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Review article

BIBLIOMETRIC ANALYSIS OF ARTIFICIAL INTELLIGENCE APPLICATIONS IN HIGHER EDUCATION USING WEB OF SCIENCE DATABASE

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Abstract. *Artificial intelligence (AI) is becoming increasingly important in higher education, which has resulted in the accelerated development of research in this area. This paper conducts a bibliometric analysis of scientific papers researching AI applications in higher education, using the Web of Science database. The analysis covers the period from 1996 to February 2024 and focuses on the most cited works in this field, a total of 82 papers, with 1011 citations (944 without self-citations). Our analysis shows that interest in AI has increased significantly over the past few years, with the most dominant research in the fields of education, computer science, and engineering. The largest number of papers was published in 2023, which indicates the growing importance of this topic. These results provide a foundation for future research on the impact of AI on educational practices, its challenges, and its potential to transform education in the future.*

Key words: *artificial intelligence, higher education, bibliometric analysis, research trends, Web of Science.*

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1. INTRODUCTION

Artificial intelligence (AI) represents one of the most important technological innovations of the 21st century, with a far-reaching impact on various aspects of modern society, including education. (Alam et al., 2022) It is defined as the ability of computer systems to perform tasks that require a certain level of human intelligence, such as learning, language comprehension, pattern recognition, and decision making. (García et al., 2019) Within education, especially higher education, AI offers the potential to transform traditional educational practices, personalize learning, and optimize administrative processes.

The development of AI technologies, such as machine learning, deep learning and natural language processing, opens new possibilities for improving educational systems. (Sarker, 2021) In higher education, these technologies can contribute to more effective learning, adapting the curriculum to the individual needs of students, as well as improving the quality of education through the analysis of large amounts of data. In addition, AI can facilitate the management of educational institutions through better resource management, performance analysis and prediction of educational trends. (Rivas et al., 2021)

However, as AI becomes more and more present in the education sector, the need for a deeper understanding of its impact, as well as for the identification of key actors and trends in research related to this topic, is growing. (Chen et al., 2020; Pedro et al., 2019) The introduction of AI in higher education is not only a technological issue, but also a social one, (Ocaña-Fernández et al., 2019) with ethical, privacy and equity challenges.

This paper deals with a bibliometric analysis (Donthu et al., 2021) of research in the field of artificial intelligence in higher education, using the Web of Science (Talan & Demirbilek, 2023) database. The aim is to present the trends and dominant themes in this growing field through the analysis of key publications, authors, countries and institutions. This analysis not only provides an insight into the current status of research, but also points to the future directions of the development of AI in education, allowing a better understanding of how this technology is integrated into the education sector and what impact it has on the improvement of educational processes.

1.1. Artificial intelligence in higher education

Artificial intelligence (AI) is increasingly being integrated into various aspects of everyday life, and its presence in education is becoming particularly significant. (Bates et al., 2020) As an advanced technology that mimics human abilities to learn, understand, and solve problems, AI offers revolutionary opportunities to improve educational processes. In higher education, AI is being used to create personalized educational experiences, improve administrative tasks and support research work. (Chen et al., 2020) This technology enables the creation of interactive and adaptive educational platforms that can respond to the specific needs of each student, thereby improving the quality and accessibility of education.

The application of AI in higher education is significantly changing the way students and teachers approach learning, teaching and research. (Ge & Hu, 2020) Advanced algorithms enable the analysis of large amounts of data on student progress, which helps identify educational needs and adjust instruction. (Bienkowski et al., 2012) AI also contributes to the automation of administrative tasks, such as grading and attendance tracking, freeing up teaching staff to devote more time to creative and mentoring roles. These changes bring a number of benefits, including the personalization of learning that allows students to progress at their own pace and access resources that are tailored to their specific needs.

