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AI-Driven Transformations in Higher Education: A Citation and Co-citation Analysis

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Abstract: Integrating artificial intelligence (AI) in the educational field can revolutionize teaching and learning outcomes, increase research capacity, and expedite administrative processes. The application of AI-powered virtual learning aids, customized learning platforms, and intelligent educational platforms, can boost the engagement of students, offer real-time feedback and support, and aid customized learning. Additionally, AI-based administrative systems may automate repetitive processes like financial aid processing, enrolment, and admissions, freeing up important resources for more strategic endeavors. Thus, this study aims to synthesize the literature exploring AI's impact on higher education through citation and co-citation analysis. Data from the Scopus database from 2015 to 2024 yielded 1140 papers. The data was analyzed using Biblioshiny and Vosviwer software to determine the publishing pattern, the most cited papers, the most prolific writers, sources, nations, and the network of co-citations between authors and references. The findings reveal a sharp and rapid growth (79.24%) in this industry, suggesting a significant spike in interest. In terms of overall citations, the UK became one of the top countries (1689). The author "Tan S" obtained the most citations (1869) with 10 publications, whereas "Kerr S" and "Poenici Sad" produced just one article and had the highest average citation (588). "Research And Practice in Technology-Enhanced Learning" and "Journal of Applied Learning and Teaching" were the most influential journals in terms of average and total citations, respectively. The uniqueness of the study is that it assesses the literature on AI's impacts in the fields of business and management as well as social science using citation and co-citation analysis. The outcomes of the study will have substantial implications that can help professionals, researchers, and decision-makers create policies.

Introduction

Artificial Intelligence (AI) refers to the intelligence exhibited by machines like computer systems. Our economy is experiencing significant technological advancements, causing a shift in people's behavior. AI simplifies and modifies people's jobs with the assistance of new technology. Certain self-service technologies under AI make people's lives easier and more feasible (Thakral and Kamra, 2024). AI has transformed the way people connect and communicate. It enables them to access various services and products to manage their lifestyles. Every sector currently offers multiple technological platforms. The education industry is no exception; students and teachers are using information and communication technology (ICT) in their studies. This strategy is considered more engaging and participatory by teachers, parents, and students (Hinojo-Lucena et al., 2019).

AI is becoming increasingly popular in higher education, which makes learning more accessible and flexible. Technology allows teachers to get their study material online and can give access to their learners. Teachers can teach their students virtually from anywhere and anytime without physical barriers (Escotet, 023). Students can also customize their education with AI's assistance. Every student can get a unique educational

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approach based on their preferences, enhancing effectiveness and engagement. Education institutions and professionals can utilize a variety of AI apps to develop courses that are suitable for students' skill levels and provide various assistance. Chatbots are among the most popular AI applications, and they assist students with their admissions, academic, and non-academic decision-making questions. Additionally, AI helps educators and learners by producing intelligent materials for all academic levels, including digital textbooks (Chatterjee and Bhattacharjee, 2020a; Kumar, 2019). The primary goal of artificial intelligence (AI) in education is to provide intelligent teaching systems to students over the Internet. There are knowledgeable tutors available who can help students grow depending on their traits and subject matter expertise. Software applications promoting communication also allow students to work with tutors(Hinojo-Lucena et al., 2019). These AI applications in education offer valuable resources for teaching and learning systems because they give students access to fully qualified virtual teachers who support them according to their needs and communicate with them anywhere, which promotes convenience, efficacy, and engagement. (Rivers and Koedinger, 2017).

The use of AI has been examined in several review studies in various sectors and scenarios, including supply chain management. (Rana and Daultani, 2023), E-commerce (Bawack et al., 2022; FRIOUI and GRAA, 2024), Digital Marketing (Ziakis and Vlachopoulou, 2023), Health care (Alhashmi et al., 2024; Guo et al., 2020; Jimma, 2023), Public relations and media (Kaleel & Alomari, 2024), Blockchain (González-Mendes et al., 2024), Financial Analysis (Bahoo et al., 2024; Nica et al., 2024), Sport Science (Mariappan and Durai, 2024), Agriculture (Slimani et al., 2024), Banking (Khuan et al., 2024) Etc. Recently several bibliometric studies have also analyzed the research landscape on AI in the education sector (Ilham et al., 2023) from different perspectives like libraries (Vasishta et al., 2024), Stem Education (Fatimah et al., 2024), Language learning (Liu et al., 2024; Lubis et al., 2024), Academic Integrity (Rodrigues et al., 2024) etc. Nevertheless, the effects of AI on higher education have not been well-studied (Aziz et al., 2024; Fernandes et al., 2024; Maphosa and Maphosa, 2021, 2023; Reis-Marques et al., 2021). A review of these studies showed that very few had used citation and co-citation analysis to examine the literature that explored the impact of AI on higher education within the domain of “social science, business, and management”. Citation analysis and co-citation analysis are two effective bibliometric analysis methods. Citations are crucial for academic publication because they evaluate researchers' productivity and work relevance and help researchers and students find pertinent material on a subject (Liang and Lee, 2023). This paper seeks to address this research gap by consolidating the literature on AI's effects on higher education, using “citation and co-citation analysis” to identify the most influential authors, documents, sources, publishing years, and countries by addressing the following queries-

RQ1. What publication patterns exist between 2015 and 2024 in this field?

