases. The research methodology consists of several stages: data collection, article selection, data processing, and bibliometric analysis(Broadus, 1987).

1. Data Collection and Selection

Articles were retrieved from Scopus using keywords "Educational Technology," "Bibliometric Analysis," "Artificial Intelligence," "E-Learning," and "Gamification." The search string used was as follows:

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"TITLE-ABS-KEY ( educational AND technology AND learning )AND  
PUBYEAR > 2017 AND PUBYEAR < 2026  
AND ( LIMIT-TO ( SRCTYPE , "j" ) ) AND ( LIMIT-TO ( SUBJAREA , "SOCI" )  
OR LIMIT-TO ( SUBJAREA , "COMP" )  
OR LIMIT-TO ( SUBJAREA , "ENGI" ) OR LIMIT-TO ( SUBJAREA , "MULT" )  
) AND ( LIMIT-TO ( DOCTYPE , "ar" ) OR LIMIT-TO ( DOCTYPE , "re" ) )  
AND ( LIMIT-TO ( LANGUAGE , "English" ) )"
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Only peer-reviewed journal articles were included in the analysis, while books and conference proceedings were excluded. The selection process followed the PRISMA 2020 statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach(Page et al., 2021), consisting of four main stages Identification collecting 9,783 articles from the Scopus database.

This PRISMA diagram shows the process of article selection in the bibliometric study of educational technology. Of the initial 9,783 articles, 7,783 articles were excluded because they did not meet the basic criteria. After 2,000 articles were screened, 1,800 articles were eliminated. Of the 200 articles evaluated, 171 articles were excluded because they did not use PRISMA/VOSviewer (90), were irrelevant topics (50), or were not bibliometric studies (31). Finally, 29 articles were selected for analysis.



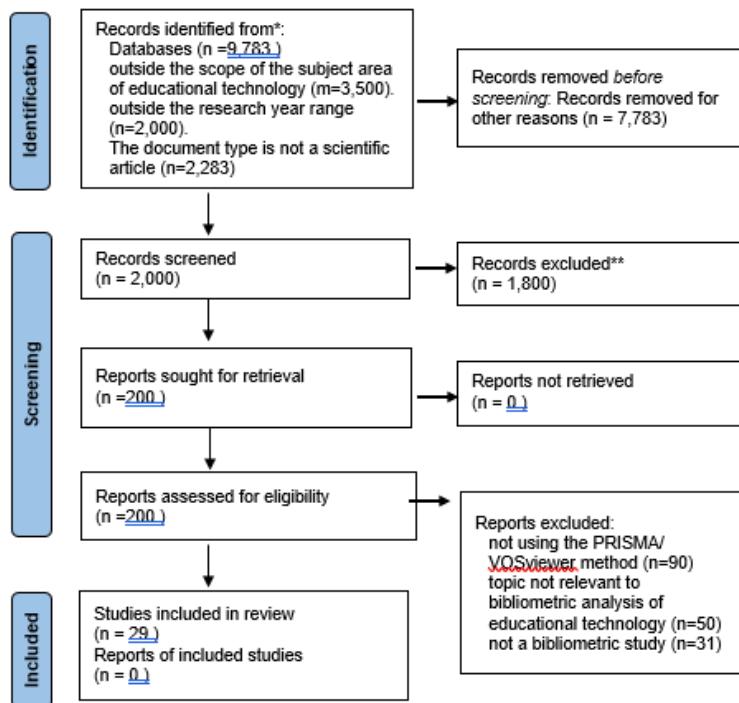


Figure 1. PRISMA Analysis

2. Data Processing and Analysis

Bibliometric analysis was conducted using VOSviewer version 1.6.20 to identify various bibliometric parameters (van Eck & Waltman, 2010). Extracted data included publication titles, publication years, author names, journal names, citation counts, and keywords, obtained in CSV format from Scopus. The analysis covered several key aspects, publication trends (number of articles per year), geographical distribution (countries and institutions contributing to educational technology research), co-authorship analysis to examine researcher collaborations. Keyword co-occurrence analysis to identify major research themes, highly cited papers to determine the most influential studies.

