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Article

Mapping the Future: A Bibliometric Analysis of Engagement Trends in Artificial Intelligence within Higher Education

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Abstract: This study conducts a comprehensive bibliometric analysis to map the landscape and research trends of artificial intelligence (AI) applications within higher education. Utilizing data from the Scopus database, encompassing 4,696 datasets from 1939 to 2024, we employed VOSviewer for visualizing and analyzing co-authorship networks, citation patterns, and keyword occurrences. The analysis identifies primary research areas, influential authors, and emerging topics, offering valuable insights into the dynamic field of AI in higher education. Key findings include the identification of significant research themes such as AI applications in education, student engagement, and the development of learning systems. Influential contributors were highlighted for their substantial impact on the research landscape. The study also revealed strong collaborative networks, particularly involving key figures, underscoring the importance of co-authorship in advancing AI research. Strong collaborative networks refer to the co-authorship and international partnerships that connect these contributors, producing high-impact research through shared expertise, resources, and cross-regional knowledge exchange. The findings validate the hypotheses that significant research areas and influential contributors can be identified, and that collaborative networks and emerging technologies play crucial roles in the field's advancement. Influential contributors are the authors, institutions, or countries whose publications and citation impacts significantly shape the research landscape of AI in higher education, setting key directions for scholarship and practice. This study provides a roadmap for future research, emphasizing the importance of strategic collaborations and innovative technologies in shaping the future of AI in higher education.

Keywords: Artificial Intelligence; Higher Education; Bibliometric Analysis; VOSviewer; Co-Authorship Networks; Citation Analysis; Emerging Technologies; Geographic Distribution

1. Introduction

The rapid advancement of technology in the 21st century has revolutionized numerous sectors, with higher education being no exception. Among the technological innovations, artificial intelligence (AI) has emerged as a pivotal force, offering transformative potential across various educational domains. This study aims to elucidate the evolving landscape of AI applications within higher education through a comprehensive bibliometric analysis. The utilization of VOSviewer for this purpose underscores the study's commitment to leveraging advanced analytical tools to uncover intricate patterns and trends in scholarly research.

Artificial intelligence, once a subject of speculative fiction, has now firmly entrenched itself in practical applications, significantly impacting education [1]. AI's capabilities range from personalized learning environments and intelligent tutoring systems to administrative support and predictive analytics. As a result, the scholarly community has increasingly turned its attention to exploring these applications, leading to a burgeoning body of research dedicated to understanding and enhancing AI's role in higher education [2]. The importance of bibliometric analysis in this context cannot be overstated. Higher education plays a critical role in shaping the future workforce and driving innovation across various fields, including artificial intelligence (AI) [3]. This study focuses on the intersection of AI and higher education, examining how AI technologies are being integrated into educational institutions to enhance learning experiences, optimize administrative processes, and support research activities. The integration of AI in higher education is pivotal for developing new pedagogical approaches, improving student outcomes, and fostering a culture of innovation [4]. By analyzing trends, influential contributors, and emerging technologies within this domain, the study aims to provide a comprehensive understanding of how AI is transforming higher education. This analysis not only highlights current advancements but also identifies potential future directions for research and application in educational contexts.

Bibliometrics, the statistical analysis of written publications, provides a robust framework for assessing the development and dissemination of research [5]. It enables scholars to identify key trends, influential authors, pivotal publications, and collaborative networks within a specific research domain. By applying bibliometric methods, researchers can gain insights into the dynamics of knowledge production and dissemination, thereby informing future research directions and policy decisions. VOSviewer, a powerful tool for constructing and visualizing bibliometric networks, facilitates this analytical process. Developed by Van Eck and Waltman (2010), VOSviewer specializes in creating maps based on network data, enabling the visualization of research landscapes [6]. Its ability to handle large datasets and produce clear, interpretable visualizations makes it an ideal tool for this study. By utilizing VOSviewer, this research aims to map the intellectual structure of AI applications in higher education, highlighting the key areas of focus, influential works, and emerging trends.

Artificial intelligence encompasses a wide array of technologies designed to perform tasks that typically require human intelligence, such as learning, reasoning, problem-solving, and decision-making. In the realm of higher education, AI applications have been diverse, ranging from intelligent tutoring systems and adaptive learning technologies to administrative support and predictive analytics. These applications aim to enhance both teaching and learning experiences, streamline administrative processes, and provide actionable insights based on data. Early explorations into the use of AI in education highlighted its potential to revolutionize learning environments. Romero and Ventura [7] emphasized the role of educational data mining and learning analytics in creating adaptive learning systems that tailor educational content to the needs of individual learners. These systems leverage AI algorithms to analyze data from various student interactions, enabling the creation of personalized learning paths that optimize educational outcomes. This foundational work set the stage for subsequent research into more specialized AI applications in education. One significant advancement in this field is the development of intelligent tutoring systems (ITS), which provide personalized instruction and feedback to learners. Luckin et al. [8] discussed how ITS can simulate one-on-one tutoring experiences by adapting to a student's learning style, pace, and performance. These systems use AI to monitor student progress, identify areas of difficulty, and offer targeted interventions, thus enhancing the overall learning experience. The implementation of ITS in higher education has been shown to improve student engagement and academic achievement. AI has also been applied to administrative functions within higher education institutions. Predictive analytics, powered by AI, can analyze vast amounts of institutional data to forecast trends and inform decision-making. For example, AI can predict student enrolment patterns, identify at-risk students, and optimize resource allocation. These applications not only improve operational efficiency but also enable institutions to proactively address challenges and improve student retention rates. Despite the evident benefits of AI in higher education, its adoption has also raised important ethical and practical considerations. Selwyn [9] explored the sociopolitical dimensions of AI adoption in universities, highlighting the need for a critical assessment of AI technologies to ensure they promote equitable and ethical outcomes. Issues such as data privacy, algorithmic bias, and the digital divide must be addressed to fully realize the potential of AI in education. This perspective underscores the need for a balanced approach that considers both the opportunities and challenges associated with AI implementation.

The growing body of research on AI in higher education reflects the field's dynamic and multifaceted nature. To understand this evolving landscape, bibliometric analysis provides a valuable methodological approach. Bibliometrics involves the statistical analysis of written publications, offering insights into research trends, influential authors, key publications, and collaborative networks. By analysing bibliometric data, researchers can identify the intellectual structure of a field, trace its development over time, and uncover emerging themes and trends.

Despite the extensive body of literature on bibliometric analysis in the academic field, there remains a significant gap in the bibliometric analysis of AI engagement in higher education. Shareefa and Moosa's [10] bibliometric analysis primarily focuses on differentiated instruction (DI), highlighting the prolific contributions and patterns in this specific educational approach. This study uses bibliometric techniques to map out influential authors, key themes, and publication trends within DI, providing a detailed overview of how this teaching method has been explored and implemented. However, there is a noticeable absence of similar comprehensive bibliometric studies focusing on the engagement trends of AI within higher education. While Shareefa and Moosa's work illustrates the depth of research and interest in DI, it does not address the rapidly evolving field of AI applications in higher education. AI's potential to transform educational practices, through personalized learning, intelligent tutoring systems, and administrative efficiencies, underscores the need for a dedicated bibliometric analysis to map out the research landscape in this area.

The gap that this current study aims to fill is the lack of a systematic and comprehensive bibliometric analysis focusing on AI engagement in higher education. By employing VOSviewer, this research will visualize and analyze bibliometric data to uncover trends, influential works, and collaborative networks within AI research in higher education. This analysis is essential for identifying key research areas, understanding the evolution of publication trends, and highlighting emerging technologies and practices. Additionally, this study will explore the geographic distribution of research contributions, offering a global perspective on the adoption and impact of AI in higher education.

This study questions and hypothesizes as follows;

1. What are the primary research areas in which artificial intelligence is applied within higher education?
   H1. *Significant research areas can be identified within the application of AI in higher education.*
2. Who are the most influential authors in the field of AI in higher education?
   H2. *Certain authors, citations, and institutions have disproportionately influenced AI research in higher education.*
3. What do the co-authorship and collaboration networks among AI researchers in higher education look like?
   H3. *Co-authorship and collaboration networks play a crucial role in advancing AI research within higher education.*
4. Which works and references have been researched in shaping the research landscape of AI in higher education?
   H4. *A set of research works and references has consistently shaped the discourse on AI in higher education.*
5. What emerging topics and technologies in AI are currently gaining traction within the higher education sector?
   H5. *Emerging topics and technologies in AI are increasingly being integrated into higher education research.*
6. What is the geographic distribution of AI research in higher education, and what global trends and regional focuses can be identified?
   H6. *AI research in higher education exhibits distinct geographic patterns, with specific regions leading in research contributions.*

One of the primary objectives of this study is to identify the most influential works and authors in the field. Citation analysis, a core component of bibliometrics, will be employed to determine the impact of specific publications and researchers. Highly cited works often serve as foundational texts that shape subsequent research, making them critical to understanding the development of a field. By focusing on these key citations, this study will shed light on the research contributions that have driven the discourse on AI in higher education. Another important aspect of this study is the exploration of collaborative networks. Research in AI and higher education is inherently interdisciplinary, often involving collaboration between computer scientists, educational researchers, and practitioners. By mapping co-authorship networks, this study will identify the key collaborations that have facilitated the advancement of knowledge in this domain. Understanding these networks can provide insights into the mechanisms of knowledge production and dissemination, highlighting the role of collaboration in driving innovation. The thematic analysis will further enrich the understanding of research trends in AI applications in higher education. By clustering related publications based on keyword co-occurrence, VOSviewer will reveal the major themes and subfields within this research area. This thematic mapping will highlight the predominant topics of interest, as well as emerging areas that are gaining traction among scholars. Such insights are crucial for identifying gaps in the literature and suggesting avenues for future research. In addition to mapping the intellectual structure of the field, this study will also examine the geographical distribution of research on AI in higher education. Bibliometric data often reveal significant regional variations in research activity, reflecting the influence of local contexts and policy environments. By analysing the geographic distribution of publications, this study will provide a global perspective on the development of AI applications in higher education, identifying regions that are leading in research and those with growth potential.

