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Evolving landscape of artificial intelligence (AI) and assessment in education: A bibliometric analysis

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Abstract: The rapid evolution of digital technologies and computer sciences is ushering society into a technologically driven future where machines continually advance to meet human needs and enhance their own intelligence. Among these groundbreaking innovations, Artificial Intelligence (AI) is a cornerstone technology with far-reaching implications. This study undertakes a bibliometric review to investigate contemporary AI and assessment topics in education, aiming to delineate its evolving scope. The Web of Science Databases provided the articles for analysis, spanning from 1994 to September 2023. The study seeks to address research questions about prominent publication years, authors, countries, universities, journals, citation topics, and highly cited articles. The study's findings illuminate the dynamic nature of AI in educational assessment research, with AI firmly establishing itself as a vital component of education. The study underscores global collaboration, anticipates emerging technologies, and highlights pedagogical implications. Prominent trends emphasize machine learning, Chat GPT, and their application in higher education and medical education, affirming AI's transformative potential. Nevertheless, it is essential to acknowledge the limitations of this study, including data currency and the evolving nature of AI in education. Nonetheless, AI applications are poised to remain a prominent concern in educational technology for the foreseeable future, promising innovative solutions and insights.

1. INTRODUCTION

Progressive developments in digital technologies and computer sciences are ushering us into a future characterized by a technologically driven society, where machines are continually engineered to fulfill human requirements while also enhancing their own intelligence. Artificial Intelligence (AI) is regarded as one of the most valuable technologies, standing shoulder to shoulder with other groundbreaking innovations like robotics, virtual reality, 3D printing, and advanced networking (Chai et al., 2020; Janpla & Piriyasurawong, 2020; Kuleto et al., 2021). Technological advancements are not limited to specific regions; therefore, it is necessary to emphasize the understanding and utilization of artificial intelligence on a global scale (Bærøe et al., 2020; Grüning, 2022). Developing a collective understanding of the potential of artificial intelligence in education is crucial for ensuring equitable access to innovative educational practices worldwide (Alam et al., 2022; Bozkurt, 2023; Bozkurt et al., 2023).

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Advancing from machine learning (ML) to deep learning and ultimately to applied AI (Hassanien et al., 2020), artificial intelligence (AI) refers to the emulation of human cognitive processes, including tasks such as language translation, speech recognition, visual perception, and virtual decision-making, performed by robots and machines (Braiki et al., 2020). These cutting-edge technologies play a pivotal role in reshaping the methods and capabilities of assessment, introducing more sophisticated and nuanced approaches that align with the dynamic nature of the educational landscape (Gardner et al., 2021; Qu et al., 2022; Zehner & Hahnel, 2023). For example, by automatically creating assessments, evaluating students' written constructed responses or essays, and offering guidance and educational materials, natural language processing systems such as ChatGPT can enhance the effectiveness and efficiency of science education (Zhai, 2023).

The motivation to employ Machine Learning (ML) in scientific assessment research received a considerable boost from the National Research Council (NRC) K-12 Framework (NRC, 2012) and the Next Generation Science Standards (NGSS, 2013). Since then, there has been a strong and enthusiastic focus on the utilization of AI in educational applications (Qu et al., 2022; Toumi et al., 2018; Zhai et al., 2021). Qu et al. (2022) point out that in education, artificial intelligence encompasses various facets, including guiding learning, evaluating teaching, and refining instructional techniques, among others. Its ultimate goal is to foster teaching innovation, enrich the learning experience, and facilitate personalized education. In the realm of practical applications, AI technologies have demonstrated their efficacy beyond theoretical discussions, particularly in formative and summative assessment scenarios (Quyang et al., 2023). For example, Saito and Watanobe (2020) introduced a learning path recommendation system employing natural language processing (NLP) to assess students' programming learning performance. In addition, Erickson et al. (2020) deployed an NLP-enabled automated assessment system in a mathematics curriculum, demonstrating the capacity of AI to assess students' learning performance. Naismith et al. (2023) attempted to assess the effectiveness of using GPT-4 in evaluating the coherence of written discourse within test-taker responses on a high-stakes English proficiency test. The study revealed that GPT-4 exhibited a notable degree of accuracy in appraising the coherence of writing samples, closely matching human ratings acknowledged as the gold standard, regardless of the particular order of the prompt.

