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Exploring the Global Development of Artificial Intelligence in Educational Practices

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ABSTRACT

The rapid integration of Artificial Intelligence (AI) into global education systems has transformed learning processes, yet the existing literature remains fragmented, lacking a comprehensive understanding of its global research dynamics . This study aims to determine the mapping of the development and direction of education and technology research in publications indexed by Scopus. This research uses bibliometric analysis techniques to explore all publications indexed in the Scopus database on education and technology from 2014 to 2024. Data analyzed using Excel and R/R-Studio. VOSviewer is used to perform visual analysis of the simultaneous occurrence of keywords and document quotes. The author found 381 publications that matched the function, subject and criteria specified. The results of this research show an annual growth rate of 6.25% with the most publications about technology in 2013. Taiwan is the country that contributes the most publications with affiliation from education technology University Taiwan. Hwang G.J is the most productive writer on the theme of education relevant to technology. The bibliometric analysis carried out was limited to Scopus data. Other national and international databases were not taken into account in this study. This research presents a brief overview of the literature accessible to researchers working in the fields of Education and technology that provides recommendations for future research.

ARTICLE HISTORY

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KEYWORDS

Education; Technology; E-learning; Generative AI; Bibliometrics.

INTRODUCTION

In recent years, the adoption of artificial intelligence (AI) technologies in global education has experienced rapid and significant growth. This trend is driven by the growing need for more adaptive learning systems, personalized education, and more efficient management of educational institutions. Since 2020, there has been a remarkable surge in scientific publications related to AI in education, especially following the COVID-19 pandemic, which accelerated global digital transformation [1], [2], [3], [4].

Quantitatively, a recent bibliometric analysis recorded over 23,000 relevant publications in this field, with an annual growth rate exceeding 8% since 2017. Countries such as China, the United States, and the United Kingdom have emerged as major contributors in AI research and publications in education. These facts highlight the urgent need to understand the development landscape, thematic trends, and patterns of scientific collaboration in the application of AI in global education systems [5], [6], [7], [8].

Several bibliometric studies have been conducted to map the evolution of AI implementation in education, including in higher education, competency-based learning, and mathematics education. However, most of these studies focus only on specific subdomains and do not provide a holistic overview of global collaboration, thematic evolution, or the latest technological trends—such as generative AI or ChatGPT in education. Furthermore, there remains a gap in mapping institutional contributions and collaborations among developing countries, particularly within the Global South [9], [10], [11], [12], [13]. Therefore, there is a need for a comprehensive and up-to-date bibliometric study that not only captures publication trends but also analyzes author networks, institutional collaborations, and thematic directions to address these research gaps.

The main issue in current literature is the lack of comprehensive mapping of the global dynamics of AI adoption in education, particularly in terms of cross-country collaboration, thematic focus, and the geographical distribution of research. This study aims to conduct a bibliometric analysis of global scientific publications on AI in education, in order to identify publication trends, author and institutional collaborations, and emerging thematic directions [14], [15], [16], [17], [18], [19].

The main contributions of this study are: (1) to provide a visual and analytical mapping of the global evolution of AI research in education; (2) to identify underexplored regions and research topics; and (3) to offer evidence-based insights for policymakers, educators, and researchers to develop more inclusive and effective AI implementation strategies in the global education context.

METHODOLOGY

All Bibliometric analysis methods were used in this research. Data was obtained using a Boolean search engine to comb the Scopus database between 2013 and 2024. The search was carried out on December 11 2023 at 13.00 WIB. Researchers used R and Rstudio, VosViewer and Microsoft Excel tools to analyze citations, document content and networks. Researchers took three stages in processing the dataset. In the first stage, researchers will conduct a literature review of related themes to ensure relevant research is carried out on bibliometric topics. Apart from that, a literature review is useful for determining appropriate keywords that are deemed to represent the scope of the research [20], [21], [22].

At this stage, the researcher employed Boolean operators in the Scopus database using the query TITLE-ABS-KEY (“educational” AND “technology”), which initially yielded 105,651 documents. To refine the results, a series of filters were applied using the Boolean expression TITLE-ABS-KEY (“educational” AND “technology”) AND PUBYEAR > 2011 AND PUBYEAR < 2024 AND (LIMIT-TO (SUBJAREA, “SOCI”)) AND (LIMIT-TO (DOCTYPE, “ar”)) AND (LIMIT-TO (EXACTSRCTITLE, “Educational Technology and Society”)) AND (LIMIT-TO (LANGUAGE, “English”)). This filtration process restricted the search to journal articles published between 2012 and 2023 in the subject area of Sociology, appearing specifically in the journal *Educational Technology and Society*, and written in English. After applying these parameters, a total of 381 documents were obtained for further analysis.