However, there are also significant challenges. With the increased availability of AI tools, there is a risk of easy exam cheating and assignment rewriting. (Yeo, 2023) Students may use technology to complete assignments without actually learning the substance of the material, which threatens the integrity of the educational process and calls into question the authenticity of the results. Colleges and universities face challenges in how to recognize and prevent misuse of these technologies. (Brundage et al., 2024; Dimitriadou & Lanitis, 2023; Jafari & Keykha, 2023; Saputra et al., 2023) Although AI tools for the detection of copying and plagiarism offer certain benefits, they are still not entirely sufficient to exclude the possibility of abuse. (Dalalah & Dalalah, 2023)

A key question in this area is how to ensure that AI is a tool that supports the educational process, rather than one that dominates it. (Akgun & Greenhow, 2022) This paper will explore the current trends, benefits and challenges of applying AI in higher education, with a particular focus on the most significant authors, countries and publications.

2. METHODOLOGY

This study uses the WoS (Web of Science Core Collection) database and follows the PRISMA framework (Gilardoni et al., 2022) to review papers on artificial intelligence in higher education. First, a research question related to the scope and impact of artificial intelligence in higher education is posed, according to Arksey and O'Malley (2005). (Arksey & O'Malley, 2005)

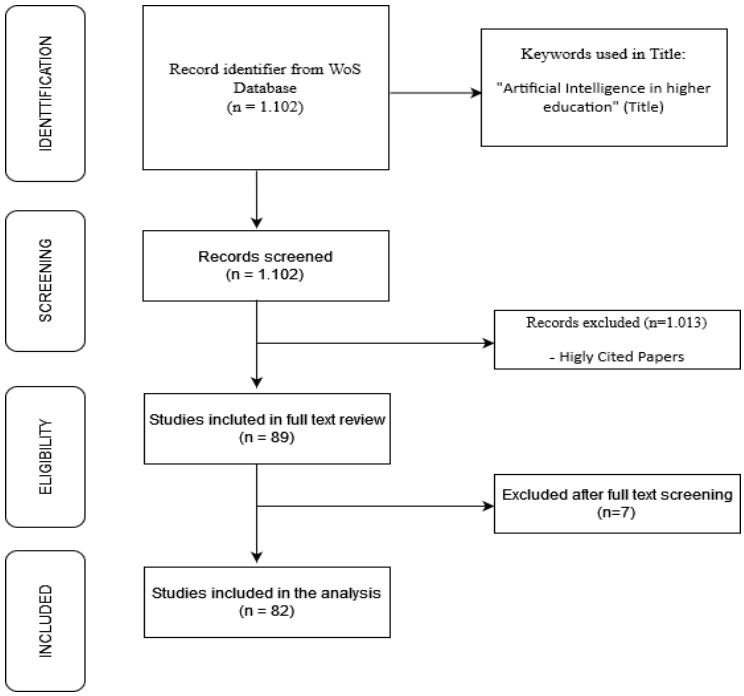


Fig. 1 PRISMA flowchart (adapted from Page et al. (Page et al., 2021)).

The search was performed based on the criteria "Artificial Intelligence in Higher Education" in the titles of the papers. Only highly cited papers were filtered. The search covered the period from 1996 to 2024 and was carried out in February 2024. The initial number of papers was 1,102, which was then reduced to 89, focusing only on the titles of papers directly related to the topic. Finally, 82 papers were selected based on quality (topical fit, publication type, temporal range and language) and relevance criteria (research design clarity, data collection and analysis, validity and reliability, sample size, context and setting, results and interpretation, limitations, reproducibility), according to Kitchenham, Mendes and Travassos (2007). (Kitchenham et al., 2007)

Data were analyzed according to categories: authors, countries/regions, publications. The analysis involved tools such as Microsoft Excel, RStudio 2023.12.1 Build 402, and Biblioshiny 4.1.4. (Cobo et al., 2011; Donthu et al., 2021) A detailed analysis included reading the full texts of the selected papers, and a final report was written and discussed.

3. ANALYSIS

In this part of the paper, we will focus on the key aspects that are shaping the trend of artificial intelligence's impact on higher education, with special reference to three key elements: the identification of the most influential researchers, the mapping of leading countries in research activities, and the analysis of the most significant publications that have left the deepest mark on the development of this field. This analysis aims to provide a comprehensive view of global and regional contributions, as well as to illuminate the key factors that have influenced the development and application of artificial intelligence in higher education institutions. Based on the identified trends and relevant sources, the goals are to define current research directions and propose future directions in this dynamic area.

