ATRAS Volume 5 (Special Issue on AI and Education, Online Learning and Education), pp. 445-463 30/09/ 2024 | ISSN: 2710-8759/ EISSN: 2992-1376

Artificial Intelligence in Education: A Comprehensive Bibliometric Study on Scopus (2010-2024)

Samira GUECHAIRI[1]
[1] University of Blida2 Lounici Ali, Algeria

Received: 28 / 07 / 2024 **Accepted**: 07 / 08 / 2024 **Published**: 30 / 09 / 2024

Abstract

This study aims to rigorously analyse publications on the use of artificial intelligence in education from 2010 to 2024 using data from the Scopus database. The significance of this study lies in its potential to elucidate trends, patterns, and the impact of AI research in the educational field, offering valuable insights for researchers, educators, and policymakers. The study employs bibliometric methods and tools, specifically Bibliometrix for data analysis and VOSviewer for visualization. An examination of 9,564 papers reveals a significant rise in AI research, peaking in 2023, with notable contributions from the Social Sciences. Researchers Wang Y, Liu Y, and Zhang Y, along with the journals "Sustainability" and "Artificial Intelligence Review," are identified as key contributors. Highly cited articles focus on algorithm transparency and deep learning. China and the USA are highlighted as leading countries in AI development, indicating substantial state investment. The study comprehensively analyses AI's role in education, emphasizing practical applications and interdisciplinary cooperation, and proposes future research directions, including ethical considerations and qualitative impact assessments. The findings underscore AI's evolving nature and transformative potential in education, advocating for ongoing investment and innovation.

Keywords: Artificial Intelligence, bibliometric analysis, education, Bibliometrix , VOSviewer, Scopus

ملخص

تهدف هذه الدراسة إلى تحليل الوثائق المتعلقة بالذكاء الاصطناعي في التعليم من عام 2010 إلى 2024 باستخدام قاعدة بيانات Scopus. تكمن أهمية الدراسة في أنها تبين التأثيرات المحتملة لبحوث الذكاء الاصطناعي في مجال التعليم مما يعطي الباحثين، المتعلمين وصناع القرار نظرة جيدة في المجال، استخدمت الدراسة المنهج الببليومتري واستعانت بأداتي Bibliometrix لتحليل البيانات و VOSviewer لعرضها. توصلت نتائج الدراسة إلى زيادة كبيرة في عدد الوثائق المنشورة حول الذكاء الاصطناعي في التعليم وصلت إلى 9564وثيقة، حيث بلغت أعلى معدل لها في عام 2023. أغلب الوثائق المنشورة كانت في العلوم الاجتماعية، كما يعد كل كم Wang Y و Liu Yلو Zhang Y بمثابة الباحثين الأكثر إنتاجية في مجال الذكاء الاصطناعي. في نفس السياق، الدوريات الأكثر إنتاجية هي "Sustainability"و "Artificial Intelligence Review" حيث اكتسبت أهمية كبيرة في نشر الأبحاث المتعلقة بالذكاء الاصطناعي. تتناول المقالات الأكثر استشهادا بشكل أساسي مواضيع شفافية الخوارزميات واستخدام التعلم العميق. توصلت هذه الدراسة أيضا إلى أن الصين والولايات المتحدة الأمريكية هما الدولتان الرائدتان في تطوير الذكاء الاصطناعي. تؤكد النتائج على الطبيعة المتغيرة لأبحاث الذكاء الاصطناعي وتأثيرها الكبير على التعليم، وتدعو إلى الاستثمار المستمر والابتكار لاستغلال الإمكانيات التحويلية للذكاء الاصطناعي في البيئات التعليمية.

الكلمات المفتاحية:

الذكاء الاصطناعي، التعليم ، الدراسات الببليومترية، bibliometrix، VOSviewer، سكوبس

Email: [1]s.guechairi@univ-blida2.dz

Introduction

Implementing Artificial Intelligence (AI) in science education has received growing attention recently. AI's effect extends across several sectors, including more than education science. (Akhmadieva et al., 2023). According to Murphy (2019), AI involves "the application of software algorithms and techniques that allow computers and machines to mimic human perception and decision-making processes to complete tasks efficiently" (p. 2).

UNESCO. International Conference on Artificial Intelligence and Education (2019) recommends AI's fair and comprehensive incorporation into educational environments. With rapid technological progress, interest in AI is on the rise, offering opportunities to improve teaching and learning processes in science education (AlKanaan, 2022). Numerous studies have explored AI's role across different educational settings, including science education (Ahmad et al., 2023: Sysoyev, 2023) , higher education (Kavitha et al., 2024), classroom settings (Qi, 2019; You et al., 2022), and broader educational contexts (Jammeli et al., 2024) .

However, the impact of AI on educational research still needs to be investigated. This bibliometric study addresses this gap by examining the development and trends of AI-related research in education over the last decade, using data from Scopus. Understanding the trajectory of AI research in education is crucial for educators, policy-makers, and technology developers to align future innovations with emerging educational needs and trends.

This study aims to provide a comprehensive overview of AI research in education by identifying major trends, influential authors, and significant publications from 2010 to 2024 in Scopus. The specific goals include mapping research growth, highlighting research hotspots, and analysing collaboration patterns. This research contributes to theory by mapping the evolution of AI research in education, offering novel insights into research dynamics. Methodologically, it employs bibliometric techniques to analyse a substantial dataset from Scopus, providing a robust framework for future studies. Practically, it offers actionable insights for educators and policy-makers to guide the adoption and implementation of AI technologies in educational contexts.

This study aims to fill the gaps by conducting a targeted bibliometric analysis of AI in education using the Scopus database from 2010 to 2024. By concentrating on this specific time frame and dataset, the research provides an in-depth analysis of current trends, key contributors, and developing topics. Additionally, this study seeks to highlight contributions from under-represented countries, offering a more comprehensive view of global research trends in AI in education. Moreover, the study emphasizes the practical implications of AI technology, exploring real-world applications and challenges. By doing this, it aims to bridge the gap between theoretical research and practical application, providing significant insights for scholars and practitioners. Finally, the paper examines the importance and efficacy of multidisciplinary partnerships, offering evidence-based suggestions for improving collaborative endeavours in AI research in education.

Preliminary findings indicate a significant increase in AI research publications within education, emphasizing personalized learning and adaptive systems. The study identifies critical contributors and emerging research clusters, highlighting the global impact of AI research in education. To achieve this aim, the researcher set the following research objectives:

- Identify and analyse major trends in AI research within education from 2010 to 2024 using Scopus data.
- Identify leading authors, journals, and countries contributing to AI research in education.

- Map key themes and subject areas emerging in AI research within education, focusing on personalized learning and adaptive systems.
- Examine the growth of AI research in education, identifying research hotspots and significant publications.
- Contribute to theoretical understanding and provide practical recommendations for educators and policy-makers.

The research questions guiding this study are:

- What are the major trends in AI research within the field of education from 2010 to 2024 in Scopus?
- Who are the leading authors, journals, and countries contributing to AI in education from 2010 to 2024 in Scopus?
- What are the key themes and subject areas emerging in AI in education from 2010 to 2024 in Scopus?

The increasing integration of AI technologies in educational settings is driven by their potential to enhance learning outcomes. Theoretically, this study uses bibliometric methods to provide fresh insights into the research landscape, addressing gaps in the current literature on AI in education.

