Spring 3-16-2024

A Bibliometric Analysis of AI Related Research in Higher Education Contexts

Gayathri Sivasubramanian

Haiyan Huang

Karthikeyan Umapathy

A BIBLIOMETRIC ANALYSIS OF AI RELATED RESEARCH IN HIGHER EDUCATION CONTEXTS

Gayathri Sivasubramanian
University of North Florida
gayathri.sivasubramanian@outlook.com

Haiyan Huang
Flagler College
HHuang@flagler.edu

Karthikeyan Umapathy
University of North Florida
k.umapathy@unf.edu

ABSTRACT

In recent years, there have been increasing research efforts to leverage advanced artificial intelligence technologies in higher education contexts. Through a bibliometric analysis, this study explores the key players contributing to artificial intelligence-related research in higher education. Drawing on the analysis of 293 journal articles published in 2015-2023, the results show that institutions from China and Saudi Arabia greatly impact the discipline. China, USA, and Spain are the top players in the field. Additionally, findings from the keyword co-occurrence analysis help to shed light on the current and emerging research topics related to artificial intelligence in higher education.

Keywords

Artificial Intelligence, Higher Education, Bibliometric Analysis, VOS viewer

INTRODUCTION

The rapid advancements of Artificial Intelligence (AI) and related technologies have transformed many sectors, including higher education. In higher education, AI has been applied to a wide range of areas, such as generating personalized content for learners, improving student experience, assisting instructors in course design and assessment, and improving administrators' decision-making. The 2023 EDUCAUSE Horizon Report suggests that the likelihood of AI becoming mainstream in higher education is undoubtedly growing and speeding up (EDUCAUSE, 2023).

With the thriving number of AI in Education (AIEd) applications in recent years, it should be noted that these AIEd innovations are in early and experimental stages, and there have been limited collaborative investigations across institutions (Zhang & Aslan, 2021). While the opportunities for AI are promising and beneficial, students, instructors, and administrators may perceive the impacts of AIEd applications negatively, and researchers have voiced concerns over ethical impacts and risks of reduction of instructor-student interactions (Seo et al., 2021). Thus, there is a critical gap between what AI technologies can do and how they are implemented in higher education contexts.

To better understand the current research efforts related to AI research in higher education, this paper addresses the following research questions: (1) Who are the leading players making contributions to artificial intelligence related research in higher education? (2) What are the commonly researched themes related to artificial intelligence in higher education? We perform bibliometric analysis using VOSviewer software to investigate the research questions. Our research contributes by revealing patterns among publications and trends in AI-related research topics in higher education contexts.

BRIEF RESEARCH BACKGROUND

Research efforts on the application of artificial intelligence in education have spanned over three decades (Zawacki-Ritcher et al., 2019). Doroudi (2022) examined the intertwined histories of artificial intelligence and education and argued that AI and learning science share deep roots in cognitive science. Zawacki-Ritcher et al. (2019) systematically reviewed research on AI applications in higher education. They classified the related research articles into four major application areas: profiling and prediction, assessment and evaluation, adaptive systems and personalization, and intelligent tutoring systems. A more recent study by Crompton and Burke (2023) reviewed 138 articles on artificial intelligence in education published from 2016 to 2022. Their research finding shows that language learning is the most studied subject domain. Focusing on a specific aspect, Labadze et al. (2023) reviewed the literature on AI chatbots in education. They suggested that AI chatbots benefit students in terms of study assistance, personalized learning experience, and skill development.

In contrast to prior research, this study utilizes a quantitative-based bibliometric analysis as the analytical method. Bibliometric analysis proves to be a robust and efficient approach to analyzing extensive scientific datasets, evaluating, making sense of the landscape of a specific discipline, and uncovering research patterns, trends, and potential knowledge gaps (Donthu et al., 2021).