The third stage, analysis was carried out on the final search documents using Scopus analyzer and R and Rstudio to determine the number of documents per year, documents by journal, author, affiliation, country and subject/field. Next, analysis was carried out at the document network level with visualization via VOSviewer and Microsoft Excel data processing.

RESULTS AND DISCUSSION

Documents Analysis

Table 1 provides an overview of the 381 documents collected over 51 years. Includes 1313 authors, 49 single authors, 19.95% international authorship collaboration, 19981 references with an average citation per document of 12.97 citations.

Table 1. Main Information About Data

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2012:2023
Sources (Journals, Books, etc)	1
Documents	381
Annual Growth Rate %	-23.17

Document Average Age	9.04
Average citations per doc	33.79
References	14335
DOCUMENT CONTENTS	
Keywords Plus (ID)	0
Author's Keywords (DE)	1313
AUTHORS	
Authors	961
Authors of single-authored docs	49
AUTHORS COLLABORATION	
Single-authored docs	49
Co-Authors per Doc	3.14
International co-authorships %	19.95
DOCUMENT TYPES	
Article	381

Bibliometric data indicate that between 2012 and 2023, there were 381 related documents, all of which were articles, involving a total of 961 authors and an average of 3.14 collaborators per document. Despite a decline in the number of publications with a negative annual growth rate of -23.17% citation levels remain high, averaging 33.79 citations per document. This suggests that existing publications continue to have significant impact and relevance.

International collaboration stands at 19.95%, indicating a moderate level of global involvement in this research area. The average document age is 9.04 years, implying that much of the literature is relatively dated and in need of updating. No automated keywords (Keywords Plus) were identified, yet there were 1,313 author keywords, reflecting a wide range of focuses and topics explored. With a total of 14,335 references cited, this highlights the field's foundation in extensive and complex literature [23], [24], [25], [26].

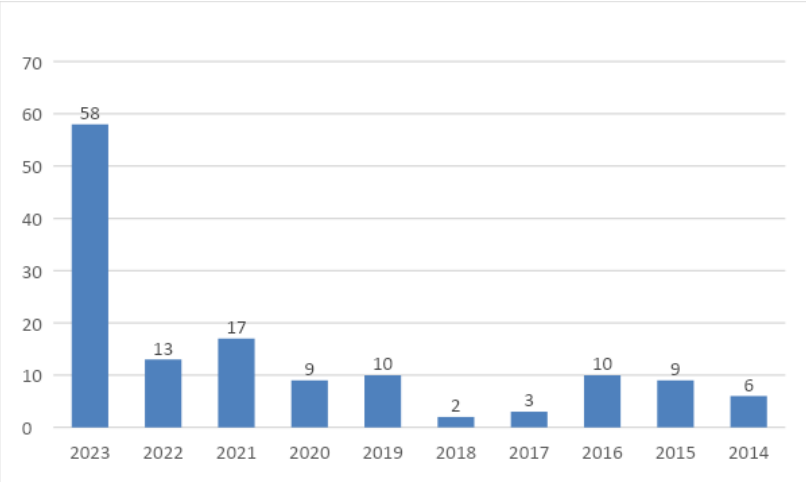

Figure 1. Document by years

The chart illustrates the annual distribution of publications from 2014 to 2023. A sharp increase is observed in 2023, with 58 publications, significantly higher than in previous years. Prior to this, the number of publications remained relatively low and stable, ranging from 2 to 17 documents per year. This notable surge indicates a growing interest and attention toward the topic most likely related to the implementation of AI technologies in education potentially driven by the emergence of new technologies such as generative AI (e.g., ChatGPT) and the impact of post-pandemic educational transformation [27], [28], [29], [30]. The sharp rise in 2023 also contrasts with the overall negative annual growth rate (-23.17%), suggesting that in earlier years, the number of publications was very limited, and only recently has the topic begun to attract broader academic attention.

