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# From algorithms to classrooms: a decade of artificial intelligence in education research

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**ABSTRACT**

The education industry has seen a substantial transformation thanks to artificial intelligence (AI), which has improved administrative effectiveness, accessibility, and individualized learning. However, issues like moral dilemmas, digital justice, and policy inconsistencies still exist. From 2015 to 2024, this bibliometric research explores how AI is revolutionizing education. Personalized learning, improved accessibility, and expedited administrative procedures have all been made possible by AI; yet, issues with cost, digital equity, and ethics still exist. We used the Web of Science (WoS) database to conduct a comprehensive bibliometric analysis of 291 peer-reviewed articles that were indexed in the Social Sciences Citation Index (SSCI). The PRISMA methodology was used in the study to find and filter pertinent material. Thematic trends, citation patterns, and co-authorship networks were examined using bibliometric tools like VOSviewer. The progress of generative AI tools like ChatGPT, the importance of AI in democratizing education, and the integration of AI into curriculum building are some of the key discoveries. The report identifies significant nations, organizations, and researchers in AI education and emphasizes global research relationships. Our research raises ethical governance issues while shedding light on AI's potential to promote individualized learning and increase student engagement. These findings support sustainable development goal (SDG) 4 on quality education by highlighting the need for responsible AI use to address the digital divide. This paper offers useful suggestions for academics, educators, and legislators to maximize AI's promise while tackling its drawbacks.



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## 1. INTRODUCTION

Artificial intelligence (AI) has become a disruptive force in education, changing how teachers and students learn. Institutions around the world can implement AI-powered tools to improve accessibility for students with different needs, automate administrative tasks, and create personalized learning experiences [1].

AI gives teachers insights into student performance through real-time analysis of massive amounts of data, allowing for prompt interventions and the creation of a more inclusive learning environment [2]. According to Zhou [3], adaptive learning platforms, for example, customize instructional materials to meet the needs of each individual student, allowing them to advance at their own speed and get focused assistance when needed. This change not only improves academic results but also frees up teachers to concentrate on more important facets of instruction, like encouraging creativity and critical thinking [4].

The application of AI in education is not without difficulties, despite its enormous potential. The ethical ramifications of data security and privacy are one major worry [5]. To work efficiently, AI systems need access to large volumes of personal data, which raises concerns about how this data is shared, stored, and safeguarded [6]. A further obstacle is the expense of deploying AI technologies, especially for underfunded educational institutions in developing nations [7]. Additionally, the use of AI tools runs the risk of causing a digital divide, which could further disadvantage students and schools with less access to technology [8]. There is also skepticism regarding the dehumanization of education, as detractors contend that an over-reliance on AI may undermine the essential human bond between educators and learners [1]. Careful planning, strong policies, and a dedication to guaranteeing fair access for all students are necessary to address these issues.

The introduction of generative AI has further transformed education by providing previously unheard-of chances for creativity and participation [9]. Students and teachers can now create content, solve challenging problems, and experiment with new teaching techniques thanks to tools like ChatGPT and other AI-driven platforms [3]. By removing barriers related to geography and socioeconomic status, these technologies have democratized access to high-quality education [10]. For example, learners can now learn new skills from almost anywhere in the world thanks to AI-driven language learning apps, virtual tutors, and immersive simulations [5]. Education is now more scalable and efficient thanks to the simplification of procedures brought about by the incorporation of AI into curriculum development and assessment [4]. AI enables teachers to devote more time to interactive and value-driven teaching activities by automating repetitive tasks like feedback and grading [11].

It is impossible to overestimate how AI will influence education in the future. AI is positioned to tackle important global issues like the need for lifelong learning and the upskilling of a workforce in the face of rapid technological advancements as technology continues to advance. Platforms for AI-driven learning could provide learners of all ages with tailored content, encouraging a lifelong learning culture [12]. Additionally, a change from traditional rote learning to more experiential and collaborative approaches will be made possible by the anticipated innovations in pedagogical practices brought about by the integration of AI in education [13]. Policymakers and leaders in education must now concentrate on developing frameworks that maximize AI's advantages while reducing its risks [14]. This study is significant in identifying research gaps, informing future AI policy and practice, and contributing to discussions on ethical AI integration in education [15].