For example, Ding and Yang (2022) surveyed platform-related research from 1978 to 2018 using bibliometric analysis to identify important publications, authors, journals, institutions, and countries in that domain. This paper offers fresh insights into the literature review of AI-related research in higher education from different perspectives.

METHOD

Data Collection and Selection

Figure 1 shows the PRISMA flow diagram of the data collection and selection process (Page et al., 2020). The initial data collection was conducted in January 2023. We used two terms, "artificial intelligence" and "higher education" to search the Web of Science (WoS) database and identified 408 records of publications, with the publication years dated from 1989 to 2023. During the Identification phase, we removed 11 inaccessible records and 2 non-English articles, resulting in a collection of 395 articles for screening.
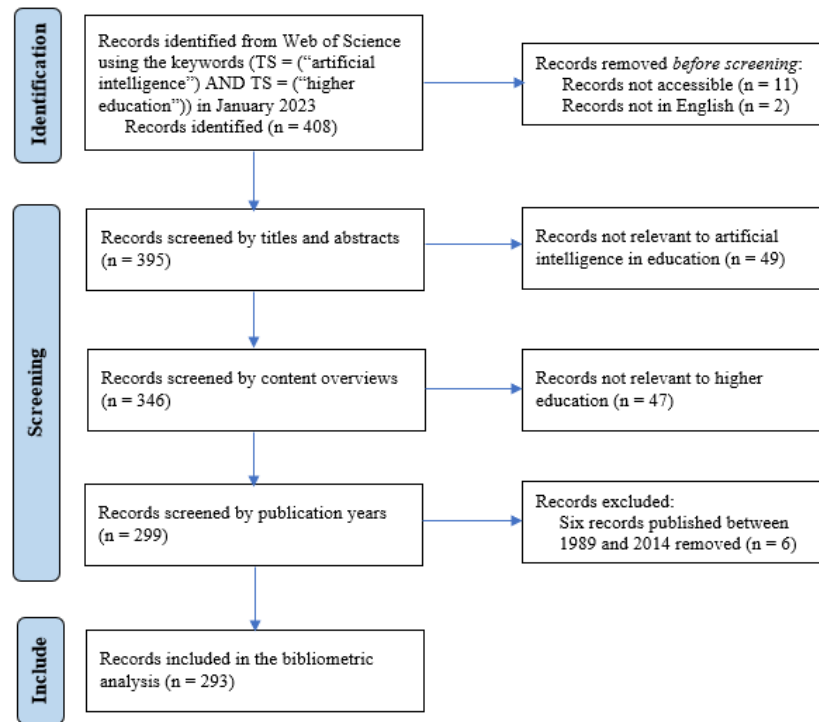

Figure 1. The PRISMA Flow Diagram of the Data Collection and Selection Process

During the Screening phase, we first checked the titles and abstracts of all the articles, then we reviewed the article contents to examine whether the papers were relevant to both "artificial intelligence" and "higher education. We eliminated 49 articles that are not relevant to artificial intelligence in education and 47 that are not relevant to higher education settings. At the end of the Screening process, we excluded 6 papers published between 1989 and 2014, as there was zero or one paper published in each of those years. This leads to a total of 293 articles to be included in the bibliometric analysis. Figure 2 shows the number of articles included in the bibliometric analysis based on the publication years (n = 293). The chart reveals that the number of articles published per year has exponentially increased between 2015 and 2022 by 66.6% yearly.

Data Analysis

We conducted a bibliometric analysis on the sample of 293 articles using VOSviewer. VOSviewer is a popular bibliometric mapping and visualization software application (Van Eck & Waltman, 2010). We employed VOSviewer to identify the leading institutions, countries, and journals in the field and to illustrate their collaborative networks and influences. We also used VOSviewer for a keyword co-occurrence analysis.