3. Network Visualization and Statistical Analysis

To construct a research network map, VOS clustering and mapping methods were applied. Additionally, co-citation analysis was used to understand relationships between articles based on shared citations (Zhang et al., 2021). Normalization using the LinLog/modularity algorithm was implemented to enhance research network readability. Moreover, the Association Strength Index (Meng et al., 2020) was used to measure the connection between articles based on shared citations (Guleria & Kaur, 2021). By employing this approach, the study provides a comprehensive overview of major trends in educational technology research, researcher collaborations, and potential future research directions.

Ethics Statement

This study did not involve human participants, animals, or any personal or sensitive data. Therefore, ethical approval was not required. The data analyzed were obtained from publicly available sources (Scopus database) and used in accordance with their terms of service.

FINDINGS AND DISCUSSION

FINDINGS

The findings of this bibliometric study reveal a dynamic and evolving landscape in educational technology research. Based on 29 selected articles from an initial pool of 9,783 Scopus-indexed publications filtered using the PRISMA protocol, several key insights emerged. The temporal trend shows a sharp increase in publications after 2020, particularly between mid-2023 and early 2025, indicating heightened scholarly attention post-COVID-19. More than 90% of the articles were published after 2020, illustrating an accelerated interest in topics like artificial intelligence (AI), virtual and augmented reality (VR/AR), and e-learning.

Trends Publication

Based on the chart showing the number of documents per year from Scopus, it can be observed that research publications in the field of educational technology have experienced a steady and significant increase over the years. Starting from 2014, the number of publications grew consistently, reaching its peak in 2023. This upward trend reflects a growing interest among researchers



in exploring educational technology topics, in line with the rapid advancement of digital technologies and their integration into educational environments. This increase also highlights the rising academic focus on areas such as online learning (e-learning), artificial intelligence (AI), augmented reality (AR), and bibliometric analysis within the educational context. The sharp rise in publications leading up to 2023 may also be influenced by the global shift toward digital learning during and after the COVID-19 pandemic, which accelerated the demand for innovative, tech-based educational solutions.

However, a notable decline in the number of publications is seen in 2024. This drop is likely due to incomplete data collection for that year at the time of analysis or possibly due to temporary changes in research priorities. Therefore, this decrease should be interpreted with caution and not necessarily viewed as a decline in overall interest in the field. Overall, the chart indicates that educational technology remains a dynamic and evolving area of research. If the previous trend continues, the number of publications is expected to rise again in the coming years. This opens further opportunities for researchers to explore new topics and contribute to the growing body of academic literature in the field of educational technology. Trends Publication is visualized in Figure 2.

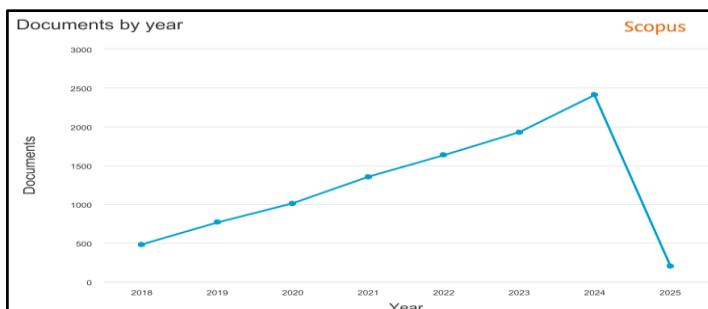


Figure 2. Trends Publication generated using Scopus

Institutional Affiliations

The institution with the highest number of citations in the study was the Costa Rica Institute, which recorded more than 250 citations, placing it as the most influential institution in this field. In addition, institutions such as National Engineering Research and several other universities also have a high number of citations, although it is still far below the Costa Rica Institute. The citation

distribution showed that only a handful of institutions dominated in the study, while most other institutions had a relatively small number of citations. This disparity in the distribution of citations indicates that research in this area is still dominated by certain institutions, which may have greater resources or active involvement in international collaborations. However, global representation remains visible in the list of influential institutions, with participation from countries such as Turkey, Indonesia, Saudi Arabia, Spain, Vietnam, and several other countries. Institutional Affiliations is visualized in Figure 3.