In contrast to earlier reviews, this study gives empirical insights into the changing field of AI in education by using bibliometric tools to map AI research trends in a comprehensive manner. Using topic clustering and network visualization, this study offers a thorough examination of the research history of AI and identifies areas that need further scholarly attention. This work is distinctive because it employs an integrated bibliometric methodology that critically integrates new trends like digital equity and generative AI with sustainable development goal (SDG) 4 and policy consequences, while mapping the research performance and thematic evolution of AI in education over a ten-year period (2015–2024). This study combines empirical trends with global educational priorities in a comprehensive, data-driven manner, unlike previous fragmented assessments. Additionally, it offers a strategic roadmap for future study, policy, and practice in AI-enhanced learning environments. The objectives of the study align with the specific bibliometric analyses and are as: i) to identify the main research trends and themes in AI education from 2015 to 2024; ii) to analyze key contributors, institutions, and collaborations in the field; and iii) to assess the impact of AI in education and its future implications.

## 2. METHOD

Bibliometric analysis, which methodically looks at the influence and patterns within a particular field of study, is a crucial tool for comprehending the state of academic research [16]. It gives researchers the ability to pinpoint important works, significant figures, and new trends, giving them a thorough picture of the discipline's intellectual framework [17]. When it comes to AI in education, bibliometric analysis provides important information about how the field has changed over time, which areas have attracted the most interest, and potential directions for future research [18]. According to Jaleniauskienė *et al.* [19], bibliometric analysis helps stakeholders make strategic decisions for research and development by measuring academic output and influence and evaluating the importance of contributions.

Performance analysis is a key element of bibliometric research that quantifies the productivity and impact of scholarly works. It evaluates authors, journals, and organizations' contributions and provides data on the most significant and influential research on a given subject [20]. The identification of leading researchers and institutions that advance the field is facilitated by performance analysis for AI in education [21]. Scholars can use it to find trustworthy sources, investigate possible collaborations, and comprehend the global production of knowledge [22]. It also looks at geographic trends in research contributions and identifies high-impact papers [23].

The results of this bibliometric study provide in-depth understandings of the key texts, writers, and organizations influencing the conversation about AI in education. Citation-based rankings that highlight the best sources and nations that have made major contributions to the field will be produced by the analysis [24]. The collaborative relationships between researchers and institutions will be depicted through visualization outputs like citation networks and co-authorship maps [18]. A roadmap for further research will be provided by these outputs, which will also highlight important themes and new trends [17]. Furthermore, the results will be a useful tool for stakeholders, allowing them to identify important players, rank funding priorities, and promote global cooperation [21]. In the end, the bibliometric analysis will help us comprehend how AI is changing education better and direct our efforts to optimize its potential for societal good [20].

### 2.1. Search string

The search strategy for conducting the bibliometric analysis on AI in education has been carefully designed to ensure a systematic and targeted approach. The analysis in Table 1 focuses on the Web of Science (WoS) database, a highly reputable platform for indexing quality research [21]. The selected time frame for the study spans from 2015 to 2024, capturing significant advancements and increasing scholarly interest in AI applications in education over the past decade [22]. To enhance precision, the search targets the title (TI) field, ensuring that only articles explicitly addressing AI in educational contexts are included. The search keywords combine terms such as "artificial intelligence" OR "AI" with "educat*" (a truncated form encompassing words like education, educational, and educating), allowing for a comprehensive retrieval of relevant literature [18].

