Artificial Intelligence in Higher Education: A Bibliometric Analysis

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Abstract

Today, artificial intelligence plays a very important role in every field. It is inevitable to say that it will play a very effective role in higher education. This study is based on bibliometric studies on the publications indexed in Web of Science on Artificial Intelligence in Higher Education. This study was carried out to determine the most cited authors, keywords, in which journals or conferences it was discussed and in which countries it was studied the most, by performing bibliometric analysis on Artificial Intelligence in Higher Education.For the analysis of these data, the analysis of the publications indexed in Web of Science is based on mapping and bibliometric analysis with VosViewer software. The analysis of the simultaneous occurrence of different keywords indicates a particular association between the concepts of artificial intelligence, higher education and performance, while reinforcing the inevitable raise of concern around ethical issues of using such technologies in educational institutions.

Keywords

Artificial Intelligence, Higher education, Bibliometric Analysis

1. Introduction

Artificial Intelligence (AI) has had a tremendous impact on organizations, businesses, students and individuals. Based on input, learning through the observation of expected results and the possibility to adaptation to changes in the surrounding environment, AI is providing complex reasoning capabilities useful in a large spectrum of applications [1]. In the initial phases, AI algorithms were firstly focused on guided learning. Over the years, researchers have proposed new AI algorithms that can handle data in its unstructured, raw form, allowing information like raw text and images to be handled and processed.

In the latest years AI methodologies and tools have started being used more and more within higher educational institutions [2]. Using AI technology in education has brought significant transformations in teaching methodologies and has popularized the usage of blended teaching techniques. These methods involved AI chatbots, mobile applications, specific tools, new teaching approaches. The aim of practically implementing such techniques is that the integration of innovative technologies into intelligent learning, might present several opportunities to enhance learning effectiveness and enhance the overall learning journey.These are the reasons

for which we propose to address the following research questions: (RQ1) determine the most cited authors with respect to "Artificial Intelligence in Higher Education"; (RQ2) which are the most cited keywords used in the literature review; (RQ3) analyze which are the journals or conferences in which (RQ1) and (RQ2) appear.

The usage of AI in higher education has been addressed in several research papers by different researchers. Recently, a very interesting approach proposed on using AI and Internet-of-Things in order to address the knowledge management (KM) process in higher education institution [3]. Different AI algorithms are used in order to analyze and classify the knowledge received from the educational process, students and staff. However, the application of AI in the processes used in higher education institutions involve ethical concerns that need to be addressed both internally in the institutions, but also by the large governmental agencies like those of European Union or UNESCO or professional organizations like Institute of Electrical and Electronics Engineers or Association for Computing Machinery [4]. A possible threat to the ethical usage of AI is considered to be the biased algorithms of AI, especially when these algorithms are used in the grading processes of different courses or even in the admission steps. It is argued that such algorithms can have "devastating effects" on the students [4]. Another concern raised in the cited paper is perspective in which the human educators can be replaced by AI programs. The proposed solutions in [4] are ranging from a close cooperation of stakeholders to a care adoption of AI in order to protect individuals. Overall, as it was presented in [5, 6, 7], there is an increase interest into how AI can be used into higher education, based on parameters like accoutnability, traceability, transparency and openness, in those ways that maximize the benefit of the students. In this regard, new, improved tools are developed [8] in order to measure the degree to which AI can enhance different skills of the students when faced to AI-based interaction.

A very notable approach is that from [9] as it comes as a mean to educate different stakeholders from higher education on how to ethically use AI in this sector. The authors base their approach on the fact that AI can be used to personalize the teaching and learning experience of tutors and students. They identify several ways in which the assessment methods can be improved, as wel as the education management can be enhanced by using AI tools. The idea of improved teaching quality by means of AI approaches is addressed in [10]. More than this, the paper is addressing not only the teaching process, but also the human resource management, as the data collected from the university processes can be used for decision-making models [11]. Such metrics can be used for developing new possiblities for AI to improve the lecturing process in regard to didactic materials, students' assessment or providing the tutors with helpfull hints on how to improve their lecture based on the feedback the algorithms is receiving from students [12].

