A BIBLIOMETRIC ANALYSIS OF THE ROLE OF ARTIFICIAL INTELLIGENCE IN MODERN EDUCATION: TRENDS AND OPPORTUNITIES

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Abstract

This research analyses the role of artificial intelligence (AI) in modern education through a bibliometric approach. The study aims to analyze the most common keywords and extract relevant terms that reveal trending topics. Bibliometric analysis offers a quantitative approach to uncover trends in sustainability research. The present study provides a comprehensive bibliometric analysis of AI in modern education, tracking research growth, countries contributing, prominent authors, institutions, subject area and identifying research clusters. Data from the Scopus database covering 2020-2024 were analyzed using bibliometric tools and VOSViewer. A search statement was developed to collect relevant articles, resulting in 1040 publications. The analysis found that there has been a significant increase in the number of publications on AI in education, especially after the COVID-19 pandemic, which boosted the adoption of technology in the learning process. Most of the research in this field comes from countries such as China, the United States, and India. The research also found that Computer Science, Social Science, and Engineering are the fields most involved in the application of AI in education. Institutions such as Carnegie Mellon University and the Indian Institute of Technology Kharagpur are significant contributors in this field, demonstrating the importance of international academic collaboration. The keywords frequently used in this research are AI, educational technology, and ChatGPT, reflecting the primary focus on personalizing learning and integrating AI into educational curricula. While AI offers great potential to transform education, it is crucial to address challenges related to ethical use and infrastructure readiness.

Keywords: Artificial Intelligence, Modern Education, Educational Technology, Bibliometric Analysis

1 INTRODUCTION

In recent years, Artificial Intelligence (AI) has emerged as a transformative digital technology with the potential to revolutionize various sectors, including education (Thuan et al., 2022). AI has prompted a paradigm shift in how educational content is delivered, personalized, and assessed, leading to more adaptive and efficient learning environments (Kondratev & Krokhin, 2024). AI technologies' rapid emergence and evolution have led to developing new systems and techniques for improving the teaching and learning experience. Its applications in various areas, such as machine learning, natural language processing, and data analytics, continue to advance

and are expected to help address the long-standing challenges in the field (Olivetti et al., 2020; Vinothkumar & Karunamurthy, 2023).

Besides technological advancements, integrating AI into education has significant implications for learning. For instance, there are changes in attitudes and behaviours toward using AI in the classroom (Wang, Y., Liu, C., & Tu, 2021). This type of innovation can be particularly beneficial for populations with varying learning needs as it complements conventional methods and data sources (Bircan & Salah, 2022).

Despite the promising benefits, integrating AI into education also raises several challenges. Ethical concerns, mainly about data privacy and the potential for bias in AI algorithms, due to AI's potential impact on the development of such technology have sparked discussions about its proper deployment and use (Vinothkumar & Karunamurthy, 2023). University teachers' ease of adopting AI technology also affects their attitude towards using AI to support teaching (Wang, Y., Liu, C., & Tu, 2021). There are various factors to consider when it comes to implementing AI. One of them is the best way to evaluate its effectiveness. Another is the technical issues that can arise when creating a productive AI system and improving performance efficiency (Chan & Zary, 2019; Chen et al., 2020).

According to research, the number of scientific articles on AI in education has increased significantly; this comprehensive analysis of academic literature can help one better understand the current state of AI in education (Chen et al., 2020; Nastasa, 2022; Thi Nguyen et al., 2024; Velastegui-Hernandez et al., 2023). The findings can inform the development of AI-based teaching methods and guide future research agendas.

Given the profound implications of AI for education, it is essential to conduct a comprehensive bibliometric analysis to better understand current trends and opportunities. This paper aims to fill that gap by providing a detailed bibliometric analysis of the literature on AI in education over the last five years. The analysis will explore key research areas, identify leading contributors, and highlight emerging trends likely to shape AI's future in education. By doing so, this study seeks to contribute to the ongoing discourse on the role of AI in modern education and provide a roadmap for future research and practice in this dynamic and rapidly evolving field.