Table 1. Inclusion criteria for bibliometric analysis

| WoS database | ALL |
|---|---|
| Time period | 2015 to 2024 |
| Search field | TI |
| Search keywords | "artificial intelligence" OR "AI" AND "educat*" |
| Document type | Article |
| Language | English |
| Open access | All open access |
| WoS index | Social Sciences Citation Index (SSCI) |

The study excludes alternative formats like conference proceedings or reviews and solely covers papers, concentrating on peer-reviewed research. In keeping with the language of scholarly communication, the study is also restricted to English-language publications [25]. Every open-access paper is taken into account, guaranteeing that the chosen studies are publicly available to the scientific community. To guarantee that the analysis includes credible and high-impact research in the social sciences and education domains, the search is further narrowed to only include papers listed in the Social Sciences Citation Index (SSCI) [26]. This clear inclusion strategy guarantees a thorough, targeted, and rigorous bibliometric study. The analysis offers important insights into significant research trends, seminal papers, and developing themes in AI applications for education by focusing on high-caliber, open-access literature from the last ten years [18]. A strong basis for comprehending the evolution of the discipline and pinpointing important areas for further study is provided by the methodical approach, which also increases the findings' dependability and usefulness.

The PRISMA methodology was employed to ensure a rigorous and transparent filtering process. Initially, 3,017 records were retrieved from the WoS database. The first stage involved filtering by publication year (2015–2024), reducing the dataset to 2,888 records. Next, only open-access, English-language, peer-reviewed journal articles were retained (1,714 records). Further refinement was conducted by excluding non-SSCI-indexed articles, yielding a final selection of 291 articles. The PRISMA flowchart, as shown in Figure 1, visually represents this selection process. This methodology ensures that only high-impact and rigorously vetted research is analyzed in this study. The analysis involved citation mapping, co-occurrence analysis, and network visualization using VOSviewer.