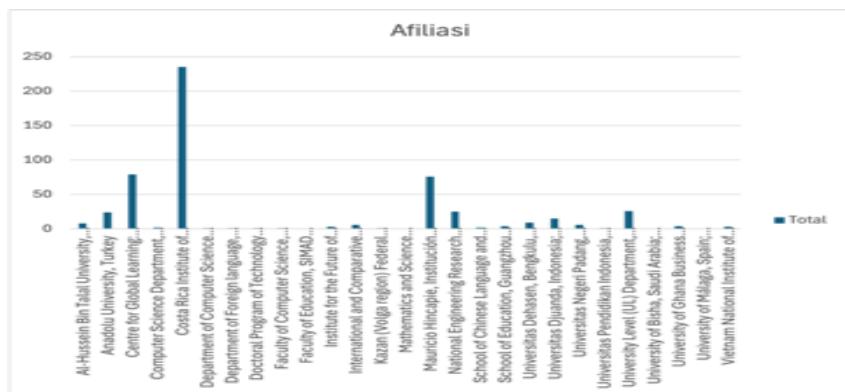


Figure 3. Affiliation generated using Scopus

This shows that research in this area has a wide international scope, although the contributions of each country vary in terms of the number of citations and publications. From Indonesia, several universities such as Juanda University and Indonesian Education University are also included in the list of institutions with high citations, although they have not been able to compete with other top institutions. This indicates that research from Indonesia is starting to gain attention at the international level, but it still needs to increase in publications and collaborations to be more influential globally. Efforts to increase the number of quality publications and expand collaboration networks with foreign institutions can be important strategies to increase the impact of research from Indonesia in this field.

Dominant Keyword Trends



This image displays a list of the most frequently appearing keywords in the selected articles. "Educational Technology" became the main keyword with 12 appearances, indicating the research focus on educational technology. "Bibliometric Analysis" appears 10 times, indicating the use of bibliometric approaches, while "Artificial Intelligence" (8 times), "Virtual Reality" (6 times), and "Augmented Reality" (4 times) highlight the application of cutting-edge technology in education. In addition, "Higher Education" (6 times) and "E-Learning" (5 times) affirmed the focus on higher education and online learning. Other keywords such as "COVID-19" (3 times) and "Gamification" (2 times) show research related to the impact of the pandemic and the application of game elements in learning. Overall, the research in this dataset largely addresses educational technology, bibliometric analysis, and technological innovations such as AI, VR, and AR, with additional attention to the impact of the pandemic and gamification in education. Dominant Keyword Trends is visualized in table 1.

Table 1. Dominant Keyword Trends

No	Keywords	Frequencies
1	Educational Technology	12
2	Bibliometric Analysis	10
3	Artificial Intelligence	8
4	Virtual Reality	6
5	Higher Education	6
6	E-Learning	5
7	Language Education	3
8	Mathematics Education	2
9	Vocational Education	2
10	Covid-19	3
11	Gamification	2
12	Augmented Reality	4

Distribution of Publications in Journal

The results of the analysis show that Education and Information Technologies is the journal with the most publications in this study (3 articles), indicating its role as the main source in the field of bibliometrics and educational technology. Several other journals, such as Sustainability (Switzerland), Heliyon, Computers and Education, and Contemporary Educational Technology, published 2 articles each, showing that this research is spread across multidisciplinary journals. In addition, some journals such as the Journal of Educational Technology & Society, IEEE Access, and Frontiers in Education have only one article, which suggests that while relevant, these journals are not major centers of publication in this field. Overall, the distribution of these publications reflects the linkages of research across a wide range of disciplines, including technology, education, sustainability, and social sciences. Distribution of Publications in Journal is visualized in table 2.

