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Review Article

Educational Revolution: Bibliometric Analysis of the Advancement of Artificial Intelligence in Education

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Abstract *- In recent years, the adoption of Artificial Intelligence (AI) in education has grown significantly, providing innovative and personalized solutions. This paper offers a bibliometric analysis of the progress of AI in education from 2015 to 2023. The Scopus database was used to collect a total of 5,603 documents for this evaluation. The methodology included the use of the VOSviewer software and the bibliometrix package using the R language to examine publication trends, keyword networks, and identify the most productive countries, along with other relevant factors. The results highlight the predominant influence of various academic journals and institutions in research related to AI in education. In addition, countries such as China and the United States dominate research in this field, and the English language is the main language used to disseminate knowledge in the field studied. Similarly, emerging applications such as chatbots, adaptive learning systems, and educational strategy formulation systems, among others, demonstrate the diverse applications of AI in education. These findings consolidate the current state of research and provide a solid foundation for informed decisions aimed at facilitating the effective integration of AI into the 21st century educational landscape. In conclusion, this study contributes significantly to the understanding of trends and developments in the convergence of AI and education, providing valuable information for future research and strategic decisions in the contemporary educational field.*

Keywords *- Emerging applications, Artificial intelligence, Education, Bibliometric analysis, Chatbot.*

1. Introduction

In the last ten years, the unstoppable progress of Artificial Intelligence (AI) has influenced various aspects of society, transforming interactions with technology and creating fresh possibilities in crucial sectors [1]. Moreover, it has become intertwined with modern innovations, penetrating not only mobile and electronic devices but also various aspects of daily life [2]. Education is one of the areas deeply influenced by the substantial impact of AI. In this scenario, AI is emerging as a key player with the ability to revolutionize education significantly. This includes improving the overall teaching and learning experience, optimizing student results, and streamlining administrative tasks [3]. In addition, the fusion of AI and education has led to innovations that go beyond simple task automation, providing tools and pedagogical approaches that promise to revolutionize the way learning and teaching are conducted [4]. Likewise, the dynamic evolution of society, aggravated by the COVID-19 pandemic, has orchestrated substantial transformations in the field of education, demonstrating the need to adapt to new learning modalities [5][6]. In addition, recent advances in AI are improving its feasibility for educational applications. Current learning systems already use AI to assist students in their learning journey and to evaluate teacher performance [7][8].

However, there is a significant problem related to the lack of a comprehensive analysis of research trends in the field. There is no consolidated information on which countries produce the most research, in which languages these studies are published, the predominant types of documents, the most productive journals, the various applications of AI in education, etc. The scientific literature in this area has grown exponentially, making it difficult to identify trends, focus areas, and potential research gaps [9].

The need for a deeper and more systemic understanding of AI development in education is critical to inform future research and guide implementation strategies. Furthermore, the integration of AI in education represents a crucial

direction in the development of future education systems. The incorporation of AI can lead to educational systems that are equipped with computational sensitivity and rationality [10]. This lack of comprehensive understanding makes it difficult to identify gaps, opportunities, and best practices in the use of AI in education.

In this context, bibliometric research emerges as an essential tool to explore the breadth and depth of research related to AI in education [11]. In fact, bibliometric methodology provides a systematic approach to evaluating scientific production, identifying publication patterns, and mapping the thematic evolution of a field of study [12].

The knowledge is that several researchers have explored the use of AI at different levels of education, from secondary to higher education. The authors [13] focused specifically on secondary education, using a descriptive bibliometric approach to analyze related publications in the Scopus database. On the other hand, the authors [14] focused on higher education, conducting a bibliometric study to examine the current state of AI at this educational level. It used Scopus data to analyze publications between 2017 and 2023, focusing on titles, keywords, and abstracts.

Finally, the authors [15] looked at the application of AI in higher education over the past two decades, using comprehensive bibliometric analysis and data visualization. Although all of these studies share a focus on AI and education, they differ in the educational level they examine and the temporal scope of their bibliometric analysis.This study addresses these gaps through a comprehensive bibliometric analysis, offering a clear perspective on the dynamics and trends in AI research within the field of education. Furthermore, the novelty of this study lies in its focus on the bibliometric analysis of the progress of AI in education in general.

Unlike previous research that has focused on specific levels of education, this study seeks to understand the progress of AI in education in a broader context, ranging from secondary to higher education. This provides a comprehensive perspective on the role of AI in transforming the entire educational landscape.

The objective of this study is to answer the following questions: What is the trend of publications related to AI in education? What are the most cited documents in the field? What are the journals with the highest production of AI in education? What are the most commonly used keywords in these papers? What is the main type of document used to disseminate knowledge about AI in education? What is the main language used to disseminate knowledge about AI in education? Which institutions contribute most to research on AI in education? What are the most common applications of AI in education?

2. Methods

2.1. Selection of Information Sources

The choice of Scopus as the foundational database for this research is based on its reputation as one of the most extensive and comprehensive databases globally, spanning multiple academic disciplines. Scopus is notable for its extensive coverage of scholarly journals worldwide [16], which guarantees the inclusion of relevant research on artificial intelligence in education. Its advanced search functionality facilitates the accurate identification of relevant studies, while the ability to provide bibliometric metrics, such as impact factor and citation frequency, strengthens the assessment of the quality and impact of selected sources.