3.1. Top ten authors by number of publications

Table 1 presents an overview of ten authors who are the most productive in the field of artificial intelligence research in higher education, ranked according to the number of published papers and their percentage share in the total sample. From the attached data, it can be noted that D. Paun leads the way with three published papers, which represent 3,659% of the total number of papers in the sample. The following authors, including K.K. Bhattacharjee, M. Bond, J. Cravino, H. Crompton, M.P. Ilić, V. Kuleto, R. Manhica and A. Santos, each have two published papers, which make up 2,439% of the total number. J. Abbott closes the list with one paper, which accounts for 1,220% of the total sample.

Based on these results, we can draw several important conclusions. First, a relatively small number of authors have a large number of papers, while the majority of authors have one or two papers each, which indicates the concentration of research contributions by certain individuals. For example, D. Paun leads the way as the most prominent author in the field with three papers, which may indicate his continued commitment to AI research in higher education, as well as his influence on the discourse within the field. His research could be the subject of a deeper analysis to determine whether it is a matter of continuity in research contribution or specialization in a certain niche.

Second, the presence of nine authors with two published papers each, including names such as Bhattacharjee and Crompton, suggests a smaller number of researchers actively contributing to the field. Their contribution may be an indicator of expanding interest in

the topic and suggests that the field of artificial intelligence in higher education is attracting a diverse group of researchers with diverse academic backgrounds.

Table 1 Top ten authors by number of publications

Authors	Record Count	%
Paun D.	3	3.659
Bhattacharjee K.K.	2	2.439
Bond M.	2	2.439
Cravino J.	2	2.439
Crompton H.	2	2.439
Ilić M.P.	2	2.439
Kuleto V.	2	2.439
Manhica R.	2	2.439
Santos A.	2	2.439
Abbott J.	1	1.220

In addition to the quantitative analysis, the qualitative aspects of these works are also important. A closer look at the content of each author's work reveals the key areas that are shaping AI's impact in higher education. Paun D. explores both opportunities and challenges of AI and machine learning in universities, including extended reality as a futuristic complement to traditional teaching. This emphasis on institutional needs and performance analysis underscores how new technologies can transform administrative and pedagogical structures.

Bhattacharjee K.K. addresses the adoption of AI in higher education from a quantitative perspective, employing structural equation modeling to understand how educators and institutions embrace AI tools. Additionally, this author's scientometric study focuses on trends in Indian higher education, providing both a national context and actionable insights for policymakers and educators worldwide.

Bond M. highlights themes of ethics, collaboration, and rigor through meta and systematic reviews of AI research, underscoring the need for methodological standards. Likewise, these works investigate the question of where educators stand in AI implementation, emphasizing the human dimension in technology integration.

Cravino J, Manhica R and Santos A, write on learning management systems (LMS) and how AI transforms their capabilities. Their research includes systematic literature reviews and position papers that detail the benefits, limitations, and future directions of AI-powered LMSs, pointing to enhanced interactivity, data-driven personalization, and improved student engagement as key outcomes.

Ilić M.P. and Kuleto V. together explore the regional dimension of AI adoption, specifically highlighting its potential in Romanian and Serbian higher education contexts. Their research blends institutional change models with technologies like machine learning and extended reality, illustrating how socio-economic factors can influence AI strategies and teaching practices.

These works collectively show the trend of AI in higher education and underscore areas where future research might focus.

Future analyses could include an assessment of the impact of these works on the field itself, for example through analysis of citations or their role in setting new research directions. Also, the distribution of researchers by country or institution can provide additional insights into global trends and the dominance of certain academic centers.

This concentration in contributions also suggests the possibility that certain researchers are closely connected to collaborative networks, which additionally affects their influence and visibility in the academic community. A deeper understanding of the collaborative patterns among these authors could shed light on how knowledge spreads and how dominant research groups in the field are formed.