The outcomes of this bibliometric analysis will have important implications for various stakeholders. For researchers, the study will offer a detailed overview of the field, highlighting key contributions and suggesting directions for future inquiry. For educators and practitioners, the insights gained from this analysis can inform the design and implementation of AI-driven educational technologies, ensuring that they are grounded in robust research. For policymakers, the findings will provide evidence-based recommendations for supporting and regulating the use of AI in higher education, promoting its benefits while addressing potential challenges. This study not only advances academic knowledge but also has practical implications for improving educational practices and policies. By mapping the future of AI engagement in higher education, the research offers a roadmap for harnessing the transformative potential of AI, ultimately contributing to more effective, inclusive, and innovative educational environments.

2. Literature Review

The integration of Artificial Intelligence (AI) in higher education has garnered significant attention in recent years, reflecting the rapid technological advancements and their implications on educational practices. This literature review critically examines key studies to understand the evolving landscape of AI applications in higher education, setting the stage for our investigation into primary research areas, influential contributors, and emerging technologies.

Guilherme [11] highlights the multifaceted implications of technology in education, noting both its potential benefits and the challenges it poses. Guilherme emphasizes that while technology can enhance learning by providing access to resources and improving performance, it also risks depersonalizing education, affecting teacher-student relationships. This perspective raises questions about whether AI applications in education can maintain a balance between technological benefits and the crucial human connections needed for effective learning environments. This study aims to explore whether AI can enhance educational experiences without compromising these essential relationships. Akinwalere and Ivanov [12] delve into the challenges and opportunities of AI in higher education, identifying areas such as personalized learning and administrative efficiency where AI can potentially enhance educational outcomes. However, they caution against over-reliance on AI, which can lead to ethical concerns and inequities. These insights prompt our investigation into whether emerging AI technologies like ChatGPT, which are gaining traction in higher education, can address these challenges effectively. The balance between leveraging AI's capabilities and mitigating its limitations is a central focus of our study. Perrotta and Selwyn [13] researched deep learning applications in education, underscoring the transformative potential of AI through adaptive learning technologies and intelligent tutoring systems. Perrotta and Selwyn [13] argued that AI can provide personalized learning experiences, improving student engagement and outcomes. This study seeks to determine whether significant research areas, such as student engagement and learning systems, as identified by Perrotta and Selwyn [13], are where AI's impact is most profound. Additionally, Perrotta and Selwyn [13] who are concerned about exacerbating existing educational inequalities through AI implementation, align with our aim to examine the geographic distribution of AI research and identify potential disparities.

Studies by Guilherme [11] and Akinwalere and Ivanov [12] emphasized the evolving role of teachers in AI-enhanced classrooms. Guilherme [11] introduces the concept of "learnification," where teachers act as facilitators rather than traditional instructors, necessitated by the increasing use of AI. This study aims to identify influential authors and institutions driving this pedagogical shift and to assess whether AI-enhanced education can preserve the critical teacher-student relationship essential for holistic education. Akinwalere and Ivanov [12] highlighted the global nature of AI research and the collaborative efforts across different regions. Our study builds on this by analyzing the geographic distribution of AI research contributions from North America, Asia, and Europe. We seek to identify whether strong co-authorship networks exist among leading countries, such as the United States and China, and to understand the role of international collaborations in advancing AI research in higher education. Emerging technologies such as ChatGPT and machine learning are prominently featured in recent AI research, reflecting a growing interest in their applications within higher education. Both Akinwalere and Ivanov [12] and Perrotta and Selwyn [13] identify these technologies as pivotal in shaping future educational practices. This study aims to determine whether these technologies are increasingly integrated into higher education research and to highlight their potential to drive innovation and improve educational outcomes.

The literature reviewed indicates the transformative potential of AI in higher education, while also highlighting significant challenges and unanswered questions. By exploring key research areas, influential contributors, and emerging technologies, this study aims to contribute to the growing body of knowledge on AI applications in higher education. Our investigation seeks to provide insights into future research directions and collaborative opportunities, addressing the balance between technological advancement and the preservation of essential human elements in education.

Theoretical Framework: Socio-Technical Systems Theory (STS)

Socio-Technical Systems Theory (STS) provides a robust theoretical framework for studying the integration of Artificial Intelligence (AI) in higher education. This theory posits that any technological system within an organization cannot be understood in isolation but must be seen as part of a larger social system [14]. Developed by Trist and Bamforth in the 1950s, STS emphasizes the interaction between people (the social system) and technology (the technical system) and how they influence each other to create meaningful outcomes [15]. In the context of AI in higher education, the technical subsystem includes AI technologies such as intelligent tutoring systems, adaptive learning platforms, AI-driven administrative tools, and emerging technologies like ChatGPT and machine learning algorithms. It also encompasses the technological infrastructure that supports AI, including software, hardware, data management systems, and network capabilities. The social subsystem involves the primary users of AI technologies in higher education: students and educators. This includes their interactions with AI tools, their perceptions and acceptance of these technologies, and the impact on teaching and learning practices. Additionally, it includes the policies, norms, and cultural aspects of educational institutions that influence how AI technologies are implemented and used.

The interaction between the technical and social subsystems is critical [16]. Human-technology interaction examines how students and educators interact with AI technologies, focusing on usability, engagement, and the overall user experience. Organizational change and adaptation involve how institutions adapt their policies, curricula, and administrative processes to effectively integrate AI technologies. The outcomes of these interactions can be seen in two primary areas: educational outcomes and operational efficiency [17]. Educational outcomes include the impact on student learning, engagement, performance, and the overall educational experience. Operational efficiency encompasses improvements in administrative efficiency, resource management, and decision-making processes within institutions. By understanding these components and their interactions, STS provides a comprehensive framework for analyzing the integration of AI in higher education.

3. Methodology

The research design follows Saunders et al.'s [18] Research Onion framework. This framework systematically addresses the layers involved in the development of a research methodology, ensuring a comprehensive and rigorous approach.

This study adopts a positivist research philosophy. Positivism is appropriate for this study because it involves the collection and analysis of quantitative data to identify patterns and trends [19]. The objective nature of bibliometric analysis aligns with the positivist view of research, which seeks to explain phenomena through observable and measurable facts. A deductive approach is employed in this study. This approach starts with the theory or hypothesis and involves testing these through data collection and analysis [20]. Given the study's objective to analyse trends, identify influential works, and map research networks, a deductive approach is suitable as it allows for testing hypotheses derived from existing literature. The research strategy is centred around bibliometric analysis, which involves the statistical evaluation of written publications. Bibliometric methods will be used to quantify the impact of AI research in higher education, including citation analysis, co-authorship analysis, and keyword co-occurrence analysis. This strategy allows for a comprehensive mapping of the research landscape. This study will utilize quantitative methods to analyse the bibliometric data. Quantitative analysis is essential for measuring publication trends, citation counts, and the frequency of keywords. The use of statistical tools will help in generating objective and replicable results. The study will adopt a longitudinal time horizon, analysing data from 1939 to 2023. This approach allows for the examination of changes and developments in AI engagement in higher education over time. By analysing a span of 84 years, the study can identify significant trends and shifts in the research landscape. The primary data source will be the Elsevier SCOPUS database, chosen for its comprehensive coverage of relevant literature. An electronic search will be conducted using specific keywords such as "AI", "artificial intelligence," and "higher education." Identified documents will undergo a rigorous data cleaning process to ensure accuracy. Relevant bibliometric data, including authors, titles, publication years, journal titles, citation counts, and keywords, will be extracted and organized for analysis. VOSviewer software will be employed for bibliometric mapping and visualization [21–23]. Using Saunders et al.'s [18] Research Onion framework, this research design ensures a structured and methodical approach to examining AI engagement trends in higher education.