RQ2. What are the most cited authors, documents, sources, and countries?

RQ3. What is the co-citation structure of the Author, documents, and references?

The remainder of the paper is structured as follows. The methodology used to identify and analyze the corpus of existing literature is presented in the next section. Following that, A detailed discussion of the results is provided. Then, the study concludes by outlining its shortcomings and possible research problems.

Methodology

Bibliometric analysis, as explained by Zupic Ivan and Cater Tomaz (2015), is concerned with determining social, conceptual, and intellectual structures through studying literature history in a specific field. Bibliometric techniques also allow for data classification and synthesis in the form of a literature review within the specific research domain. This enables scholars to trace shifts in publication volume, intellectual integration, and interactions within the domain and assists them in carrying out future research (Mavric et al., 2021; Suban, 2023). Furthermore, examining past studies that included elements of AI intervention within higher education frameworks through bibliometric analysis could also reveal additional possible aspects (Michael Hall, 2011). This research utilized biblioshiny and Vos viewer for “Citation and co-citation analysis”.

Data Source and Extraction

Scopus database is the largest and most well-structured database of high-quality articles. This allows researchers to effectively investigate a range of academic disciplines.(Burnham, 2006). Thus, this study chose the Scopus database to retrieve the relevant data using the following keywords: “Artificial Intelligence” OR “AI” AND “Higher Education”. The search resulted in 4316 documents. We confined our search to only social science, business, and management domains, yielding 2266 documents. To maintain quality and consistency, 1084 documents were excluded based on the following exclusion criteria. First, articles published in a language

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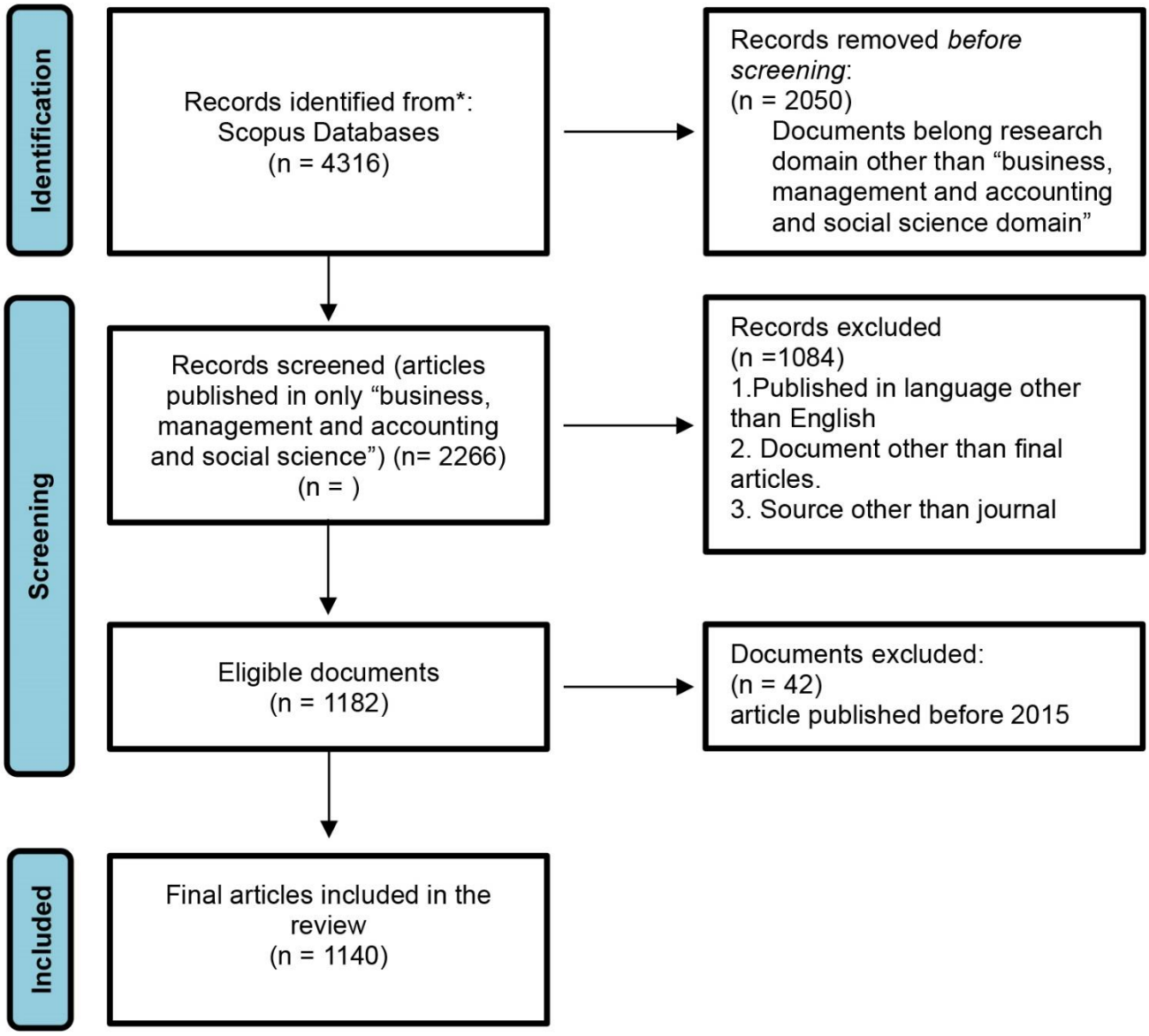