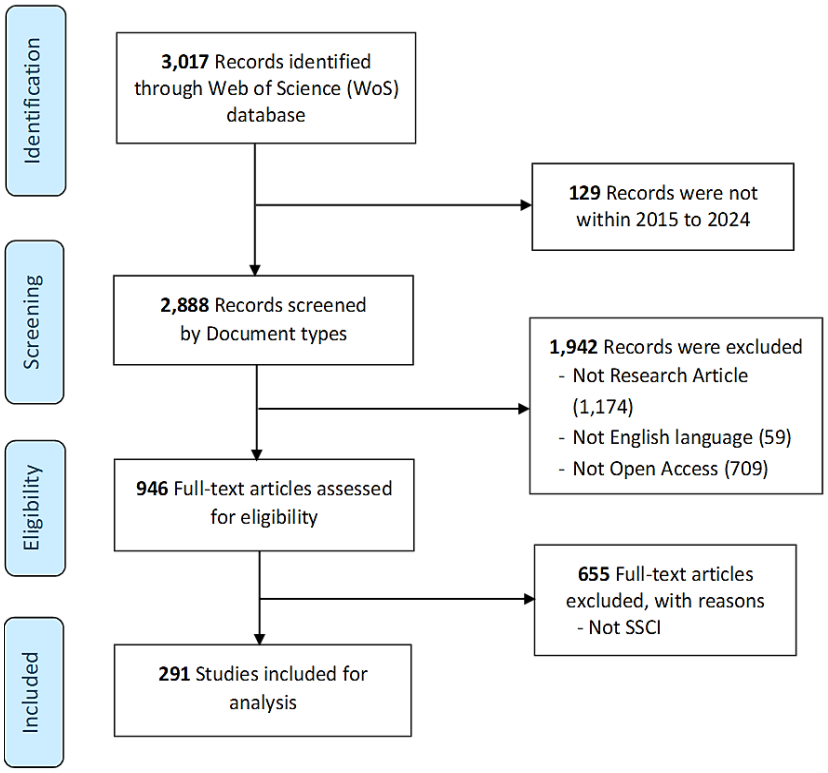


Figure 1. PRISMA flowchart

## 3. RESULTS AND DISCUSSION

These techniques helped identify the most influential research clusters, thematic patterns, and potential research gaps within the field. Additionally, performance analysis of top-cited documents provided insights into the evolution of AI education research over time. The number of papers and citations during the 2015-2024 timeframe shows consistent development, highlighting the growing interest of academics in the relationship between AI and education. The results in Figure 2 demonstrate not only the amount of research but also its tremendous influence and prominence in scholarly circles. All things considered, the information highlights the applicability and expanding impact of AI as a revolutionary instrument in education, opening the door for more research into its potential uses and difficulties.

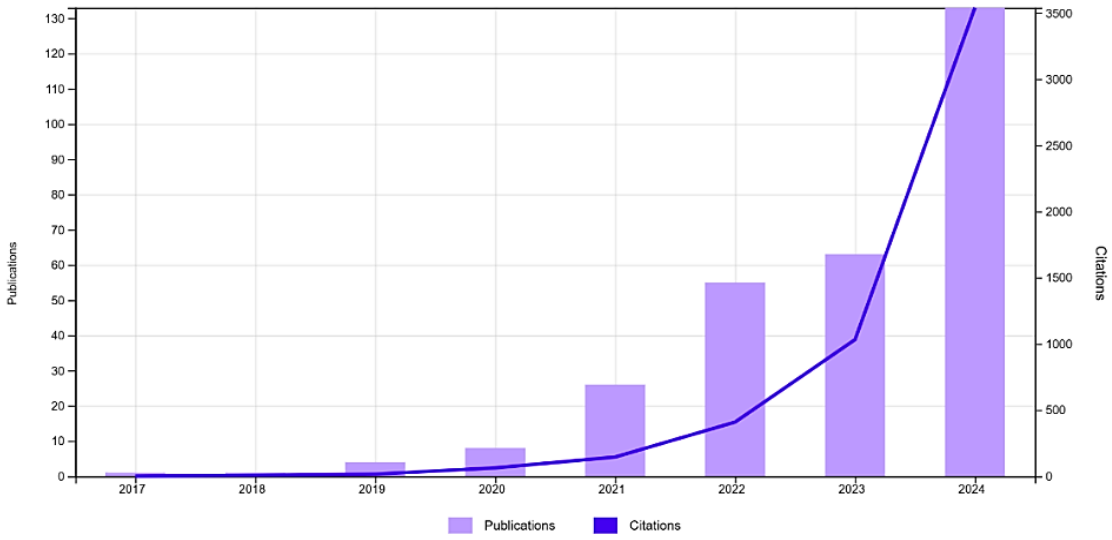


Figure 2. Quantity of publications and citations between 2015 and 2024

### 3.1. Performance analysis

Performance analysis plays a critical role in understanding the productivity, impact, and contributions within a research field. By evaluating key documents, sources, authors, organizations, and countries, performance analysis provides insights into the most influential works and stakeholders that drive scholarly advancements. In the context of AI in education, this analysis highlights high-impact research, leading contributors, and the global distribution of knowledge, offering a comprehensive understanding of the field's development and future directions.

#### 3.1.1. Documents

The significant contributions that have influenced AI in education research are shown by the examination of the most cited papers in Figure 3. The expanding interest in AI's involvement in science education is seen in Cooper's study [27], which has the most citations at 280 citations. With 276 citations, Lim *et al.* [28] come in second with their paper, which presents a paradoxical viewpoint on the use of AI in education. With 174 citations, Chan and Hu [29] discuss how students view generative AI in higher education, emphasizing both its advantages and disadvantages. Furthermore, Nguyen *et al.* [30] with 126 citations, examine ethical guidelines for incorporating AI into education, while Crompton and Burke [31], with 155 citations, give an assessment of AI's current status in higher education.