Limitations

During the data collection phase, we searched and retrieved metadata about relevant research articles from the Web of Science database. Although most journals indexed in Web of Science are peer-reviewed, we did not individually verify the peer review status of all the source journals included. In the screening process, we reviewed the article title, abstract, and overall content to exclude articles irrelevant to artificial intelligence or higher education. We did not differentiate those articles based on whether they focused on developing AI applications, assessing AI applications or perceptions, reviewing literature about AI in higher education, or employing AI techniques for research in higher education contexts.
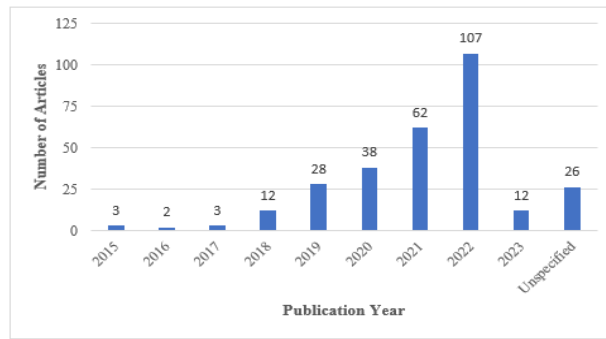
Figure 2. Number of Articles vs. Publication Year (2015 – January 2023)

RESULTS AND DISCUSSIONS

Top 10 Institutions and Collaboration Analysis

To understand which institutions might have the greatest influence in the realm of artificial intelligence in higher education, we conducted a collaboration analysis based on institutions. There are 490 institutions that have published at least one article in this domain. The institution collaboration network of the largest set of interconnected institutions (216) is shown in Figure 3, with the size of the nodes representing the institution's influence (measured by the number of publications). The links between the nodes show the cooperative relationships between institutions across countries.
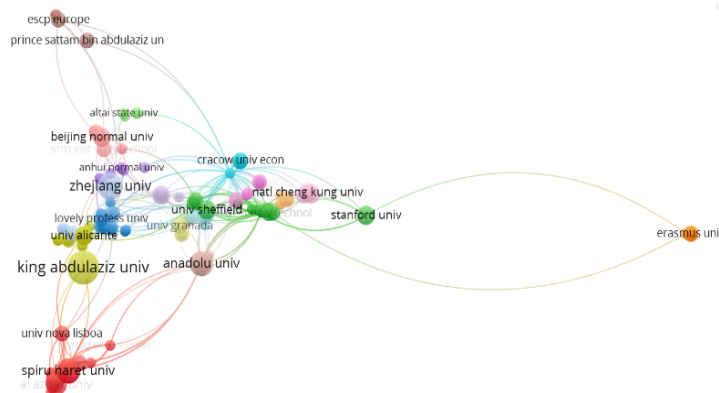

Figure 3. Institution Collaboration Network

Table 1 displays the top 10 institutions contributing to AI-related research in higher education. King Abdulaziz University in Saudi Arabia is ranked No. 1 in the field of interest (with 9 publications and 100 citations), followed by Zhejiang University in China (with 6 publications and 108 citations), Spiru Haret University in Romania (with 5 publications and 47 citations), University Business Academy in Novi Sad in Serbia (with 5 publications citations), and Tecnológico Universitario Monterrey in Mexico (with 5 publications and 44 citations). In addition, Table 1 indicates that Zhejiang University in China has the highest number of citations (108) and the greatest average citation/publication ratio (18.0).

Institution	Country	Publications	Citations	Avg. Cit. Per Pub.
King Abdulaziz University	Saudi Arabia	9	100	11.1
Zhejiang University	China	6	108	18.0
Spiru Haret University	Romania	5	47	9.4
University Business Academy in Novi Sad	Serbia	5	47	9.4
Tecnológico Universitario Monterrey	Mexico	5	44	8.8
Anadolu University	Turkey	5	39	7.8
Universitat Oberta de Catalunya	Spain	4	50	12.5
Al-Azhar University	Egypt	4	1	0.3
Instituto Politecnico de Braganca	Portugal	3	42	14.0
Beijing Normal University	China	3	2	0.7