Figure 1. PRISMA framework.

other than English. Second, documents other than the final articles, such as a book, book chapter, conference proceedings, editorial, etc. Third, articles published in other than journals. To evaluate the impact of AI on higher education over a decade, articles published between 2015 and 2024 were taken into account. Once these parameters had been applied, 1140 articles were identified and the data was processed for analysis.

Results and Discussions

The data in this study is analyzed through citation and co-citation methods. The initial phase involved the examination of citation analysis-based publication trends, documents, authors, countries, and sources over time. The author's co-citations and references are discussed in the second part.

Citation analysis

Citation analysis is a method of bibliometric evaluation that evaluates the impact and relevance of academic works by examining their frequency of reference to another research (Frachtenberg, 2023). Through this method, researchers can determine the influence of authors and articles in their fields while also identifying trends and key contributions throughout history. Additionally, it can be used across disciplines and shows patterns of citation behavior (Mukhedkar et al., 2024). The significance of citations in academic publications lies in their ability to measure the productivity and relevance of academics' work and aid researchers in locating pertinent information on a specific issue (Liang and Lee, 2023).

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Citation analysis of publication pattern

Figure 1 and Table 1 depict a generally rising trend in the annual number of articles published, while the growth rate remained modest until 2022. The findings show that just about 20% of the total papers were publications published between 2015 and 2022. The quantum of publications increased significantly (219%) in 2023 compared to previous years. According to the statistics, the year 2024 had the most publications (656), accounting for 57.5% of all the articles analyzed. The average publication growth rate in this field is 76.24%. Articles published in 2023 and 2024 make up 81% of all articles, surpassing the total amount of publications published before 2023. Table 1 also presents the "Average number of citations per article" and "means total citations per year". The year 2017 had the highest average amount of citations per article, even though it published less than 1% of all publications (101). According to this, 2017 was the most productive year in terms of producing the most relevant articles and getting the most citations. Earlier research has shown that there has been impressive growth in the literature on AI for higher education (Bozkurt et al., 2021). These data demonstrate that this area has recently started to gain more attention and is a developing field of study. There is also enough room for further investigation.

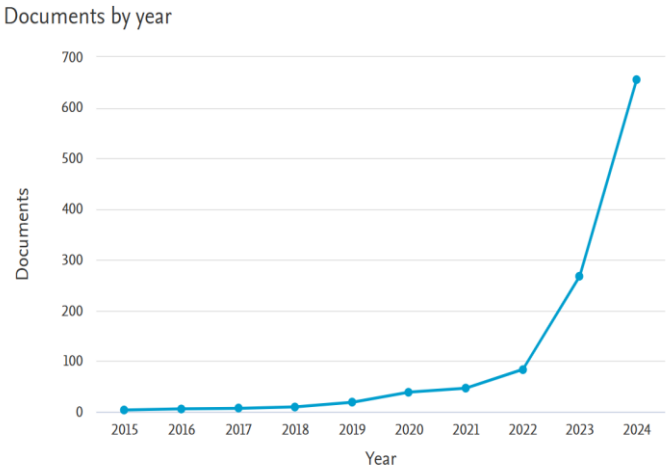

Figure 2. Publication Pattern.

Table 1. Year wise publication.