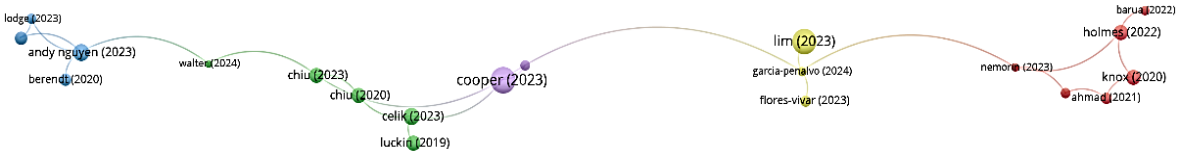


Figure 3. Most cited documents

#### 3.1.2. Sources

Prominent journals are essential venues for sharing important research. With 55 publications and 860 citations in Figure 4, Sustainability comes in first, demonstrating its widespread appeal in sustainable AI applications. With 10 articles and 687 citations, the International Journal of Educational Technology in Higher Education stands out for its emphasis on integrating technology into teaching and learning. With 18 papers and 289 citations, Education and Information Technologies comes next, demonstrating its involvement in investigating AI tools in educational settings. Furthermore, notable contributions to AI and educational technology research are highlighted by the British Journal of Educational Technology (8 papers and 278 citations) and Learning Media and Technology (6 papers and 303 citations).

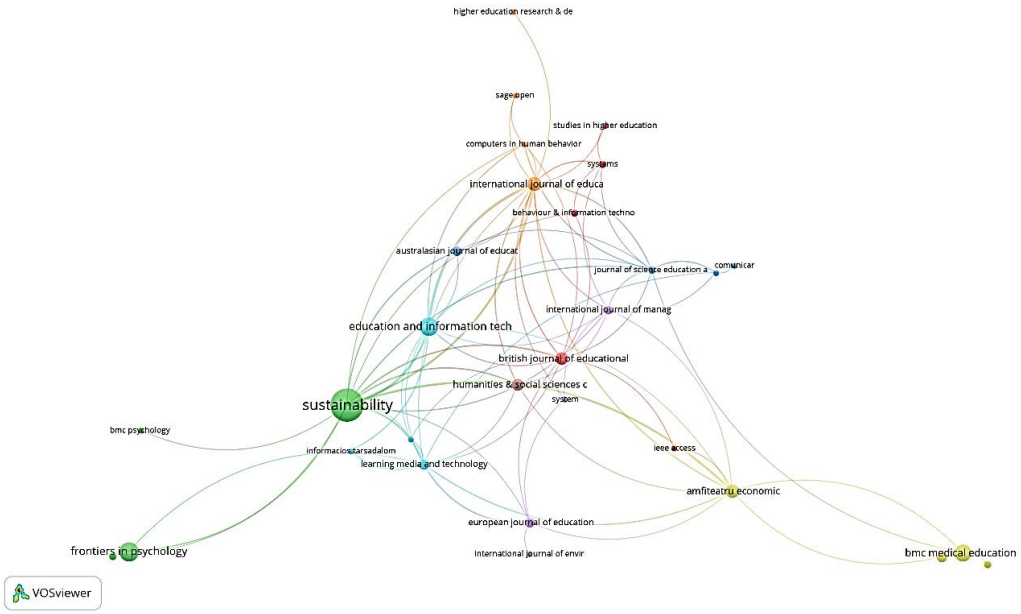


Figure 4. Journal performance

### 3.1.3. Authors

The performance analysis identifies prominent authors whose contributions have advanced the field of AI in education as shown in Figure 5. Cukurova, M., with 5 documents and 208 citations, emerges as a leading researcher in AI-driven educational technologies. Cooper, G. has made notable contributions with 3 documents and 287 citations, particularly in studies exploring AI applications like ChatGPT in science education. Ahmad, S. F. and Alam, M. M., each with 4 documents and 150 citations, demonstrate consistent scholarly output focusing on AI adoption in education. Chiu, T. K. F., with 3 documents and 209 citations, is recognized for research on sustainable AI curriculum planning, bridging theory and practice in education.