2.2. Criteria for Inclusion and Exclusion Decisions

For the selection of documents, only those classified as articles and conference papers and published between January 2015 and December 2023 were considered. Preference was given to articles that were in the final stage of publication in order to ensure the inclusion of more consolidated and revised contributions. The source of the documents was also limited to academic journals to ensure quality and peer review. Other types of documents and sources were excluded in order to maintain consistency in the collection of information and to focus the research on relevant and recent academic studies on the advancement of AI in education.

2.3. Data Collection Process

Figure 1 shows the search strategy process. The identification of information was carried out through an exhaustive search using keywords related to artificial intelligence in education, combined with Boolean operators ("Artificial Intelligence" AND "Education") to refine the relevance of the results. Inclusion and exclusion criteria were then applied. This process ensured the selection of relevant and high-quality studies, resulting in a total of 5,603 documents. Finally, the collected data were exported in CSV format for subsequent bibliometric analysis, allowing for efficient and structured management of the information obtained.

2.4. Bibliometric Analysis

Analysis of the gathered documents was performed utilizing specialized tools. In order to visualize patterns and relationships in the research network, the VOSviewer software was used, which facilitates the generation of bibliometric maps based on key terms and the structure of collaborations between authors and institutions.

In addition, the package bibliometrix was used for a more detailed quantitative analysis. The combination of these tools allows for a holistic and detailed comprehension, offering valuable information about the evolution, connections, and key characteristics of AI research in education.