Year	Articles	Percentage	Average citation per article (ACA)	Mean Total citation per year (MTCpy)
2015	4	0.4%	8.50	0.85
2016	6	0.5%	37.83	4.20
2017	7	0.6%	101.00	12.62
2018	10	0.9%	32.40	4.63
2019	19	1.7%	43.42	7.24
2020	39	3.4%	35.03	7.01
2021	47	4.1%	28.55	7.14
2022	84	7.4%	20.38	6.79
2023	268	23.5%	26.88	13.44
2024	656	57.5%	4.22	4.22

Citation Analysis of Relevant Sources

For a study to be considered strong and reliable, one must examine various sources so that the most pertinent resources may be properly outlined. In this sense, the term "most relevant sources" implies the exclusive use of selected materials to retrieve from reputable databases like Scopus, depending on their relevance to the study. The leading journals in this sphere are presented in Table 2. The "Journal of Applied Learning and Teaching" took first place, with the highest number of citations, 1636, with 21 articles. It is followed by the "International Journal of Educational Technology in Higher Education" with 26 articles and a total citation of 1389. Conversely, the average citation counts for "Research and Practice in Technology-Enhanced Learning" and "Innovations in Education and Teaching International" are 209 and 179 respectively with fewer than 5 articles. This demonstrates that these journals were able to pinpoint journals of a very high standard. The journals "Education and Information Technologies" and "Computers and Education: Artificial Intelligence" are the most contributing journals in terms of publications. "Computers and Education: Artificial Intelligence" journal was considered an influential source because of previous work done in education technology (Chen et al., 2019, 2020).

Table 2. Most Relevant Sources.

Journals	No Of Articles	Total Citation	Average citation
"Journal Of Applied Learning and Teaching	21	1636	78
International Journal of Educational Technology In Higher Education	26	1389	53
Innovations In Education and Teaching International	5	895	179
Sustainability (Switzerland)	36	866	24
Education and	57	850	15

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Information Technologies			
Computers and Education: Artificial Intelligence	49	759	15
Education Sciences	45	704	16
Journal of University Teaching and Learning Practice	19	670	35
Research and Practice in Technology-Enhanced Learning	3	628	209
Computers and Education”	8	480	60

Citation analysis of authors

Authors are responsible for the credibility of findings in research, ensuring further funding and promotion of these results or targeting scientific and intellectual enhancement of the society as a whole (Tarkang et al., 2017). Authorship is important for the advancement of research, reputation, and obtaining grants for projects. Unfortunately, it is overlooked in educational technology projects because of a multitude of responsibilities (Thompson et al., 2022). Citation distribution and publication count may all be used to explain an author's influence (Chai et al., 2020). Table 3 lists the most important researchers in this field. “Tan S” is the most prolific author of this particular area. He holds the first position in total citations (1869) and the number of publications (10), it has the highest G-index (10) and H-index (7). On average, his documents have been cited about 187 times each. “Rudolph J” takes second place with 953 citations, 8 documents, 5 G-index, and 8 H-index. He received an average of 119 citations per document. Contrarily, "Kerr S" and "Poenici Sad" have only one paper each with 588 citations. Such statistics suggest that articles published by "Kerr S" and "Poenici Sad" have a greater impact. All these results draw attention to the remarkable productivity, impact, and influence that the authors had in this discipline. A broad selection of works about AI’s Impact on higher education for comprehending economic progress would be included in their portfolio, showcasing their significant contributions to the advancement of the sector. This demonstrates their work's is importance in advancing research agendas and encouraging creativity. These results are consistent with other studies that emphasize authors' critical role information distribution and their substantial contributions to the advancement of knowledge in pertinent fields (Kumar and Sudhakar, 2024).

Table 3. Top 10 Authors

Authors	Tc	Np	G-Index	G-Index	H-Index
Tan S	1869	10	187	10	7
Rudolph J	953	8	119	8	5
Kerr S	588	1	588	1	1
Popenici Sad	588	1	588	1	1
Chan Cky	587	7	84	7	4
Cotton Dre	584	2	292	2	2
Shipway Jr	576	2	288	2	1
Cotton Pa	575	1	575	1	1
Jiao P	351	4	88	4	3
Ouyang F	351	4	88	4	3

Citation analysis of countries

Figure 2 displays the top ten nations with the most citations obtained. The UK has made the most contribution in this area, with 1689 total citations and an average citation of 21.10. The USA secures the second position with 1606 total citations and 13.4 average citations. When it comes to average article citations, the Netherlands leads the world (53.7), followed by Hong Kong (41.3). One explanation may be that these nations have generated influential and high-Caliber publications that encourage people to mention them. A further factor would be that most of the publications published in the Netherlands and Hong Kong are open access, raising the visibility of readability and citations. It was uncovered by previous studies that the USA and the UK are the most influential nations in several research domains, including computer science (Zurita et al., 2021), Palliative care (Abu-Odah et al., 2022), library service quality research (Ashiq et al., 2022), Special education (Arslan et al., 2023), Academic engagement (Pham et al., 2024), Digital solution (Asghar et al., 2021), Recommendation Systems Research (Olufunke and Okuoyo, 2023) etc.