This article is structured as follows: Section One introduces the study; Section Two reviews relevant literature; Section Three outlines the methods and materials used; Section Four presents the results; Section Five discusses the findings; and Section Six concludes with a summary and future research directions.

Literature Review

Integrating Artificial Intelligence (AI) into the educational sector has garnered significant interest over the past decade. This literature review comprehensively analyses theoretical and practical works on AI in education, emphasizing fundamental discoveries, limitations, inconsistencies, conflicts, and areas requiring further research. Additionally, the review identifies significant similarities and differences between past and current studies, aiming to address these research gaps through theoretical and empirical approaches.

In their study, Akhmadieva et al. (2023) performed a bibliometric analysis of AI usage in scientific education from 2002 to 2023, noting a surge in publications between 2016 and 2022, with the United States, the United Kingdom, and China leading the field. Talan (2021) examined AI in education from 2001 to 2021 using Web of Science data, highlighting the United States as the most prolific country and emphasizing the importance of co-authorship networks and keyword trends.

Bircan and Salah (2022) explored the application of AI and Big Data in social sciences from 2015 to 2020, noting extensive use of these technologies but a need to integrate core social scientific principles. Metli (2023) investigated the relationship between education and AI from 1980 to 2022, finding an annual publication growth rate of 22.68% and identifying China, the US, and the UK as the most productive countries in this field.

Saputra et al. (2023) carried out a semi-systematic literature review on AI in education, identifying numerous opportunities, challenges, risks, and barriers to AI integration in education. Kaban (2023) executed a bibliometric analysis of AI in education papers from the Web of Science, noting a significant increase in research after 2019 and identifying critical journals in the field.

Zhang and Aslan (2021) provided a comprehensive analysis of empirical research on AI

in education from 1993 to 2020, highlighting the benefits of AI technologies in education and the need for multidisciplinary collaborations and ethical considerations. Jaleniauskienė et al. (2023) conducted a bibliometric study on AI in language instruction, discovering a consistent annual output of publications, with China and the USA being the leading countries (Jaleniauskienė et al., 2023).

Chen et al. (2020) qualitatively assessed AI's impact on education, emphasizing its widespread use in enhancing administrative tasks, instructional methods, and personalized learning. Triansyah et al. (2023) analysed AI publications in middle schools using Scopus data, revealing significant growth from 2010 to 2021, with China emerging as the leading nation.

Maphosa and Maphosa (2021) performed a bibliometric study of AI research in higher education using Scopus, observing substantial growth over the last two decades, with China and the USA leading. Prahani et al. (2022) performed a bibliometric analysis to examine AI in education research trends over the past decade, identifying significant growth, with China being the most prolific nation. Ahmad et al. (2023) provided a comprehensive analysis of data-driven AI in education, highlighting the United States as a critical player and emphasizing student grading and assessment as the most studied applications.

Despite notable advancements in AI research in education, several areas require further investigation. Many studies rely on specific databases, time frames, and bibliometric indicators. There is a need for broader bibliometric analyses utilizing multiple databases and extended time frames to capture the entirety of AI research in education. Additionally, while numerous studies focus on higher education, research on AI's application at various educational levels, including middle schools and K-12, is limited. The practical implications and real-world applications of AI in education have yet to be thoroughly explored, with most research focusing on theoretical possibilities rather than concrete evidence of implementation. Furthermore, despite their acknowledged importance, the effects and effectiveness of multidisciplinary collaboration have yet to be extensively examined.

Methods and Materials

This study examined the use of bibliometric analysis methods to analyse the use of AI in education. Bibliometrics is a very useful scientific method that is widely used in several fields (Zhu et al., 2023). This analytical methodology illustrates the changing patterns of production in articles and journals, the relationships between publications and authors, and the patterns of cooperation using visual maps (Donthu et al., 2021; Zupic & Čater, 2015).

Participants

The article search and data collection were conducted in July 2024 using Scopus, a recognized and comprehensive bibliometric analysis database (Mongeon & Paul-Hus, 2016). The technique included three successive phases: The process includes establishing the topic, scope, and eligibility criteria, as well as evaluating and including the articles, as seen in Figure One. The first search query was centred on articles on AI and Education, with the designated keywords shown in Figure One. The research used rigorous criteria for inclusion and exclusion, stipulating that only studies published in English in academic journals from 2010 to 2024 were considered. The search method resulted in a total of 9564 articles.

Research Instruments

This study comprehensively analyses publication trends, highlighting the most influential authors and countries. It also identifies the most frequently cited publications and journals within the field. Furthermore, the research delves into co-occurrence keywords,

employing advanced tools such as Bibliometrix and VOSviewer to offer in-depth insights into the research landscape.

