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BIBLIOMETRIC ANALYSIS OF ARTIFICIAL INTELLIGENCE IN EDUCATION: STUDY FROM SCIENCEDIRECT DATABASE

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ABSTRACT

Phenomenon/Issue: *The rapid development of technology, particularly artificial intelligence (AI), has transformed various sectors, including education. The increasing interest in AI in education has prompted further research to understand its impact and applications.*
Purpose: *This study aims to analyze the publication landscape of AI in education using bibliometric analysis, identifying key trends, influential authors, and frequently used keywords in the field.*
Novelty: *The study offers a comprehensive bibliometric analysis of publications on AI in education, providing a detailed mapping of authorship networks and keyword usage patterns from 2020 to 2024, a period marked by significant AI advancements.*
Research Methods: *The study employs bibliometric analysis using VOSviewer 1.6.20 software. Data were sourced from 50 publications on ScienceDirect, focusing on co-authorship and co-occurrence techniques. The analysis generated network, overlay, and density visualizations to illustrate key findings.*
Results: *The analysis reveals interconnected authors and identifies Hwan and Gwo Jen as the most cited contributors. The co-occurrence analysis highlights "artificial intelligence" as the most frequently used keyword, underscoring its centrality in discussions about AI in education.*
***Research Contributions**: This study contributes to understanding the publication trends and scholarly networks in AI in education, offering valuable insights for researchers and educators. The bibliometric mapping serves as a resource for identifying influential works and emerging themes, guiding future research and development in the field.*

INTRODUCTION

The digital era has seen technology develop rapidly and diversely, influencing various sectors, including artificial intelligence (AI). AI simulates human intelligence through machine learning algorithms, neural networks, and natural language processing (Chiu et al., 2023). Artificial intelligence technology has integrated into various sectors, including healthcare, business, and manufacturing, with numerous studies focusing on AI in business, economics, and education (Igbokwe, 2023). Talan (2021) stated in his bibliometric research from 2001 to 2021 that publications related to AI in education have fluctuated, with a significant increase after 2015, about 60% of the total publications, with most research conducted in the United States.

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Artificial intelligence (AI) uses in education include virtual mentors, presentation translators, and automated assessments. AI in education can improve teaching, learning, and assessment. In addition, research by Jafari and Keykha (2023) discusses the opportunities of artificial intelligence technology in higher education, stating that AI can provide personalized examination, reduce workload, and automate specific tasks. Pedró (2019) mentioned that AI use by faculty in higher education can improve the development of educational objectives, the design and implementation of educational programs, and curriculum processes.

Research on AI in education is a global endeavor, as demonstrated by the work of Zhang & Aslan (2021) who used bibliometric analysis to map AI in education research publications from 1993 to 2020, using the Web of Science database. Their study showed the integration of AI in education research conducted in many countries, identifying 40 articles related to AI in education across 16 countries. Similarly, Moreno-Guerrero et al. (2020) used bibliometric analysis on AI in education using the Web of Science database and the Science Mapping Analysis Tool. They recommended expanding bibliometric analysis to other databases (such as Scopus and Google Scholar) and applications (such as VOSviewer and HistCite) to get a broader understanding of the topic, highlighting the collaborative nature of AI research and the global community of scholars and practitioners working in this field.

Therefore, this study, which focuses on AI in education using bibliometric analysis with the ScienceDirect database for the 2020-2024 publication period, is of significant importance. It aims to map publications based on co-authorship and co-occurrence, providing a comprehensive analysis of document types, sources, keywords, language, titles, and subject areas contributing to AI in education research. Moreover, this research will identify visualization trends, provide an overview of studies related to AI in education, and uncover patterns, research trends, novelties, and recommendations in the field, thereby enlightening the reader on the current state of AI in education research.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Artificial Intelligence

Artificial Intelligence (AI) is a technology that simulates human intelligence using machines like computer systems, allowing computers to perform tasks typically done by humans (Dinesh et al., 2023). AI systems can operate activities usually requiring human labor and intelligence (Kirana et al., 2023). Thus, AI is modern technology that mimics human thinking and behavior.

Cholissodin et al. (2021) have categorized artificial intelligence systems as follows: 1) Thinking humanly. 2) Acting humanly. 3) Reasoning. 4) Acting rationally. Meanwhile, Thayyib et al. (2023) mentioned that the branches of AI are as follows: 1) Machine Learning. 2) Deep Learning. 3) Natural Language Processing. 4) Robotics. 5) Fuzzy Logic. 6. Expert System.