Table 2. Publications in Journal

No	Journal	No. of Articles
1	Education and Information Technologies	3
2	Sustainability (Switzerland)	2
3	Heliyon	2
4	Computers and Education	2
5	International Journal of Learning, Teaching and Educational Research	2
6	Humanities and Social Sciences Communication	2
7	Contemporary Educational Technology	2
8	Journal of Educational Technology & Society	1
9	IEEE Access	1
10	Frontiers in Education	1

Keyword Relevance Analysis

The keyword linkage map generated by VOSviewer from 29 selected articles shows the close relationship between the various concepts in this study. "Bibliometric Analysis" is at the center of the network and is the dominant keyword, indicating the major role of bibliometrics in this study. Keywords are divided into three main clusters based on theme. The red cluster focuses on the interconnectedness of education and artificial intelligence (AI), with keywords



such as Educational Technology, Artificial Intelligence, and ChatGPT (Shuhaiyer, Kuhail, and Salman 2025). The blue cluster highlights technological innovations in learning, covering keywords such as Augmented Reality, Virtual Reality, and Technology (Latorre-Cosculluela et al., 2025). Meanwhile, green clusters relate to online learning and higher education, including keywords such as E-learning, Online Learning, and Covid-19. Further analysis shows that "Bibliometric Analysis" is closely related to various key concepts, such as Educational Technology and Artificial Intelligence, showing that the trend of AI studies in learning is growing (Vermeiren et al., 2025)

The connection with VOSviewer and Bibliometrics confirms that bibliometric tools are the main method in this study. In addition, the relationship between Online Learning and Covid-19 shows how bibliometry is used to examine the impact of the pandemic on online education. In conclusion, this study maps the use of bibliometry in education, technology, and AI. The focus includes e-learning, learning technology innovation, and the impact of COVID-19. In addition, AI and ChatGPT are starting to emerge as increasingly relevant research topics in educational bibliometric studies (Lampropoulos et al., 2025). Keyword Relevance Analysis is visualized in Figure 4.

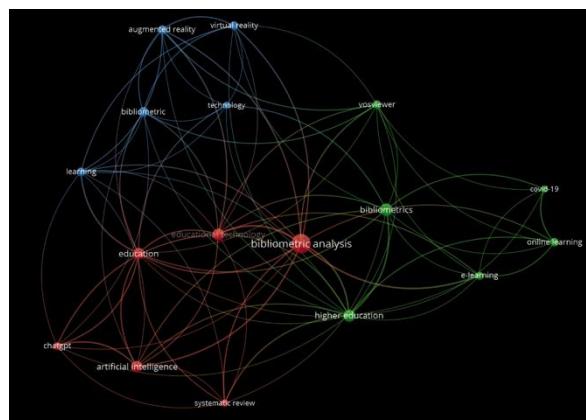


Figure 4. Keyword Relevance generated using VOSviewer version 1.6.20

Temporal Visualization of KEYWORD TRENDS

The temporal visualization (overlay visualization) of VOSviewer shows the evolution of keywords based on the year of publication. The color in this

network represents when a keyword started appearing or being used frequently, according to the time scale displayed. Color-based analysis shows that in the period 2022 - early 2023 (purple/blue), keywords such as Augmented Reality, Virtual Reality, and Technology dominate, indicating that research on AR/VR-based learning technologies is more popular than other topics (Hanafi et al., 2025). Entering mid-2023 (green), the research focus began to shift to Bibliometric Analysis, Higher Education, E-learning, and Covid-19, which shows the dominance of bibliometric research in higher education and online learning, most likely influenced by the impact of the pandemic. In late 2023 - early 2024 (yellow), topics such as Artificial Intelligence, ChatGPT, Systematic Review, and VOSviewer are increasingly emerging, indicating that research linking AI and bibliometrics is on a significant increase (Yildiz Durak et al., 2025).