In short, while the quantitative analysis of the number of published works provides an insight into the productivity of certain authors, for a deeper understanding of the research dynamics in this area, it is necessary to additionally analyze the quality of those works, their citations, the impact on future research, as well as the networks of collaboration between authors.

3.2. Top ten countries that publish articles in the field

Table 2 shows the distribution of papers by country, as well as their percentage in the total number of papers.

Table 2 Top ten countries that publish articles in the field

Countries/Regions	Record Count	%
Peoples R China	15	18.293
India	8	9.756
Romania	6	7.317
USA	6	7.317
Saudi Arabia	5	6.098
Spain	5	6.098
Ecuador	4	4.878
England	4	4.878
Serbia	3	3.659
South Africa	3	3.659

The largest number of papers originates from the People's Republic of China, with a total of 15 papers, which accounts for 18,293% of the total number of papers. The next largest number of papers is from India, with 8 papers that make up 9,756% of the total number. Romania and the United States of America share the third place with 6 papers each, which represents 7.317% of each of these countries.

Both Saudi Arabia and Spain have 5 papers, each with a 6.098% share of the total number of papers. Ecuador and England are in sixth place with 4 papers each, which represents 4,878% of the total number of papers. Serbia and South Africa have 3 papers each, with a 3.659% share.

The People's Republic of China stands out as the leader in terms of the number of published papers. Several factors contribute to this high volume of research papers: substantial government fundings, a booming tech industry, and a dense network of research institutions and universities dedicated to cutting-edge technology. These conditions create a supportive ecosystem that fosters collaboration among academia, industry, and government.

It is also interesting to note that a small country like Serbia is among the top ten countries in terms of the number of published papers. Serbia, with its three papers that make up 3,659% of the total number of papers, occupies a significant place in the analysis.

Serbia's position indicates that even countries with relatively small research capacities can achieve significant influence in specific research areas. The presence of Serbia among

the leading countries can be attributed to high-quality research and contributions provided by local researchers. This result not only highlights the global importance of papers coming from Serbia, but also shows that qualitative research can come from countries that are not large or economically dominant on the world stage. It also indicates serious potential for Serbia as a resource for research in this field, which is crucial for the initial stage of the migration to the industry 4.0 paradigm.

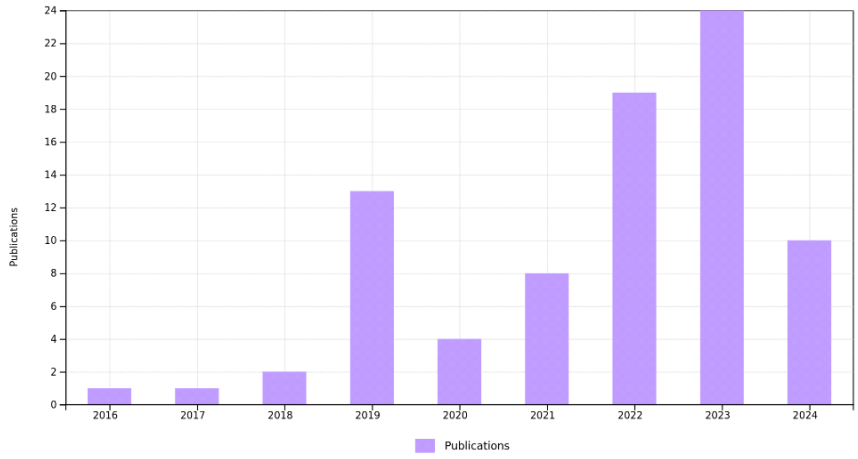
This situation can serve as an inspiration for other small or medium-sized countries, showing that the commitment and quality of research can overcome geographical and economic barriers and enable a significant contribution to the global scientific community.

3.3. Analysis of the number of publications by year

Trends in the number of publications in the field of artificial intelligence in higher education provide valuable insight into the dynamics of scientific production over the past few years. Following the publications from 2016 to 2024, it is possible to identify several key stages in the development of this field.