2 METHODOLOGY

This study employs bibliometric methodology to analyze the role of artificial intelligence (AI) in modern education, focusing on current trends and opportunities. The method used in this research is bibliometric analysis. Researchers collect data using the Scopus database (Halepoto et al., 2022). According to (Moher et al., 2009), gathering information involves several steps. This includes identifying individuals, screening them, and ensuring they are eligible for inclusion.

The data collection and filtering process was conducted systematically to ensure the final dataset was reliable and ready for in-depth analysis. The initial step involved defining the specific topic and scope, which, in this case, was research on AI in modern education, available in the Scopus database. This database was chosen because it is the most extensive academic database globally, with citations that provide abstracts from various scientific and research literature that have been reviewed (Tupan et al., 2018). The selection of documents for this study followed a research protocol outlined in Figure 1, with data extracted from the Scopus database as of August 23, 2024. Keywords such as "artificial intelligence" and "education" were used to identify relevant publications.

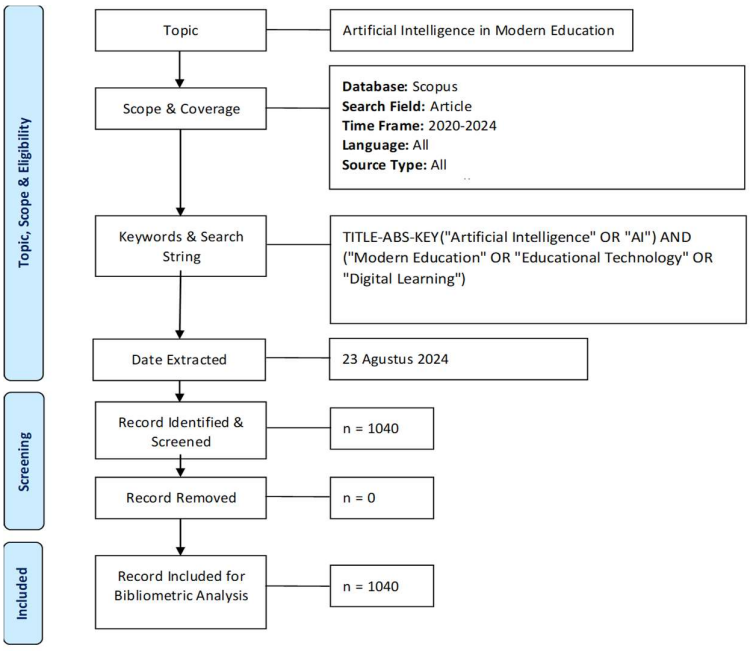

Figure 1. Data Collection Process

In Figure 1, the first step in the data collection process is identification. Focused only on documents with titles explicitly mentioning "artificial intelligence," "modern education", “educational technology”, or “digital technology”, which resulted in a total of 1040 documents. After thorough data cleaning, no duplicates were found; all documents were retained. The data obtained from Scopus were then exported into comma-separated values (.csv) and research information systems (.ris) formats for further analysis. This study adopted a bibliometric approach to assess research trends in AI in education, with the dataset providing publication details, including type, year, language, subject area, source title, keywords, abstract, country, affiliation, citations, and authorship. This article describes various outcome indicators for bibliometric analysis. Bibliometric analysis, or scientometric, is a field of research that aims to explore the latest literary developments that provide direction and motivation for further research. A complete record of the number of publications from the source. A complete citation of the number of citations obtained by this publication. Citation documents are used to evaluate the number of citations obtained divided by the number of publications. The bibliometric approach used in this study uses modern technology in information engineering, database management, and statistics. A bibliometric approach was used to empirically and visually analyze discovery learning research from 2020 to 2024, combined with the VOS viewer software.

3 FINDINGS AND DISCUSSION

This section shows bibliometric results for different performance indicators, including documents by year, country/territory, author, affiliation, subject area, Co-word analysis, and author collaboration analysis.