Research Procedures

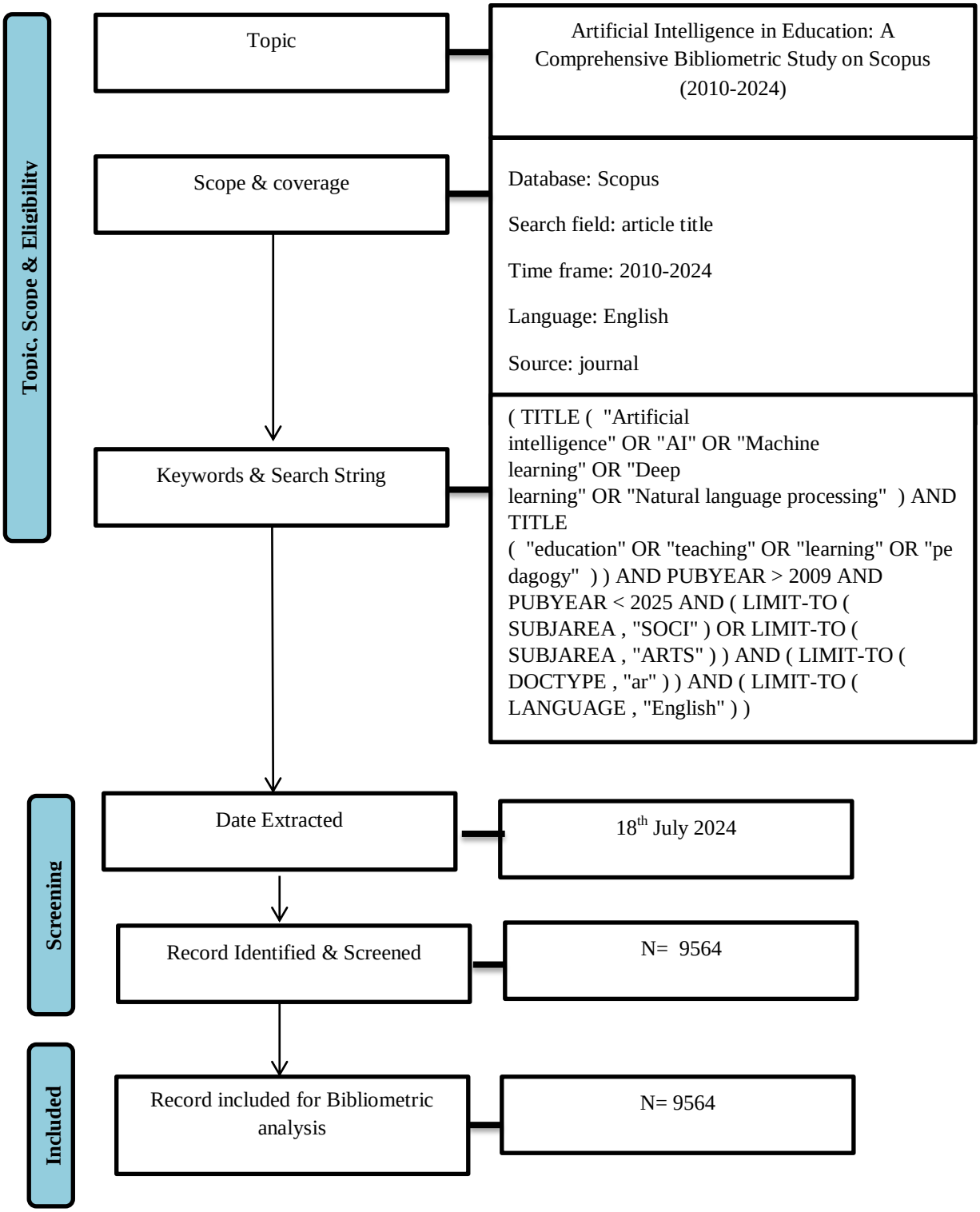


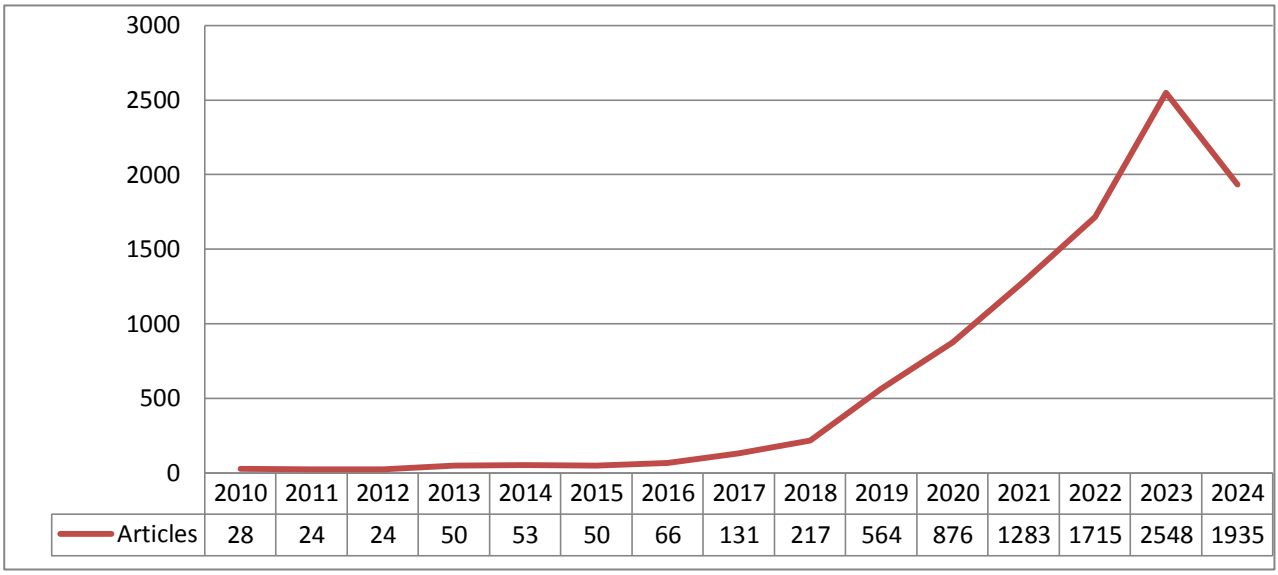
Figure1. The Search Strategy Flow Diagram: Adapted From (Kavitha et al., 2024, p. 1124)

Results

The study objectives obtained the following findings, shown in tables and figures.

Annual publication counts on the use of AI in education from 2010 to 2024

This paper presents the yearly number of publications focusing on using artificial intelligence in education from 2010 to 2024. This research examined the dissemination of papers in the Scopus database between 2010 and 2024. The results are shown in Figure Two:



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Articles	28	24	24	50	53	50	66	131	217	564	876	1283	1715	2548	1935

Figure2. Annual publication counts on the use of AI in education from 2010 to 2024.

Source: Elaborated by the author based on Scopus.

The publication trends on the use of AI in education from 2010 to 2024 reveal a remarkable and consistent upward trajectory. Beginning with a modest count of 28 articles in 2010, the field saw gradual growth in the early years, with annual publications staying below 70 until 2016. A notable surge began in 2017, followed by a significant rise in 2018 and a dramatic increase in 2019, where the number of articles more than doubled from the previous year. This upward momentum continued, peaking at 2,548 articles in 2023. The slight decline to 1,935 articles in 2024 may indicate the beginning of a stabilization phase in research output.

Several factors contribute to this exponential growth:

- Rapid advancements in AI technologies
- Increased recognition of AI's transformative potential in education
- Enhanced funding and policy support for AI research
- The accelerated adoption of AI-driven educational tools during the COVID-19 pandemic

These elements collectively underscore a robust and expanding research domain, reflecting technological progress and heightened academic and practical interest in AI applications within educational settings.

This trend analysis underscores the dynamic evolution of AI research in education, highlighting the field's transition from a nascent interest to a mature, high-impact study area. The data illustrate significant strides made over the past decade and emphasize the critical importance of continued investment and innovation in this transformative domain.

Subject Area Distribution on AI in education from 2010 to 2024

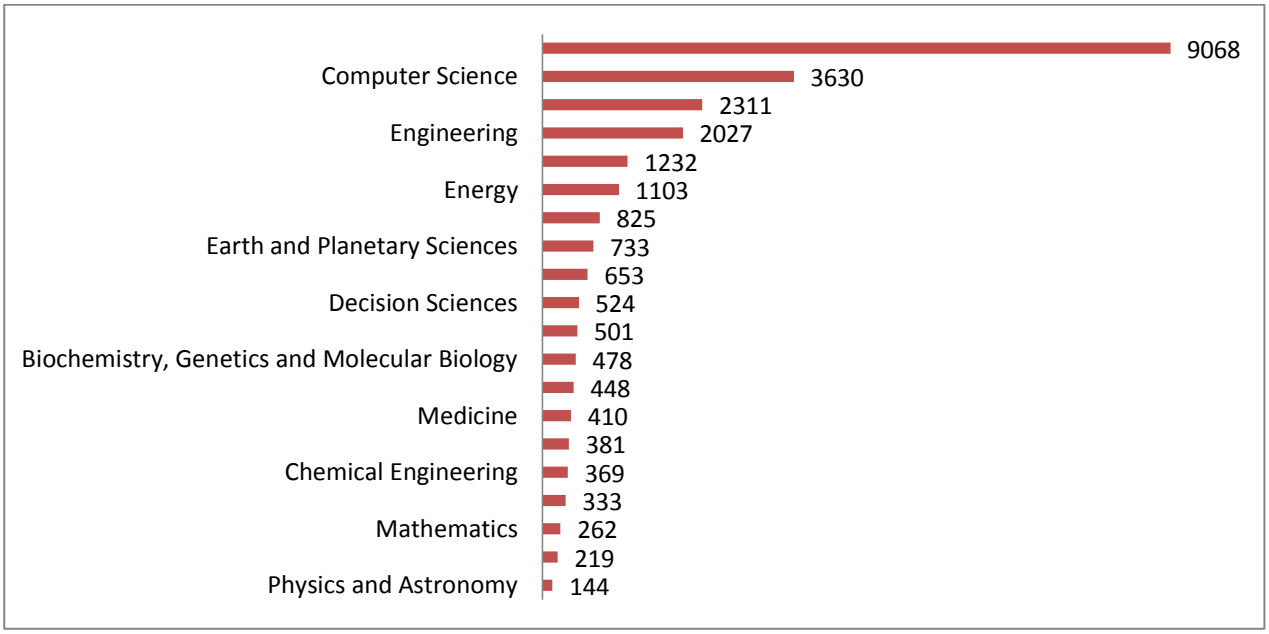


Figure3. Subject Area Distribution on AI in education from 2010 to 2024

Source: Elaborated by the author based on Scopus.