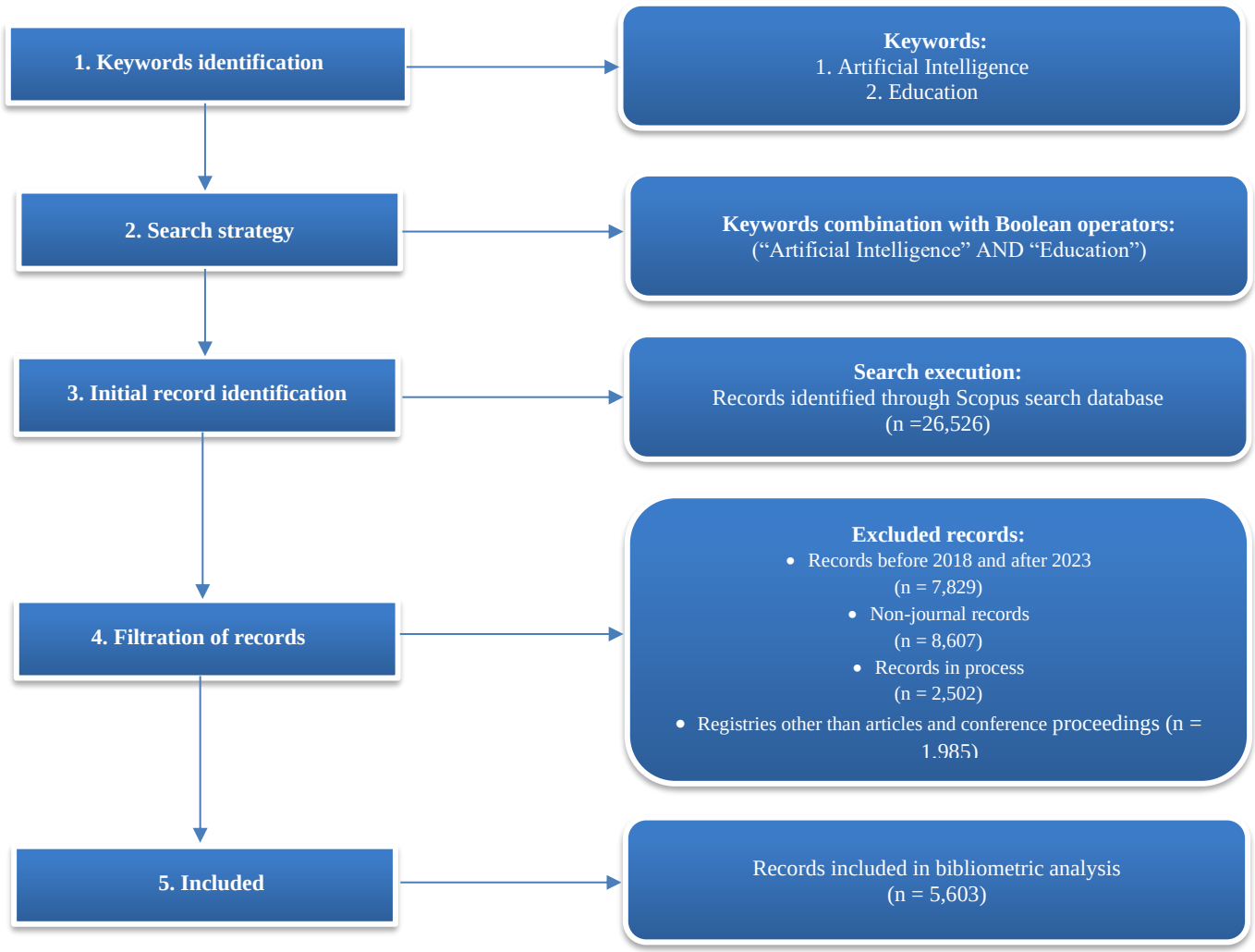

Fig. 1 Search strategy flow diagram

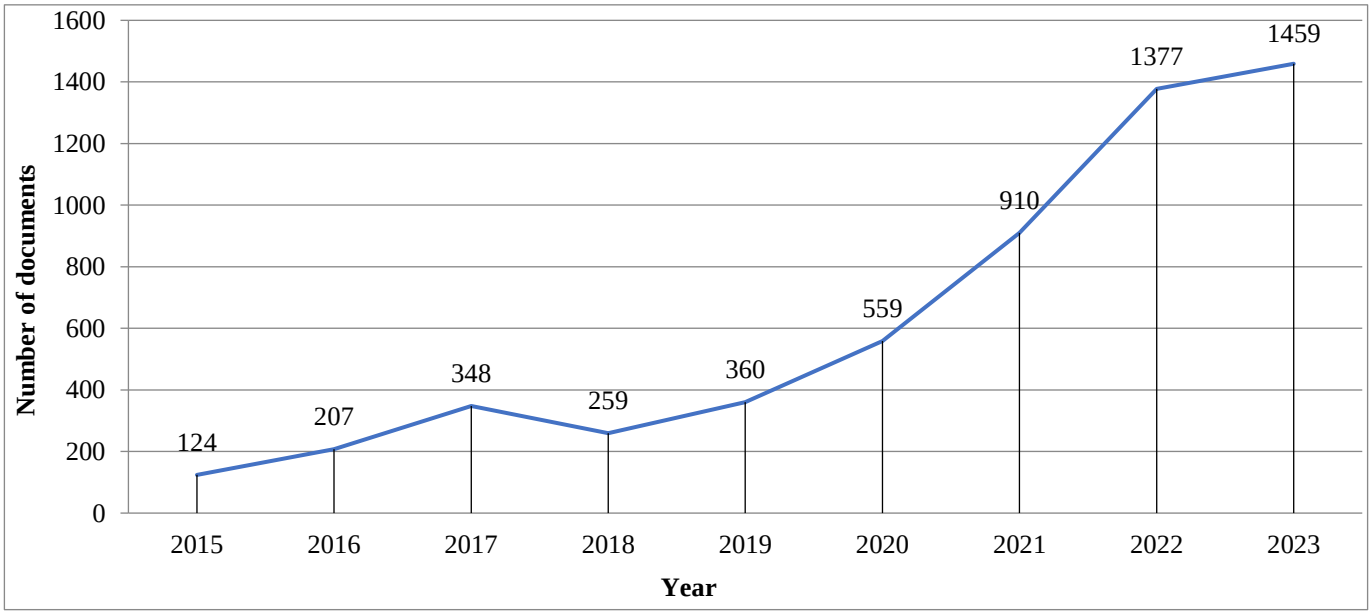

Fig. 2 Trend of AI in education publications by year

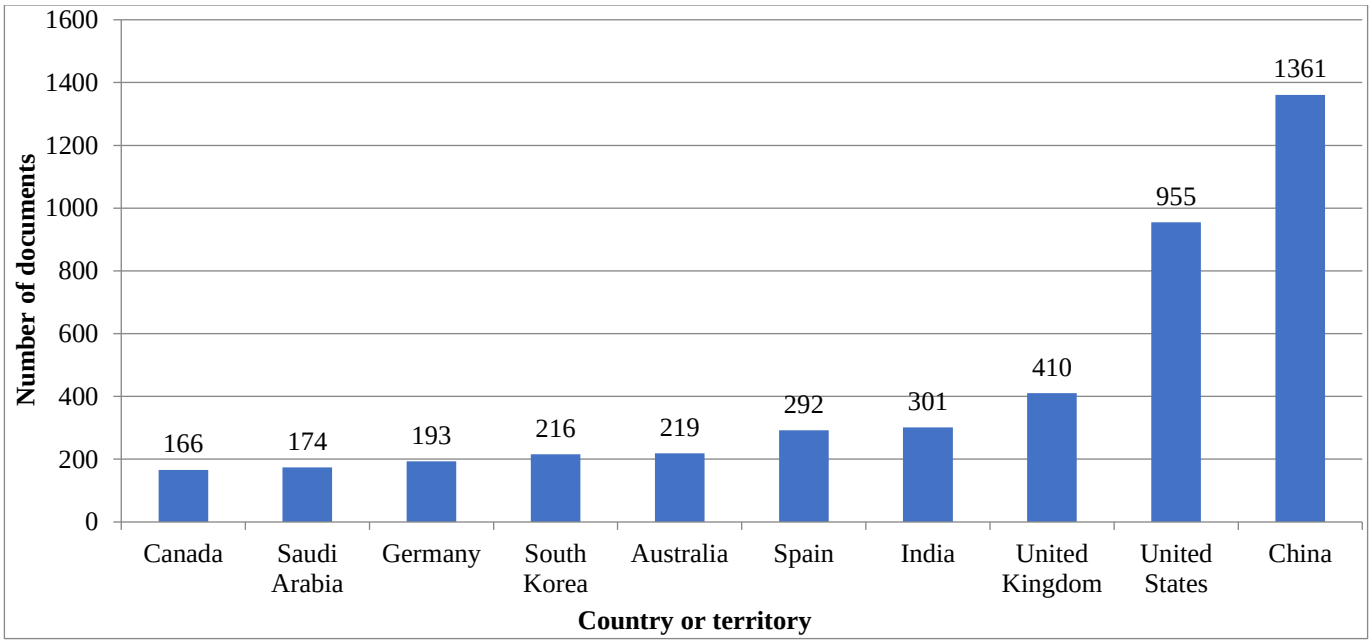

Fig. 3 The 10 countries with the highest production on AI in education (2015-2023)