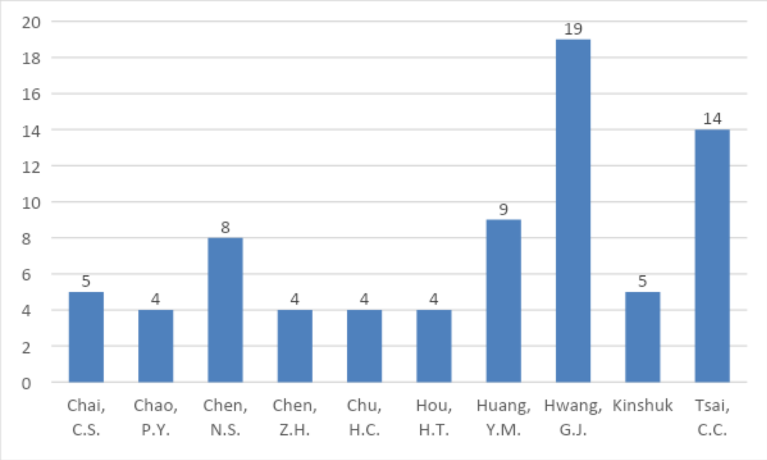

Figure 2. Document based on authors

This bar chart displays the most prolific authors in the field likely related to the implementation of AI in education. Hwang, G.J. stands out as the most productive author with 19 publications, followed by Tsai, C.C. with 14, and Huang, Y.M. with 9. Other notable contributors include Chen, N.S. with 8 publications, and both Chai, C.S. and Kinshuk with 5 each. Several other authors, such as Chao, P.Y., Chen, Z.H., Chu, H.C., and Hou, H.T., each have 4 publications. The data suggests that research in this domain is being led by a few key scholars, many of whom appear to be based in East Asia, indicating the region's strong presence and leadership in AI-focused educational research [31].

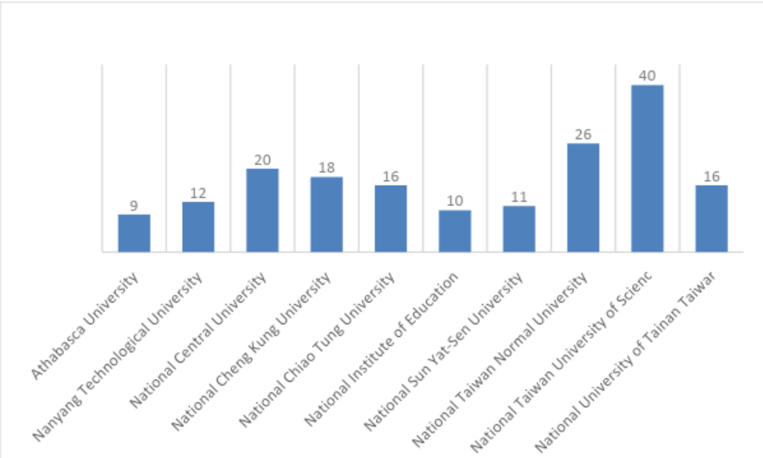

Figure 3. Document based on affiliation

This bar chart illustrates the most productive institutions in publishing research likely within the domain of AI in education. National Taiwan University of Science and Technology leads significantly with 40 publications, followed by National Taiwan Normal University with 26, and National Cheng Kung University with 20. Other key contributors include National Chiao Tung University (18), National University of Tainan (16), and National Institute of Education (16). Institutions such as Nanyang Technological University (12), Athabasca University (9), and National Sun Yat-Sen University (10) also show notable involvement. The data highlights that Taiwanese universities dominate research output in this field, indicating Taiwan's strong academic leadership and investment in the advancement of AI in education [32], [33], [34], [35], [36].

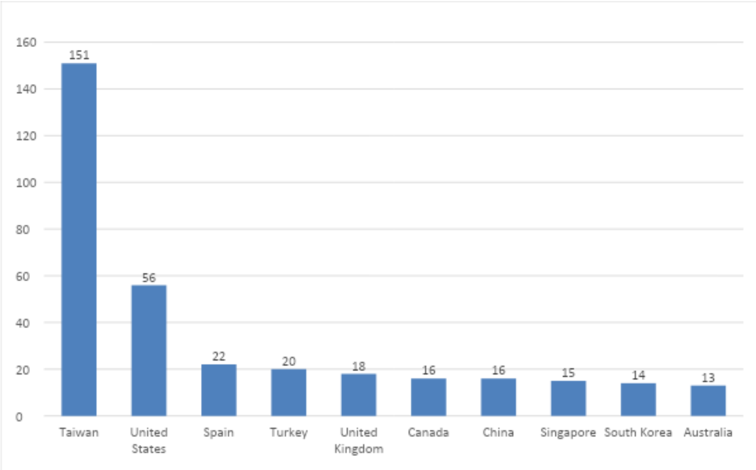

Figure 4. Document by country

This bar chart presents the distribution of research publications by country, likely related to AI implementation in education. Taiwan overwhelmingly leads the field with 151 publications, far surpassing the United States, which ranks second with 56. Other countries contribute considerably less, with Spain (22), Turkey (20), and the United Kingdom (18) following. Nations like Canada and China (16 each), Singapore (15), South Korea (14), and Australia (13) also show modest contributions. This data clearly highlights Taiwan's dominant role in advancing AI-related educational research globally, underscoring the country's strong academic infrastructure and investment in educational innovation through technology [37], [38], [39].