Citation analysis of documents

Good research articles allow readers to follow the process, accurately depict and explain the research study, and encourage debate, discussion, and critical thinking (Finlay, 1997). Research articles are crucial in academic discourse since an academic's publishing record may determine their quantity and quality. Research papers are the most reliable source of meticulously reviewed fact-based material that may guide work and assist readers in determining the accuracy of information (Scandlyn, 1987). The most significant works on AI's effects on higher education are compiled in Table 4, with an

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Table 4. Most cited documents.

Rank	Title	Journal	Year	Total Citation	Reference
1	"ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?	Journal of Applied Learning and Teaching	2023	593	(Rudolph et al., 2023a)
2	Exploring the impact of artificial intelligence on teaching and learning in higher education	Research and Practice in Technology-Enhanced Learning	2017	588	(Popenici & Kerr, 2017))
3	Chatting and cheating: Ensuring academic integrity in the era of ChatGPT	Innovations in Education and Teaching International	2024	575	(Cotton et al., 2024)
4	War of the chatbots: Bard, Bing Chat, ChatGPT, Ernie, and beyond. The new AI gold rush and its impact on higher education	Journal of Applied Learning and Teaching	2023	314	(Rudolph et al., 2023c)
5	A SWOT analysis of ChatGPT: Implications for educational practice and research	Innovations in Education and Teaching International	2024	310	(Farrokhnia et al., 2024)
6	A comprehensive AI policy education framework for university teaching and learning	International Journal of Educational Technology in Higher Education	2023	259	(Chan, 2023)
7	Students' voices on generative AI: perceptions, benefits, and challenges in higher education	International Journal of Educational Technology in Higher Education	2023	249	(Chan & Hu, 2023)
8	Academic integrity considerations of AI Large Language Models in the post-pandemic era: ChatGPT and beyond	Journal of University Teaching and Learning Practice	2023	242	(Perkins, 2023)
9	Adoption of artificial intelligence in higher education: a quantitative analysis using structural equation modeling	Education and Information Technologies	2020	239	(Chatterjee & Bhattacharjee, 2020b)
10	Artificial intelligence in higher education: the state of the field	International Journal of Educational Technology in Higher Education	2023	236	(Crompton & Burke, 2023)"

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emphasis on total citations globally. The research paper titled "ChatGPT: Bullshit Spewer or the End of Traditional Assessments in Higher Education?" was published in the prestigious "Journal of Applied Learning and Teaching" in 2023 by Rudolph et al. (2023a) and has received the most citations (593). The second spot was secured by an article published by Popenici and Kerr (2017) in 2017. The title of the paper was "Exploring the Impact of Artificial Intelligence on Teaching and Learning in Higher Education," and it was printed in the esteemed journal "Research and Practice in Technology Enhanced Learning." It has received 588 citations. These articles provide insights and information that significantly progress the AI and Higher Education field. Previous studies have also highlighted the importance of articles in advancing knowledge in any research field (İNCİ and KÖSE, 2024; Yadava et al., 2019).

Co-citation Analysis

A bibliometric technique called "co-citation analysis" examines how frequently the two works are cited together in other studies. It facilitates mapping significant references, journals, documents, and authors (Salouw et al., 2023). It assists in recognizing trends, intellectual connections, relationships, and the relevance of scholarly works. It also reveals patterns in citation behavior and the structure of academic literature (Gupta et al., 2023; Phan et al., 2024). Reviews of scientific literature can be made more rigorous and less biased by using co-citation analysis in bibliometric techniques (Zupic and Čater, 2015).

In this study, two co-citation analyses were conducted, i.e., co-citation of references and co-citation of authors.

Co-citation of references

In this co-citation analysis of references, 23 met the threshold with 20 minimum number of cited references. We got four clusters representing cited references with their citations and total link strength. The topmost cited references are Chen et al. (2020), with 60 citations (Rudolph et al., 2023b), with 42 citations and 41 citations (figure 3)(Braun and Clarke, 2006).