From these results, it can be concluded that bibliometrics in e-learning and higher education have been a stable trend since 2023, while AI, ChatGPT, and systematic review are the latest trends in 2023-2024. AR/VR technology developed before AI began to be included in educational studies, indicating a shift in research focus from immersive technology to artificial intelligence in supporting learning innovation (Kus & Newcombe, 2025). Temporal Visualization of keyword trends is visualized in Figure 5.

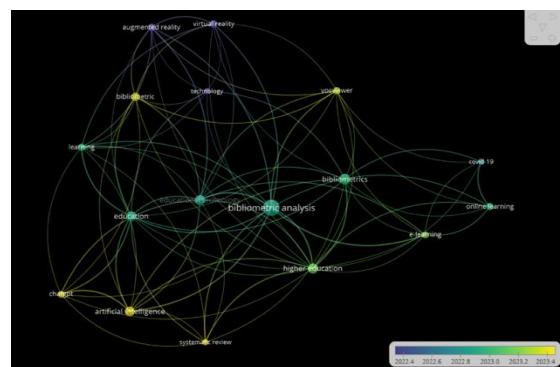


Figure 5. Temporal Visualization of keyword trends generated using VOSviewer version 1.6.20

Interpretation of Density Visualization

The density visualization from VOSviewer shows the rate of occurrence of keywords in the analyzed dataset. The bright yellow color indicates the keyword with the highest frequency, where Bibliometric Analysis is the most dominant keyword in this study. The green color indicates keywords with moderate frequency, including Higher Education, Artificial Intelligence, Online Learning, Bibliometrics, and Education, which appear quite frequently but are still below Bibliometric Analysis.

Meanwhile, blue to light green colors indicate keywords with lower frequency, such as ChatGPT, Systematic Review, Augmented Reality, Virtual Reality, and VOSviewer, which although appear in the dataset (Abulibdeh et al., 2025), but not as many as other main keywords. From these results, it can be concluded that Bibliometric Analysis is the most frequently researched topic in this field. AI and ChatGPT (Naznin et al., 2025) are starting to gain attention, but they are still not as big as research related to bibliometrics in higher education and e-learning (Valdivieso & González, 2025). In addition, while AR/VR and educational technology play an important role in learning innovation, their frequency is still smaller than the other main topics in this dataset. Interpretation of density visualization is visualized in Figure 6.

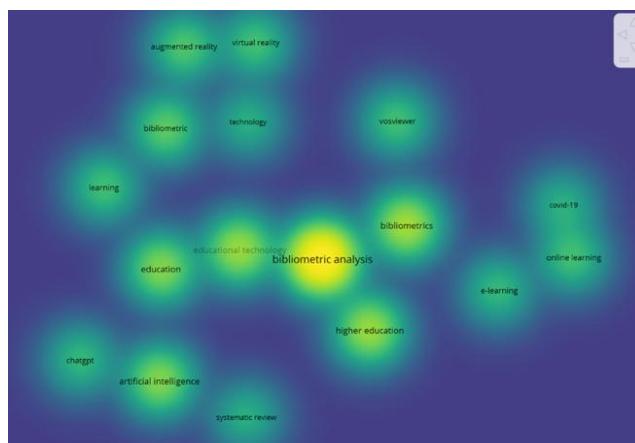


Figure 6. Density Visualization generated using VOSviewer version 1.6.20

DISCUSSION

Institutional affiliation analysis revealed that the Costa Rica Institute led with over 250 citations, marking it as the most influential research body in this domain. Other contributing institutions, including from Indonesia, Turkey, and Saudi Arabia, showed increasing global collaboration despite disparities in citation impact. This indicates that while global representation is improving, a few dominant institutions still lead knowledge production.