3.1. Search Strategy

We form the Elsevier SCOPUS index search query to select literature and apply various filters so that optimal results match our research objectives. The final search query consists of TITLE-ABS-KEY (AI) OR TITLE-ABS-KEY (artificial AND intelligence), AND TITLE-ABS-KEY (higher AND education). SCOPUS was chosen due to its broader coverage of materials [24]. SCOPUS includes approximately 70% more sources than WoS [25]. An electronic search of the SCOPUS database was conducted on June 13, 2024. The search was confined to articles that included these terms in their titles, abstracts, and keywords. The initial search returned 4872 documents, which were then refined according to the inclusion and exclusion criteria outlined below.

3.2. Inclusion and Exclusion Criteria

The criteria for inclusion were: (i) journal articles written in English, and (ii) articles published between the years 1939 and 2023. This time frame was selected to capture the significant advancements in AI technology and its integration into educational practices during this period. Articles that did not meet these inclusion criteria were excluded. This refined list amounts to 4696. These documents underwent a data cleaning process to check for incomplete or incorrect entries. Two main steps were followed: (i) verifying that all required fields (columns) contained data, and (ii) cross-checking the data to ensure alignment with the field titles. Incorrect or missing entries were removed accordingly. A flow chart of the search process, based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, is shown in **Figure 1**.

3.3. Bibliometric Analysis

VOSviewer is used for bibliometric analysis tool. VOSviewer, a powerful tool for constructing and visualizing bibliometric networks, facilitates this analytical process. The components of the bibliometric analysis in this study include: (i) the number of citations, (ii) authors, (iii) journals, (iv) countries, (v) institutions, (vi) year of publication, and (vii) author keywords for the 4696 selected papers.

4. Results and Discussion

This section details the outcomes of the analyses conducted, as described in the methodology. The results are organized according to the research questions (RQ). The analysis results are presented using tables and/or visualizations of bibliometric networks. Each analysis is discussed in relation to the respective findings.

RQ 1: Here we seek answer to "What are the primary research areas and themes in which artificial intelligence is applied within higher education?" and hypothesize that "Significant research areas can be identified within the application of AI in higher education."

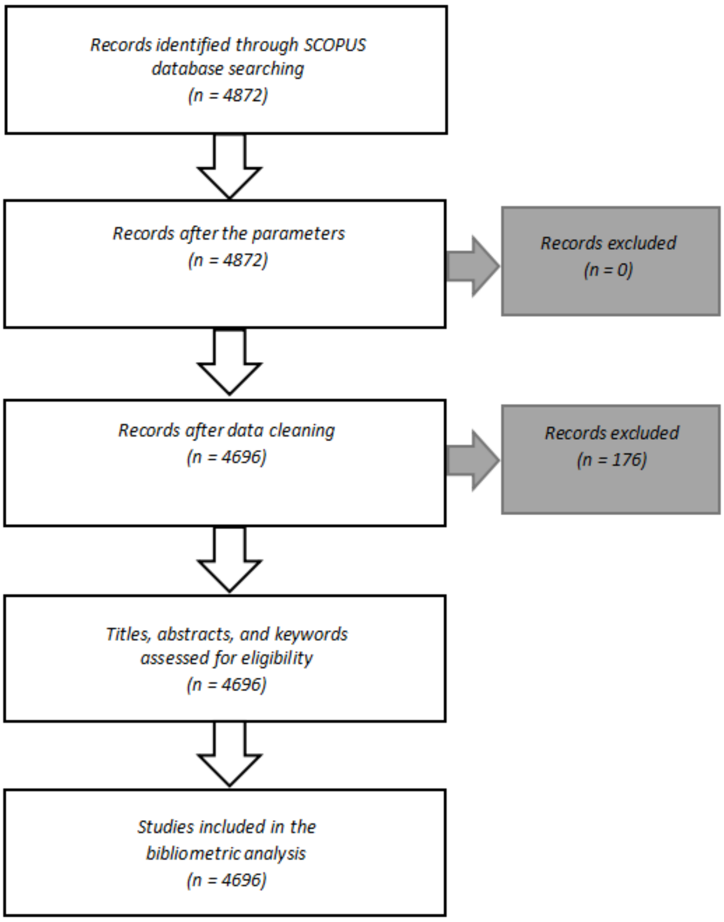

Figure 1. PRISMA flow diagram illustrating the identification and screening process for the bibliometric analysis of DI research.

Note: DI: Differentiated Instruction; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

To identify the primary research areas, the VOSviewer co-occurrence analysis function is utilized. Co-occurrence analysis refers to the tendency of certain events or phenomena to occur together more frequently than would be expected by chance. This analysis will visualize and identify the most common keywords and their relationships, helping to delineate the primary research areas and themes. The data summary includes a total of 21,727 keywords, with a minimum occurrence threshold set at 50, narrowing the dataset to 108 keywords. For each of these 108 keywords, the co-occurrence with the greatest strength is selected, while the total links to all keywords are also calculated, providing a comprehensive view of the key research areas. The keywords with the strongest link strength are listed in **Table 1**.

Table 1. Keywords and links.

Keyword	Occurrences	Total Link Strength
Artificial intelligence	2,538	10,842
Students	1,257	6,756
Human	531	4,222
Higher education	1,041	3,935
Education	685	3,692
learning systems	618	3,551
Article	384	3,392
Humans	402	3,385
Engineering education	651	3,218
education computing	575	3,208
Teaching	522	3,098
high educations	546	2,883

Table 1. *Cont.*

Keyword	Occurrences	Total Link Strength
Female	281	2,712
e-learning	500	2,697
Male	244	2,402
Adult	236	2,353
Machine learning	352	1,935
Curricula	343	1,900
Controlled study	182	1,740
ChatGPT	354	1,364

Table 1 lists keywords along with their occurrences and total link strength, indicating their significance and interconnectedness within the dataset. Keywords such as "artificial intelligence," "students," "higher education," and "education" show high occurrences and strong link strengths, highlighting their central roles in the research field. "Artificial Intelligence" has 2,538 occurrences with 10,842 link strengths, "Students" has 1,257 occurrences with 6,756 link strengths and "Higher Education" has 1,041 occurrences with 3,935 link strengths. Keywords like "ChatGPT" and "machine learning" exhibit considerable occurrences, indicating growing interest, emerging themes, and research focus in these areas.

4.1. Keywords and Links

Figure 2 provides a graphical representation of the relationships between these keywords. The visualization identifies different clusters, each representing a group of closely related keywords. Red Cluster is central to AI in higher education, including keywords such as "artificial intelligence," "students," "learning systems," and "machine learning."Green Cluster focuses on human-related studies, including keywords such as "human," "female," "male," and "controlled study."Blue Cluster highlights educational technology and emerging AI applications, such as "ChatGPT" and "educational technology."The lines connecting nodes (keywords) indicate co-occurrences, reflecting the interrelationships between different research areas and themes. Strong connections between "artificial intelligence," "students," and "higher education" show frequent co-occurrence in the literature, reinforcing their central role. The visualization also reflects the temporal aspect of research themes. For instance, newer themes like "ChatGPT" are emerging, shown in blue, indicating their growing prominence in recent research.

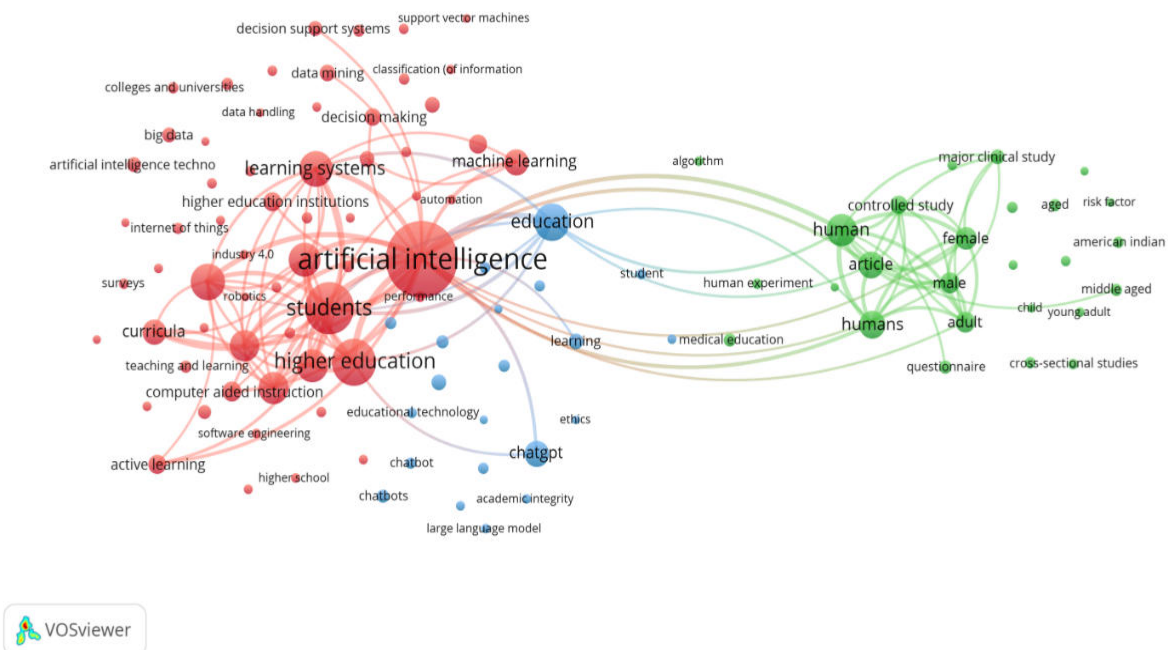

Figure 2. Network visualization for keywords and links.