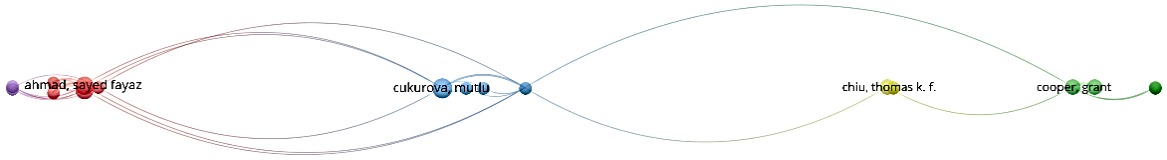


Figure 5. Author contributions

### 3.1.4. Organizations

Leading universities are essential in advancing AI in education research as in Figure 6. University College London (UCL) is at the forefront of developing AI applications in education, as evidenced by its 10 publications and 368 citations. Strong contributions to technology-based education frameworks may be seen in the University of Hong Kong's 5 papers and 360 citations and Curtin University's 7 papers and 316 citations. Further demonstrating the collaborative and international character of research in this field are Monash University (5 papers and 128 citations) and the Chinese University of Hong Kong (7 papers and 224 citations).

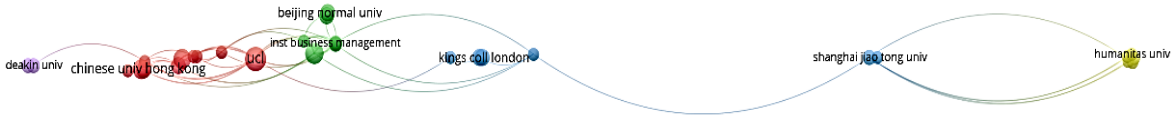


Figure 6. Key organizations

### 3.1.5. Countries

China has the most contributions in Figure 7, with 77 papers and 952 citations, highlighting its important position in AI research and development. Following as a significant contributor with 38 papers and 761 citations is England, which reflects its emphasis on incorporating AI into educational systems and policies. Australia's impressive research production and impact are demonstrated by its 25 publications and 887 citations. The USA demonstrates its impact on educational technology and innovation with 27 documents and 607 citations. Furthermore, as evidence of its increasing involvement with AI-driven educational efforts, Spain provides 231 citations and 17 publications.

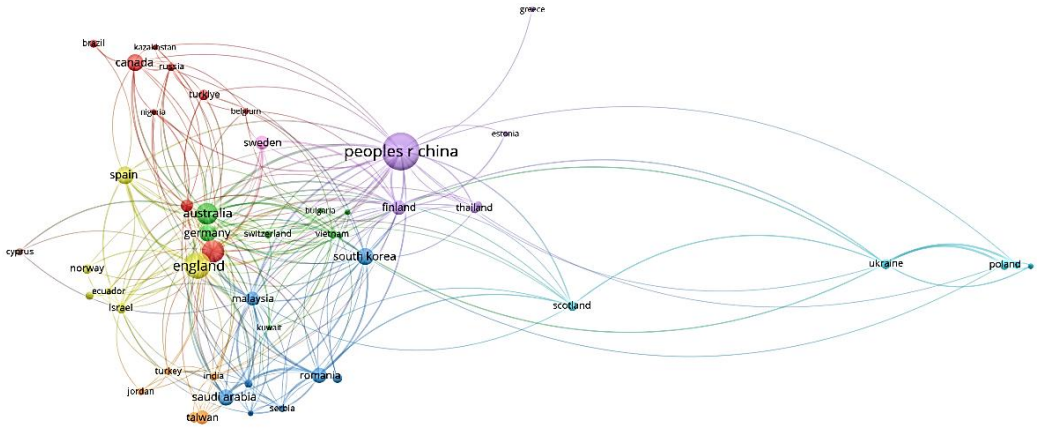


Figure 7. Citations by countries

### 3.2. Most cited articles

The top 10 articles in Table 2 provide significant insights into the role, challenges, and applications of AI in education. Together, these 10 articles collectively address the evolving landscape of AI in education, highlighting systematic reviews, ethical concerns, and the integration of generative AI tools. These studies form the intellectual backbone of AI in education research, offering a roadmap for future inquiry and practical applications.