Keyword analysis, conducted through VOSviewer, identified "Educational Technology" (12 occurrences), "Bibliometric Analysis" (10), and "Artificial Intelligence" (8) as the most frequent themes. These were followed by "Virtual Reality," "Higher Education," and "E-Learning," reflecting the integration of advanced technology in digital learning environments. COVID-19 and "Gamification" also appeared, demonstrating the pandemic's role in accelerating tech-based education and the growing interest in motivational learning strategies. The study also analyzed journal distribution. Education and Information Technologies emerged as the most frequent publication outlet (3 articles), while journals such as Sustainability (Switzerland), Heliyon, and Computers and Education followed with two each. This indicates a multidisciplinary interest in educational technology across education, sustainability, and social sciences.

Network visualization using VOSviewer presented dense keyword linkages, divided into three primary clusters: red (AI and education), blue (VR/AR and emerging tech), and green (e-learning and pandemic-related topics). The centrality of "Bibliometric Analysis" in these clusters confirms its foundational role in the literature analyzed. Notably, "ChatGPT" and "Systematic Review" began emerging as keywords in late 2023, suggesting a shift in interest toward AI-driven educational research tools. Temporal visualization further highlighted these shifts. Initially, AR/VR technologies were prominent (2022–early 2023), followed by a rise in bibliometric studies and e-learning (mid-2023), and a strong emergence of AI, ChatGPT, and systematic methods by early 2024. This progression suggests a transition from immersive learning technologies toward data-driven and AI-enhanced education models.

Finally, the density visualization confirmed "Bibliometric Analysis" as the most concentrated keyword, with others like "Artificial Intelligence," "Online Learning," and "Higher Education" showing moderate density. "ChatGPT,"



although emerging, appeared with relatively lower frequency, indicating a new yet growing research area. These findings not only map the current state of educational technology research but also forecast future trends emphasizing AI integration, international collaboration, and the critical role of bibliometric methodologies in navigating this rapidly developing field.

The results of this study show that educational technology continues to develop rapidly, especially in the application of Artificial Intelligence (AI), Virtual Reality (VR), Augmented Reality (AR), and E-Learning (Muktiarni et al., 2023). This technology plays an important role in creating a more immersive and interactive learning experience. Keyword analysis revealed that "Educational Technology" (12 times), "Bibliometric Analysis" (10 times), and "Artificial Intelligence" (8 times) were the main topics in this study, while COVID-19 (3 times) showed the influence of the pandemic on the acceleration of educational digitalization.

Collaborative analysis shows an increase in cross-country and institutional research in this field. Some of the institutions with the highest number of citations come from various countries, indicating a global contribution to the development of educational technology (Li et al., 2025). In addition, network mapping with VOSviewer identified close relationships between topics, particularly in the areas of AI in learning, VR/AR-based learning, and gamification trends in education(Boateng et al., 2024). These findings provide insight into the evolution of educational technology research and the direction of future development. The study confirms that the trend of digital learning and adaptive technology is increasingly the main focus of research, which can be a reference for academics and practitioners in developing technology-based educational innovations (Delen et al., 2024).

CONCLUSION

The results of this bibliometric analysis indicate that research in the field of educational technology continues to evolve, with key trends focusing on bibliometric analysis, artificial intelligence, virtual reality, e-learning, and gamification. The number of publications has significantly increased in recent years, particularly after 2020, reflecting growing academic interest in technological innovations for learning. Keyword analysis and VOSviewer

visualizations reveal that AI and ChatGPT are emerging as increasingly studied topics, while AR/VR has been more established in digital education. Collaboration analysis shows that only a few institutions dominate publications with the highest citations, despite the global scope of research in this field. These findings suggest that technology's role in education is becoming increasingly crucial, and future research directions are likely to expand further into AI, data-driven learning, and digital innovations in higher education. Additionally, this study provides insights for academics, practitioners, and policymakers to explore new opportunities and address research gaps in educational technology.