The combination of the table and network visualization effectively supports Hypothesis H1 by Clearly identifying significant research areas and themes such as AI applications in education, student engagement, and the development of learning systems; Showing how these themes are interconnected, providing a comprehensive view of the research landscape; and indicating the emergence of new research topics like "ChatGPT," which suggests evolving interests and potential future research directions. These visual and tabular data confirm that significant research areas and themes within AI applications in higher education can be identified and analyzed. This validation of the hypothesis provides a clear answer to the research question, demonstrating the utility of bibliometric analysis in mapping the landscape of AI research in higher education.

RQ 2: Here we seek answer to "Who are the most influential authors in the field of AI in higher education?" and hypothesize that "Certain authors, citations, and institutions have disproportionately influenced AI research in higher education."

To determine the most influential authors in the field of AI in higher education, we utilized VOSviewer's Citation Analysis. Citation Analysis highlights authors and their citation influence, identifying the most frequently cited authors in the field. Overall, there are 14,136 authors. For this analysis, we selected authors with a minimum of 5 publications, resulting in 23 authors meeting the criterion. The focus is on the top 20 authors based on the number of documents and citations, as indicated in **Table 2**. This approach helps to pinpoint key contributors who have significantly impacted the research landscape through their influential works.

Table 2. Most influential authors.

Author	Documents	Citations	Total Link Strength
Rudolph, Jürgen	6	590	28
Tan, Shannon	5	589	27
Ouyang, Fan	6	226	6
Kuleto, Valentin	5	208	2
Chan, Cecilia Ka Yuk	5	199	2
Crawford, Joseph	8	164	14
Chen, Yu	5	157	8
Cowling, Michael	6	148	8
Ilić, Milena P.	5	134	0
Ciolacu, Monica Ionita	5	101	0
Buchwald, Dedra	5	100	1
Khosravi, Hassan	6	92	3
Sakr, Majd	6	56	0
Molina, Arturo	5	41	0
Ponce, Pedro	5	41	0
Maphosa, Mfowabo	5	26	0
Maphosa, Vusumuzi	5	26	2
Weber, Felix	5	21	0
Sousa, Maria José	5	19	2
Schrumpf, Johannes	5	18	0

4.2. Influential Author

Figure 3 overlay visualization provides a graphical representation of the selected authors based on the year of their publications, indicated by color coding. The color gradient from purple to yellow represents the timeline from 2016 to 2024. Purple indicates earlier publications from 2016, green represents more recent publications from 2018 to 2022, and yellow indicates the most recent or upcoming publications in 2024. The size of each node reflects the number of documents authored by each individual, while the position of the nodes reflects their temporal publication trend and the extent of their research activity over time. This visualization helps to identify influential authors and understand the evolution of their contributions within the field of AI in higher education.

Among the most prolific authors, Jürgen Rudolph and Shannon Tan stand out with 6 publications each, indicated by larger green nodes, signifying recent active contributions. Joseph Crawford is highlighted with 8 publications, also shown by a significant node size. Emerging authors such as Gyula Kártás, Mfowabo Maphosa, and Milena P. Ilić are depicted with green to yellow nodes, indicating their recent or ongoing contributions to the field. Temporal trends show that József Gáti and Johannes Schrumpf have nodes in purple, reflecting their earlier contributions around 2016, while authors like Vusumuzi Maphosa and Monica Ionita Ciolacu are shown in green, indicating active research around 2020.

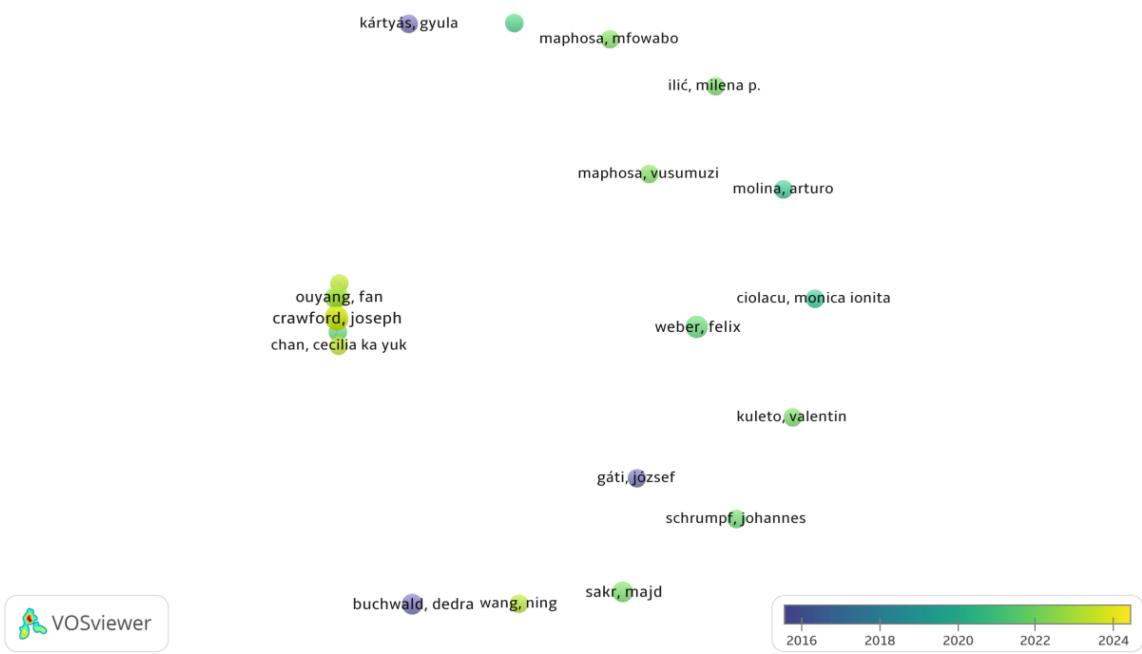

Figure 3. Overlay visualization for an influential author.

The visualization indicates that AI in higher education is a dynamic field with ongoing research contributions from multiple authors. The green and yellow nodes suggest that many authors have been actively publishing in recent years, highlighting the field's growth and evolving nature. The large node sizes of authors like Rudolph and Tan suggest they are key influencers in the field, contributing significantly to the body of research. The presence of emerging authors with recent publications (yellow nodes) points to new and potentially groundbreaking research directions. These authors might be contributing to novel applications or methodologies in AI within higher education. The temporal distribution of publications reveals the sustained and increasing interest in AI applications in higher education over the years. The shift from purple to yellow nodes indicates that while the field has established roots, it continues to grow with new research and findings.

4.3. Most Cited Author

Figure 4 provides a comprehensive overview of the most influential researchers in the field of AI in higher education. The data encompasses a total of 14,136 authors, from which those with a minimum of 5 publications were selected. This criterion narrowed the pool to 23 authors. The table focuses on the top 20 authors based on the number of documents and citations, highlighting their significant contributions to the field. The VOSviewer overlay visualization represents the citation impact of these selected authors over time, with color coding indicating the average number of citations per author. The color gradient from blue to yellow depicts the range from fewer to more citations. Specifically, blue indicates authors with lower citation counts (0–10 citations), green represents authors with moderate citation counts (10–20 citations), and yellow indicates authors with higher citation counts (30–40 citations). The size of each node reflects the number of documents authored by each individual, providing a sense of their productivity. Larger nodes signify a higher number of publications, indicating prolific authors. The position of the nodes reflects the authors' relative citation impact and temporal contribution, showing how their influence and research activity have evolved. This visualization helps identify not only prolific authors but also those who have made significant impacts through their research, offering a clear picture of key contributors in the AI in higher education landscape.