Table 2. Top 10 most cited articles

| Rank | Authors | Title | Citations | Total link strength |
|---|---|---|---|---|
| 1 | Zawacki-Richter *et al.* [32] | Systematic review of research on artificial intelligence applications in higher education–where are the educators? | 52 | 218 |
| 2 | Chen *et al.* [5] | Artificial intelligence in education: a review | 28 | 98 |
| 3 | Dwivedi *et al.* [33] | Opinion paper: "So what if ChatGPT wrote it?" Multidisciplinary perspectives on opportunities, challenges and implications of generative conversational AI for research, practice and policy | 21 | 96 |
| 4 | Holmes *et al.* [34] | Ethics of AI in education: towards a community-wide framework | 19 | 96 |
| 5 | Kasneci *et al.* [35] | ChatGPT for good? On opportunities and challenges of large language models for education | 19 | 89 |
| 6 | Hwang *et al.* [36] | Vision, challenges, roles and research issues of artificial intelligence in education | 18 | 82 |
| 7 | Popenici and Kerr [37] | Exploring the impact of artificial intelligence on teaching and learning in higher education | 18 | 80 |
| 8 | Cooper [27] | Examining science education in ChatGPT: an exploratory study of generative artificial intelligence | 17 | 67 |
| 9 | Ouyang *et al.* [38] | Artificial intelligence in online higher education: a systematic review of empirical research from 2011 to 2020 | 16 | 88 |
| 10 | Crompton and Burke [31] | Artificial intelligence in higher education: the state of the field | 14 | 65 |

A key study in this list, systematically reviews AI applications in higher education [32]. The authors draw attention to a crucial gap—the low participation of educators in the creation and application of AI—and emphasize the necessity of cooperation between scholars, practitioners, and decision-makers. The foundation for a meaningful integration of AI into education is laid by this study, which addresses the role of educators in technological adoption. Chen *et al.* [5] expand on this by offering a thorough analysis of AI in education, encompassing its developments, prospects, and difficulties. They highlight how AI can revolutionize education through better assessments, individualized learning, and administrative efficiency, making this article a key resource for comprehending the technology environment.

ChatGPT and other generative AI tools are the main topic of debate in studies [33], [35]. Dwivedi *et al.* [33] examined the consequences of generative AI for research, education, and academic integrity using a multidisciplinary approach. They draw attention to both the advantages and disadvantages of AI, including the possibility of becoming overly dependent on its tools and the requirement for regulatory frameworks to guarantee responsible use. A community-wide approach for tackling AI ethics in education is proposed by Holmes *et al.* [34] and ethical considerations emerge as a major theme. This paper highlights the significance of responsibility, equity, and transparency in AI systems and provides a guide for moral application. In keeping with this concept, Popenici and Kerr [37] investigate AI's wider effects on education. They emphasize the disruptive nature of AI and the significance of equipping institutions and educators to deal with these technological shifts.

### 3.3. Discussion

This bibliometric study of AI in education from 2015 to 2024 offers significant theoretical and applied understandings of how AI and educational practices are changing together. As a theoretical framework for redefining pedagogical paradigms, the analysis highlights the transformative potential of AI. By bringing adaptive, data-driven, and personalized approaches, AI technologies, as shown in the reviewed literature, challenge conventional theories of learning and teaching [9]. They facilitate real-time feedback and personalized learning pathways that encourage active engagement and skill acquisition, bridging the divide between behaviorist and constructivist paradigms [39]. This places AI at the forefront of the conversation about education today and is consistent with theories that support experiential and differentiated learning [22]. The results also show that generative AI tools like ChatGPT are becoming more prevalent, adding layers of complexity to current educational models and highlighting the need for new theories that incorporate digital equity, ethical considerations, and human-machine collaboration into educational frameworks [21].