In the initial years (2016 and 2017), only one publication per year was recorded, which indicates the relatively modest interest of researchers in this field in its early stages. These years can be considered the initial period of development of the scientific discussion on the application of artificial intelligence in higher education.

The first hint of growth comes in 2018, when the number of publications doubles, but the real jump is recorded in 2019 with 13 published papers, which indicates a growing interest and increased activity in research. This jump can be linked to the growing understanding of the potential of artificial intelligence in education, as well as global trends in the digitization of educational processes.



However, 2020 saw a decline with only four papers. This reduction may be the result of global challenges, such as the COVID-19 pandemic, which slowed or halted many research projects. Although the pandemic had a negative impact on numerous sectors, 2021 shows signs of recovery with eight papers, and a significant increase is recorded in 2022 with 19 publications, which suggests that research activity is expanding again.

The year 2023 shows the highest number of publications - 24 papers, which represents the peak of scientific production in the period analyzed. This sharp increase can be partially attributed to the wider adoption of AI tools in education, as well as global technological advances, including the proliferation of apps like ChatGPT, the first version of which was released in late 2022. Its introduction probably caused increased attention and engagement regarding the topic of artificial intelligence in education.

At the beginning of 2024, although the analysis was done in February, ten papers were already recorded, which indicates the possibility that the number of papers this year will reach or even exceed the level of 2023. This suggests the continued growth of scientific production, as well as the increasing focus of researchers on the application and implications of artificial intelligence in higher education.

3.4. Key papers in the field of artificial intelligence in higher education

The table below shows some of the most important papers in this field, along with their number of citations by year, average per year, and total number of citations. These papers provide detailed insight into specific topics that dominate the discourse and are key sources for further research.

Table 3 Key papers in the field of artificial intelligence in higher education

Article	2020	2021	2022	2023	2024	Average Per Year	Total
Systematic review of research of artificial intelligence applications in higher education - where are the educators?	26	73	134	145	20	66,33	398
A Conversation of Artificial Intelligence, Chatbots and Plagiarism in Higher Education	0	0	0	109	10	59,5	119
Adoption of artificial intelligence in higher education: a quantitative analysis using structural equation modelling	4	22	30	37	4	19,4	97
Artificial Intelligence in Higher Education: A bibliometric Study on its Impact in the Scientific Literature	9	14	18	19	3	11,67	70
Artificial Intelligence and its Implications in Higher Education	4	13	9	21	2	8,5	51

The most prominent paper in terms of the number of citations is "Systematic review of research on artificial intelligence applications in higher education - where are the educators?" with a total of 398 citations. This paper, with an average of 66.33 citations per year, clearly represents a key reference in the field and indicates a continued interest in understanding the role of educational professionals in the implementation of artificial intelligence.

3.5. Citation of papers during the last five years

The table below shows the citations of papers during the last five years. This analysis shows how interest in these papers has increased in the global scientific community.

Table 4 Citation of papers during the last five years

2020	2021	2022	2023	2024	Average Per Year	Total
43	129	249	511	67	168,5	1,011

The highest number of citations was recorded in 2023, with a total of 511 citations, which indicates a significant jump in interest in this field. The increased citations, especially in 2023, may be due to the wider application of artificial intelligence in education, including the development of tools like ChatGPT, which have attracted considerable attention from researchers. This data also suggests that 2024, although in its early stages, is likely to continue this upward trend.