Qualitative Insights and Contextual Reflections

The analysis of publication distribution reveals a dominance of developed countries and several East Asian nations, particularly Taiwan, China, and the United States. However, contributions from the Global South remain very limited. This indicates a regional gap in research on AI in education. In fact, the social, economic, and cultural contexts of developing countries strongly influence how AI technologies are applied and received in classrooms. The limited number of publications from regions such as Africa, Southeast Asia, and Latin America risks creating bias in the global literature, where local perspectives and needs are underrepresented. Such a gap may hinder the development of inclusive implementation strategies, even though in regions with constrained educational infrastructure, AI holds significant potential to improve both access and learning quality. Therefore, future research should promote broader international collaboration and ensure stronger representation from diverse regions of the world.

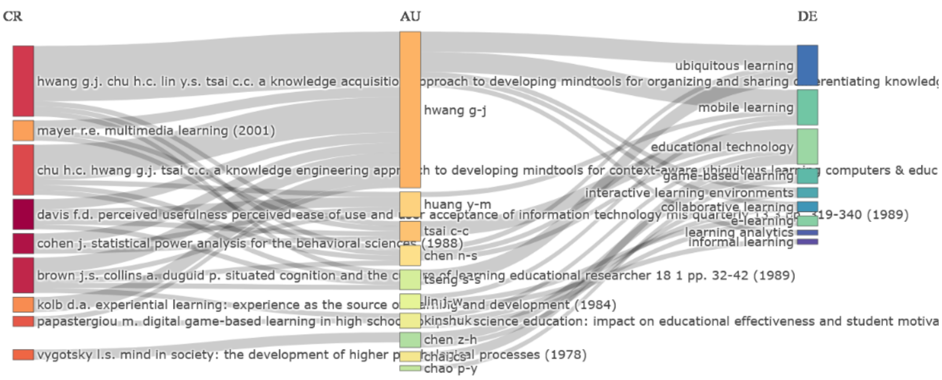

Figure 5. Plot three fields or reference, author, and keyword

This Sankey diagram visualizes the connections between Cited References (CR), Authors (AU), and Keywords/Descriptors (DE) in the field most likely focusing on AI in education.

1. On the left (CR), we see foundational works frequently cited, including Hwang G.J., Chu H.C., Tsai C.C., and seminal theories like Vygotsky's "Mind in Society" and Mayer's Multimedia Learning (2001), indicating a blend of educational psychology and learning technology.

2. The middle column (AU) identifies key authors such as Hwang G.J., Tsai C.C., and Chen N.S. central figures in the research network, acting as bridges between theory and application.

3. On the right (DE), frequently studied concepts include ubiquitous learning, mobile learning, educational technology, collaborative learning, and learning analytics, highlighting major research themes and application areas.

Overall, the diagram illustrates how leading scholars ground their work in classic learning theories while advancing modern educational technologies like mobile and game-based learning. Taiwan-based authors dominate the network, reinforcing Taiwan's central role in shaping the global discourse on AI and educational technology [40], [41], [42], [43], [44].