3. Results

3.1. Analysis of Publication Trends Over Time

Figure 2 shows the analysis of the trends of publications related to AI in the educational field, which covers the period between January 2015 and December 2023, revealing a dynamic and significant evolution in documentary production over the years. Initially, in 2015, 124 articles were registered, marking the beginning of research in this disciplinary intersection. From then on, continuous and sustained growth is observed, with a notable increase in 2016 (207 documents) and a constant rise until reaching a peak in 2022 with 1,377 documents. This exponential increase in 2022 could indicate a period of consolidation and maturation of research, possibly driven by technological advances, greater acceptance of artificial intelligence in educational settings, and growing recognition of its potential impact.

The upward trend continues into 2023, with 1,459 papers recorded as of December, signaling an increasing vibrancy in research where AI and education intersect. This continued increase suggests sustained interest and growing relevance in the field, likely reflecting the need to address emerging challenges and capitalize on the opportunities that AI presents in education.

3.2. Geographical Distribution

An analysis of the top ten countries for papers on AI in education reveals a clear dominance of research by China, with an impressive total of 1,361 papers, highlighting its leading role at the forefront of this emerging field. The United States follows closely with 955 papers, underscoring the significant influence of American research at the intersection of AI and education.

Table 1. Language distribution

Language	Published documents	Percentage
English	5123	91.4%
Chinese	185	3.3%
Spanish	106	1.9%
Russian	70	1.2%
Portuguese	29	0.5%
Japanese	16	0.3%
Italian	14	0.2%
German	11	0.2%
Korean	10	0.2%
French	8	0.1%
Others	31	0.6%
Total	5603	100%

The United Kingdom, India, and Spain occupy prominent positions with 410, 301, and 292 papers, respectively, highlighting the geographic diversity of the research. Australia, South Korea, Germany, Saudi Arabia, and Canada also make significant contributions to knowledge in this area (see Figure 3). This distribution suggests global participation in research on artificial intelligence in education, with a particular concentration in Asia and North America, highlighting the importance of international collaboration further to drive the advancement and global applicability of this discipline.

Likewise, as shown in Table 1, of the 5,603 documents analyzed the preeminence of English as the dominant language of research stands out, with an impressive 91.4% of the contributions written in this language. This overwhelming proportion underlines the predominant position of scientific and academic literature in English in the field of study. In a significant second place, the Chinese language contributes 3.3%, indicating the expanding impact of research on AI in the area of education in China. However, the analysis also reveals remarkable linguistic diversity, with significant contributions from Spanish (1.9%), Russian (1.2%), Portuguese (0.5%), and other languages. The presence of these languages suggests global participation in the field, enriching the diversity of perspectives and approaches. Interestingly, although English is overwhelmingly dominant, the inclusion of other languages raises the possibility of international collaboration opportunities and the need to facilitate knowledge sharing in a multilingual environment, underscoring the truly global and collaborative nature of research in AI in education.

3.3. Type of Documents

Of the total documents analyzed, 98.70% of the contributions are presented in the form of articles, highlighting the preeminence of this modality in the dissemination of knowledge about artificial intelligence in education. This predominance suggests a preference for a more detailed and exhaustive format, probably intended for the presentation of in-depth research results. On the other hand, 1.30% of the documents are classified as conferences, indicating a more modest but still significant presence of research presented in more specialized and ephemeral contexts (see Figure 4). This balance reveals the complexity and richness of research in this field, where articles are the norm, but papers presented at conferences continue to play a distinct and valuable role in the communication and discussion of advances in AI applied to education.

3.4. Most Productive Journal

The analysis of the most prolific journals in the AI in education domain unveils a significant prevalence of high-quality publications and highlights journals such as *IEEE Access* from the United States and *Sustainability* from Switzerland, both ranked Q1, indicating their position in the top quartile in terms of impact. These journals lead the scientific production with 135 and 130 publications, respectively, consolidating their influence on the convergence between artificial intelligence and education. Notably, geographic diversity is reflected by the presence of journals such as Wireless Communications and Mobile Computing and Mobile Information Systems from Egypt and Frontiers in Psychology from Switzerland. In addition, journals such as Computers and Education: Artificial Intelligence from the Netherlands and International Journal of Artificial Intelligence in Education from the United States, both ranked Q1, underscore the commitment of these nations to being at the forefront of research in this field. This analysis provides a strategic vision for researchers and academics by identifying the leading journals, their impact levels, and the global diversity of scientific production (see Table 2).