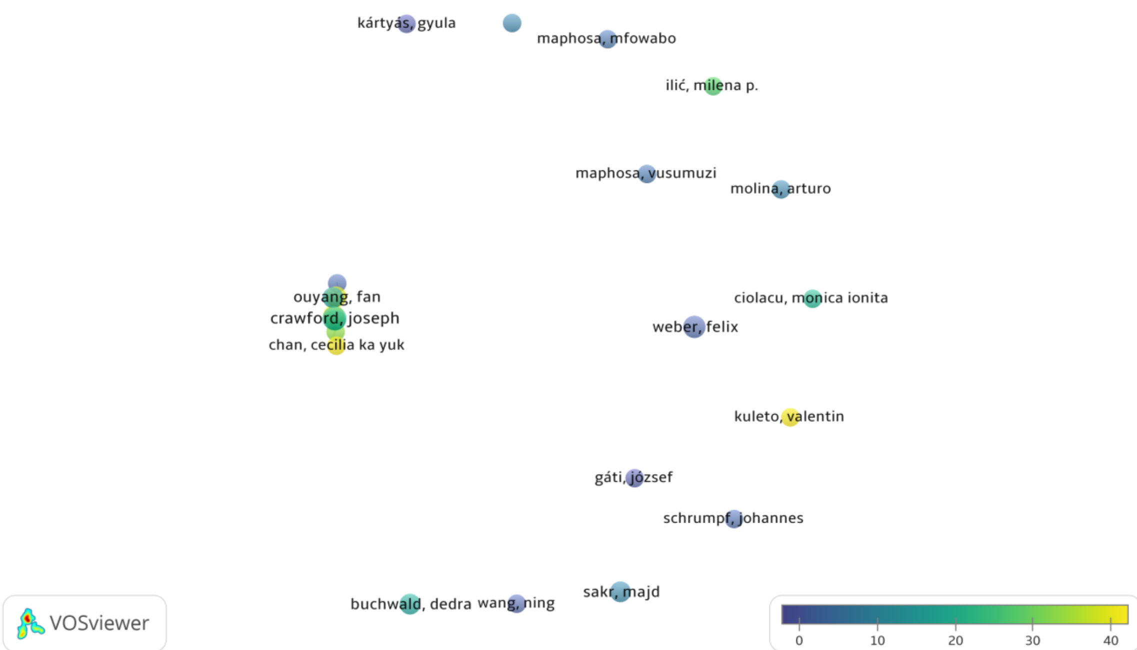

Figure 4. Overlay visualization for the most cited author.

Among the highly cited authors, Jürgen Rudolph and Shannon Tan stand out with high citation counts of 590 and 589, respectively. These authors are indicated by larger yellow nodes, reflecting their significant impact in the field. Joseph Crawford also shows substantial citations (164) with a green to yellow node, highlighting his influential contributions. Moderately cited authors such as Fan Ouyang, Cecilia Ka Yuk Chan, and Monica Ionita Ciolacu are depicted with green nodes, indicating moderate citation counts and solid contributions to the research field. Authors like Vusumuzi Maphosa and Arturo Molina are also in green, showing a consistent and impactful research presence. Less cited authors, such as Valentin Kuleto and Johannes Schrumpf, are depicted in blue, indicating lower citation counts, which suggests either newer contributions or less impactful research within this dataset. Emerging researchers like Mfowabo Maphosa and Milena P. Ilić are in blue to green, indicating they are emerging researchers with growing citation counts and showing potential for future influence.

The authors with higher citation counts are likely contributing to highly relevant and influential research areas within AI in higher education. Rudolph and Tan are key influencers, as indicated by their high citation impact. The green to yellow nodes for authors like Crawford and Ciolacu suggest their research is gaining traction and becoming more influential over time. While some authors have many publications, their citation impact varies, indicating that productivity does not always correlate directly with impact. For example, Crawford has a high number of documents and moderate citations, whereas Rudolph has fewer documents but a higher citation impact. The positioning of nodes and their sizes can also hint at collaborative versus individual contributions. Authors with large nodes and high citations likely engage in significant collaborative work that enhances their visibility and impact. The visualization helps identify leading researchers and emerging scholars, providing a roadmap for potential collaborations and identifying influential works to guide future research.

4.4. Most Influential Institution

Overall, there are 9,404 organizations involved in AI research in higher education. For this analysis, we selected only those organizations with a minimum of 5 publications, narrowing the pool to 6 organizations. **Table 3** focuses on the top 6 organizations based on this criterion. The data summary for these organizations shows that the number of documents ranges from 5 to 8, the number of citations ranges from 7 to 193, and the total link strength is 0 for all institutions. This indicates that, although these organizations are prolific in their research output, their collaborative link strength with other institutions within the dataset is not reflected, suggesting a potential area for increasing collaborative efforts.

Table 3. Most influential institution.

Institution	Documents	Citations
University of Tasmania, Australia	8	193
Charles Sturt University, Wagga Wagga, Australia	5	103
Carnegie Mellon University, Pittsburgh, USA	6	60
Institute for the Future of Education, Tecnológico de Monterrey, Mexico	5	12
Óbuda University, Budapest, Hungary	8	11
Ahlia University, Manama, Bahrain	5	7

Figure 5 provides a graphical representation of the institutions based on their publication activity over time, indicated by color coding. The color gradient from blue to yellow represents the timeline from 2014 to 2024. Purple (2014–2016) indicates earlier publications, green (2018–2020) represents more recent publications, and yellow (2022–2024) indicates the most recent or upcoming publications. The size of each node reflects the number of documents produced by each institution, while the positioning of nodes indicates the temporal publication trend.

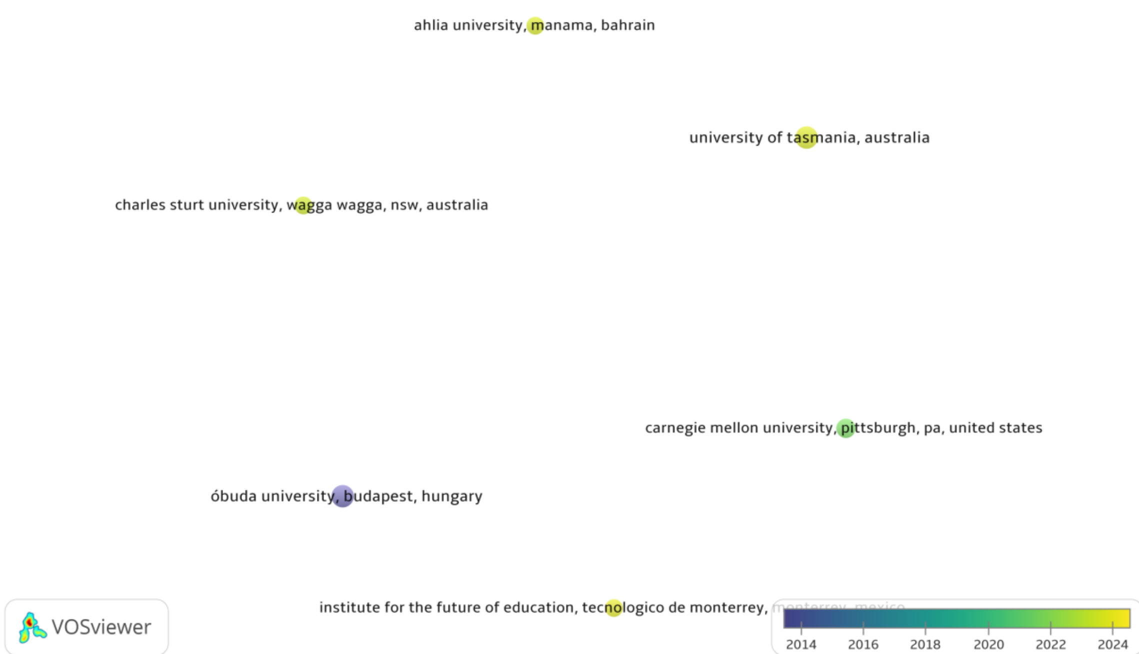

Figure 5. Overlay visualization for the most influential institution.

The University of Tasmania, Australia, and Óbuda University, Budapest, Hungary, have produced the highest number of documents (8 each), indicated by larger nodes. Charles Sturt University, Wagga Wagga, Australia, and Ahlia University, Manama, Bahrain, have produced 5 documents each, shown with moderately sized nodes. Charles Sturt University, Wagga Wagga, Australia, and Ahlia University, Manama, Bahrain, are highlighted in yellow, indicating very recent publications and suggesting ongoing active research contributions. The University of Tasmania, Australia, and Carnegie Mellon University, Pittsburgh, USA, are shown in green, indicating steady publication activity in recent years. Óbuda University, Budapest, Hungary, is depicted in blue, indicating its publications occurred earlier in the timeline (Around 2014–2016).

The institutions with a higher number of publications, such as the University of Tasmania and Óbuda University, are likely contributing significantly to the body of research in AI within higher education, supporting the hypothesis that certain institutions disproportionately influence the field. Institutions like Charles Sturt University and Ahlia University, with nodes in yellow, suggest they are emerging as active contributors in recent years, aligning with the increasing research focus on AI applications in higher education. The temporal distribution of publication activity, from blue to yellow, indicates sustained and increasing interest in AI applications within higher education. Institutions like Carnegie Mellon University and the University of Tasmania show steady contributions over time. The visualization shows a global spread of publication activity, with significant contributions from institutions in Australia, the USA, Hungary, Bahrain, and Mexico, highlighting the international nature of AI research in higher education.

RQ 3: Here we seek answer to "What do the co-authorship and collaboration networks among AI researchers in higher education look like?" and hypothesize that "Co-authorship and collaboration networks play a crucial role in advancing AI research within higher education."

To assess such collaborations, we use VOSviewer Co-authorship Network Analysis. This analysis helps visualize the collaboration networks among researchers, highlighting the extent and nature of research partnerships. A total of 14,136 co-authorships were analyzed. For this study, we selected co-authors with a minimum of 5 publications, narrowing the pool to 23 co-authors who met the criterion. **Table 4** focuses on the top 20 co-authors based on the number of documents and citations. Among these, only 4 co-authors have active co-authorships. The VOSviewer overlay visualization represents the co-authorship and collaboration networks among these top 20 most influential authors in AI research within higher education, providing insights into their collaborative efforts and their impact on the field.