The distribution of papers on AI in education from 2010 to 2024 reveals significant interdisciplinary engagement, with Social Sciences leading at 35.35% (9068 papers), underscoring the focus on AI's impact on educational practices and societal implications. Computer Science follows with 14.15% (3630 papers), emphasizing the technical development of AI tools and algorithms for educational purposes. Environmental Science and Engineering contribute 9.01% (2311 papers) and 7.90% (2027 papers), respectively, reflecting AI's role in environmental education and the development of educational technologies. Arts and Humanities account for 4.80% (1232 papers), highlighting AI's integration into creative and humanities education. Energy, with 4.30% (1103 papers), shows interest in AI for promoting renewable energy education. Under-represented fields include Business, Management, and Accounting (3.22%, 825 papers), Earth and Planetary Sciences (2.86%, 733 papers), and Agricultural and Biological Sciences (2.55%, 653 papers), suggesting slower adoption of AI in these areas. Decision Sciences (2.04%, 524 papers), Chemistry (1.95%, 501 papers), and Biochemistry, Genetics, and Molecular Biology (1.86%, 478 papers) also demonstrate modest integration of AI. Psychology (1.75%, 448 papers) and Medicine (1.60%, 410 papers) indicate a growing interest in AI for personalized education and medical training. Niche fields such as Economics, Econometrics, and Finance (1.49%, 381 papers), Chemical Engineering (1.44%, 369 papers), and Mathematics (1.02%, 262 papers) reveal emerging engagement with AI. This comprehensive distribution highlights both the dominant and emerging fields in AI education research, pointing to areas ripe for further exploration and development.

Most relevant Authors in the domain of AI in education from 2010 to 2024

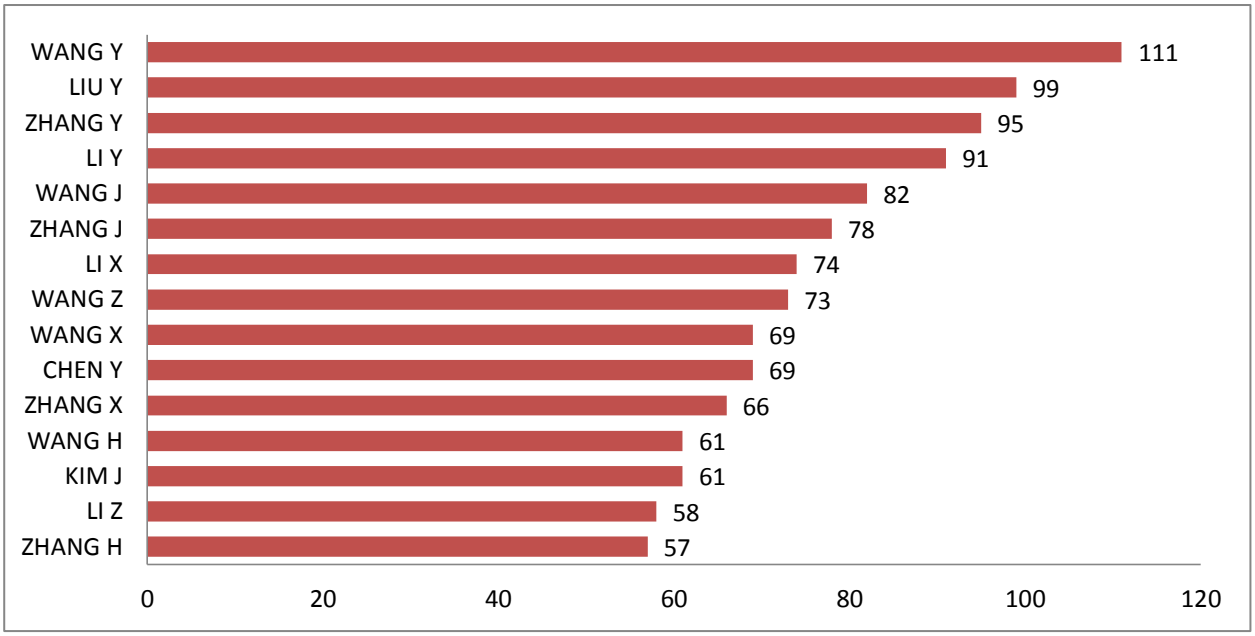


Figure 4.Most relevant Authors in the domain of AI in education from 2010 to 2024

Source: elaborated by the author based on Scopus

The provided table offers a comprehensive overview of the most prolific authors in the domain of AI in education, ranked by their number of published articles from 2010 to 2024. Leading the list is WANG Y, with an impressive contribution of 111 articles, underscoring their significant influence and sustained research activity in this burgeoning field. Following closely are LIU Y and ZHANG Y, with 99 and 95 articles respectively, highlighting their pivotal roles in advancing AI research in education. LI Y, with 91 articles, also demonstrates substantial engagement, while WANG J (82 articles) and ZHANG J (78 articles) showcase considerable contributions, reflecting collaborative efforts within the community. The recurrence of certain surnames, such as WANG, LI, and ZHANG, suggests common Chinese surnames in the dataset, indicating a strong representation of researchers from China. This is further evidenced by LI X (74 articles), WANG Z (73 articles), and CHEN Y (69 articles), pointing to a robust network of scholars contributing extensively to this domain. KIM J (61 articles) stands out as a significant contributor, likely from South Korea, indicating the international scope of AI in education research. This analysis not only highlights the high productivity of these authors but also underscores the prominent role of Chinese researchers, suggesting China as a leading country in AI education research. The table reflects the collaborative and international nature of AI research in education, providing valuable insights into the trends and developments driving this dynamic and rapidly evolving field.

Core journals by Brasford's Law

Bradford's Law is a bibliometric principle that describes the distribution of scientific articles across journals in a given field. It states that a small core of journals will contain a large proportion of the relevant articles, while the remaining articles are distributed across a larger

number of less prolific journals (Hjørland & Nicolaisen, 2005). The law is typically illustrated as follows:

1. **Core Zone**: A few journals publish a significant number of articles on a specific topic.
2. **Zone 2**: A moderate number of journals publish a moderate number of articles on the same topic.
3. **Zone 3**: A large number of journals publish a few articles on the topic.

Bradford's Law helps researchers identify the most influential journals in their field and is useful for library collection management and resource allocation.