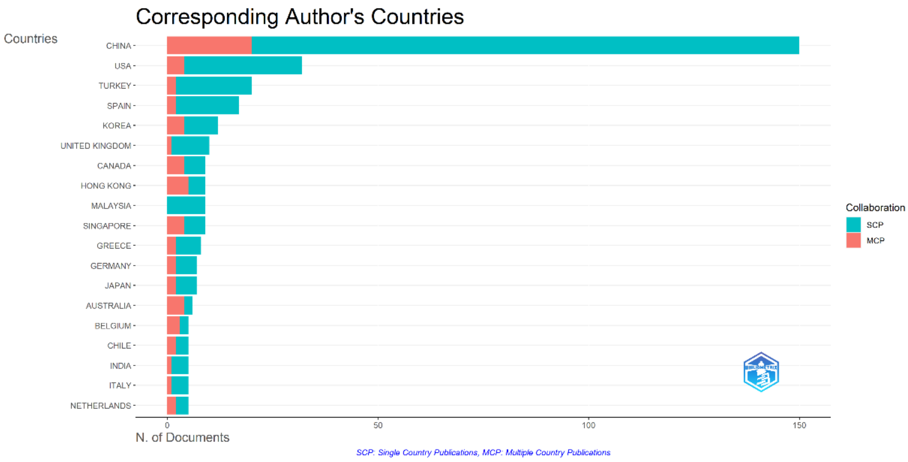

Figure 6. Document by corresponding author

This figure 6 displays the number of documents by the corresponding author's country, distinguishing between Single Country Publications (SCP) and Multiple Country Publications (MCP). China leads by a significant margin with over 150 publications, the majority being single-country collaborations (SCP), indicating a strong domestic research output. The USA follows with a smaller but notable volume, showing a more balanced mix between domestic and international collaboration. Countries like Turkey, Spain, and Korea also show active participation, though at a lower scale. The red portions (MCP) in countries such as the United Kingdom, Germany, and Canada suggest a greater emphasis on international collaboration. In contrast, China and Turkey rely more heavily on internal (national) collaboration. Overall, this chart reveals that while China dominates in total research volume, Western countries tend to be more engaged in international research networks, suggesting different strategic approaches to global academic collaboration in AI and education research [45].

Table 2. Most global cited document

Paper	Total Citations	TC per Year	Normalized TC
Greller W, 2012, Educational Technology And Society	556	46.33	11.78
Shum Sb, 2012, Educational Technology And Society	375	31.25	7.94

Chai Cs, 2013, Educational Technology And Society	301	27.36	9.47
Dyckhoff Al, 2012, Educational Technology And Society	241	20.08	5.11
Macfadyen Lp, 2012, Educational Technology And Society	221	18.42	4.68
Zhu C, 2012, Educational Technology And Society	221	18.42	4.68
Eseryel D, 2013, Educational Technology And Society	197	17.91	6.19
Chu H-C, 2013, Educational Technology And Society	179	16.27	5.63
Hung C-M, 2012, Educational Technology And Society	177	14.75	3.75
Yang T-C, 2013, Educational Technology And Society	147	13.36	4.62

This table 2 ranks the most influential papers—primarily from *Educational Technology and Society* based on citation metrics. The key takeaways are:

1. Greller & Drachsler (2012) leads significantly with 556 total citations, averaging 46.33 citations per year and a normalized citation score of 11.78, making it the most impactful work overall in terms of both volume and consistency.
2. Shum & Ferguson (2012) and Chai (2013) follow, with 375 and 301 total citations respectively, and strong normalized scores, indicating sustained influence over time.
3. Although some papers like Eseryel (2013) and Chu (2013) have lower total citations, their normalized scores (6.19 and 5.63) show solid annual performance relative to their publication year.
4. The normalized total citations (TC) metric helps identify impactful work independent of publication date. For instance, Chai (2013) ranks third in total citations but has the second-highest normalized TC (9.47), suggesting strong relevance over time.

Overall, this data highlights foundational contributions in educational technology, particularly in areas related to learning analytics, technology adoption, and pedagogical innovation [46], [47], [48],[49], [50], [51].