This study has several limitations that should be acknowledged. First, the bibliometric data were collected solely from the Scopus database, which may exclude relevant studies indexed in other databases such as Web of Science or Dimensions. Second, the analysis relied exclusively on quantitative bibliometric methods without triangulation using qualitative or mixed approaches, which may limit interpretive depth. Third, while VOSviewer effectively visualizes co-authorship and keyword relationships, its clustering algorithms may oversimplify complex conceptual linkages. Future research could expand the data sources, combine bibliometric mapping with content or thematic analysis, and employ multiple analytical tools to strengthen validity and provide richer insights.

REFERENCES

Abulibdeh, A., Baya Chatti, C., Alkhereibi, A., & El Menshawy, S. (2025). A Scoping Review of the Strategic Integration of Artificial Intelligence in Higher Education: Transforming University Excellence Themes and Strategic Planning in the Digital Era. *European Journal of Education*, 60(1). <https://doi.org/10.1111/ejed.12908>

Ashraf, M. A., Alam, J., & Kalim, U. (2025). Effects of ChatGPT on students' academic performance in Pakistan higher education classrooms. *Scientific Reports*, 15(1). <https://doi.org/10.1038/s41598-025-92625-1>

Boateng, S. L., Penu, O. K. A., Boateng, R., Budu, J., Marfo, J. S., & Asamoah, P. (2024). Educational technologies and elementary level education – A bibliometric review of scopus indexed journal articles. *Heliyon*, 10(7), e28101. <https://doi.org/10.1016/j.heliyon.2024.e28101>

Broadus, R. N. (1987). Early approaches to bibliometrics. *Journal of the*



American Society for Information Science, 38(2), 127-129.
[https://doi.org/10.1002/\(SICI\)1097-4571\(198703\)38:2<127::AID-ASI6>3.0.CO;2-K](https://doi.org/10.1002/(SICI)1097-4571(198703)38:2<127::AID-ASI6>3.0.CO;2-K)

Daniel, K., Msambwa, M. M., Antony, F., & Wan, X. (2024). Motivate students for better academic achievement: A systematic review of blended innovative teaching and its impact on learning. *Computer Applications in Engineering Education*, 32(4). <https://doi.org/10.1002/cae.22733>

Delen, I., Sen, N., Ozudogru, F., & Biasutti, M. (2024). Understanding the Growth of Artificial Intelligence in Educational Research through Bibliometric Analysis. *Sustainability (Switzerland)*, 16(16). <https://doi.org/10.3390/su16166724>

Eswaran, U. (2024). Project-based learning: Fostering collaboration, creativity, and critical thinking. In *Enhancing education with intelligent systems and data-driven instruction* (pp. 23-43). IGI Global.

Guleria, D., & Kaur, G. (2021). Bibliometric analysis of ecopreneurship using VOSviewer and RStudio Bibliometrix, 1989-2019. *Library Hi Tech*, 39(4), 1001-1024. <https://doi.org/10.1108/LHT-09-2020-0218>

Han, M., & Lorenzo Najord, I. (2024). Virtual reality with e-learning model in business management and knowledge complex environment for gaming analysis. *Entertainment Computing*, 50. <https://doi.org/10.1016/j.entcom.2024.100703>

Hanafi, B., Ali, M., & Singh, D. (2025). Quantum algorithms for enhanced educational technologies. In *Discover Education* (Vol. 4, Issue 1). Springer International Publishing. <https://doi.org/10.1007/s44217-025-00400-1>

Khan, S., Mazhar, T., Shahzad, T., Khan, M. A., Rehman, A. U., Saeed, M. M., & Hamam, H. (2025). Harnessing AI for sustainable higher education: ethical considerations, operational efficiency, and future directions. *Discover Sustainability*, 6(1). <https://doi.org/10.1007/s43621-025-00809-6>

Kus, M., & Newcombe, N. S. (2025). Facilitation of students' disembedding in an online visual arts and mathematics education program. *International Journal of STEM Education*, 12(1). <https://doi.org/10.1186/s40594-024-00524-0>