Table1. *The distribution of journals by Brasford's Law*

Zone	Journals	%	Articles	%
Zone1(core)	18	1.09	3184	33.29
Zone2	166	10.10	3228	33.75
Zone3	1458	88.79	3152	32.95
Total	1642	100	9564	100

The analysis follows Bradford's Law, categorizing journals into three distinct zones to explain the distribution of AI research in education. Zone 1, the core zone, comprises a mere 18 journals (1.09% of the total), yet these journals account for an impressive 33.29% of all articles published in this field. Zone 2 encompasses 166 journals, representing 10.10% of the total, and contributes 33.75% of the articles. In stark contrast, Zone 3 includes the vast majority of journals, with 1,458 titles (88.79% of the total), but these publish only 32.95% of the articles. This distribution underscores the concentration of research output within a few core journals, highlighting their pivotal role in disseminating AI research in education. The dataset spans 1,642 journals and 9,564 articles, offering a comprehensive overview of the publication landscape in this domain.

Core Journals by Bradford's Law

Table2. *Core journals by Brasford's Law*

Journal Title	Rank	Freq	cumFreq	Zone
Sustainability (Switzerland)	1	756	756	Zone 1
Water (Switzerland)	2	388	1144	Zone 1
Journal of chemical information and modelling	3	341	1485	Zone 1
ISPRS International Journal of geo-information	4	179	1664	Zone 1
Artificial intelligence review	5	167	1831	Zone 1
International journal of scientific and technology research	6	153	1984	Zone 1
Education and information technologies	7	149	2133	Zone 1
Geocarto international	8	128	2261	Zone 1
Sustainable cities and society	9	121	2382	Zone 1
Building and environment	10	116	2498	Zone 1
Computers and Security	11	113	2611	Zone 1
Remote sensing applications: society and environment	12	107	2718	Zone 1
Foods	13	93	2811	Zone 1
Journal of the Acoustical Society of America	14	81	2892	Zone 1
Journal of cheminformatics	15	78	2970	Zone 1
International journal of emerging technologies in learning	16	76	3046	Zone 1

Sustainability (Switzerland)	17	69	3115	Zone 1
Transportation Research Part C: Emerging Technologies	18	69	3184	Zone 1

The Bradford's Law analysis reveals a clear hierarchy of core journals publishing on AI in education. Zone 1, comprising the top 16 journals, accounts for a significant proportion of the research output, highlighting their prominent role in disseminating knowledge in this field. Notably, the top three journals – Sustainability, Water, and the Journal of Chemical Information and Modeling – showcase the interdisciplinary nature of AI in education research, encompassing environmental, sustainability, and data science perspectives. Including journals like Artificial Intelligence Review, Education and Information Technologies, and the International Journal of Emerging Technologies in Learning underscores the central role of AI advancements and technological innovation in transforming educational practices. The emergence of journals dedicated to specific themes like sustainable cities and society and foods indicates a growing interest in exploring the application of AI in these contexts. This table provides a valuable starting point for researchers seeking to identify high-impact journals for their publications, ensuring maximum visibility and reach within the field.

Highly cited publications in the field of AI in education from Scopus between 2010 and 2024

Table3. *Highly cited publications in the field of AI in education*

N	Reference	Article title	Journal title	N of citations
01	(Burrell, 2016)	How the machine ‘thinks’: Understanding opacity in machine learning algorithms	Big Data and Society	1322
02	(Zhao et al., 2017)	LSTM network: A deep learning approach for Short-term traffic forecast	IET Intelligent Transport Systems	1305
03	(Polson & Sokolov, 2017)	Deep learning for short-term traffic flow prediction	Transportation Research Part C: Emerging Technologies	757
04	(Lee et al., 2018)	Speeding Up Distributed Machine Learning Using Codes	IEEE Transactions on Information Theory	574
05	(Wu et al., 2018)	A hybrid deep learning-based traffic flow prediction method and its understanding	Transportation Research Part C: Emerging Technologies	561
06	(Ke et al., 2017)	Short-term forecasting of passenger demand under on-demand ride services: A spatiotemporal deep learning approach	Transportation Research Part C: Emerging Technologies	536
07	(Popenici & Kerr, 2017)	Exploring the impact of artificial intelligence on teaching and learning in higher education	Research and Practice in Technology Enhanced Learning	497
08	(Nguyen et al., 2019)	Machine Learning and Deep Learning frameworks and libraries for large-scale data mining: a survey	Artificial Intelligence Review	491
09	(Yadav & Vishwakarma, 2020)	Sentiment analysis using deep learning architectures: a review	Artificial Intelligence Review	465
10	(Lusci et al., 2013)	Deep architectures and deep learning in chemoinformatics: The prediction of aqueous solubility for drug-like molecules	Journal of Chemical Information and Modeling	422

This bibliometric analysis explores the most influential publications on the application of AI in education from 2010 to 2024, using citation data from Scopus. Our investigation reveals critical

research trends and seminal contributions that are significantly shaping the field. Leading with 1322 citations, (Burrell, 2016) addresses the opacity of machine learning algorithms in "Big Data and Society," emphasizing transparency challenges.

Zhao et al. (2017) and Polson and Sokolov (2017), cited 1305 and 757 times, respectively, highlight the critical role of deep learning in traffic prediction (Lee et al., 2018), with 574 citations, advanced distributed machine learning in "IEEE Transactions on Information Theory." Wu et al. (2018) and Ke et al. (2017) further explore hybrid deep learning techniques for traffic flow and passenger demand forecasting, earning 561 and 536 citations. Popenici and Kerr (2017) underscore AI's impact on higher education, cited 497 times, while (Nguyen et al., 2019) survey machine learning frameworks, reflecting their utility in large-scale data mining with 491 citations. Yadav and Vishwakarma (2020) reviewed deep learning architectures for sentiment analysis, receiving 465 citations. Lusci et al., 2013 apply deep learning in chemoinformatics for predicting aqueous solubility, with 422 citations. These publications exemplify the multidisciplinary nature of AI research, from traffic forecasting to educational impacts, and highlight the evolution and influence of AI methodologies. The high citation counts attest to these studies' pivotal role in advancing AI applications and guiding future research.

Most relevant countries in AI research in education from 2010 to 2024

The following figure and table illustrate, based on data from Scopus, the most relevant countries contributing to AI research in education from 2010 to 2024.

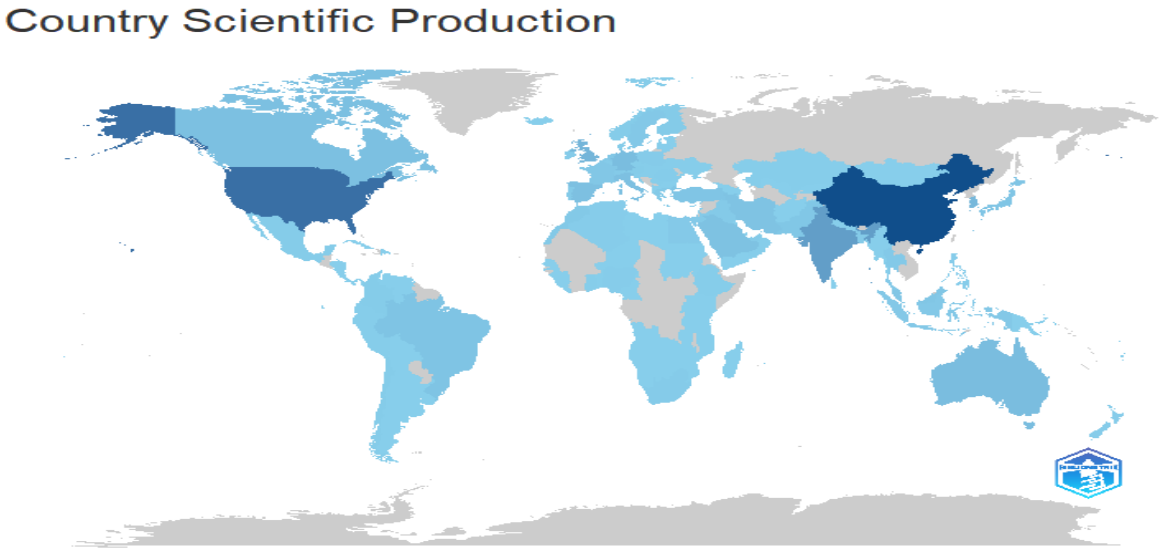


Figure7. Most relevant countries in AI research in education.
Source: Elaborated by the author based on Scopus using Bibliometrix