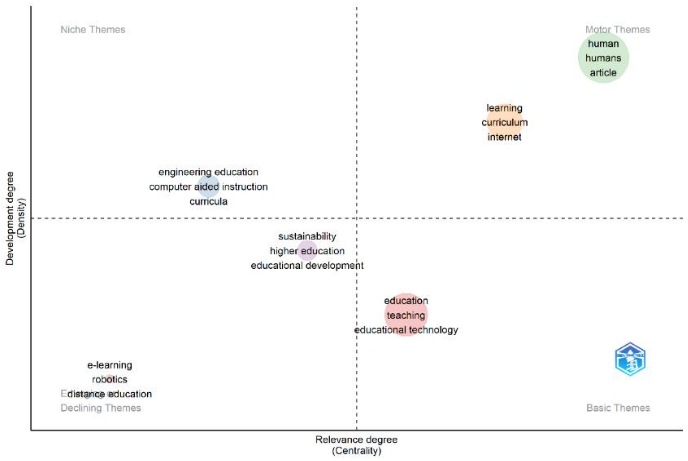

Figure 7. Thematic Maps

This strategic diagram illustrates the thematic mapping of research trends along two dimensions: centrality (relevance to the field) and density (development or maturity of the theme). The chart is divided into four main quadrants. Motor Themes with high centrality and high density are both well-developed and highly relevant; here, “Human,” “Humans,” and “Article” stand out, highlighting a strong human-centered focus in AI and education research. Basic Themes high centrality but low density represent important foundational topics still evolving in complexity, such as “Education,” “Teaching,” and “Educational Technology.” Niche Themes low centrality and high density are specialized and mature but with limited broader relevance, including “Engineering Education,” “Computer Aided Instruction,” and “Curricula.” Declining or Emerging Themes low centrality and low density are underdeveloped and may be losing momentum or just starting to gain attention; examples include “E-learning,” “Robotics,” and “Distance Education.” Between these categories lie Intermediate Themes such as “Learning,” “Curriculum,” and “Internet,” which are moving toward motor theme status, while “Sustainability,” “Higher Education,” and “Educational Development” show stable growth and consistent interest [18], [32], [52], [53].

Network Analysis

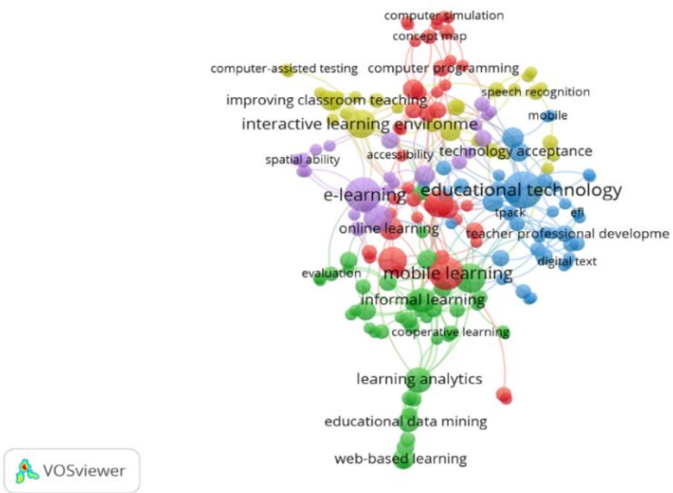

Figure 8. Event based keyword network distribution

This VOSviewer keyword co-occurrence network illustrates the most frequently used terms in research on AI and education, grouping them into color-coded clusters based on how often the terms appear together in the same documents. The Blue Cluster represents core concepts and educational practice, dominated by terms such as “educational technology,” “teacher professional development,” and “digital text,” reflecting the pedagogical integration of technology into formal education. The Red Cluster focuses on mobile and e-learning themes, including “mobile learning,” “e-learning,” “online learning,” and “interactive learning environments,” highlighting the rise of flexible, technology-driven formats especially significant in the post-COVID-19 context. The Green Cluster captures data and analytics themes, featuring “learning analytics,” “educational data mining,” and “web-based learning,” which point to the expanding use of AI-powered data tools for assessing and enhancing learning outcomes. The Yellow Cluster emphasizes technical integration, with keywords like “computer-assisted testing,” “computer programming,” and “speech recognition,” indicating the infrastructure and tools enabling AI in education. Finally, the Purple Cluster addresses usability and acceptance, including “technology acceptance,” “accessibility,” and “spatial ability,” signaling a focus on user experience, inclusivity, and the challenges of adoption [54], [55], [56].

Emerging AI Technologies in Education

Beyond earlier trends such as e-learning and mobile learning, recent years have seen the rise of more advanced and disruptive AI technologies. Generative AI, such as ChatGPT, has opened up new possibilities for conversational learning, automated content creation, and real-time personalized learning. Similarly, adaptive learning technologies allow systems to tailor content to students' abilities, interests, and learning pace. However, these developments also bring challenges. On the one hand, AI can enhance efficiency, student engagement, and the quality of feedback. On the other hand, concerns have emerged regarding plagiarism, algorithmic bias, and the potential decline of students' critical thinking skills due to overreliance on automated systems. Academic discussions therefore need to consider the balance between technological innovation and pedagogical integrity, ensuring that the use of AI truly strengthens learning processes rather than undermining them.