It is possible to say that the fundamental idea behind artificial intelligence (AI) in both summative and formative scenarios revolves around the concept of “machine learning." In this process, computers are essentially educated on how to discern patterns in data and are trained to execute predetermined actions based on these interpretations (Gardner et al., 2021; Zhai et al., 2021). Figure 1 presents the relationship between the intelligent assessment process and technology (Qu et al., 2022).

Figure 1. *The relationship between intelligent assessment process and technology (Qu et al., 2022, p.586)*

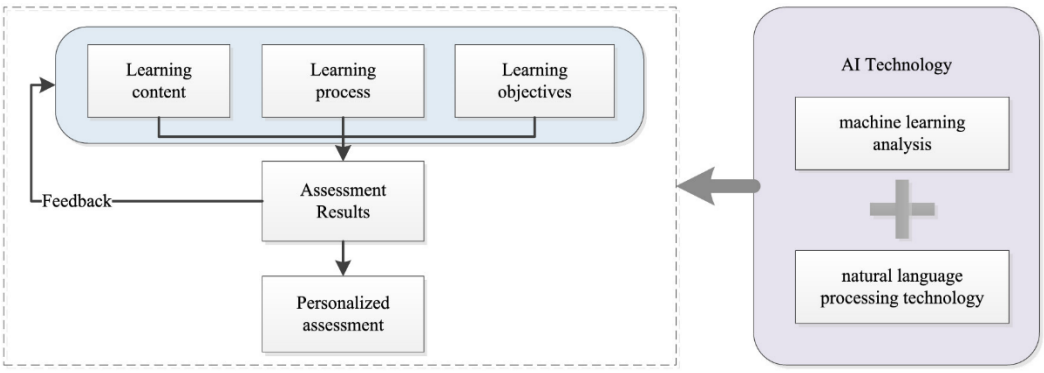


Figure 1 depicts that the advancement of intelligent assessment should be driven by the aspiration for personalized learning. It should be guided by educational theories, bolstered by machine learning analysis, and harnessed with natural language processing technology. The overarching aim is to encourage students to attain their educational objectives.

There also has been a growing debate on whether "artificial intelligence in educational assessment is a breakthrough or a buncombe and a ballyhoo?" (Gardner et al., 2021, p.1207). Zhai et al. (2020) indicate that evaluating three-dimensional learning necessitates a rethinking of assessment methodologies due to the language- and diagram-intensive characteristics of assessments grounded in scientific practices such as argumentation, explanation, and modeling. Besides, Zhai et al. (2021) put forth the argument that machine learning (ML) has the potential to enhance educational assessment by effectively capturing complex constructs, deriving precise inferences from intricate data, and simplifying the task of human grading. In parallel, commentaries and position papers (Kubsch et al., 2022; Li et al.2023; Zhai & Nehm, 2023) have extensively deliberated on the argument presented by Zhai et al. (2021). These discussions have centered around the crucial topics of equity and bias concerns, shedding light on the ethical considerations surrounding the utilization of AI in formative assessment. This issue has garnered significant attention, raising important questions about both the feasibility and desirability of incorporating AI into assessment practices. González-Calatayud et al. (2021) highlight that the field of education stands out as one of the most pertinent and pioneering areas for applying AI innovations and that the research on AI and formative assessment is essential not only for its relevance in education but also for its broader implications in shaping the future of our society.