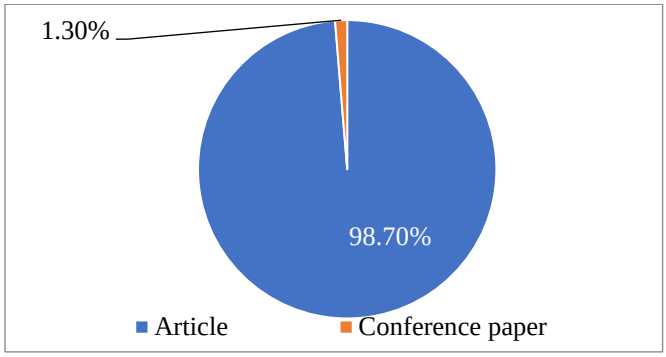

Fig. 4 Percentage of publications according to document type

Table 2. The 10 most productive journals

Order	Journal	Total publication	Quartile	H-Index	Country
1	IEEE Access	135	Q1	204	United States
2	Sustainability	130	Q1	136	Switzerland
3	Wireless Communications and Mobile Computing	87	Q2	73	Egypt
4	Mobile Information Systems	84	Q3	42	Egypt
5	Frontiers in Psychology	83	Q2	157	Switzerland
6	Journal of Intelligent and Fuzzy Systems	76	Q2	73	Netherlands
7	International Journal of Emerging Technologies in Learning	75	Q2	39	Austria
8	Applied Sciences (Switzerland)	64	Q2	101	Switzerland
9	Computers and Education: Artificial Intelligence	62	Q1	17	Netherlands
10	International Journal of Artificial Intelligence in Education	51	Q1	56	United States

3.5. More Productive Affiliations

Figure 5 shows the analysis of the most prominent affiliations in the area of AI applied to education, evidencing those that make the greatest contributions and that are recognized worldwide for their academic work. University College London tops the list with 39 publications, closely followed by King Abdulaziz University and the Chinese Academy of Sciences with 35 and 34 publications, respectively. The presence of institutions from different countries, such as the *Massachusetts Institute of Technology*, the *University of Granada*, and the *Chinese University of Hong Kong*, underlines the global nature of research in this field. In addition, the influence of governmental bodies such as the *Ministry of Education of the People's Republic of China* indicates a significant interest at the governmental level in the convergence of artificial intelligence and education. This analysis provides valuable insight into the leading institutions in scientific production on this topic, highlighting the collaboration and diversity of approaches at the intersection of AI and education.

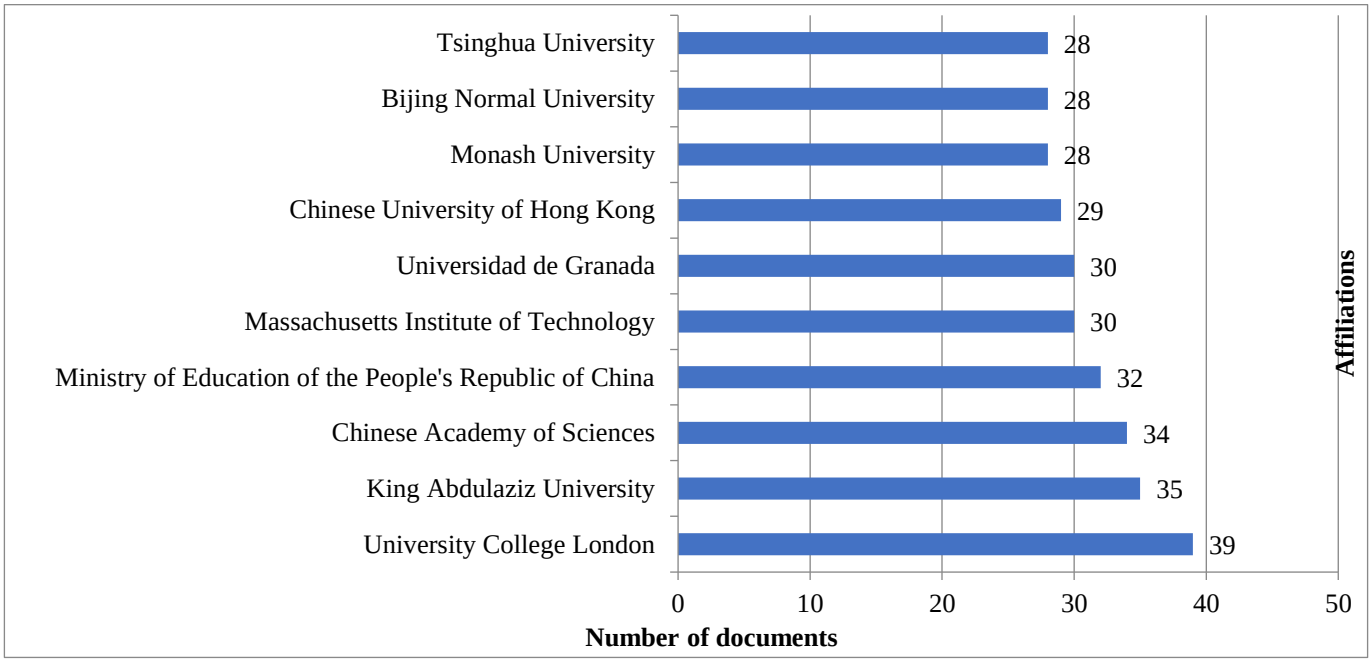

Fig. 5 The 10 most productive affiliations in the field of AI in education (2015-2023)

Table 3. Ten documents with the highest number of citations (2015-2023)