Table 4. Top 20 co-authors.

Author	Documents	Citations
Crawford, Joseph	8	164
Weber, Felix	7	21
Rudolph, Jürgen	6	590
Ouyang, Fan	6	226
Cowling, Michael	6	148
Buchwald, Dedra	6	100
Khosravi, Hassan	6	92
Sakr, Majd	6	56
Tan, Shannon	5	589
Kuleto, Valentin	5	208
Chan, Cecilia Ka Yuk	5	199
Chen, Yu	5	157
Ilić, Milena P.	5	134
Ciolacu, Monica Ionita	5	101
Molina, Arturo	5	41
Ponce, Pedro	5	41
Maphosa, Mfowabo	5	26
Maphosa, Vusumuzi	5	26
Sousa, Maria José	5	19
Schrumpf, Johannes	5	18

As per **Figure 6**, Joseph Crawford is identified as a central node with high average citations, indicating significant influence and active collaboration within the network. Connected to him are Michael Cowling, Jürgen Rudolph, and Shannon Tan, showing active co-authorships. The lines connecting these nodes represent the strength and impact of their collaborations, with thicker lines indicating stronger, more frequently cited partnerships. For instance, Joseph Crawford's connections to Michael Cowling and Jürgen Rudolph are particularly impactful. Nodes in green to yellow suggest higher citation impacts, indicating that these co-authorships are producing highly influential research.

Figure 6 highlights central figures like Joseph Crawford, who are pivotal in the co-authorship network. His central position and high citation count underscore his role in advancing AI research in higher education through collaborative efforts. The high average number of citations for the connections indicates that collaborative research makes a significant contribution to the field's advancement. Collaborative efforts, particularly those involving key figures, tend to produce high-impact research. The network dynamics show that collaborations among highly cited authors, such as Joseph Crawford with Michael Cowling and Jürgen Rudolph, are particularly influential. This suggests that forming collaborative networks with established researchers can enhance research visibility and impact. The visualization supports Hypothesis H4 by demonstrating that co-authorship and collaboration networks are crucial for advancing AI research within higher education. The strong and impactful collaborations highlighted in the network underscore the importance of these relationships in driving high-quality research output. Researchers looking to increase their impact in the field might benefit from strategic collaborations with central, highly cited authors. Building such networks can facilitate knowledge exchange and foster innovative research developments.

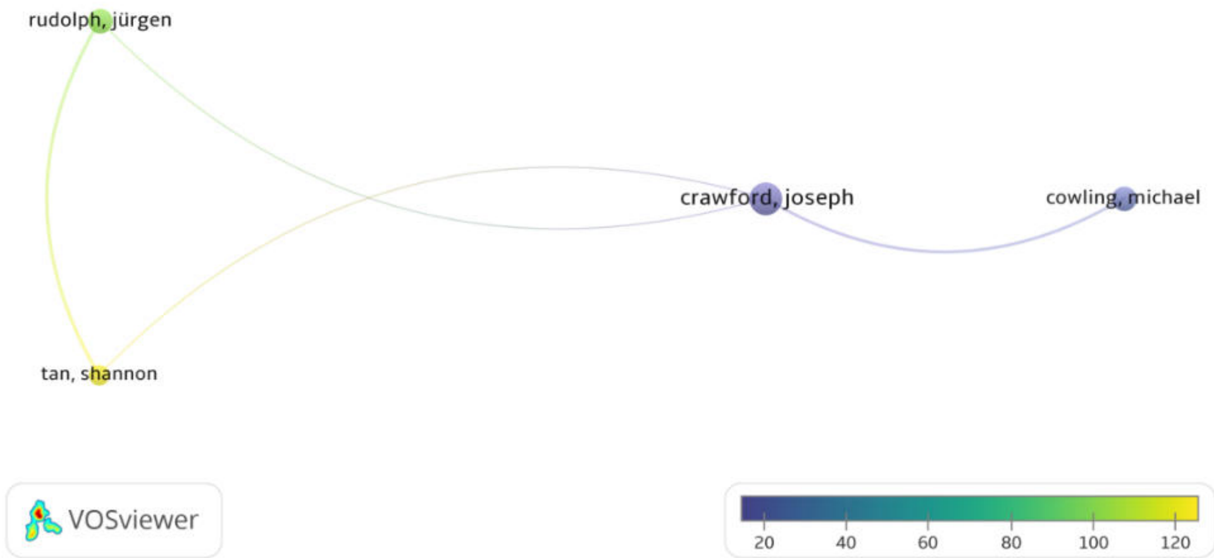

Figure 6. Overlay visualization for top co-authors.

RQ 4: Here we seek answer to "Which works and references have been researched in shaping the research landscape of AI in higher education?" and hypothesize that "A set of research works and references have consistently shaped the discourse on AI in higher education."

To this end, we use VOSviewer Bibliographic Coupling. Bibliographic coupling occurs when two publications both cite a third publication, helping to identify research works and the relationships between citing and cited documents. For this analysis, a total of 4,696 documents were analyzed. We selected documents with a minimum of 100 citations, resulting in 68 documents meeting the criterion. **Table 5** focuses on the top 20 documents based on their citation counts. This method provides a clear view of influential research works and how they are interconnected through shared citations, offering insights into the most impactful studies in AI within higher education.

Table 5. Top 20 documents.

Document	Citations	Total Link Strength
Sidiropoulos (2017)	1026	0
Zawacki-Richter (2019)	899	14
Shafique (2020)	759	3
Lu (2017)	731	4
Chen (2020)	593	2
Maenner (2023)	470	0
Popenici (2017)	466	1
Pesapane (2018)	431	2
Ghosh-Dastidar (2009)	415	0
Rudolph (2023b)	365	39
Basharat (2008)	316	0
Cotton (2024)	310	14
Wang (2017)	297	4
Androutsopoulou (2019)	271	1
Zheng (2017)	271	0
Hahner (2010)	271	0
King (2023)	252	0
Alyahyan (2020)	247	4
Aoun (2017)	244	0
Ding (2019)	207	0

According to **Figure 7**, Sidiropoulos (2017) is the central node with the highest number of citations, indicating its significant influence. Zawacki-Richter (2019), Shafique (2020), and Lu (2017) are also prominent nodes, highlighting their importance in the research landscape. The thickness and color of the lines connecting the nodes represent the strength and impact of the collaborations, with connections between highly cited documents indicating strong and impactful collaborations, as shown by thicker lines. Nodes in green to yellow suggest higher citation impacts, indicating that these documents are producing highly influential research. For instance, collaborations involving Sidiropoulos (2017) and Zawacki-Richter (2019) show notable citation impacts. The color gradient from blue (earlier years) to yellow (recent years) indicates the evolving nature of influential works over time, with recent influential documents highlighted in yellow, suggesting ongoing and active research contributions.

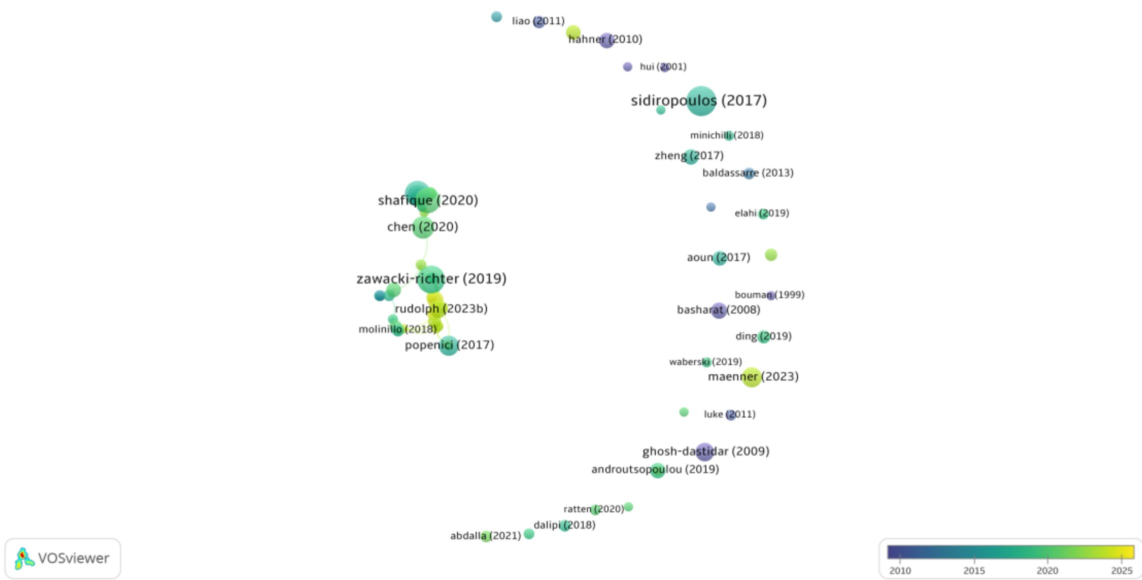

Figure 7. Overlay visualization for the top document.