Table 1. Top 10 Influential Institutions

Top 10 Countries and Collaboration Analysis

A total of 71 countries have at least one article published in AI and higher education-related areas. To reveal the collaborative relationships between countries, we utilized VOSviewer for collaboration analysis based on countries, shown in Figure 4. It highlights that China, USA, Spain, England, Saudi Arabia, and India prominently emerge as the leading countries with respect to the number of publications (size of the nodes). Furthermore, the graph indicates strong connections between three influential countries, China-Saudi Arabia, and China-India. On the other hand, Norway appears to foster strong collaborative ties with two top influential countries, USA, and Spain, while establishing strong linkages with Germany, Sweden, and Pakistan.
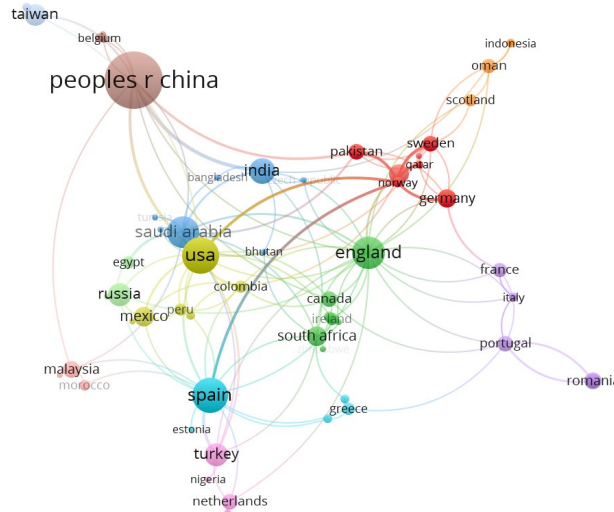

Figure 4. Country Collaboration Network

Table 2 exhibits the number of publications and citations and the average citation/publication ratio of the top 10 countries. The countries with the highest number of publications are China (98), USA (31), and Spain (28). The countries with the highest number of citations are China (745), Saudi Arabia (256), and Spain (187). The countries with the highest average citation/publication ratio are Saudi Arabia (10.2), Turkey (9.6), and China (9.1).

Country	Publications	Citations	Avg. Cit. Per Pub.
Peoples Republic of China	82	745	9.1
United States of America	31	165	5.3
Spain	28	187	6.7
England	26	133	5.1
Saudi Arabia	25	256	10.2
India	17	111	6.5
Turkey	13	125	9.6
Russia	13	37	2.8
Taiwan	12	26	2.2
Australia	10	48	4.8

Table 2. Top 10 Influential Countries

Top 10 Influential Journals

Aside from the institution and country collaboration networks, we also examined influential journal sources. 182 journals have published at least one article about AI-related research in higher education. Table 3 exhibits the number of publications and citations and the average citation/publication ratio of the top 10 journals. While Engineering and the International Journal of Educational Technology in Higher Education are ranked 2nd and 3rd in terms of the number of publications, they set themselves apart from other journals by having a remarkably higher number of citations (584 and 388, respectively) and notably elevated average citation/publication ratio compared to other top journals.

Journal	Publications	Citations	Avg. Cit. Per Pub.
Sustainability	15	90	6.0
Engineering	11	584	53.1
International Journal of Educational Technology in Higher Education	11	388	35.3
Frontiers in Psychology	9	45	5.0
Education and Information Technologies	7	61	18.7
IEEE Access	6	104	17.3
International Journal of Emerging Technologies in Learning	6	101	16.8
Applied Sciences-Based	6	42	7.0
Wireless Communications & Mobile Computing	6	1	0.2
International Journal of Advanced Computer Science and Applications	5	12	2.4