Artificial Intelligence In Education

Artificial Intelligence in Education, commonly called AIEd, holds significant opportunities and potential in educational practice. Applications in this field include intelligent tutoring systems, teaching robots, learning analysis dashboards, adaptive learning systems, and human-computer interaction (Chen et al., 2020; Ouyang & Jiao, 2021). AIEd can support the integration of knowledge from various scientific disciplines with technology, creating significant opportunities to enrich children's learning and inspire hope for the future of education.

The roles of artificial intelligence in education are tutors, intelligent learning tools/partners, and policy-making advisors (Dakakni & Safa, 2023; Hwang et al., 2020). AI-based solutions in education cover various applications and technologies, including intelligent tutoring systems, adaptive learning platforms, virtual and augmented reality, learning analytics, automated grading and feedback, and speech recognition (Sharma & Sharma, 2023).

METHOD

Bibliometric analysis determined developing patterns in specific sectors (Alhashmi et al., 2024). This study used bibliometric methods to provide an overview of studies related to artificial intelligence (AI)

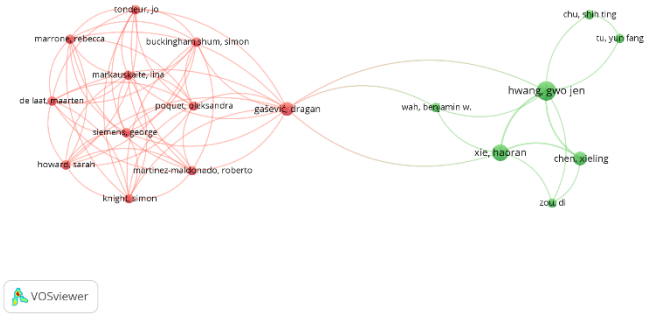
in education, identifying patterns, research trends, novelties, and recommendations in the field. The data were analyzed using co-authorship and co-occurrence, using VOSviewer software version 1.6.20, developed by the Center for Science and Technology Studies at Leiden University in the Netherlands (Xiao et al., 2024).

The inclusion criteria in this research include determining the database, keywords, and year range. Literature was obtained through the ScienceDirect database using the keywords "artificial intelligence," "education," or "artificial intelligence in education" and filtered based on topic relevance and publication dates from 2020 to 2024. The 50 selected articles were added to Mendeley software and downloaded in RIS (Research et al.) format. The search results in RIS format were uploaded to VOSviewer software for bibliometric analysis and presented as network visualization, overlay visualization, and density visualization.

RESULTS AND DISCUSSIONS

Bibliometric Analysis Based Co-Authorship

Bibliometric analysis based on co-authorship is used to analyze the author network and collaboration using 50 literature search results with predetermined keywords. The results of the co-authorship bibliometric analysis are presented as follows:



Source: VOSViewer (2024)

Figure 2. Connected Co-Authorship Network Visualization

Based on the connected co-authorship network visualization, a network of authors on artificial intelligence in education shows that some researchers are interconnected. These relationships are characterized by lines and circular symbols, illustrating the interconnected network of researchers. Among the 165 authors involved in the bibliometric analysis, only 18 were found to have networks and relationships in the co-authorship visualization. In addition, the bibliometric mapping identified two clusters, marked with different colors, red and green, on the lines and circular symbols.

2 clusters of bibliometric analysis-based connected co-authorship network visualization are as follows:

1. Buckingham shum, simon; de laat, marten; gasevic, dragan; howard,sarah; knight, simon; markauskaite, lina; marrone, rebecca; martinez-maldonado, roberto; poquet, oleksandra; siemens, george; tondeour,jo.
2. Chen, xieling; chu, shih ting; hwang, gwo jen; tu, yun fang; wah, benjamin w; xie, haoran; zou,di.