Author	Study focus	Year	Citations
Popenici and Kerr [17]	Examining the effects of artificial intelligence on teaching and learning dynamics within higher educational settings.	2017	350
Costa et al. [18]	Assessing the efficiency of educational data mining approaches for early identification of students at risk of academic failure in introductory programming courses.	2017	279
Timms [19]	Exploring the unleashing of AI in education through educational cobots and smart classrooms.	2016	175
Hwang and Chien [20]	Exploring the concept, functions, and possible investigative challenges of the metaverse in educational contexts from the viewpoint of AI.	2022	160
Xu et al. [21]	Employing machine learning techniques to monitor and forecast student achievement in academic programs.	2017	139
Tlili et al. [22]	Exploring ChatGPT as a case study for implementing chatbots in educational settings.	2023	135
Rudolph et al. [23]	Exploring ChatGPT whether or not it is a revolution in higher education assessments.	2023	135
Chatterjee and Bhattacharjee [24]	Exploring the integration of AI in higher education using structural equation modeling for quantitative analysis.	2020	119
Yang et al. [25]	Exploring the impact of human-centred AI on education.	2021	100
Jalal and Mahmood [26]	Utilizing cognitive processes and information technologies to analyze students' behavior in e-learning settings.	2019	95

3.6. Most Cited Documents

Table 3 presents the most cited published documents. Among the most influential works are those that have been repeatedly referenced in the academic literature. The study of Popenici and Kerr [17], which explores the influence of AI on the teaching and learning environment in higher education, stands out as the frontrunner, with a remarkable 350 citations since its publication in 2017, highlighting its relevance and wide recognition in the academic community. Other notable studies encompass research on the effectiveness of educational data mining techniques in anticipating academic challenges, along with research exploring the integration of AI into higher education using structural equation modeling. Furthermore, recent studies, such as those conducted by Tlili et al. [22] and Rudolph et al. [23], which were published in 2023, have observed a considerable surge in citation rates. This trend underscores the increasing acknowledgement and influence of ChatGPT technology within the realm of education. These papers not only provide a panoramic view of current trends but also highlight key areas of research that have attracted significant attention and interest from the academic community.

3.7. Author Keyword Network

Figure 6 shows the authors' keyword network in the context of AI applied to education, revealing the interconnections and semantic relationships between the fundamental terms associated with this area of study. The most prominent keywords include AI and machine learning, underscoring the centrality of these concepts in the convergence of AI and education. Education and higher education highlight the specific application of these technologies in educational contexts, while deep learning suggests a focus on advanced machine learning methods. The presence of e-learning and educational technology reflects the growing importance of technology in distance learning and the evolving role of educational technology in this area. This network of keywords reflects the interconnectedness of key concepts that define contemporary research in the concurrence of AI in the area of education and provides a strategic vision of the most relevant topics being explored by the academic community.

3.8. Application of AI in the Educational Field

Table 4 shows a wide range of applications of AI in education, indicating its flexibility and significant contribution to the field of teaching and the learning process. Among these applications, the presence of virtual tutors, such as chatbots, that provide personalized support and guidance to students stands out. The predictive ability of AI to assess academic performance provides valuable insights to adapt pedagogical strategies and improve educational outcomes. Personalized learning systems are another key application, allowing content and teaching approaches to be tailored to the individual needs of students. In addition, educational strategy formulation will benefit from the analytical capabilities of AI, providing educators and administrators with tools to design more effective curricula.

The inclusion of image recognition for language learning highlights the applicability of AI in specific areas of the curriculum, improving the interactivity and effectiveness of the language learning process. These applications are just part of the wide variety of tools that artificial intelligence brings to education, demonstrating its fundamental role in the ongoing transformation of teaching.