Table4. *Most relevant countries in AI research in education*

Region	Articles	Citation
China	8116	30248
USA	5890	25534
India	2909	8552
UK	1465	7135

South Korea	1277	5064
Germany	1014	4841
Australia	1008	6214
Canada	825	3573
Italy	820	2455
Spain	818	2491

Source: Elaborated by the author based on Scopus using Bibliometrics

This global analysis examines the leading countries in AI research in education from 2010 to 2024. China emerges as the top contributor with 8116 articles and 30248 citations, highlighting its dominant role and substantial impact. The United States follows with 5890 articles and 25534 citations, reflecting significant contributions and high influence. India ranks third with 2909 articles and 8552 citations, indicating robust research output but lower citation impact. The United Kingdom, with 1465 articles and 7135 citations, maintains a strong presence. South Korea and Germany, with 1277 and 1014 articles and 5064 and 4841 citations respectively, show active participation and moderate influence. This analysis underscores China's leadership, followed by the USA, with significant contributions from other countries. The variation in citation counts reflects differing levels of impact and global recognition.

Keyword analysis of AI research in education from 2010 to 2024

Table 5. *Keyword analysis of AI research in education from 2010 to 2024*

N	Words	Occurrences	N	Words	Occurrences
01	machine learning	4350	11	artificial neural network	530
02	deep learning	1950	12	Humans	437
03	learning systems	1204	13	Article	394
04	machine-learning	985	14	decision trees	389
05	Algorithm	854	15	China	367
06	Forecasting	852	16	support vector machines	339
07	artificial intelligence	712	17	regression analysis	327
08	learning algorithms	645	18	machine learning models	326
09	Human	619	19	classification (of information)	291
10	Prediction	554	20	decision making	290

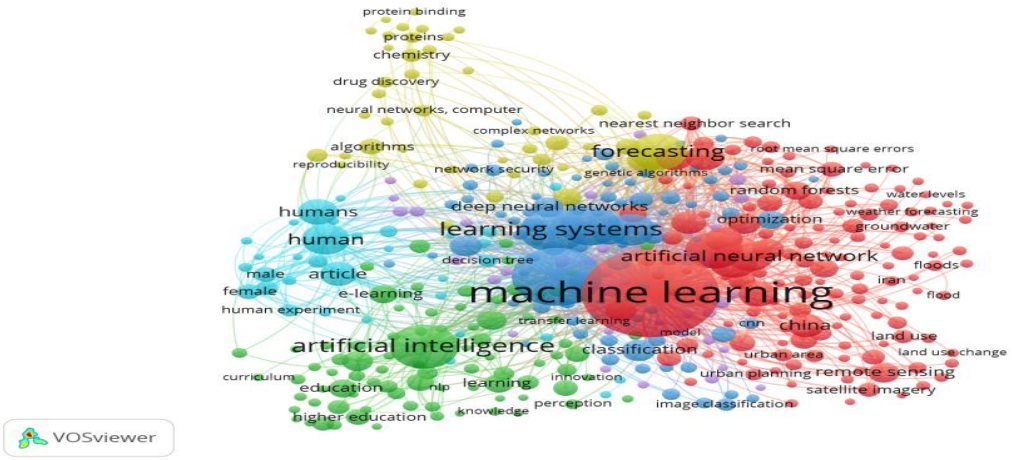


Figure 8. Keyword analysis of AI research in education from 2010 to 2024
Source: Elaborated by the author based on Scopus using Vosviewer

This keyword analysis of AI research in education from 2010 to 2024 highlights the most frequently occurring terms, underscoring key themes and trends. "Machine learning" leads with 4350 occurrences, emphasizing its centrality in AI research. "Deep learning" (1950 occurrences) and "learning systems" (1204 occurrences) reflect the significant interest in advanced neural network methodologies and adaptive learning processes. The prominence of "algorithm" (854 occurrences) and "forecasting" (852 occurrences) underscores the importance of predictive modeling and optimization in educational AI applications. "Artificial intelligence" (712 occurrences) and "learning algorithms" (645 occurrences) indicate a broad and specific focus on AI technologies and their development. Human-centric terms like "human" (619 occurrences) and "decision making" (290 occurrences) highlight the role of human interaction and the impact of AI on decision processes. "Artificial neural network" (530 occurrences) and "support vector machines" (339 occurrences) are essential machine learning techniques frequently referenced. "China" (367 occurrences) suggests significant contributions from this region. The analysis reveals a strong emphasis on developing and applying AI methods to predict and enhance educational outcomes, with a clear focus on technical advancements and human-centric research. This comprehensive keyword analysis provides valuable insights into the evolving landscape of AI in education, reflecting its multidisciplinary nature and global reach.

Discussion

The current study significantly enhances the scientific literature on the use of AI in education, showing a consistent upward trajectory in AI publications from 2010 to 2024, with a peak in 2023 and a slight decline in 2024, indicating a potential stabilization phase. The leading contributors to AI education research include authors WANG Y, LIU Y, and ZHANG Y, with core journals such as "Sustainability" and "Journal of Chemical Information and Modeling" playing crucial roles. China leads in global contributions, followed by the USA and India, reflecting significant national investment and leadership. The key themes identified are "machine learning," "deep learning," and "learning systems," with Social Sciences being the most engaged discipline at 35.35%, followed by Computer Science and Environmental Science. The findings highlight AI's transformational potential in education and underscore the need for continued research, interdisciplinary collaboration, and consideration of ethical implications.

***Publication Trends**:* The analysis reveals a consistent upward trajectory in AI publications within education, peaking in 2023 with 2,548 articles. The early years (2010-2016) showed modest growth, with significant increases starting in 2017. However, a slight decline to 1,935 articles in 2024 suggests a potential stabilization phase. These findings are consistent with Kavitha et al. (2024), who also reported significant growth in the frequency of publications in this study area.

***Interdisciplinary Engagement**:* Social Sciences dominate AI education research at 35.35%, followed by Computer Science (14.15%), Environmental Science (9.01%), and Engineering (7.90%). Fields like Business (3.22%) and Medicine (1.60%) remain underrepresented, indicating potential areas for further exploration.

***Prolific Authors and Institutions**:* Leading contributors include WANG Y (111 articles), LIU Y (99 articles), and ZHANG Y (95 articles).