A notable approach is that from [13] as it proposes a complete system which is collecting several learning and teaching materials and stores them on a Learning Experience Platform. The collevted materials are both video and audio format. The AI algorithms will process the input data and will offer the possibility for users (tutors and students) to search according to several criteria. The module also has the possiblity to generate assessment exercises. The idea of improving students' study plans, but also a physical robots to assist the students are presented in [14]. Using AI-based robots brings another important problem, that of legal community. From this point of view, in [15] the questions of legality of AI in higher education, the involvement of

legal community into the AI debate etc. It has been proved [16] that these AI-usage challenges, as well as the use-case for AI in higher education are all part of Education 4.0. In this context, AI is offering multimodal learning analytics, based on the user data, taking into consideration the user's stress situation and well-being, everything in a legal and ethical environment [17].

It can be noted that applying AI in higher education has started back at the end of eighties and currently there are different approaches into how this can be done [18, 19, 20, 21, 22]. Still, a lot of work needs to be done in order to use AI in higher education, but also to research the impact that AI-based methods and tools has upon the stakeholders, mainly tutors and students. The research on using AI in higher education is still concerned alot with the ethics and legality of AI. But, as we have previously presented, several innovative studies are presenting their experience on using AI for the benefit of students and tutors.

2. Method

This study was carried out on 12 July 2023 by selecting "all fields" in Web of Science with the keyword "Artificial Intelligence in Higher Education" 22 studies were reached with the related word. The data were analyzed using the VosViewer software.

While analyzing, it was limited to Citation of authors, Co-occurrence-all keywords, Bibliographic coupling of documents, Bibliographic coupling of sources, Bibliographic coupling of countries. The purpose of the selection of these criteria is to determine which keywords the authors working on Artificial Intelligence in Higher Education use, where they publish and in which countries the authors publish.
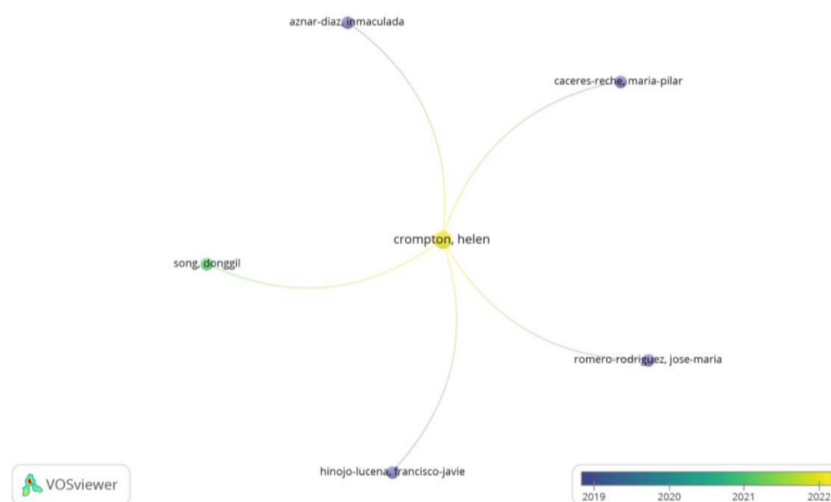
3. Findings

3.1. Citation of authors

Figure 1: Figure generated with VosViewer for citation of authors, the nodes representing the authors.

While performing this analysis, type of analysis and counting methods were selected as citation of authors in VosViewer, in order to address (RQ1) from the research questions proposed for this study. While performing the analysis, the minimum number of documents of an author 2 was selected, while the minimum number of citations of an author 1 of the 70 authors, 21 meet the treshold.