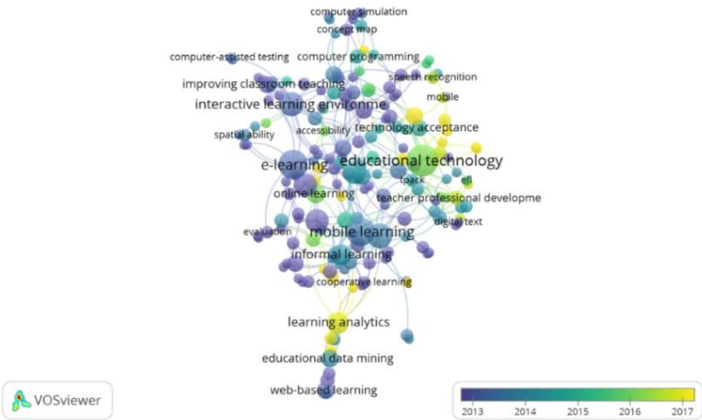

Figure 9. Keyword network distribution based on overly

This VOSviewer overlay visualization maps the temporal evolution of keywords in educational technology research between 2013 and 2017, using a color gradient to indicate their emergence over time. Older topics (2013–2014, blue purple) include "e-learning," "web-based learning," "informal learning," "online learning," and "educational data mining," reflecting the foundational areas that established the early base of technology-enhanced education research. Transitional topics (2015–2016, green) such as "mobile learning," "interactive learning environments," and "educational technology" mark a shift from passive content delivery toward more interactive, learner-centered, and mobile platforms. Emerging or future-oriented topics (2016–2017, yellow) like "learning analytics," "technology acceptance," and "speech recognition" highlight cutting-edge developments focused on data-driven insights, AI-enabled personalization, and intelligent feedback systems. Overall, the progression moves from basic e-learning frameworks to increasingly sophisticated, AI-enhanced educational technologies, signaling a growing emphasis on analytics, automation, and adaptive user interaction [57], [58], [59], [60].

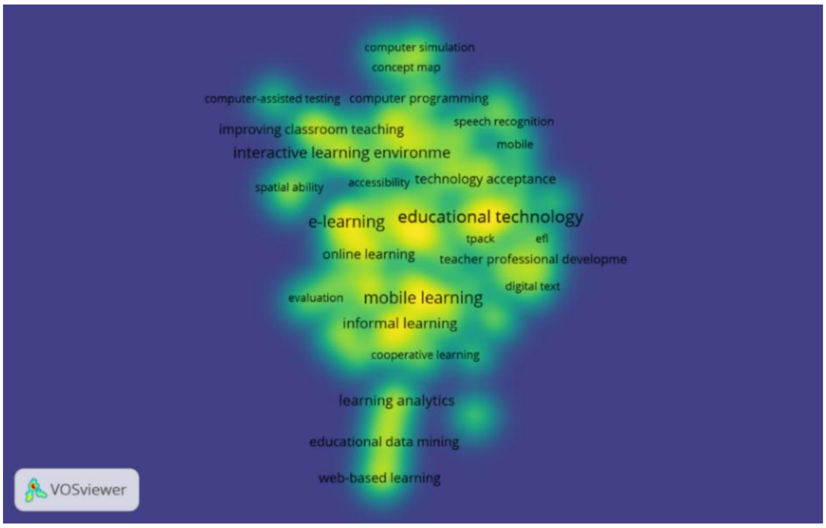

Figure 10. Keyword network distribution by density

This VOSviewer heatmap illustrates the intensity of keyword usage in educational technology research, particularly within AI-driven learning, using a color gradient to indicate frequency bright yellow for the highest occurrence (hotspots), green for moderate frequency, and blue for low occurrence. Hotspot keywords such as "educational technology," "e-learning," and "mobile learning" dominate the map, forming the backbone of AI-enhanced education and representing its primary areas of application and innovation. Moderate-intensity keywords like "interactive learning environments," "online learning," "informal learning," and "technology acceptance" indicate growing interest in learner engagement and the adoption of technology across diverse educational contexts. Peripheral or emerging topics, including "learning analytics," "educational data mining," and "web-based learning," occupy cooler zones, suggesting either niche specialization or underrepresented but promising directions. Overall, the heatmap reflects a shift from content delivery toward evidence-based, data-driven, and AI-supported educational decision-making [50], [61], [62], [63].