Lampropoulos, G., López-Belmonte, J., Marín-Marín, J. A., & Pozo-Sánchez, S. (2025). Exploring the General and Educational Use of the Metaverse: Public Perspectives, Sentiments, Attitudes, and Discourses. *SN Computer Science*, 6(2). <https://doi.org/10.1007/s42979-024-03623-5>

Latorre-Coscalluelas, C., Sierra-Sánchez, V., & Vázquez-Toledo, S. (2025). Gamification, collaborative learning and transversal competences: analysis of academic performance and students' perceptions. *Smart Learning Environments*, 12(1). <https://doi.org/10.1186/s40561-024-00361-2>

Li, Y., Chen, Y., Wei, G., Ma, F., Hu, Q., Wei, W., & Bai, Y. (2025). Application of desktop virtual reality technology in nursing student education: a realist review. *BMC Medical Education*, 25(1), 78. <https://doi.org/10.1186/s12909-025-06697-8>

Meng, L., Wen, K.-H., Brewin, R., & Wu, Q. (2020). Knowledge atlas on the relationship between urban street space and residents' health-a bibliometric analysis based on vos viewer and cite space. *Sustainability (Switzerland)*, 12(6). <https://doi.org/10.3390/su12062384>

Miroshnyk, R., Matviy, I., Bahlai, I., & Halaz, L. (2023). Peculiarities of E-learning in Modern Conditions and Prospects for its Development. *International Scientific and Technical Conference on Computer Sciences and Information Technologies*. <https://doi.org/10.1109/CSIT61576.2023.10324039>

Muktiarni, M., Rahayu, N. I., Ismail, A., & Wardani, A. K. (2023). Bibliometric Computational Mapping Analysis of Trend Metaverse in Education using VOSviewer. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 32(2), 95–106. <https://doi.org/10.37934/ARASET.32.2.95106>

Naznin, K., Al Mahmud, A., Nguyen, M. T., & Chua, C. (2025). ChatGPT Integration in Higher Education for Personalized Learning, Academic Writing, and Coding Tasks: A Systematic Review. *Computers*, 14(2). <https://doi.org/10.3390/computers14020053>

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., ... Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *The BMJ*, 372. <https://doi.org/10.1136/bmj.n71>

Ravichandran, K., Virgin, B. A., Edwin, M. R. S., Morris, V. S., & Milton, B. J. (2024). Moving towards a Blended Tomorrow: The Evolution of EdTech in Education. *Library of Progress-Library Science, Information Technology & Computer*, 44(3).

Stracqualursi, L., & Agati, P. (2024). Twitter users perceptions of AI-based e-

learning technologies. *Scientific Reports*, 14(1). <https://doi.org/10.1038/s41598-024-56284-y>

Valdivieso, T., & González, O. (2025). Generative AI Tools in Salvadoran Higher Education: Balancing Equity, Ethics, and Knowledge Management in the Global South. *Education Sciences*, 15(2), 1–31. <https://doi.org/10.3390/educsci15020214>

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523–538. <https://doi.org/10.1007/s11192-009-0146-3>

Vermeiren, H., Kruis, J., Bolsinova, M., van der Maas, H. L. J., & Hofman, A. D. (2025). Psychometrics of an Elo-based large-scale online learning system. *Computers and Education: Artificial Intelligence*, 8(November 2024), 100376. <https://doi.org/10.1016/j.caeai.2025.100376>

Yıldız Durak, H., Egin, F., & Onan, A. (2025). A Comparison of Human-Written Versus AI-Generated Text in Discussions at Educational Settings: Investigating Features for ChatGPT, Gemini and BingAI. *European Journal of Education*, 60(1), 1–15. <https://doi.org/10.1111/ejed.70014>

Zhang, J., Song, L., Xu, L., Fan, Y., Wang, T., Tian, W., Ju, J., & Xu, H. (2021). Knowledge Domain and Emerging Trends in Ferroptosis Research: A Bibliometric and Knowledge-Map Analysis. *Frontiers in Oncology*, 11. <https://doi.org/10.3389/fonc.2021.686726>