Table 1
Table for citation of authors

| Author	Documents	Citations	Total Link Strength
Aznar-Diaz, İnmaculada	1	57	1
Bhattacharjee, Kalyan Kumar	1	65	0
Caceres-Reche, Maria-Pilar	1	57	1
Chatterjee, Sheshadri	1	65	0
Ciolacu, Monica İonita	1	9	0
Crompton, Helen	2	2	5
Dou Chenxu	1	4	0
Hinojo-Lucena, Francisco-Javier	1	57	1
Karakose, Mehmet	1	4	0
Li Dan	1	4	0
Ozbey, Nigar	1	4	0
Pang Nan	1	4	0
Romero-Rodriguez, Jose-Maria	1	57	1
Song, Donggil	1	2	1
Sun, Ting	1	2	0
Svasta, Paul	1	9	0
Teng, Yusi	1	2	0
Ucar, Aysegul	1	4	0
Xu Xin	1	4	0
Yu Shu-Jiang	1	4	0
Zhang, Jie	1	2	0

3.2. Co-occurrence-all keywords
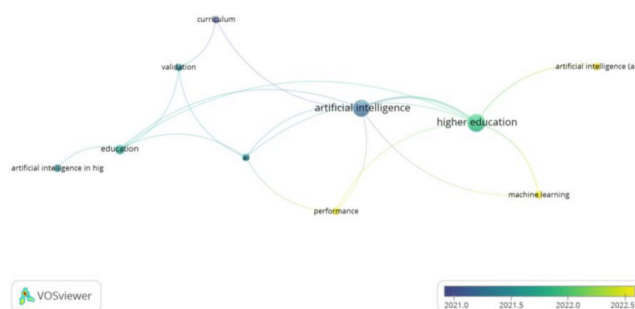
Figure 2: Figure generated with VosViewer for co-occurrence-all keywords, the nodes representing the keywords.

In this analysis, type of analysis and counting methods were selected as Co-occurrence-all keywords in VosViewer, in order to address (RQ2). Afterwards, the minimum number of occurrences of a keyword 2 of the 106 keywords, 10 meet the threshold. Number of the keywords selected 10.

Table 2
Table For Co-Occurrence-All Keywords

Keyword	Occurrences	Total Link Strength
Ai	2	5
Artificial İntelligence	9	12
Artificial İntelligence (Ai)	2	2
Artificial İntelligence İn Higher Education	2	1
Curriculum	2	2
Education	3	5
Higher Education	10	14
Machine Learning	2	3
Performance	2	3
Validation	2	3

3.3. Bibliographic coupling of documents

In this analysis, type of analysis and counting methods in VosViewer were chosen as Bibliographic coupling of documents. Afterwards, the minimum number of citations of a document was set to 1 of the 22 documents, 13 meet the threshold.
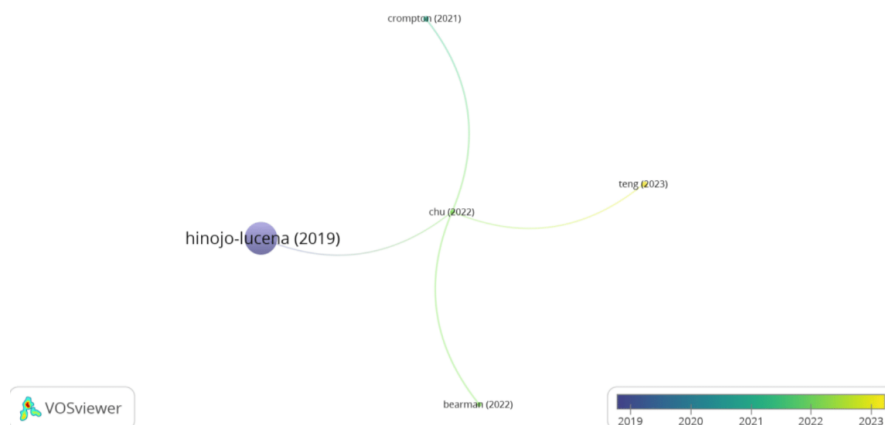

Figure 3: Figure generated with VosViewer for bibliografic coupling of documents, the nodes representing the documents

Table 3
Table for bibliographic coupling of documents

Document	Citations	Total Link Strength
Makarov et al. [15]	1	0
Altinay et al. [21]	1	0
Hinojo-Lucena et al. [20]	57	1
Crompton and Song [17]	2	2
Stratil et al. [23]	1	0
Bearman et al. [6]	1	2
Chatterjee and Bhattacharjee [18]	65	0
Ozbey et al. [22]	4	0
Teng et al. [11]	2	1
Chu et al. [7]	1	6
Ciolacu and Svasta [16]	9	0
Mosteanu [14]	1	0
Xu Xin et al. [10]	4	0