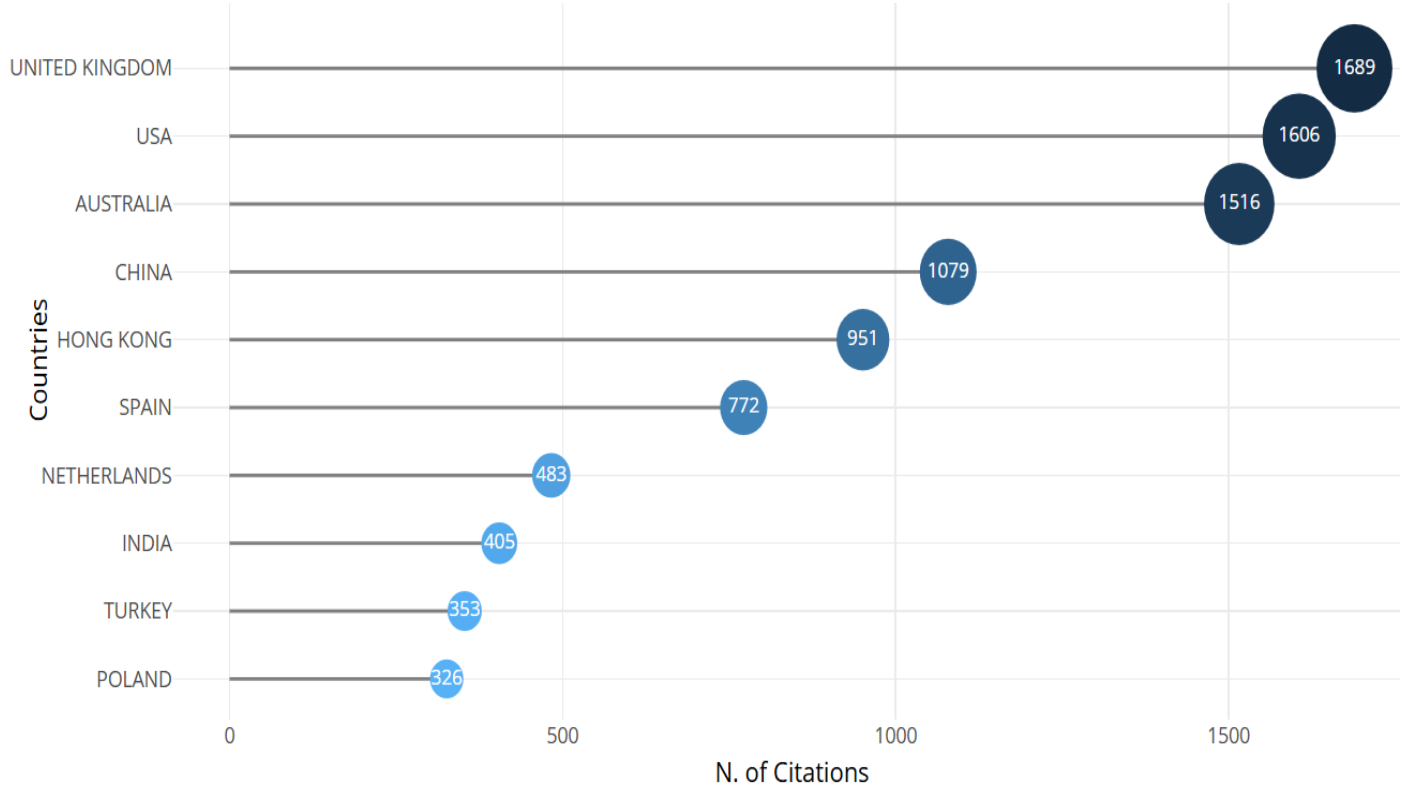

Figure 3. Most cited countries.

Co-citation of authors

Furthermore, co-citation analysis was also chosen to analyze 'cited authors' within the VOS viewer program. To reduce the clutter in the data visualization, a threshold value of 20 was established (Genc and Kocak, 2024). A closer look at the map in the figure reveals three different colored clusters that are there with similar cited authors. "Tan S." is in the center of the blue cluster, "Gasevic D." is in the center of the red cluster, and "Sarstedt M." is in the center of the green cluster. Tan S. (349 citations), Gasevic D. (261 clusters), and Sarstedt M. (239 citations) are the most cited authors. (figure 4)