The findings compared previous studies to establish broader research implications. This study corroborates prior research highlighting AI's potential in personalized education while raising concerns about ethical governance [32], [33]. Unlike earlier studies that focus on technological developments [5], [35], this bibliometric analysis provides a holistic view of AI research trends, leading contributors, and policy implications. Specifically, the increased role of generative AI in education aligns with recent studies emphasizing ChatGPT's transformative impact [27], [34]. However, issues related to AI ethics and digital equity remain largely unresolved, as pointed out in recent research [36], [38].

This study offers feasible ways to apply AI in education from a practical perspective. It showcases important works by well-known writers, organizations, and countries that set the standard for innovation. According to Akhmadieva *et al.* [40], adaptive learning platforms and AI-driven assessment tools, for instance, are useful ways to improve student outcomes, lessen administrative workloads, and democratize access to high-quality education. These technologies, particularly in settings with limited resources, offer scalable and economical ways to meet the needs of diverse learners [17], [41]. According to Afzaal *et al.* [42], the focus on nations like China and Australia shows how national investments in AI research and policy-making can result in significant improvements in education and offer a path forward for other countries hoping to capitalize on AI's potential.

Additionally, the analysis identifies key themes and emerging trends, such as the convergence of generative technologies and AI with sustainability [43], [44]. These findings have important ramifications for curriculum development going forward, indicating that learning materials need to change to incorporate digital literacy, problem-solving, and critical thinking skills appropriate for AI-rich environments [45], [46]. Furthermore, the worldwide distribution of research contributions suggests that there may be chances for cross-border cooperation to tackle shared issues and take advantage of different viewpoints in influencing the direction of AI in education [47]. As a result, this bibliometric analysis advances our knowledge of the theoretical developments and real-world uses of AI in education. It offers a thorough framework for further investigation, emphasizing important topics like the deployment of AI in an ethical manner, cross-cultural research, and long-term effects on learning outcomes [48], [49]. By using these insights, stakeholders can address AI's drawbacks and optimize its advantages, opening the door to a creative and egalitarian educational environment [50].

## 4. CONCLUSION

This bibliometric analysis highlights the transformative role of AI in education by documenting the technology's rapid development and wide range of applications from 2015 to 2024. By automating administrative tasks, promoting inclusivity, and offering personalized learning experiences, the study highlights AI's potential to completely transform the teaching and learning process. Important contributions from well-known scholars, organizations, and nations demonstrate a cooperative international effort to investigate the possibilities of AI and tackle its difficulties. Leading themes like generative AI, adaptive learning, and sustainable education highlight how important AI is in influencing modern teaching methods.

Significant obstacles are also noted by the analysis, such as moral dilemmas, digital disparities, and the cost of implementing AI. Multidisciplinary research initiatives, fair access, and comprehensive policies are needed to address these. This study aligns with SDG 4—quality education—by advocating for equitable access to AI-driven educational tools and promoting inclusive learning opportunities for all. For educators, policymakers, and researchers looking to effectively use AI, insights from high-impact papers, performance analysis, and emerging trends offer invaluable guidance. This study advocates for the creation of ethical frameworks, the incorporation of AI into various educational contexts, and a greater emphasis on lifelong learning. It also acts as a roadmap for future research. The education sector can unleash AI's transformative potential and build a more inventive, equitable, and flexible learning ecosystem for coming generations by adopting a strategic and inclusive approach to AI.

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## AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

| Name of Author | C | M | So | Va | Fo | I | R | D | O | E | Vi | Su | P | Fu |
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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

## CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

## DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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