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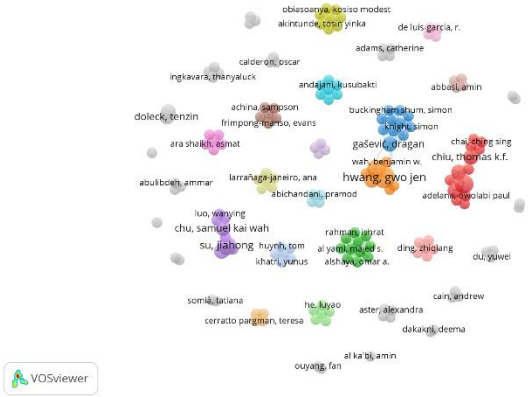
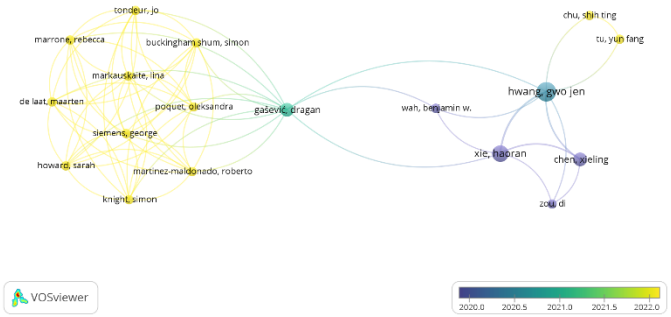


Source: VOSviewer (2024)
Figure *3.* Unconnected Co-authorship Network Visualization

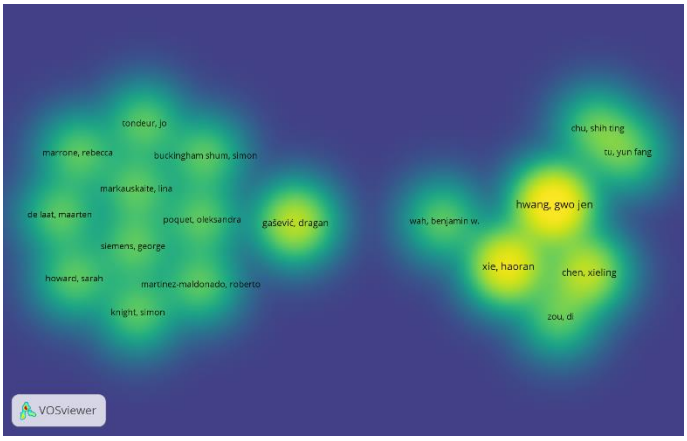
The unconnected co-authorship network visualization shows a network of authors who, despite choosing the same topic, do not have connections with each other. Based on a selection of at least one author for each document, 165 authors are involved. These authors are divided into 36 clusters, each represented by different colors in the unconnected co-authorship network visualization.



Source: VOSviewer (2024)
Figure 4. Co-authorship Overlay Visualization

The co-authorship overlay visualization shows the periods in which researchers conducted their studies, indicated by different colors. A light color (yellow) signifies more recent research, while a darker color (purple) represents older research. For example, the lightest color (yellow) indicates research conducted in 2022, and the darkest color (purple) indicates research from 2020. Analysis based on the co-authorship overlay visualization can be summarized as follows:

1. The darker color of Chen et al. (2020) visualization indicates research conducted by Chen et al. (2020), which is cited by Hwang et al. (2020).
2. Research conducted by Hwang et al. (2020) is cited by Markauskaite et al. (2022), which is indicated by the darker color of Hwang et al. 's (2020) visualization.
3. Research conducted by Hwang et al. (2020) is cited by Chu et al. (2022), which is indicated by the darker color of Hwang et al. 's (2020) visualization.

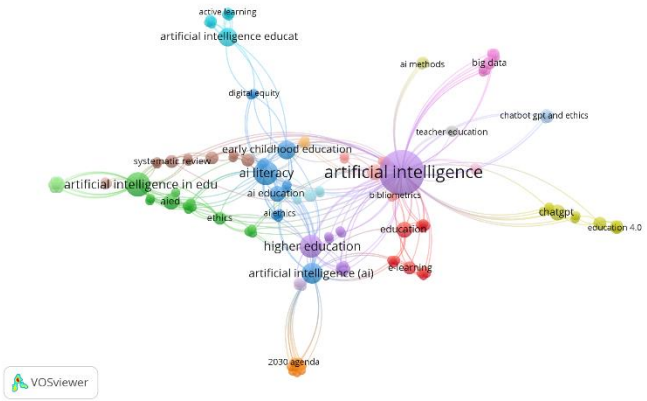


Source: VOSviewer (2024)
Figure 5. Density Visualization

In the co-authorship density visualization, there is a density in the round symbol showing collaboration between authors who research artificial intelligence in education (Zakiyyah et al., 2022). The largest font in the visualization shows the most robust network, referring to the author Hwang, Gwo Jen.