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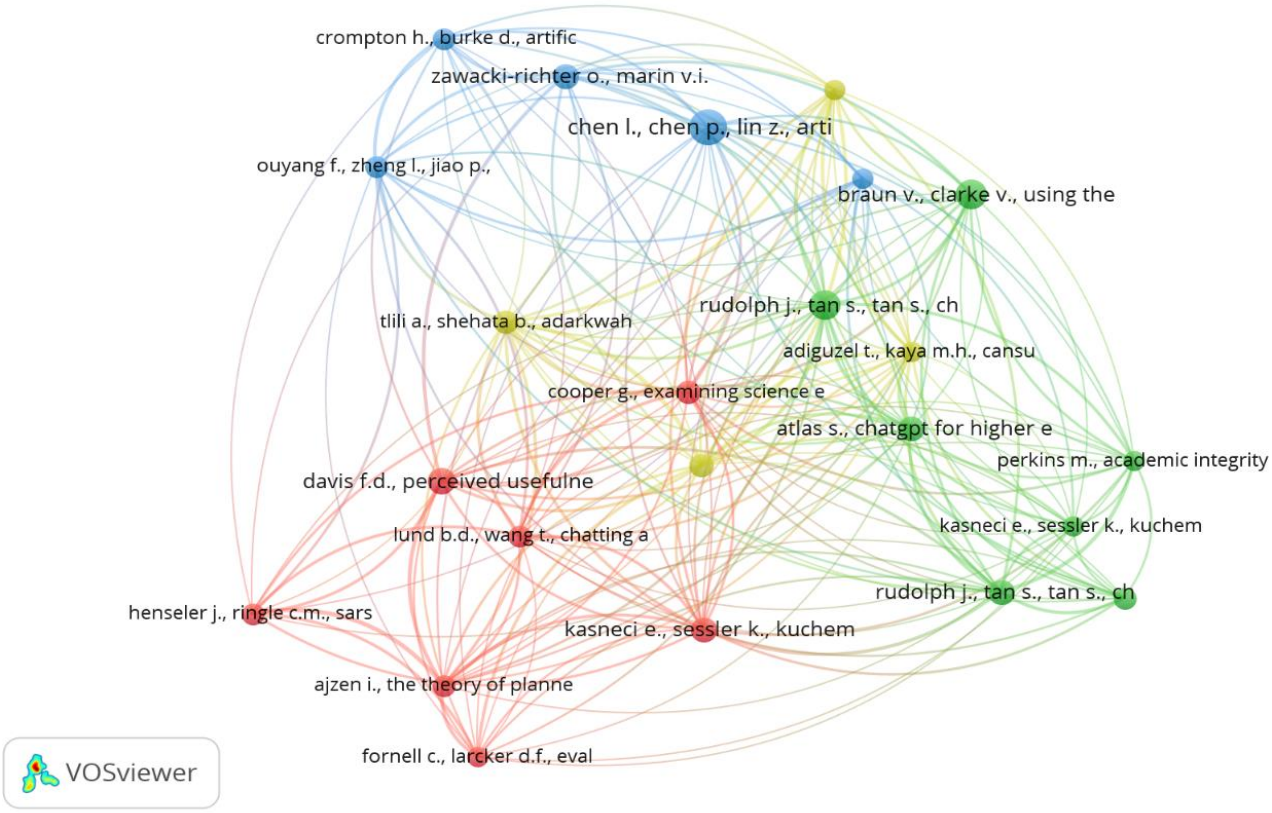

Figure 4. Co-Citation of Cited References.