The visualization highlights research works, such as Sidiropoulos (2017), which are pivotal to the research network. Their central positions and high citation counts underscore their role in advancing AI research in higher education. These research works have consistently shaped the discourse, as evidenced by their strong citation impacts and collaborative networks. The high average citations of these documents indicate that research works significantly contribute to the field's advancement. These works are widely referenced and form the foundation of current research, likely leading to the development and dissemination of influential research themes and methodologies. The network dynamics show that collaborations among highly cited documents, such as those involving Sidiropoulos (2017) and Zawacki-Richter (2019), are particularly influential. This suggests that forming collaborative networks around research works can enhance research visibility and impact, further highlighting their importance. The visualization supports Hypothesis H5 by demonstrating that a set of research works and references have consistently shaped the discourse on AI in higher education. The strong and impactful collaborations highlighted in the network underscore the importance of these research works in driving high-quality research output. Researchers and institutions looking to increase their impact in the field might benefit from strategic collaborations with authors of research works. Building such networks can facilitate knowledge exchange and foster innovative research developments, leading to the production of research works that significantly influence the research landscape.

RQ 5: Here we seek answer to "What emerging topics and technologies in AI are currently gaining traction within the higher education sector?" and hypothesize that "Emerging topics and technologies in AI are increasingly being integrated into higher education research."

To determine how emerging topics and technologies in AI are increasingly being integrated into higher education research, we use the VOSviewer Keyword Analysis. This Keyword Analysis tracks the frequency and emergence of new keywords over time, indicating emerging topics and technologies. The analysis focuses on the co-occurrence of the author's keywords, providing insights into their relevance and interconnectedness. The total co-occurrence of the author's keywords is 9,660. For this analysis, we selected co-occurrence of keywords with a minimum of 100 occurrences, narrowing the dataset to 7 keywords that meet this criterion (**Table 6**). This approach helps identify the most frequently discussed topics and their relationships, highlighting emerging trends in AI within the higher education research landscape.

Table 6. Emerging topics and technologies in AI.

Keyword	Occurrences	Total Link Strength
Artificial intelligence	1,124	724
Higher education	795	564
ChatGPT	334	346
Machine learning	270	226
Education	205	190
AI	135	133
Active learning	153	49

Figure 8 overlay visualization illustrates the co-occurrence network of the top 7 keywords from 2021 to 2022, using a color gradient to represent the temporal aspect of keyword usage. Artificial intelligence is the central node with the highest number of occurrences and link strength, indicating its significant influence. Higher education, ChatGPT, and machine learning are also prominent nodes, highlighting their importance in the research landscape. The thickness and color of the lines connecting the nodes represent the strength and impact of the co-occurrences. The connections between artificial intelligence, higher education, and other keywords indicate strong and impactful relationships, as shown by thicker lines. Nodes like ChatGPT and machine learning are shown in green to yellow, indicating that these are emerging topics that have gained traction in recent years. The presence of ChatGPT as a prominent keyword indicates a growing interest in this technology within higher education research. The color gradient from blue (earlier years) to yellow (recent years) indicates the evolving nature of keyword usage over time. Recent keywords, such as ChatGPT and AI, are highlighted in yellow, suggesting ongoing and active research contributions.

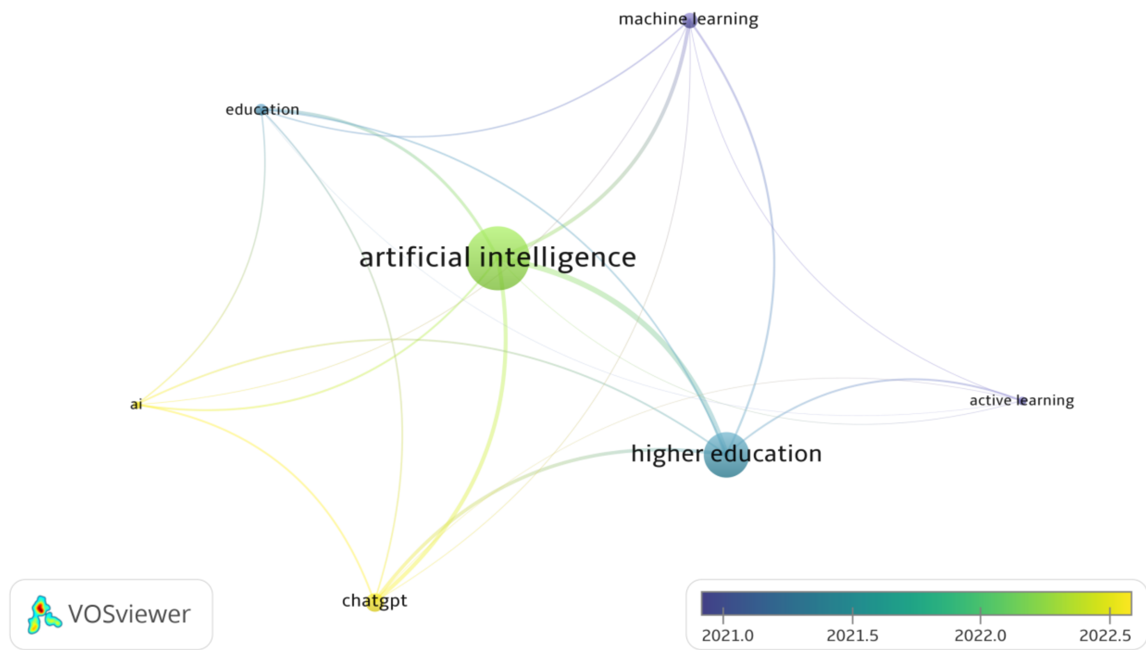

Figure 8. Overlay visualization for emerging topics and technologies in AI.

The visualization highlights key areas such as artificial intelligence and higher education, which are central to the research landscape. Their central positions and high co-occurrence counts underscore their importance in AI research within higher education. The emergence of keywords, such as ChatGPT and machine learning indicates that these topics are gaining traction and becoming increasingly integrated into higher education research. This suggests that researchers are increasingly focusing on these technologies and their applications. The strong co-occurrence between artificial intelligence and higher education suggests a concentrated research focus on integrating AI into educational contexts. This implies that AI is being actively explored and implemented in higher education settings. The visualization supports Hypothesis H6 by demonstrating that emerging topics and technologies in AI, such as ChatGPT and machine learning, are increasingly being integrated into higher education research. The strong and impactful co-occurrences highlighted in the network underscore the importance of these emerging technologies in driving innovation and research output. Researchers and institutions looking to increase their impact in the field might benefit from focusing on emerging topics like ChatGPT and machine learning. These areas are shown to be gaining traction and can provide new opportunities for research and development. Engaging in research on these emerging topics can lead to the production of influential work that significantly impacts the research landscape.

RQ 6: Here we seek answer to "What is the geographic distribution of AI research in higher education, and what global trends and regional focuses can be identified?" and hypothesize that "AI research in higher education exhibits distinct geographic patterns, with specific regions leading in research contributions."

To ascertain the geographic distribution of AI research in higher education and identify global trends and regional focuses, we use VOSviewer's geographic mapping analysis. Geographic mapping analysis maps the geographic distribution of publications and collaborations, highlighting regional research hubs and global trends. For citation analysis by countries, a total of 183 countries were analyzed. For this analysis, we selected countries with a minimum of 100 citations, resulting in 10 countries meeting the criterion (**Table 7**). This approach provides a clear view of where significant AI research in higher education is occurring and the collaborative networks that exist within and between these regions. By identifying these key areas, we can better understand the global landscape of AI research in higher education and the regional focuses driving innovation and development in this field.

Table 7. Geographic mapping analysis.

Country	Documents	Citations	Total Link Strength
United States	858	12,077	131
China	819	6,141	161
United Kingdom	281	3,307	94
Australia	197	2,960	123
Saudi Arabia	114	2,856	61
Germany	175	2,725	53
Spain	184	1,858	77
India	310	1,773	103
Canada	116	1,465	32
Mexico	102	695	37

Figure 9 overlay visualization illustrates the co-authorship and collaboration networks among the top 10 countries from 2019 to 2021, using a color gradient to represent the temporal aspect of their collaborations. The United States and China are the central nodes with the highest number of documents and citations, indicating their significant influence and extensive collaborative efforts. India, the United Kingdom, Australia, and Germany are also prominent nodes, highlighting their active participation in co-authorship networks. The thickness and color of the lines connecting the nodes represent the strength and impact of the collaborations. The connections between the United States, China, India, and other countries indicate strong and impactful collaborations, as shown by thicker lines. Nodes in green to yellow suggest higher citation impacts, indicating that these collaborations are producing highly influential research. For instance, collaborations involving the United States and China show notable citation impacts. The color gradient from blue (earlier years) to yellow (recent years) indicates the evolving nature of collaborations over time. Recent collaborations are highlighted in yellow, suggesting ongoing and active research partnerships.