Bibliometric analysis-based Co-occurrence

Bibliometric analysis based on co-occurrence is used to determine the results of the analysis of literature that has been selected based on keywords. The results of the co-occurrence bibliometric analysis are presented as follows:



Source: VOSviewer (2024)
Figure 6. Connected Co-Occurrence Network Visualization

Figure 6 shows the connected co-occurrence network visualization, showing the relationships between each literature keyword. Interconnected lines and round symbols characterize these linkages. Based on the selection of at least one keyword per document, 155 keywords were identified, with 142 connected keywords divided into 19 clusters in the mapping.
19 clusters of bibliometric analysis based on connected co-occurrence network visualization are as follows:

1. Adaptive learning, COVID-19, e-learning, education, intelligent tutoring system, large language models, machine learning (ML), natural language processing, pandemic, personalization, pharmacy, research, tam.
2. Accountability; AI in k-12 education; AI, artificial intelligence in education; children's rights; digital leadership; education; settings; ethics; fairness; pedagogical appropriateness; teacher well-being; teachers' barriers to change; transparency.

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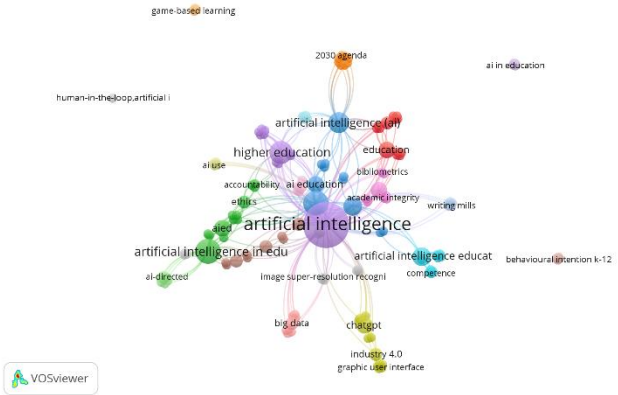
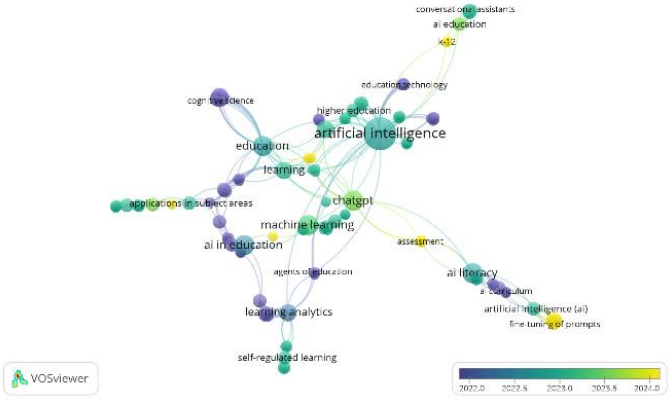
3. AI curriculum, AI education, AI ethics, AI literacy, artificial intelligence (AI), challenges and opportunities, digital equity, digital story writing, early childhood education, inquiry-based learning, kindergarten, learning and teaching, and pedagogical consideration.
4. Ai-chatbot; Bloom taxonomy; ChatGPT; education 4.0; nursing education; self-regulated learning; sustainable higher education.
5. Academic essay; artificial intelligence; employability skills; equity; experimental philosophy; higher education; pls-sem; postgraduate students; socio-technical; system theory; writing.
6. Active learning; artificial intelligence education; competence; computer vision; computer vision education; k-12; collaboration; drones in education; Nigeria; teamwork
7. 2030 agenda; community outreach actions; federal university of Uberlandia; higher education institutions; natural language processing (nlp); sdgs; sustainable development goals (sdgs); topic modeling; universities.
8. Ai; application gap; assessment; learning; medical education; medical students; systematic review; teaching; theory gap.
9. Big data, China, India, neural network, pre-teaching effect evaluation, personalized education, random forest model, USA.
10. Academic integrity, audio feedback, bibliometrics, computer science, learning, management systems, machine learning, pedagogy, teaching and learning.
11. Ai-directed; ai-empowered; ai-supported; learner-as-collaborator; learner-as-leader; learner-as-recipient; paradigms.
12. Chatbot GPT and ethics; digital technology; writing skills; ethical uses of AI.
13. AI methods; AI technology application; AI use; k-12 education.
14. Attention process; communication system; deep learning; neural network.
15. Educational robots; literature review; research trends; teaching ai.
16. Conceptions; primary education; students.
17. Funding trends, major research issues, multiple perspectives.
18. Image super-resolution, problem-fixing, psychological education.
19. Teacher education; technology integration; tpack.