4. DISCUSSION

Analysis of publication and citation trends in the field of artificial intelligence in higher education provides several key insights that illuminate the development of the field over the past years, pointing to important patterns in research papers, distribution of scholarly contributions, and global interest in the topic. A significant increase in the number of publications since 2018, with a peak in 2023, can be interpreted as a result of the spread of digital technologies in education, whereby artificial intelligence has become an indispensable element of pedagogical practices. The increase in research activities can be linked to the growing availability of technologies, such as machine learning, intelligent tutors and data analytics, which are increasingly present in the educational environment. On the other hand, the decline in the number of publications in 2020 probably reflects the impact of the COVID-19 pandemic, which slowed down many projects, while the recovery in 2021 and continued growth in 2022 and 2023 indicate a renewed momentum in research activities and increased interest in digital solutions in education. Geographical analysis reveals China's dominance in the number of publications, while countries such as India, Romania and Serbia also have significant contributions, showing that even smaller countries with limited resources can become significant players in this field thanks to specific research projects. An analysis of the citations of the papers reveals that a few key publications dominate the discourse, with papers such as " Systematic review of research on artificial intelligence applications in higher education - where are the educators?" not only having the highest number of citations, but also becoming central to discussions about the role of artificial intelligence in education, focusing on key topics such as its application in classrooms, ethical challenges and its impact on pedagogy.

5. Conclusion

Based on these results, it can be concluded that artificial intelligence has become a central topic in higher education, with an increasing number of papers and citations every year. Chinese researchers and institutions dominate the number of publications, but other countries, even those with smaller economic capacity, also play an important role in the global research effort. The increased number of publications and citations in recent years indicates that artificial intelligence is recognized as a key technology for the transformation of the educational system, and this growth is likely driven by both technological progress and global challenges that have spurred innovation in education. Although 2020 saw a decline in the number of publications, the recovery in the following years indicates the resilience and adaptability of the research community, while 2023 represents a peak in research activity, with increased citations, reflecting the wider acceptance and practical applications of AI in education. Future research should focus on the further development of the application of artificial intelligence in educational practices, as well as the ethical challenges that these technologies bring, with special attention to the role of smaller countries, whose innovative approaches can overcome the limitations of larger research systems. This study provides better insight into the research output in the field of artificial intelligence in higher education and highlights the key trends that will shape the future development of the field. In particular, future studies should investigate monitoring strategies for AI use in higher education - examining how to detect and prevent misuse such as unauthorized assistance on student work, unethical data collection or over-reliance on automated grading. Researchers should also explore guidelines and best practices to ensure AI is deployed responsibly and preserves academic integrity. The consequences of improper AI integration could negatively affect both the quality of learning and institutional credibility, underscoring the need for strong policy frameworks. Educators must remain central in the teaching process, applying their expertise to guide and shape AI driven innovations in a manner that enhances, rather than undermines, the human element of education. Additionally, research should investigate the specific applications of AI that enhance educational outcomes, such as personalized learning environments, intelligent tutoring systems, and data-driven decision-making tools. By focusing on these areas, future studies can provide insights into how AI can be implemented to support both students and educators. Furthermore, longitudinal studies are needed to assess the long-term impacts of AI integration on educational quality and equity.

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BIBLIOMETRIJSKA ANALIZA PRIMENE VEŠTAČKE INTELIGENCIJE U VISOKOM OBRAZOVANJU KORIŠĆENJEM WEB OF SCIENCE BAZE PODATAKA

Veštačka inteligencija (VI) postaje sve značajnija u visokom obrazovanju, što je rezultiralo ubrzanom razvoju istraživanja u ovoj oblasti. Ovaj rad sprovodi bibliometrijsku analizu naučnih radova koji istražuju primenu VI u visokom obrazovanju, koristeći Web of Science bazu podataka. Analiza obuhvata period od 1996. do februara 2024. godine, a fokusira se na najcitiranije radove u ovoj oblasti, ukupno 82, sa 1011 citata (944 bez autocitata). Naša analiza pokazuje da se interesovanje za VI značajno povećalo u poslednjih nekoliko godina, pri čemu su najdominantnija istraživanja u oblastima obrazovanja, računarskih nauka i inženjeringa. Najveći broj radova objavljen je 2023. godine, što ukazuje na rastući značaj ove teme. Ovi rezultati pružaju temelj za buduća istraživanja o uticaju VI na obrazovne prakse, njenim izazovima i potencijalu za transformaciju obrazovanja u budućnosti.

Ključne reči: *veštačka inteligencija, visoko obrazovanje, bibliometrijska analiza, trendovi istraživanja, Web of Science.*