3.4. Bibliographic coupling of sources

In this analysis, type of analysis and counting methods in VosViewer were chosen as Bibliographic coupling of sources. Afterwards, the minimum number of documents of a source 1 and the minimum number of citations of a source 1of the 21 sources, 13 meet the thresholds.The results for (RQ3) are summarized in Table 4.
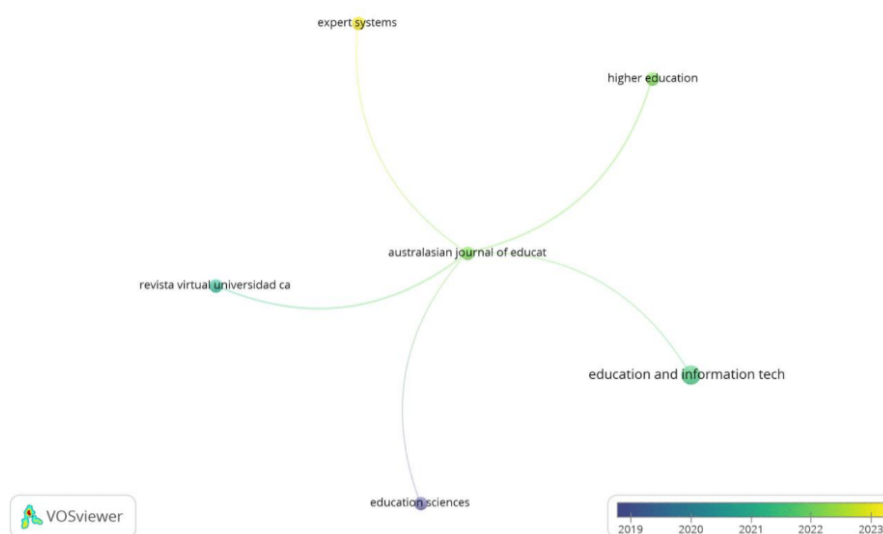

Figure 4: Figure generated with VosViewer for bibliografic coupling of sources, the nodes representing the sources

Table 4
Table for bibliographic coupling of sources

Source	Documents	Citations	Total Link Strength
2016 15th İnternational Conference On İnformation Technology Based	1	4	0
Australasian Journal Of Educational Technology	1	1	7
Education And İnformation Technologies	2	65	1
Education Sciences	1	57	1
Educational & Training Technology İnternational	1	1	0
Expert Systems	1	2	1
Higher Education	1	1	2
Journal Of İnnovation & Knowledge	1	4	0
Mobility For Smart Cities And Regional Development - Challenges For	1	1	0
New Technologies And Redesigning Learning Spaces, Vol İi	1	1	0
Proceedings Of The 2021 İeee Global Engineering Education Conference	1	9	0
Revista Virtual Universidad Catolica Del Norte	1	2	2
romanian journal of information science and technology	1	1	0

3.5. Bibliographic coupling of countries

In this analysis, type of analysis and counting methods in VosViewer were chosen as Bibliographic coupling of countries. Afterwards, the minimum number of documents of a country 2 and the minimum number of citations of a country 0 of the 18 countries, 6 meet the thresholds.

Figure 5: Figure generated with VosViewer for bibliografic coupling of countries, the nodes representing the countries

Table 5
Table for bibliographic coupling of countries

Country	Documents	Citations	Total Link Strength
Germany	3	9	24
İndia	2	65	0
China	3	6	0
Romania	2	9	23
Spain	2	57	0
Usa	2	2	1

4. Discussion

The foundations of the presented study consist in the specification of 5 different bibliometric analysis on the corpus of data provided by Web of Science, performed by the VosViewer software tool, being respectively: Citation of authors, Co-occurrence-all keywords, Bibliographic coupling of documents, Bibliographic coupling of sources and finally, Bibliographic coupling of countries. We also proposed to address 3 research questions, namely (RQ1) determine the most cited authors with respect to "Artificial Intelligence in Higher Education" from Web of Science; (RQ2) understand which the most cited keywords used in the literature review; (RQ3) analyze which are the journals or conferences in which (RQ1) and (RQ2) appear.