3.1 Research Growth and Geographical Distribution

Artificial intelligence in modern education was published in Scopus in 2020 with 96 documents, rising to 108 in 2021 and decreasing to 122 in 2022. In 2023, it will decrease to 288 documents. In 2024, the highest number of publications was 386 documents (see Figure 2). The metric results show that 95 countries have contributed to artificial intelligence research over the last five years. Figure 3 shows the top 10 countries contributing to artificial intelligence research. China leads the productivity with 189 articles, followed by the USA with 156 articles, India with 98 articles, etc. This is because the State Council of China published A next-generation artificial intelligence development plan with a clear plan that AI should be broadly applied at all education levels so that the generation in China has talent in the field of AI [40]. Another

factor that causes this difference is the difference in the databases used; they use the Web of Science database, while we use the Scopus database.

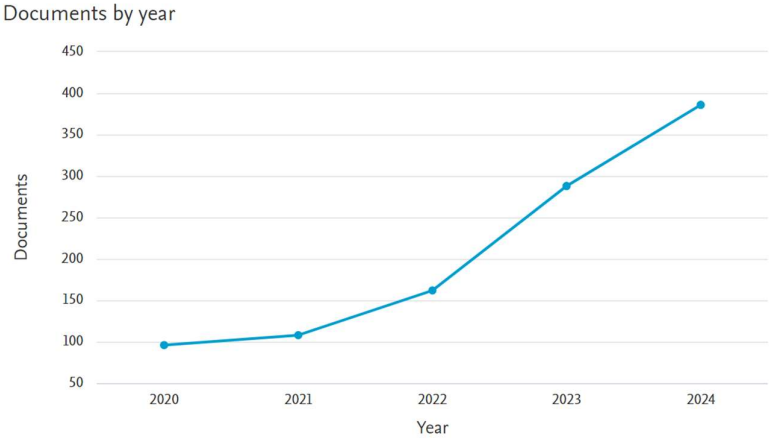

Figure 2. Research Growth, Sources: Scopus

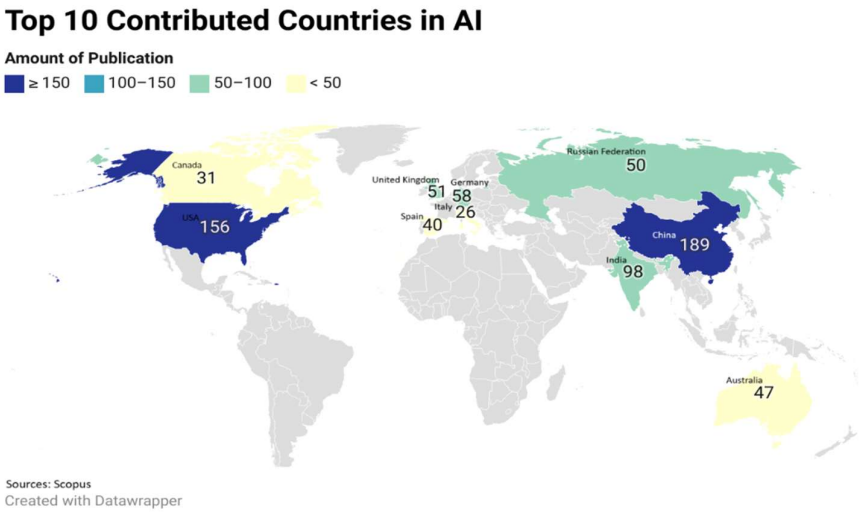

Figure 3. Geographical Distribution

3.1.1 Subject Area and Affiliation

This section is analyzed by classifying published documents by subject area, as shown in Figure 3. The delivery of discovery learning research mostly came from Computer Sciences (31,6%), Social Science (23,4%), Engineering (12,3%), Mathematics (7,5%), Decision Sciences (5,2%), Physics and Astronomy (2,6%), Arts and Humanities (2,5%), Medicine (2,5%), Psychology (2,1%), Business, Management and Accounting (1,9%), and Other (8,4%) can be seen in Figure 4.