***Core Journals**:* Key journals such as Sustainability, Water, and the Journal of Chemical Information and Modeling play crucial roles in disseminating interdisciplinary research, emphasizing the centrality of AI advancements.

***Influential Publications**:* Notable studies include (Burrell, 2016) on algorithm transparency, Zhao et al. (2017) and Polson and Sokolov (2017) on deep learning in traffic prediction, and (Lee et al., 2018) on distributed machine learning.

***Global Contributions**:* China leads with 8116 articles and 30248 citations, followed by the USA and India. These observations align with findings by Kavitha et al. (2024) and Ivanova et al. (2024), identifying China and the US as the most influential countries in AI education research.

Keyword Analysis and Trends: The keyword analysis of AI research in education from 2010 to 2024 reveals that "machine learning" is the most frequently cited term, followed by "deep learning" and "learning systems," indicating a focus on advanced AI techniques. This emphasizes the field's strong interest in sophisticated algorithms and adaptive learning processes. Additionally, the prominence of human-centric terms and the mention of "China" suggest significant contributions from this region and highlight the importance of integrating AI with human interaction and decision-making.

The findings demonstrate rapid and sustained growth in AI research within education, driven by the increasing recognition of AI's transformative potential. The broad interdisciplinary engagement underscores AI's applicability across various fields, suggesting a holistic approach to its integration in educational contexts. The significant contributions from Chinese researchers reflect substantial national investment and leadership in AI research.

These results align with previous studies highlighting the exponential growth of AI research in education and China's prominent role. For instance, Prahani et al. (2022) noted China's dominance in AI education research, corroborating our findings of China's leading article count and citation impact. Furthermore, the interdisciplinary nature of AI research, as discussed by Liu et al. (2024) and Li and Wong (2023), is consistent with our observations of significant engagement from diverse fields like Social Sciences, Computer Science, and Environmental Science.

Despite providing a comprehensive overview, the study is limited by its reliance on publication and citation data, which may not fully capture the qualitative impact of the research. The slight decline in publications in 2024 may not necessarily indicate stabilization

but could be influenced by external factors such as publication delays or shifts in research focus.

Future research should explore:

- Assess the qualitative impact of AI research on educational practices and outcomes.
- Conduct longitudinal studies to track AI applications' long-term effects and sustainability in education.
- Promote international collaborations to leverage diverse perspectives and address global educational challenges using AI.
- Examine the ethical implications of AI in education, including issues related to data privacy, algorithmic bias, and the digital divide.

This discussion highlights the dynamic and evolving landscape of AI in education, emphasizing the need for continued research and collaboration to fully realize the potential of AI technologies in transforming educational practices.

Conclusion

This study comprehensively examines the evolution and impact of Artificial Intelligence (AI) research within the education sector, offering valuable insights into the field's dynamic growth and interdisciplinary engagement. Our analysis reveals a significant upward trajectory in AI-related publications, culminating in a peak of 2,548 articles in 2023. The overall trend underscores the increasing importance and relevance of AI in educational research.

The data highlights a predominant focus on Social Sciences, with notable contributions from Computer Science, Environmental Science, and Engineering. Fields such as Business and Medicine still need to be explored, presenting opportunities for future research. Leading contributors include prominent researchers such as WANG Y, LIU Y, and ZHANG Y, driving significant advancements in the field.

Key journals such as *Sustainability*, *Water*, and the *Journal of Chemical Information and Modeling* are pivotal in disseminating interdisciplinary research, emphasizing AI's central role in shaping educational practices. Influential studies on algorithm transparency and deep learning further illustrate the breadth and impact of AI research.

China's leadership in AI research is evident, with the highest number of publications and citations, reflecting substantial national investment and leadership. This aligns with previous findings highlighting China's prominence in AI education research. The interdisciplinary nature of AI research, observed in this study, reinforces the applicability of AI across diverse fields and supports a holistic approach to its integration in educational contexts.

Despite these contributions, the study is constrained by its reliance on publication and citation data, which may not fully capture the qualitative impact of AI research. The observed decline in publication volume for 2024 may be attributed to external factors such as publication delays or shifts in research focus rather than an actual stabilization trend.

In conclusion, this study highlights AI research's rapid and sustained growth in education and the significant role of key contributors and interdisciplinary engagement. Continued research and collaboration are essential to fully leverage AI's transformative potential in educational settings and address emerging challenges and opportunities.

About the Author

Samira GUECHAIRI Graduated from the University of Algiers 2 Abou El Kacem Saâdallah, Algeria. She is currently a lecturer in Library and Information Science at the University of Blida 2 Lounici Ali, Algeria. She has participated in numerous national and international conferences and has published in high-quality journals.ORCID: 0000-0002-7680-8925

Declaration of AI Refined

This research paper has undergone language correction using AI-powered tools, specifically, Grammarly and QuillBot, to correct address grammatical, spelling, and stylistic errors. It is acknowledged that the use of such tools may introduce standardised patterns typical of AI-generated content. Consequently, a certain percentage of content may reflect AI- AI-generated language structures. Yet, the intellectual content and the analysis remain entirely the work of the authors.

Statement of Absence of Conflict of Interest

The authors mentioned above hereby solemnly declare that they are not and shall not be in any situation that could give rise to a conflict of interest in what concerns the findings and recommendations contained in this academic article.

References

Ahmad et al. (2023). Data-Driven Artificial Intelligence in Education: A Comprehensive Review. *IEEE Transactions on Learning Technologies, 17,* 12–31. https://doi.org/10.1109/TLT.2023.3314610

Akhmadieva, R. S. et al. (2023). Artificial intelligence in science education: A bibliometric review. *Contemporary Educational Technology*, *15*(4), ep460. https://doi.org/10.30935/cedtech/13587

AlKanaan, H. M. N. (2022). Awareness Regarding the Implication of Artificial Intelligence in Science Education among Pre-Service Science Teachers. *International Journal of Instruction, 15*(3), 895–912.

UNESCO, & International Conference on Artificial Intelligence and Education, P. E. in the A. E. L. the L. (2019). *Beijing Consensus on Artificial Intelligence and Education*. https://unesdoc.unesco.org/ark:/48223/pf0000370967?posInSet=2&queryId=N-EXPLORE-a14d39fa-4452-4248-b486-ce88899e2b6e

Bircan and Salah (2022). A Bibliometric Analysis of the Use of Artificial Intelligence Technologies for Social Sciences. *Mathematics*, *10*(23), Article 23. https://doi.org/10.3390/math10234398

Burrell, J. (2016). How the machine 'thinks': Understanding opacity in machine learning algorithms. In *Big Data and Society* (Vol. 3, Issue 1). https://doi.org/10.1177/2053951715622512

Chen et al. (2020). Artificial Intelligence in Education: A Review. *IEEE Access, 8,* 75264–75278. https://doi.org/10.1109/ACCESS.2020.2988510

Donthu et al. 2021. How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research, 133,* 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Hjørland & Nicolaisen, 2005. Bradford's Law of Scattering: Ambiguities in the Concept of "Subject". In F. Crestani & I. Ruthven (Eds.), *Context: Nature, Impact, and Role* (Vol. 3507, pp. 96–106). Springer Berlin Heidelberg. https://doi.org/10.1007/11495222_9