Table 3. Top 10 Influential Journals

Keyword Co-occurrence Analysis Between 2020 and 2022

To identify the recent focal points of AI-related research in higher education and explore emerging trends, we conducted a keyword co-occurrence analysis. A total of 207 articles (70.6% of the sample) were included in the analysis. Figure 5 illustrates the evolution of keywords between 2020 to 2022. We can observe that the overall predominant keywords are "artificial intelligence", "higher education", "machine learning", "education" and "performance" across 2020-2022. Additionally, other popular keywords in 2020 include "technology", "e-learning", "industry 4", etc. In 2021, the additional noticeable keywords involved "students", "learning analytics", "prediction", "educational innovation", and "digital transformation" among others. Keywords such as "analytics", "covid-19", "natural language processing", "blockchain", and "robotics" started to emerge in 2022.
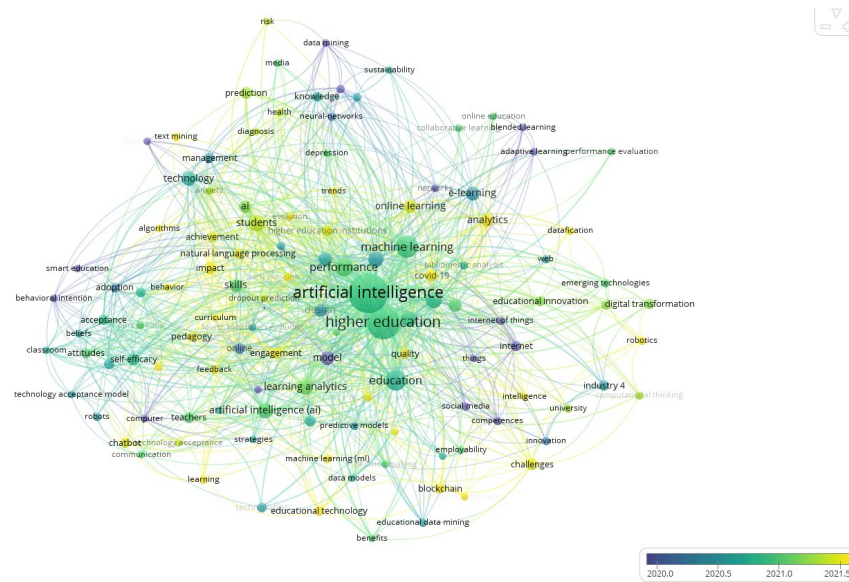

Figure 5. Evolution of Keyword Co-Occurrence Between 2020 and 2022

Discussions

The rankings of leading institutions and countries highlight that institutions from China and Saudi Arabia substantially impact the discipline. China is leading other countries with respect to the total number of publications and citations, with Zhejiang University ranking second in terms of number of publications and featuring the highest average citation/publication ratio. King Abdulaziz University from Saudi Arabia holds the top spot in the list of influential institutions. Saudi Arabia is in 5th place in the list of influential countries and has the highest average citation/publication ratio. The country collaboration network reveals a strong collaborative relationship between China and Saudi Arabia. Despite the absence of any U.S. institution in the top 10 institution list, the USA is the second most influential country with 31 publications. The list of top 10 journals reflects the interdisciplinary nature of AI-related research in higher education (Renz & Hilbig, 2020). Beyond journals primarily centered on technological innovations and their applications in education, the top 10 list encompasses the computing, engineering, psychology, sociology, and business disciplines.

The keyword co-occurrence analysis reinforces the validity and relevance of the articles included in the data sample of this research. The predominant keywords provide an overarching view of the discipline: artificial intelligence, machine learning, and various technologies act as the driving forces. From the higher education context, student engagement and performance improvement stand out as the primary objectives. Furthermore, keywords such as personalization, adaptive learning, learning analytics, predictive models, and performance evaluation manifest the current major applications of artificial intelligence in higher education (Zawacki-Richter et al., 2019). In 2021, the research focuses appear to shift to student-centered digital transformation and educational innovation. Transitioning into 2022, technological advancements like natural language processing, blockchain, and robotics have become trending in this discipline. However, the much-needed discourses and research on the development, adoption, accessibility, privacy, and ethical concerns surrounding AI applications in higher education are noticeably absent from the current landscape, highlighting a crucial knowledge gap that warrants attention and investigation in the future (Holms et al., 2022).