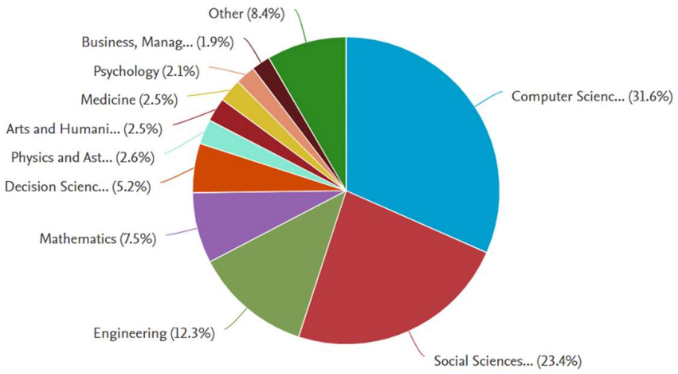

Figure 4. Distribution Document by Subject Area

We also evaluate documents based on the top 10 affiliates. Most of the artificial intelligence in modern education studies came from Carnegie Mellon University (14 documents), Indian Institute of Technology Kharagpur and The Education University of Hong Kong (13 documents), Monash University (12 documents), Chinese University of Hong Kong (10 documents), South China Normal University and University College London (8 documents), Arizona State University, Technische Universität München and National Taiwan Normal (7 documents). Clearly, documents by affiliation are shown in Figure 5.

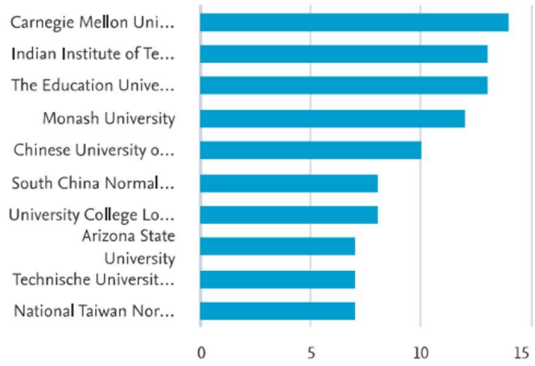

Figure 5. Distribution Document by Affiliation

3.1.2 Author of The Most Documents

Many discovery AI publications extracted and sorted the authors with the most documents from the Scopus database. Alam et al. has 11 documents; Bozkurt, A., and Cukurova, M. each have 6 documents; Alexandron, G., Bittencourt, I.I., Gašević, D., Istani, S., Mohanty, A., and Ogata, H., with 5 documents. Meanwhile, the other author, Buckingham Shum, S., has only 4

documents. This can be seen more clearly in Figure 5.

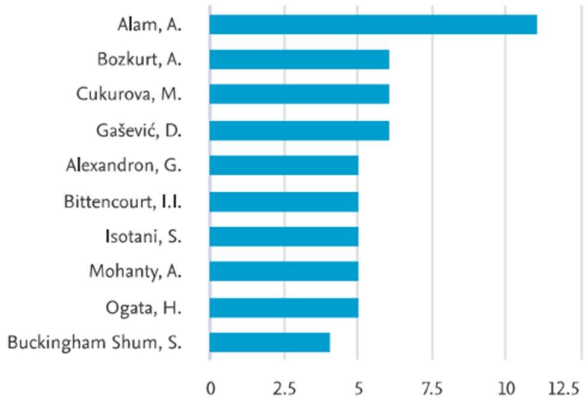

Figure 5. Distribution Documents by Author

3.1.3 Co-word analysis

The co-word analysis applies to the same database. Of the 2,647 keywords, 62 met the minimum of 7 occurrences, resulting in four clusters. The highest co-occurrence keywords are big data (313), educational technology (245), ChatGPT (86), and others. Table 1 summarizes the top 10 co-occurred keywords with their number of occurrences and total link strength.