The graphically generated results indicate a particular intensity in collaborations for the Executive Director of the Research Institute for Digital Innovation in Learning (RIDIL) and Professor of Instructional Technology at Old Dominion University, Helen Crompton, the total link strength for "crompton, helen" being 5. From a quantitative analysis regarding the most individually cited authors in the literature, the present study highlights the scientific relevance in the "Artificial Intelligence in Higher Education" domain of Professors Inmaculada Aznar Diaz, Francisco Javier Hinojo-Lucena, Maria Pilar Caceres Recheand Jose Maria Romero Rodriguez from the University of Granada, Associate Professor Kalyan Kumar Chattopadhyay and Professor Sheshadri Chatterjee.

The analysis of the simultaneous occurrence of different keywords indicates aparticular association between the concepts of artificial intelligence, higher education and performance in the specified literature, revealing the influencial nature of intelligent systems on the performative results of students in higher education [11, 12]. A relevant result may be observed in the relatively high total link strength for the "education" keyword, suggesting that the impact of artificially intelligent systems extends beyond education of higher degree, while the presence of "validation" keyword reinforces the inevitable raise of concern around ethical issues of using such technologies in educational institutions [4].

The analysis of the common source of citations for different works individuates a higher number of citations for Professor Francisco Javier Hinojo-Lucena's "Artificial Intelligence in Higher Education: A Bibliometric Study on its Impact in the Scientific Literature " [20] and for Dr.Sheshadri Chatterjee's "Adoption of artificial intelligence in higher education: a quantitative analysis using structural equation modelling", indicating also a close relationship between the study of the impact of intelligent systems on higher education and the domain of psychology [18].

The results of our study indicates the importance of the "Education and Information Technologies" journal, cited also in "A help or a threat to contemporary education. Should students be forced to think and do their tasks independently?" and the "Education Sciences" journal, published by MDPI.The 2021 IEEE Global Engineering Education Conference has also been highly influential, resulting one of the most cited conferences by the studied scientific literature [16].

Two countries have significally been contributing to the documentation of the studied domain: India, having 65 citations and Spain having 57, due to impactful works of Professors Inmaculada Aznar Diaz, Francisco Javier Hinojo-Lucena, Maria Pilar Caceres Reche and Jose Maria Romero Rodriguez from the University of Granada and Associate Professor Kalyan Kumar Chattopadhyay

and Professor SheshadriChatterjee.In Europe, countries such as Romania and Germany have scored high total link strengths, suggesting the importance of their collaborative work, being graphically observable in the VosViewer analysis' generated graph.

5. Conclusions and Future Work

The bibliometric studies obtained in the presented paper were computed using Web of Science's indexed publications on Artificial Intelligence in Higher Education. The studies were based on the use of Vos Viewer software for mapping and data analysis and tackled 5 different analytic approaches, revealing connections between citations of authors, keywords' correlations in the scientific literature and bibliographic couplings of documents, sources and countries. The results of this study are limited to Web of Science's query on "Artificial Intelligence in Higher Education". This gave a total of 22 articles. As future work, our study will be expanded by taking into consideration other databases like Scopus, DBLP, IEEExplore, as well as further queries like "Artificial Intelligence in Education". In this way, our research will provide in the future a comparison on how Artificial Intelligence is used in Higher Education and in Education in general.

In our present study, the most noticeable impact has been made by the work of Spanish Professors Inmaculada Aznar Diaz, Francisco Javier Hinojo-Lucena, Maria Pilar Caceres Reche and Jose Maria Romero Rodriguez from the University of Granada and Associate Professor Kalyan Kumar Chattopadhyay and Professor Sheshadri Chatterjee, rendering Spain and India the most cited countries in the field of study of the impact intelligent systems have on higher education.

The study also indicates the importance of the "Education and Information Technologies" and "Education Sciences" journals while highlighting the 2021 IEEE Global Engineering Education Conference's influence too, resulting one of the most cited conferences in the studied domain.

Also, the analysis of the simultaneous occurrence of different keywords indicates a particular association between the concepts of artificial intelligence, higher education and performance, while reinforcing the inevitable raise of concern around ethical issues of using such technologies in educational institutions.

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