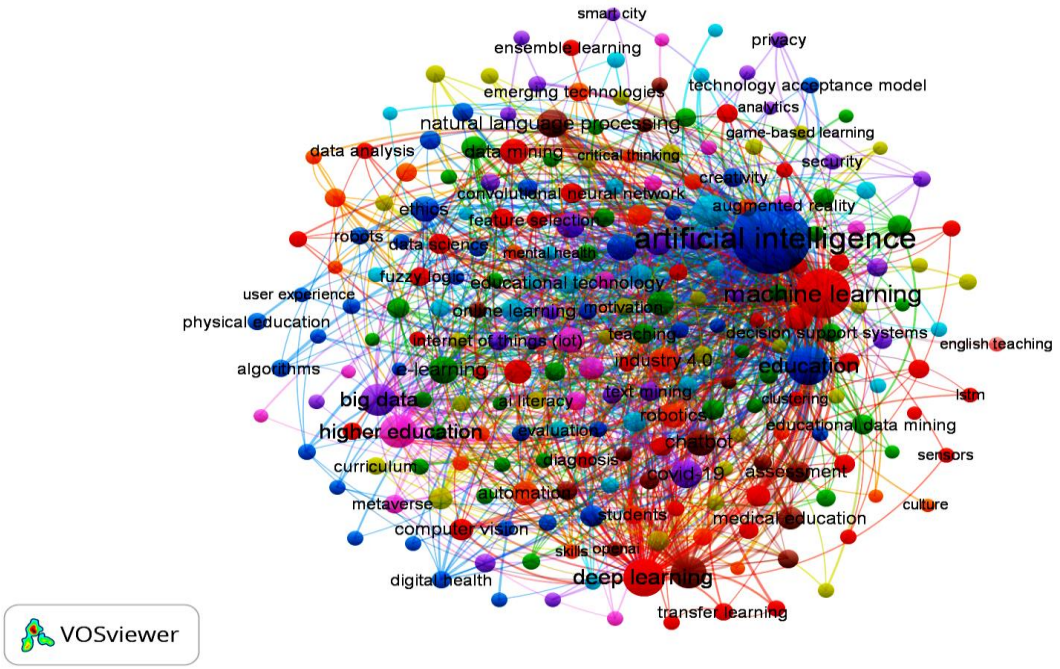

Fig. 6 Author keyword network

Table 4. Application of AI in the educational field

IA Application	Publication data (Focus and reference)	Publication Findings
Virtual tutor (Chatbot)	Analysis of the influence of an educational program that uses an AI chatbot in non-face-to-face classes using a quasi-experimental design [27].	The results indicate that AI-based chatbot programs have the potential to serve as educational tools, promoting nursing students' interest and autonomy in non-face-to-face situations.
	Analysis of the influence of a virtual teaching assistant on student learning outcomes in higher education in Ghana [28].	Students who conversed with the chatbot outperformed those who spoke with the instructor in terms of academic performance.
	Exploring the potential of chatbots to support inclusive learning through a chatbot-led interview approach [29].	Leveraging AI-based chatbots in interactive learning through Information and Communication Technologies (ICT) proves suitable for acquiring proficiency in foreign language skills while simultaneously grasping cultural content.
Adaptive learning systems	Exploring the development and effectiveness of an interactive block-based programming environment designed for large-scale machine learning education [30].	The experiments demonstrate elevated ratings from both teachers and pre-service teachers across all four assessment criteria for this innovative block-based programming environment.
Academic Performance Prediction	Exploring an AI-based prediction model for student's academic performance in online engineering education [31].	The use of a prediction model based on evolutionary computation is presented as a practical approach to evaluating student learning performance in online courses.
	Prediction of students' final performance through the use of artificial neural networks [32].	The application of neural networks as a method for data mining is presented as an important contribution to providing good scores and predictions in the specific context studied.
Personalized learning system	Deepen the implementation and effectiveness of AI in Education to develop personalized learning routes [33].	Training provides 24/7 access in virtual environments, tailoring content to individual requirements with immediate feedback. This not only boosts learning but also ensures students remain mentally involved.
Formulation of educational strategies	Development and application of an intelligent assessment system to evaluate mathematics learning strategies among high school students, with Jianzha County as a case study [34].	The system demonstrates an accurate diagnostic capability for assessing high school students' approaches to learning mathematics. Through targeted interventions, it successfully enhances both these strategies and performance in the subject.
	Analysis of the impact of AI technology in the definition of educational strategic processes [35].	The recommended Random Forest method showed consistent and improved functionality in formulating educational strategies.
Student Monitoring System	Exploring student attention tracking during virtual classes using an XGBoost model [36].	Create a comprehensive, anonymous student attention assessment report accessible from a dedicated web page. This report provides a detailed summary of student behavior in online classes, providing a comprehensive and accessible view of student attention and engagement levels.
Image recognition for language learning	Implementation of machine learning algorithms and image target recognition techniques to improve English learning activities [37].	It highlights an improved phoneme recognition system with promising ramifications for integrating error correction techniques into learning networks. Students can choose assignments from teachers or complete them on their own, which makes it simple for them to use the self-directed learning platform to enhance their English.

4. Discussion

4.1. Continuous Growth in Research on AI in Education

The growing trend of publications on AI in education is highlighted in the bibliometric analysis of 5,603 investigations from January 2015 to December 2023. This significant increase, from 124 publications in 2015 to 1,459 in 2023, shows a significant expansion, especially from 2019 with 260 publications. The development of IAED is considered a transformative factor for education, influencing classroom management, teacher collaboration, and the

development of AI-based platforms [38]. This phenomenon is linked to the rapid technological development that has revitalized the education industry [39]. This evolution in the integration of distance learning technologies into the academic programs of educational institutions, in response to the growing demand for knowledge in a knowledge-based society, is closely related to the upward trend in the publication of research on AI in education. The increase in the adoption of remote modalities by students has been driven by the need to meet the expectations of learners seeking flexibility and accessibility. In this context, advances in artificial intelligence stand out as fundamental elements for the development of distance education programs, acting as support tools that not only facilitate tasks and provide continuous feedback but also contribute to closing educational and organizational gaps between students and teachers. This convergence between the demand for distance learning and advances in artificial intelligence reflects an effective adaptation of educational institutions to the changing needs of society and is reflected in the increasing trend of publications on IA in education [40].

4.2. Productivity by Country and Language in the Field of AI in Education

The distribution of productivity among the top 10 countries in AI in education research shows that China is the most prominent country, followed by the United States and the United Kingdom, while Canada and Saudi Arabia appear to be the least productive in this field. This disparity reflects the prominence of certain countries at the forefront of research in AI applied to education. It is also worth noting that English is the dominant language used to disseminate knowledge, being used in 91.4% of publications. This fact highlights the influence and centrality of English in global scientific communication on the topic, followed by Chinese and Spanish with lower percentages. This linguistic distribution suggests the importance of accessibility and international dissemination of research in this field. It also highlights the need to promote linguistic diversity to ensure the equitable and global dissemination of AI knowledge in education [41].

Furthermore, within the scope of technological advancement, the adoption of AI in education presents not just challenges but also significant opportunities in different countries. In this sense, the AI era requires a dynamic adaptation of vocational education to meet the changing skill needs of each country. Vocational education reform should adjust its goals, change teaching methods, deepen training methods, and supplement training content to effectively prepare students for the current intelligent era [42].