Table 1: Top 10 keywords in the co-occurrence of keywords analysis

Ranking	Keyword	Occurrences	Total link strength
1.	Artificial intelligence	313	531
2.	Educational technology	245	458
3.	Chatgpt	86	191
4.	Education	88	191
5.	Higher education	71	173
6.	Learning	35	116
7.	Machine learning	40	90
8.	E-learning	36	86
9.	Generative ai	34	81
10.	Large language models	24	78

Figure 6 presents the network map of the co-word analysis. The map produces five clusters, classified and labelled based on the author's inductive interpretation of the occurring words. All the clusters are shown to be closely related and partially integrated.

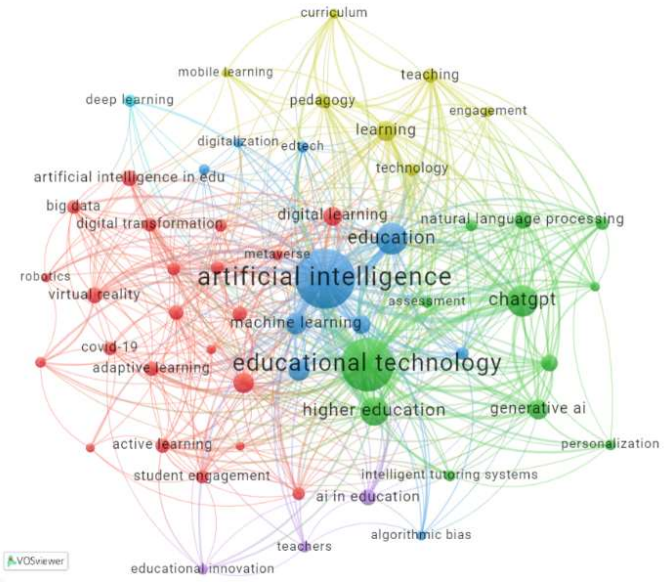

Figure 6: Network of co-word analysis

- Cluster 1 (blue) consists of 11 keywords. This cluster represents the theme "The Central Role of AI in Education" AI, the central keyword in this map shows that AI has become a major pillar in modern education. AI is used for various applications such as machine learning, deep learning, and NLP (Natural Language Processing), which allows for personalized learning and increased efficiency in the educational process. This reflects how AI is the foundation for educational innovation and improving learning methods.

- Cluster 2 (red) presents 22 keywords. It is labelled as "Technological Innovation in AI-Powered Education." Advanced technologies such as robotics, virtual reality, and adaptive learning mentioned in the red cluster show how AI drives digital transformation in education. These technologies are not only improving the way learning is done but are also changing the entire education ecosystem, especially in the post-COVID-19 pandemic era. It underscores the importance of AI as a catalyst in driving technological innovation that enables remote and interactive learning.

- Cluster 3 (green) comprises 12 keywords. It is labelled "Personalizing Education through AI." One of the key advantages of AI in modern education is its ability to provide personalization in learning. Keywords such as ChatGPT, intelligent tutoring systems, and generative AI show how AI enables the adaptation of learning content to meet the unique needs of each student. This is relevant to the trend of modern education that is increasingly moving towards more personalized and individual-based learning.

- Cluster 4 (yellow) with 6 keywords dealt with "Integration of AI with Educational Practices." This cluster highlights educational elements such as teaching, learning, and curriculum, which are increasingly integrated with AI technology. It shows how AI is not only changing the way teaching is done but also redefining curriculum and pedagogy in the modern era of education. Modern AI-powered education is becoming more dynamic, adaptive, and relevant to technological developments.

4 DISCUSSION

The results of this discussion include research growth, geographical distribution, subject area, affiliation, author, and analysis of keywords that often appear in AI-related research in education. In addition, this discussion will also link these findings to the current literature, providing a broader context regarding the development of AI in education.