CONCLUSION AND FUTURE RESEARCH

This research is intended to survey the landscape of AI-related research in higher education. Through bibliometrics analysis using VOSviewer, we identify some major influential players in the discipline. Additionally, the keyword co-occurrence analysis findings reveal the patterns, trends, and possible knowledge gaps in current research.

For future research, our initial plan involves expanding the sample pool by incorporating additional international databases to construct a more comprehensive profile of AI research in higher education. In addition, we plan to extend the metadata analysis to an in-depth systematic review of the discipline to examine both the major theoretical frameworks and empirical applications of artificial intelligence in higher education. Furthermore, these investigations can be extended to compare K-12 against higher education contexts and study variations across educational disciplines.

REFERENCES

1. Crompton, H. & Burke, D. (2023). Artificial Intelligence in Higher Education: The State of the Field. *International Journal of Artificial Intelligence in Higher Education, 20*(22). Retrieved from: https://doi.org/10.1186/s41239-023-00392-8

2. Ding, X. & Yang, Z. (2022). Knowledge Mapping of Platform Research: A Visual Analysis Using VOSviewer and CiteSpace. *Electronic Commerce Research, 22*, 787-809.

3. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., and Lim, W. M. (2021). How to Conduct a Bibliometric Analysis: An Overview and Guidelines. *Journal of Business Research, 133*, 285-296.

4. Doroudi, S. (2023). The Intertwined Histories of Artificial Intelligence and Education *International Journal of Artificial Intelligence in Education, 33*, 885-928.

5. EDUCAUSE. (2023). Horizon Report: Teaching and Learning Edition. Retrieved from: https://library.educause.edu/-/media/files/library/2023/4/2023hrteachinglearning.pdf

6. Holmes, W., Porayska-Pomsta, K., et al. (2022). Ethics of AI in Education: Towards a Community-Wide Framework. *International Journal of Artificial Intelligence in Education, 32*, 504-526.

7. Labadze, L., Grigolia, M., & Machaidze, L. (2023). Role of AI Chatbots in Education: Systematic Literature Review. *International Journal of Artificial Intelligence in Higher Education, 20*(56). Retrieved from: https://doi.org/10.1186/s41239-023-00426-1

8. Renz, A. & Hilbig, R. (2020). Prerequisites for Artificial Intelligence in Further Education: Identification of Drivers, Barriers, and Business Models of Educational Technology Companies. *International Journal of Artificial Intelligence in Higher Education, 17*(14). Retrieved from: https://doi.org/10.1186/s41239-020-00193-3

9. Page, M. J., McKenzie, J. E., Bossuyt, P. M. et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Systematic Reviews, 10*(89). Retrieved from: https://doi.org/10.1186/s13643-021-01626-4

10. Seo, K., Tang, J., Roll, I., Fels, S., & Yoon, D. (2021). The impact of Artificial Intelligence on Learner–Instructor Interaction in Online Learning. *International Journal of Educational Technology in Higher Education*, 18(1), 1-23.

11. Van Eck, N. J. & Waltman, L. (2010). Software Survey: VOSviewer, A Computer Program for Bibliometric Mapping. *Scientometrics, 84*(2), 523–538.

12. Zawacki-Richter, O., Marin, V. I., Bond, M., & Gouverneur, F. (2019). Systematic Review of Research on Artificial Intelligence in Higher Education – Where are the Educators? *International Journal of Artificial Intelligence in Higher Education, 16*(39). Retrieved from: https://doi.org/10.1186/s41239-019-0171-0

13. Zhang, K., & Aslan, A. B. (2021). AI technologies for education: Recent research & future directions. *Computers and Education: Artificial Intelligence*, 2, 100025.