4.3. Productivity by Magazine and Affiliation in the Area of AI in Education

The productivity of research on AI in education is clearly reflected in the leading journals and affiliations. Among the most productive journals, IEEE Access from the United States and Sustainability from Switzerland stand out, leading the list with 135 and 130 publications, respectively. In contrast, Computers and Education: Artificial Intelligence and the International Journal of Artificial Intelligence in Education occupy lower positions on the list, with 62 and 51 publications, respectively. This analysis suggests a concentration of academic production in certain journals and highlights the geographical diversity of knowledge sources in the field. Similarly, when looking at the most productive affiliations, University College London tops the list, followed by King Abdulaziz University and the Chinese Academy of Sciences, among others. These institutions demonstrate a significant commitment to AI research in education. The presence of internationally renowned affiliations underscores global collaboration in this area and highlights the importance of the contribution of different institutions to the advancement of knowledge at the intersection of AI and education. The diversity of affiliations suggests an international collaborative network that enriches the research landscape and reflects the global interest in the application of AI in education [8].

4.4. Applications of Educational Technologies Based on AI

A review of various studies reveals a growing trend towards the incorporation of AI technologies in educational settings. These technologies, ranging from chatbots to image recognition, are being explored to improve learning quality, accessibility, personalization, and technologically advanced teaching. First, the study carried out by Han *et al.* [27] underscores the capability of AI chatbot programs as tools for educational support. Although no statistically significant differences in knowledge and competence were observed, the increase in interest and self-directed learning among students who used the chatbot stood out. On the other hand, Essel *et al.* [28] investigated the impact of a virtual teaching assistant (chatbot) on the academic achievement of university students in Ghana. Their findings revealed that students who interacted with the chatbot demonstrated superior academic performance compared to those who interacted solely with the course instructor. Amin et al. [6] focused on the development of a personalized learning model enabled by an intelligent E-Learning (EL) platform. The research used various machine learning techniques to recommend beneficial courses based on students' academic performance, interests, and preferences. Another study by Jiao et al. [31] focused on predicting students' academic performance using AI models based on the learning process. The research emphasized the relevance of variables such as the acquisition of knowledge, participation in class, and overall performance assessments. Lastly, the investigation conducted by Zhan and Chen [37] delved into the utilization of image target recognition in the context of English learning. It brought attention to a task-oriented approach that prioritizes communication and meaning.

The studies differ in the specific technologies evaluated and the educational aspects addressed. The common thread, however, is the accumulating evidence that AI technologies can improve academic engagement and performance, as well as promote the personalization of learning. These promising approaches suggest a shift toward a more student-centred, adaptive, and accessible educational paradigm, although they highlight the need for ongoing and adaptive evaluation to ensure their long-term effectiveness and applicability in different educational contexts.

4.5. Comparative Analysis of Analytical Techniques

Compared to the state-of-the-art techniques reported in the literature, this study achieved superior results due to several key factors. Both the VOSviewer software and the Bibliometrix package with the R language were used, which allowed for a more comprehensive and detailed bibliometric analysis. Unlike previous studies [14–16], this focused exclusively on secondary or higher education and used only VOSviewer for analysis. The present study covered education in general, providing a more comprehensive view of the advancement of AI in this field.

In addition, by using a combination of bibliometric tools, patterns and trends could be identified and analyzed with greater precision and depth. Data collection from the Scopus database ensured broad and relevant coverage of existing publications. This methodology made it possible not only to highlight the dynamics and trends in research on AI in education but also to provide a more robust and complete comparison with previous studies.

4.6. Limitation of Research and Future Work

A major limitation of this research lies in the temporal scope and data source selected for the bibliometric analysis. The Scopus database was used to collect articles published between January 2015 and December 2023, with a particular focus on those presented in the form of articles and conference papers. This temporal limitation and the exclusive choice of Scopus as a data source may have influenced the global representativeness of trends and developments in the field of study. The decision to limit the search to this specific area may have omitted more recent or relevant past developments that could have contributed to a more complete picture. In addition, selecting Scopus as the sole database may have omitted valuable research available on other platforms. The limitation to the article and conference paper formats could also have excluded other types of important contributions, such as systematic reviews, books, or other types of publications that could have further enriched the bibliometric analysis.

Furthermore, these limitations may affect the generalizability of trends and the comprehensiveness of the bibliometric review. In future work, it is suggested to consider multiple data sources and extend the temporal range in order to obtain a more complete and updated perspective of the bibliometric panorama of the topic in question.

5. Conclusion

In conclusion, this bibliometric study on the progress of AI in education presents a thorough and current perspective on the trends and advancements in this ever-evolving field. The results show the clear preeminence of leading journals, highlighting the influence of academic institutions and global organizations on scientific production. It also identifies key documents that have had a significant impact on the academic community, addressing subjects like the influence of AI on teaching and learning, the efficacy of data mining techniques in academic forecasting, and the integration of AI in the educational area. In addition, emerging applications such as chatbots, adaptive learning systems, and educational strategy formulation are discussed. They highlight the diversity of applications of artificial intelligence, from the implementation of virtual tutors to student monitoring systems and personalized educational strategies.

The importance of these results lies in their capacity to enlighten and steer forthcoming research and development in the intersection of AI applied to education. These findings not only consolidate the understanding of critical areas of research but also provide researchers, educators, and policymakers with a solid foundation for informed decision-making, thus promoting the effective integration of AI in 21st century education.

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