4.1 Growth of Research and Geographic Distribution

In 2020, 96 documents were published in Scopus that discussed AI in education; this number increased to 108 in 2021 and continues to increase to 386 in 2024. This growth reflects the growing global interest in the application of AI in education, especially after the COVID-19 pandemic, which accelerated the adoption of technology in the learning process. The geographical distribution of the study shows that China leads with 189 articles, followed by the United States with 156 articles and India with 98 articles. China's leadership in AI research productivity can be attributed to their clear national policy of developing AI for education at all levels. This shows the role of national policies in encouraging AI research and application in various countries.

4.2 Subject Areas and Affiliations

AI in education has a broad subject coverage, with the largest contributions coming from Computer Science (31.6%), Social Sciences (23.4%), and Engineering (12.3%). This distribution reflects how AI is applied in various disciplines to improve learning and teaching. The institutions most active in the study include Carnegie Mellon University and the Indian Institute of Technology Kharagpur, each of which contributed many documents. The contributions from these various universities highlight the importance of international academic collaboration in advancing AI research in education.

4.3 Author Analysis and Collaboration

The authors with the most publications in this field are Ala, A., with 11 documents. Bozkurt, A., and Cukurova, M., with 6 documents each. The dominance of some of these authors indicates the existence of strong research groups focused on AI in education. Collaboration between authors is also very important in this area, as shown by the keyword analysis often appearing in their research.

4.4 Keyword Analysis (Co-word Analysis)

Keyword analysis shows that AI, educational technology, and ChatGPT are the keywords that appear most frequently in this study. These findings show that AI is becoming a major focus in modern education and is also beginning to be widely applied through technologies such as ChatGPT and machine learning. The first cluster focusing on the central role of AI in education shows how AI is becoming a key pillar in modern education, with applications in machine learning and natural language processing that enable personalization of learning. This aligns with the research of Saaida (2023), which stated that AI could improve education by allowing for data-driven methods and personalized learning.

The second cluster highlights technological innovations in education powered by AI, such as robotics and virtual reality, which have changed how learning is done and redefined the education ecosystem, especially in the post-pandemic era. This is consistent with the findings of Kamruzzaman et al. (2023) that the emergence of the COVID-19 pandemic highlighted the need for online and remote education. This increased interest in utilizing IoT and AI in educational technology.

The third cluster highlights the personalization of education through AI, which is becoming a major trend in modern education. AI allows the adaptation of learning content to meet the unique needs of each student, which can improve motivation and learning outcomes. This is reinforced by research by Shoaib et al. (2024), which demonstrated that integrating AI-based learning management systems can enhance learning outcomes and teaching methods in universities. The fourth cluster underlines the integration of AI with educational practices, including teaching and curriculum, that are increasingly integrated with AI technology. Ejjami, (2024) the curriculum will be balanced with broader educational objectives and the use of technology. In addition, this position will integrate lessons and activities that foster empathy, social skills, and creativity.

5 CONCLUSION

Artificial intelligence (AI) has become an essential component of modern education, with significant growth in publications and contributions from various countries, notably China, the United States, and India. The subject areas most involved in the study are Computer Science, Social Sciences, and Engineering, demonstrating how AI is applied across various disciplines to improve the learning and teaching process.

Leading institutions, such as Carnegie Mellon University and the Indian Institute of Technology Kharagpur, dominate the number of publications, emphasizing the importance of international academic collaboration in developing AI innovations in education. The most prolific authors in this field also show the existence of a solid and collaborative research community.

Keyword analysis shows that AI, educational technology, and tools like ChatGPT are the focus of the study, with personalization of learning and the integration of AI in the curriculum as key trends that are growing. However, challenges related to the ethics of AI use and infrastructure readiness still need to be addressed to ensure AI's inclusive and sustainable application in education.

Overall, AI has great potential to transform education at various levels, but its successful implementation is highly dependent on supportive policies, collaboration between institutions, and addressing existing ethical and infrastructure challenges. Further research is needed to continue exploring AI's opportunities and challenges in education and ensure that this technology can be used to improve learning outcomes for all students.

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