Ivanova et al. (2024). Unveiling Insights: A Bibliometric Analysis of Artificial Intelligence in Teaching. *Informatics*, *11*(1), 10. https://doi.org/10.3390/informatics11010010

Jaleniauskienė et al. (2023). Artificial Intelligence in Language Education: A Bibliometric Analysis. *Sustainable Multilingualism*, *23*(1), 159–194. https://doi.org/10.2478/sm-2023-0017

Jammeli et al. (2024). The Impact of AI Tools in the Education Environment. *Int. Conf. Inf. Educ. Technol., ICIET*, 208–214. https://doi.org/10.1109/ICIET60671.2024.10542830

Kaban, A. (2023). Artificial Intelligence in Education: A Science Mapping Approach. *International Journal of Education in Mathematics, Science and Technology*, *11*(4), Article 4. https://doi.org/10.46328/ijemst.3368

Kavitha et al. (2024). Artificial Intelligence in Higher Education: A Bibliometric Approach. *European Journal of Educational Research*, *13*(3), 1121–1137. https://doi.org/10.12973/eu-jer.13.3.1121

Ke et al., (2017). Short-term forecasting of passenger demand under on-demand ride services: A spatio-temporal deep learning approach. In *Transportation Research Part C: Emerging Technologies* (Vol. 85, pp. 591–608). https://doi.org/10.1016/j.trc.2017.10.016

Lee, K., et al., (2018). Speeding Up Distributed Machine Learning Using Codes. In *IEEE Transactions on Information Theory* (Vol. 64, Issue 3, pp. 1514–1529). https://doi.org/10.1109/TIT.2017.2736066

Li, K. C., & Wong, B. T.-M. (2023). Artificial intelligence in personalised learning: A bibliometric analysis. *Interactive Technology and Smart Education*, *20*(3), 422–445. https://doi.org/10.1108/ITSE-01-2023-0007

Liu, J. et al. (2024). A bibliometric analysis of generative AI in education: Current status and development. *Asia Pacific Journal of Education*, *44*(1), 156–175. https://doi.org/10.1080/02188791.2024.2305170

Lusci et al., 2013. Deep architectures and deep learning in chemoinformatics: The prediction of aqueous solubility for drug-like molecules. *Journal of Chemical Information and Modeling*, *53*(7), 1563–1575. https://doi.org/10.1021/ci400187y

Maphosa, V., & Maphosa, M. (2021). The Trajectory of Artificial Intelligence Research in Higher Education: A Bibliometric Analysis and Visualisation. *2021 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD)*, 1–7. https://doi.org/10.1109/icABCD51485.2021.9519368

Metli, A. (2023). Articles on Education and Artificial Intelligence: A Bibliometric Analysis. *Journal of Social Sciences And Education*, *6*(Education Special Issue), Article Education Special Issue. https://doi.org/10.53047/josse.1352197

Mongeon, P., & Paul-Hus, A. (2016). The journal coverage of Web of Science and Scopus: A comparative analysis. *Scientometrics*, *106*(1), 213–228. https://doi.org/10.1007/s11192-015-1765-5

Murphy, R. F. (2019). *Artificial Intelligence Applications to Support K–12 Teachers and Teaching: A Review of Promising Applications, Challenges, and Risks*. RAND Corporation. https://www.rand.org/pubs/perspectives/PE315.html

Nguyen, G. et al. (2019). Machine Learning and Deep Learning frameworks and libraries for large-scale data mining: A survey. *Artificial Intelligence Review*, *52*(1), 77–124. https://doi.org/10.1007/s10462-018-09679-z

Polson, N. G., & Sokolov, V. O. (2017). Deep learning for short-term traffic flow prediction. In *Transportation Research Part C: Emerging Technologies* (Vol. 79, pp. 1–17). https://doi.org/10.1016/j.trc.2017.02.024

Popenici, S. A. D., & Kerr, S. (2017). Exploring the impact of artificial intelligence on teaching and learning in higher education. In *Research and Practice in Technology Enhanced Learning*, *12*(1),p.1-13. https://doi.org/10.1186/s41039-017-0062-8

Prahani et al. (2022). Artificial Intelligence in Education Research During the Last Ten Years: A Review and Bibliometric Study. *International Journal of Emerging Technologies in Learning*, *17*(8), 169–188. https://doi.org/10.3991/ijet.v17i08.29833

Qi, B. W. (2019). Analysis of the Application of Artificial Intelligence in the Classroom. Journal of Physics: Conference Series, *1345*(4). https://doi.org/10.1088/1742-6596/1345/4/042075

Saputra et al., (2023). Integration of Artificial Intelligence in Education: Opportunities, Challenges, Threats and Obstacles. A Literature Review. *Indonesian Journal of Computer Science*, *12*. https://doi.org/10.33022/ijcs.v12i4.3266

Sysoyev, P. V. (2023). Artificial Intelligence in Education: Awareness, Readiness and Practice of Using Artificial Intelligence Technologies in Professional Activities by University Faculty. *Vysshee Obrazovanie v Rossii*, *32*(10), 9–33. https://doi.org/10.31992/0869-3617-2023-32-10-9-33

Talan, T. (2021). Artificial Intelligence in Education: A Bibliometric Study. *International Journal of Research in Education and Science*, *7*(3), Article 3. https://doi.org/10.46328/ijres.2409

Triansyah et al. (2023) . Bibliometric Analysis: Artificial Intelligence (AI) in High School Education. *Jurnal Imiah Pendidikan Dan Pembelajaran*, *7*(1), 112–123. https://doi.org/10.23887/jipp.v7i1.59718

Wu et al. (2018). A hybrid deep learning based traffic flow prediction method and its understanding. In *Transportation Research Part C: Emerging Technologies* (Vol. 90, pp. 166–180). https://doi.org/10.1016/j.trc.2018.03.001

Yadav, A., & Vishwakarma, D. K. (2020). Sentiment analysis using deep learning architectures: A review. In *Artificial Intelligence Review* (Vol. 53, Issue 6, pp. 4335–4385). https://doi.org/10.1007/s10462-019-09794-5

You et al. (2022). Deep Learning Based a Novel Method of Classroom Behavior Recognition. IEEE 2nd International Conference on Educational Technology, *ICET*, 155–159. https://doi.org/10.1109/ICET55642.2022.9944414

Zhang, K., & Aslan, A. B. (2021). AI technologies for education: Recent research & future directions. *Computers and Education: Artificial Intelligence*, *2*, 100025. https://doi.org/10.1016/j.caeai.2021.100025

Zhao, Z. et al. (2017). LSTM network: A deep learning approach for Short-term traffic forecast. In *IET Intelligent Transport Systems*, *11*(2), 68–75. https://doi.org/10.1049/iet-its.2016.0208

Zhu, Y., Yang, Q., & Mao, X. (2023). Global Trends in the Study of Smart Healthcare Systems for the Elderly: Artificial Intelligence Solutions. *International Journal of Computational Intelligence Systems*, *16*(1), 105. https://doi.org/10.1007/s44196-023-00283-w

Zupic, I., & Čater, T. (2015). Bibliometric Methods in Management and Organization. *Organizational Research Methods*, *18*(3), 429–472. https://doi.org/10.1177/1094428114562629

Cite as

Guechairi, S. (2024). Artificial Intelligence in Education: A Comprehensive Bibliometric Study on Scopus (2010-2024). *Atras Journal*, *5*(Special Issue), 445-463.