Conceptual Framework

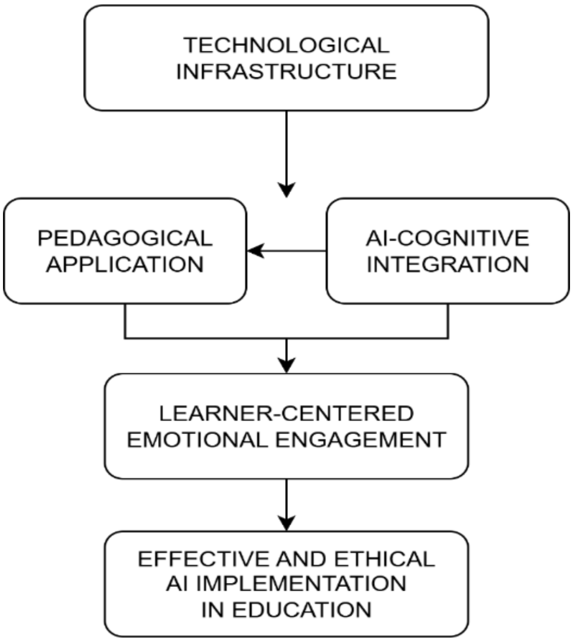

Figure 11. Conceptual Framework

The figure 11 illustrates a holistic model for the effective and ethical implementation of Artificial Intelligence (AI) in education, emphasizing the interconnected roles of technology, pedagogy, cognition, and emotion. At the top of the framework is Technological Infrastructure, which serves as the foundational layer enabling AI-driven educational tools and systems. This infrastructure supports two critical, interrelated components: Pedagogical Application and AI–Cognitive Integration. Pedagogical application focuses on integrating AI into teaching strategies and classroom practices, while cognitive integration ensures that AI systems align with learning theories and support deeper cognitive engagement. Both components feed into Learner-Centered Emotional Engagement, acknowledging the importance of students' affective experiences in AI-enhanced environments. This emotional dimension includes motivation, satisfaction, and personalized learning experiences, which are essential for successful adoption Ultimately, the interaction among all these elements leads to the desired outcome: Effective and Ethical AI Implementation in Education a system that not only leverages technological power but also respects pedagogical principles, cognitive development, and learner well-being [67], [68], [69], [70].

Multi Dimensional Approach to AI in Education

A comprehensive understanding of AI adoption in education requires a multi-dimensional perspective. The technological dimension encompasses digital infrastructure, AI algorithms, and learning platforms that underpin integration. The pedagogical dimension highlights the ways in which AI can support teaching strategies, the evolving role of teachers, and curriculum design. The socio-cultural dimension draws attention to issues of access, the digital divide, and societal perceptions of emerging technologies. The ethical and regulatory dimension, meanwhile, addresses concerns related to data protection, algorithmic fairness, and governance in educational contexts. Taken together, this multi-dimensional framework ensures that discussions on AI in education extend beyond technical considerations to include broader social, cultural, and ethical implications. Such an approach is essential to guide AI integration toward fostering inclusive, equitable, and sustainable education [71].

CONCLUSION

This research aims to determine the mapping of adult learning and self-development in publications indexed by Scopus. This research uses bibliometric analysis techniques to explore all publications indexed in the Scopus database on adult value reflection from 2014 to 2024. Data analyzed using Excel and R/R-Studio. VOSviewer is used to perform visual analysis of the simultaneous occurrence of keywords and document quotes. The author found 381 publications that matched the function, subject and criteria specified. The results of this research show an annual growth rate of 6.25%, with the most publications about education and technology in 2014. The countries with the largest SCP are China, USA and Turkey, while the countries with the largest MCP are China with 130 documents, USA with 30 documents and Turkey with 18 documents. Documents are dominated by the Asian continent. The minimum cluster size is 1, with the clusters formed being 5 clusters, cluster 1 with 46 items, cluster 2 with 45 items, cluster 3 with 41 items, cluster 4 with 30 items and cluster 5 with 23 items. With "Education Technology" being the dominant keyword with a total link strength of 28. keyword network analysis based on overlay. It can be seen that the keyword Education Technology is a keyword that has been used in the most recent year. Meanwhile, the keywords E-Learning, Collaborative learning are keywords that have been used for a relatively long time since 2013. Network analysis with keywords based on density. It can be seen that the keywords "mobile learning and educational learning are keywords with high density and the keywords "inquiry based learning, cooperative learning and elementary school" are keywords that are rarely researched.

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Author Contribution

All authors contributed substantially to the conception, design, data analysis, and preparation of this manuscript. Miranti Merliana developed the conceptual framework, conducted the bibliometric data collection, and performed visualization using RStudio and VOSviewer. Muhammad Tanzil contributed to data interpretation, literature synthesis, and refinement of the methodological structure. Nadzir Qaylan provided theoretical insights, critical review, and ensured alignment with international academic standards. All authors collaborated in discussing the findings, revising the manuscript for intellectual content, and approving the final version for publication.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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