The visualization highlights central countries like the United States and China, which are pivotal in the co-authorship network. Their central positions and high citation count underscore their role in advancing AI research in higher education through collaborative efforts. The high average number of citations for the connections indicates that collaborative research makes a significant contribution to the field's advancement. Collaborative efforts, particularly those involving key countries, tend to produce high-impact research. The global distribution of collaborations shows that North America (the United States), Asia (China, India, Saudi Arabia), and Europe (the United Kingdom, Germany, Spain) are the leading regions in AI research in higher education. The geographic patterns reveal distinct regional focuses, with the United States and China being the most prominent contributors. This pattern suggests a concentrated effort in these regions to advance AI research within higher education. Europe and Australia also show significant research activities, indicating a strong regional focus on AI in educational contexts. The visualization supports Hypothesis H7 by demonstrating distinct geographic patterns in AI research contributions. Specific regions, particularly North America, Asia, and Europe, are leading in research contributions, highlighting their pivotal role in driving innovation and advancements in AI within higher education.

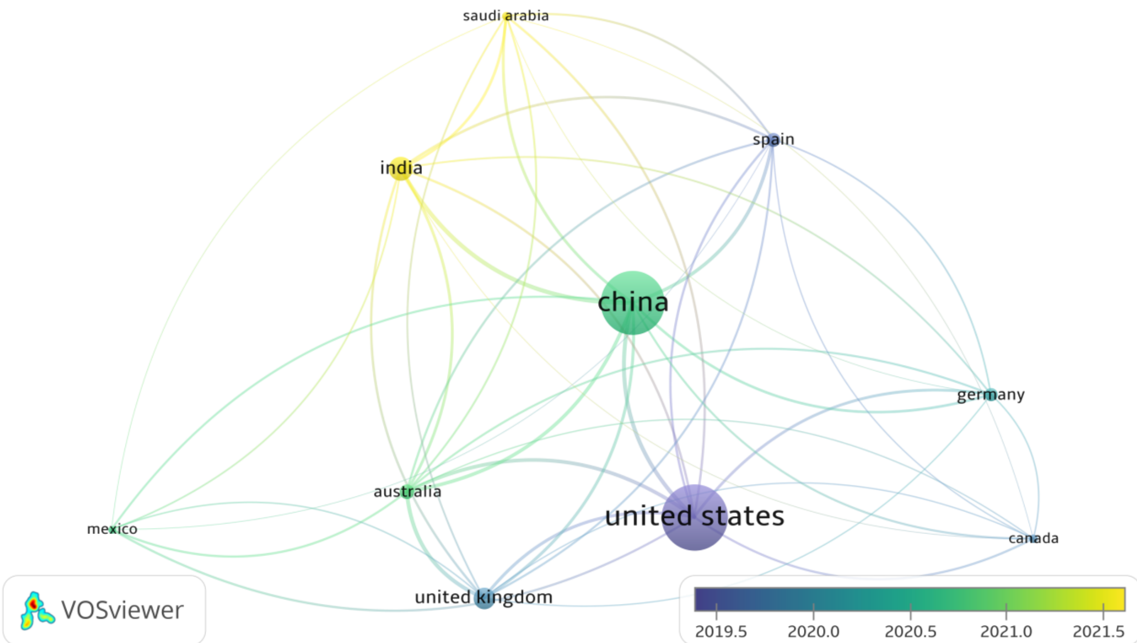

Figure 9. Overlay visualization for geographic mapping analysis.

5. Conclusions

This study aimed to provide a comprehensive bibliometric analysis of AI research in higher education, using VOSviewer to visualize and analyze data. The results were organized according to the research questions, with each analysis discussed in relation to the respective findings.

RQ 1: Primary research areas and themes

To identify the primary research areas, the VOSviewer co-occurrence analysis function was utilized, revealing significant research areas within AI applications in higher education. The analysis included a total of 21,727 keywords, with a minimum occurrence threshold set at 50, narrowing the dataset to 108 keywords. The top keywords, such as "artificial intelligence," "students," and "higher education," exhibited high occurrences and strong link strengths, indicating their central roles in the research field. The network visualization highlighted clusters, with key themes emerging such as AI applications in education, student engagement, and the development of learning systems. This supports Hypothesis H1, confirming the identification of significant research areas and themes. Studies by Zawacki-Richter et al. [26] and Chen et al. [27] further validate these findings, highlighting the central role of AI in transforming educational practices.

RQ 2: Influential authors

To determine the most influential authors, VOSviewer's Citation Analysis was used. Out of 14,136 authors, 23 met the criterion of having a minimum of 5 publications. The analysis highlighted key contributors such as Jürgen Rudolph, Shannon Tan, and Joseph Crawford. The visualization showed their influence through the number of documents and citations, indicating their significant impact on the research landscape. This supports Hypothesis H2, demonstrating that certain authors and institutions disproportionately influence AI research in higher education. The works of Rudolph and Tan, as cited by Lampropoulos and Sidiropoulos [28], underscore their influential contributions.

RQ 3: Co-authorship and collaboration networks

VOSviewer Co-authorship Network Analysis was used to assess collaborations among researchers. A total of 14,136 co-authorships were analyzed, with 23 co-authors meeting the criterion of having a minimum of 5 publications. The visualization revealed strong collaborative networks among influential authors like Joseph Crawford, Michael Cowling, and Jürgen Rudolph. This supports Hypothesis H3, showing that co-authorship and collaboration networks are crucial for advancing AI research in higher education. Studies by Luckin et al. [8], Ferri [29], and Atchley et al. [30] highlight the importance of collaborative research in producing high-impact publications.

RQ 4: Influential research works and references

Using VOSviewer Bibliographic Coupling, the study identified influential research works and references that have shaped the discourse on AI in higher education. The analysis included 4,696 documents, with 68 meeting the criterion of having a minimum of 100 citations. Key documents such as Sidiropoulos (2017) and Zawacki-Richter [26] were highlighted for their significant influence and high citation counts. This supports Hypothesis H4, confirming that a set of research works consistently shapes the AI research landscape. These findings are corroborated by the works of Lampropoulos and Sidiropoulos [28] and Gill et al. [31], which have also significantly impacted the field.

RQ 5: Emerging topics and technologies

VOSviewer Keyword Analysis was employed to identify emerging topics and technologies in AI within higher education. The analysis included 9,660 keywords, with 7 meeting the criterion of having a minimum of 100 occurrences. Keywords like "ChatGPT" and "machine learning" were identified as emerging themes. The visualization showed the growing integration of these technologies into higher education research, supporting Hypothesis H5. Research by Adadi et al. [32] illustrates the increasing relevance of these technologies in academic research.

RQ 6: Geographic distribution

To ascertain the geographic distribution of AI research, VOSviewer Geographic Mapping Analysis was used. The analysis included 183 countries, with 10 meeting the criterion of having a minimum of 100 citations. The visualization highlighted central countries like the United States and China, which are pivotal in the co-authorship network. This supports Hypothesis H6, demonstrating distinct geographic patterns in AI research contributions. This is further supported by studies from Zawacki-Richter et al. [26–33], which highlight the geographic dispar-disparities and collaborative efforts in AI research.

The study successfully mapped the landscape of AI research in higher education, identifying key research areas, influential authors, and emerging technologies. The findings underscore the importance of collaborative networks and the significant contributions of specific regions and institutions. These insights provide a roadmap for future research and highlight the dynamic and evolving nature of AI applications in higher education.

The findings of this study have several implications for researchers, practitioners, and policymakers in the field of higher education. The identification of key research areas and influential contributors provides a roadmap for future research, encouraging new collaborations and interdisciplinary approaches. The emerging trends and geographic distribution insights highlight the need for global cooperation and knowledge sharing to maximize the benefits of AI in education. Moving forward, it is essential to continue monitoring the evolving landscape of AI research in higher education. Researchers should focus on addressing the identified gaps and exploring new applications of AI technologies to enhance educational outcomes. Policymakers and educational leaders must support and invest in AI research, fostering an environment that encourages innovation and the ethical use of AI in education. This bibliometric analysis provides a comprehensive overview of the current state and future directions of AI research in higher education. By leveraging advanced analytical tools and methodologies, this study contributes to a deeper understanding of the dynamic and rapidly evolving field of AI in education, paving the way for future advancements and innovations. A key limitation of this study is its exclusive reliance on the SCOPUS database. While comprehensive, this approach may introduce selection bias by excluding relevant publications from other sources such as Web of Science, IEEE Xplore, or Google Scholar, potentially narrowing the scope of analyzed research and insights.

Author Contributions

Conceptualization, T.E. and S.A.C.; methodology, T.E.; software, T.E.; validation, T.E. and S.A.C.; formal analysis, T.E.; investigation, T.E.; resources, S.A.C.; data curation, T.E.; writing—original draft preparation, T.E.; writing—review and editing, T.E. and S.A.C.; visualization, T.E.; supervision, S.A.C.; project administration, S.A.C. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement

The quantitative data used to support the findings of this study have been deposited in the Mendeley data repository (DOI: https://doi.org/10.17632/6gk8czckvb.1).

Conflicts of Interest

The authors declare that there is no conflict of interest.

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