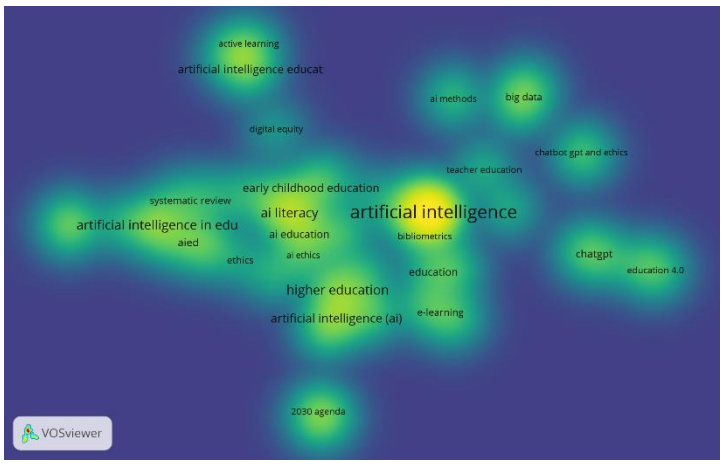
Source: VOSviewer (2024)
Figure 7. Unconnected Co-Occurrence Network Visualization

Figure 7 shows the unconnected network visualization, displaying the unconnected keywords in some literature. Based on the figure, there are 23 clusters, and it is known that the most prominent keyword is artificial intelligence, which is characterized by the writing and the size of the most significant round symbol.



Source: VOSviewer (2024)
Figure 8. Co-occurrence Overlay Visualization

The co-occurrence overlay visualization shows the keyword usage period in the literature, which is from 2022 to 2024. Recent keywords are shown in bright yellow (year 2024), and past keywords are shown in purple (year 2022).



Source: VOSviewer (2024)
Picture 9. Co-Occurrence Density Visualization

Based on the co-occurrence density visualization, the keyword “artificial intelligence” is the largest and most prominent, indicating it is the most frequently used keyword. Furthermore, other significant keywords include “AI literacy,” “artificial intelligence in education,” “artificial intelligence (AI),” “higher education,” and “early childhood education.”

CONCLUSION

This study on artificial intelligence in education has examined 155 authors and 165 keywords from the ScienceDirect database through bibliometric analysis using VOSviewer software version 1.6.20. The result of bibliometric analysis shows two research network clusters (co-authorship), which identify groups of authors or publications that are interconnected and frequently cited as references in artificial intelligence technology in education research. The clusters help understand collaboration networks and relationships between researchers in that field. Furthermore, there are 19 keyword clusters (co-occurrence), showing keywords that appear simultaneously in the articles. These clusters can be developed to fill research gaps and create novelties.

Based on the co-authorship that the authors network in conducting research, the author with the most robust network is Hwang, Gwo Jen, who has the most robust network and has high productivity in publications, citations, and collaborations with other researchers. The co-occurrence analysis shows that

"artificial intelligence" is currently the most popular keyword. This bibliometric analysis provides an overview of research development trends in AI in education, potentially improving research quality, resource access, and knowledge exchange among collaborating researchers. Future research should explore rarely used keywords, such as "accountability“ and “competence,“ as these are important for ensuring ethical and effective implementation in education.

According to the reviewed research, this study on artificial intelligence in education has primarily relied on the ScienceDirect database and bibliometric methods. Future research should consider utilizing a broader range of databases and research methodologies, as this topic holds significant potential for further exploration. This study is limited to the short period of 2020-2024. Future research should consider a longer timeframe, such as 10 years, for a more comprehensive analysis. Moreover, this study only focuses on mapping publications related to AI in education, and the trend of artificial intelligence publications in education needs to be profoundly examined.

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