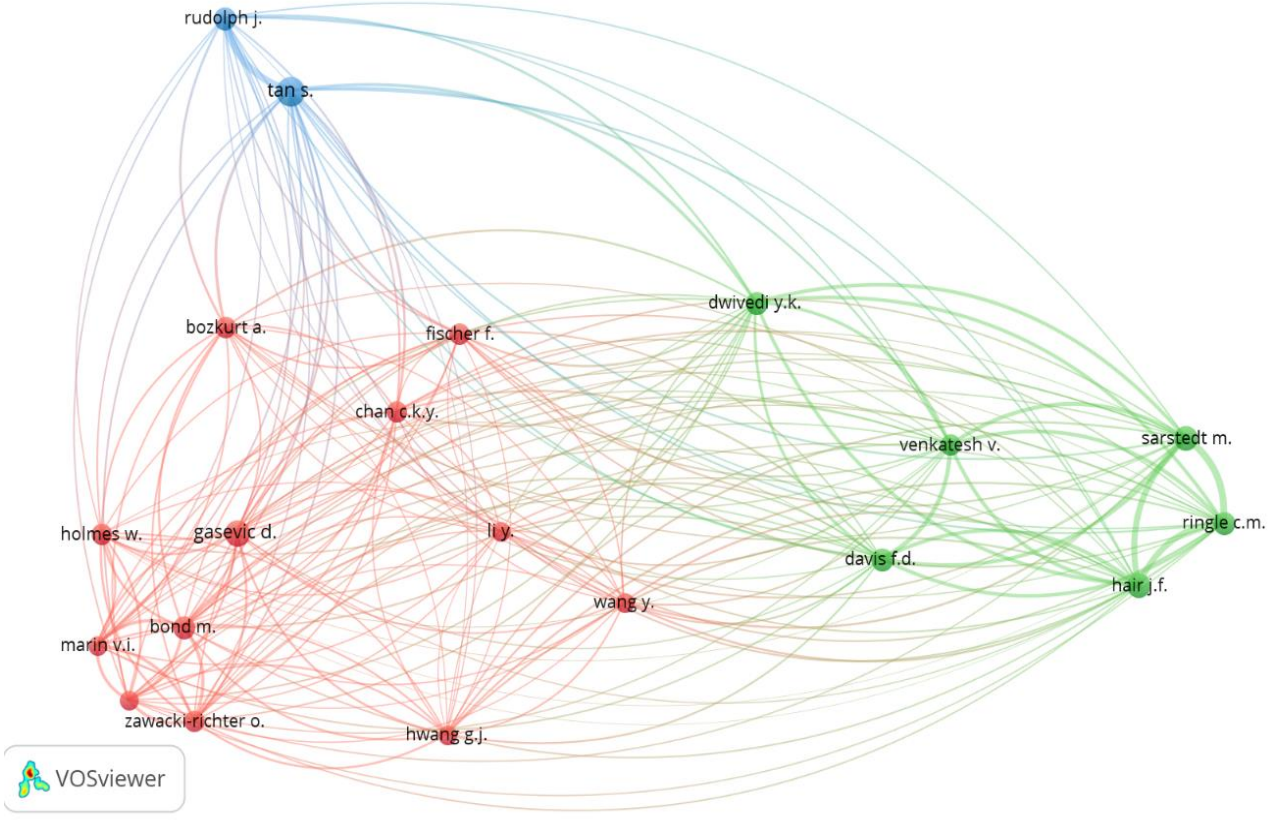

Figure 5. Co-citation of cited authors.

Conclusion

This study concludes by doing a comprehensive bibliometric analysis on the topic of Artificial intelligence and its impact on higher education using citation and co-citation analysis. The study analyzed 1140 data from the Scopus database through biblioshiny and Vosviewer software. The research findings shed light on several important facets of the research environment, such as the important documents, authors, sources, country, and co-citation network. The total number of publications released in 2023 and 2024 surpassed the total number published before 2023, accounting for 81% of the total papers. Publication in this field showed a significant growth of 76.24%. This result indicates that this topic is a trending topic that attracts the interest of various researchers, and there is a lot of scope for research in this field. Most of the articles in this field have been published in the "Education and Information Technologies" journal (57), while the most impactful journals were "Research and Practice in Technology-Enhanced Learning" and "Journal of Applied Learning and Teaching" in terms of average citations (209) and total citations (1636) respectively. A paper titled "ChatGPT: Bullshit spewer or the end of traditional assessments in higher education?" is the most cited article (593). The author named "Tan S" received the highest number of citations (1869) and publications (10), while "Kerr S" and "Poenici Sad" published only one article and got the highest average citation, 588 citations. The future researcher interested in this field can find the most relevant information from these sources. The UK emerges as the leading country in this field. It has gained the highest number of citations (1689). Next, through science mapping, we find the co-citation of cited references and the co-citation of cited authors. The topmost cited references are (L. Chen et al., 2020) with 60 citations, (Rudolph et al., 2023b) with 42 citations and (Braun and Clarke, 2006) with 41 citations, While Tan S. (349 citations), Gasevic D. (261 clusters) and Sarstedt M. (239 citations) are the most co-cited authors. This study aims to offer researchers valuable guidance in identifying key issues and efficiently addressing gaps in their research. This study recommends that policymakers and concerned authorities make effective policies and focus on infrastructure development to support AI Implementation. This will contribute to knowledge management and will improve the learning outcome. This study also concluded that the future of AI in higher education is high as AI benefits the teacher and students a lot and the growing use of AI in higher education is very effective and engaging for the students.

Limitations and Future Scope

Despite the contribution of this paper, some limitations need to be addressed, such as the use of only the Scopus database. Although Scopus has many relevant and high-quality research papers, including other databases, it will help to cover more relevant studies. Further, we have applied some criteria which also limit the scope of research. We have included only articles published in English within social sciences, business, management, and accounting domains. Covering articles from other domains leads to more comprehensive coverage of the topic. For future studies, other tools can also be utilized like CiteSpaceII and Tableau in addition to VOS viewer and biblioshiny. This research has used only "Artificial intelligence", "AI" and "higher education". Future studies can use more keywords like machine learning, chatbots, blockchain, etc, to retrieve more inclusive data. Only citation and co-citation analysis have been conducted in this study. Future studies can explore co-authorship, bibliographic coupling, keyword analysis, co-word analysis, collaboration network analysis, and topic modeling. Furthermore, the results of this study contribute to the understanding of more pertinent subjects that might gain popularity in this sector in the years to come. The article will thus aid scholars and experts in their future studies as well as the public in learning more about this area.

Conflict of Interest

There is no conflict of interest.

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