A fundamental approach to conceptualizing any academic discipline involves a systematic examination of the associated scholarly output, as each field periodically reassesses its contributions (Agarwal et al., 2016). Studies that adeptly chart the current terrain and prevalent research directions serve as pivotal reference points for future scholarly undertakings in the discipline (Okagbue et al., 2022). Therefore, considering the growing interest and debates of utilizing AI in educational assessment practices the principal aim of the present research is to thoroughly investigate contemporary topics in AI and assessment in education with a bibliometric review, aiming to delineate its evolving scope. To reach the aims, the articles in the Web of Science Databases were examined, analyzing the articles and the emerging trends in research articles published between 1994 and September 2023. This study examines pertinent data from prior research to address the research questions outlined in Table 1.

Table 1. *Research Questions of the Study.*

	Research Question	Objective	Motivation
RQ1	Which publication years, authors, countries, universities, journals, and citation topics stand out in the field of AI and education assessment literature, and which articles have garnered the highest number of citations?	To determine the sources and authors with the highest productivity	To enhance comprehension of the leadership dynamics in the intersection of AI and educational assessment within the scientific community
RQ2	What do the bibliographic maps, graphs, and tables reveal about the data? How do they shed light on the conceptual, intellectual, and social frameworks that underpin the knowledge base necessary to advance AI in educational assessment?	To conduct a thorough analysis and present the findings concisely	To aid in grasping the current state of AI research in the field of educational assessment

2. METHOD

The present research aims to thoroughly investigate contemporary topics in AI and assessment in education, aiming to delineate its evolving scope. Numerous methods are available to analyze research trends within a field, including literature review, content analysis, meta-analysis, and meta-synthesis, among others (Kaya, 2023). The present study utilizes bibliometric analysis as a widely used and robust approach for the examination and evaluation of extensive sets of research studies conducted in a field (Zupic & Cater, 2015; Donthu et al., 2021). Bibliometric analysis allows researchers to quantitatively analyze scholarly output, such as publications, citations, and collaborations, to gain insights into the research landscape of a specific field (Agarwal et al., 2016; Donthu et al., 2021). By employing bibliometric analysis, researchers can identify interconnections, key trends, influential authors, and important research topics within a given discipline (Zupic & Cater, 2015; Okagbue et al., 2022).

2.1. Data Collection

In the present research, a chosen dataset is subjected to a quantitative examination, incorporating a bibliometric analysis. In the realm of bibliometric analysis, two primary approaches namely performance analysis and scientific mapping are commonly employed for constructing a dataset (Donthu et al., 2021). The first approach entails the selection of one or more journals, encompassing all the studies published within these journals, or including studies identified through thorough examination in the analysis. On the other hand, the second approach provides a visual representation of the interrelationships between disciplines, fields, specialties, individual papers, and authors (Small, 1999). This method is often used in studies that concentrate on specific subject areas (Donthu et al., 2021; Zupic & Cater, 2015).

In the present study, a performance analysis and scientific mapping were conducted. Performance analysis involved the utilization of carefully chosen keywords and phrases to identify relevant research. A four-step methodology, comprising keyword selection, data cleaning and formatting, preliminary analysis, and comprehensive data analysis followed in the study (Fahimnia et al., 2015). The selection process commenced with a search using keywords related to "assessment" and "AI" within the WoS Core Collection, as outlined in Table 2. The combination of "artificial intelligence" AND "assessment" ensures that articles included in the study specifically address the intersection of AI and assessment in education. This conjunction emphasizes the need for relevance to both AI and assessment topics simultaneously. The inclusion of "assess*" provides flexibility, allowing the search to capture a variety of articles that may use different forms of the term "assessment." This helps account for potential variations in terminology used across the literature. The decision to utilize the WoS Core Collection was driven by several factors (Durán-Sánchez et al.,2019). First, it is renowned for its high-quality indexes. Second, it boasts extensive coverage over a substantial timeframe. Lastly, it offers the capability to download a significant number of stored references simultaneously. To further refine the search, the research area of "Educational Education Research", “Education Scientific Disciplines” and “Psychology Educational” were applied as Web of Science Categories. Furthermore, it's important to note that only articles written in the English language were considered among the selected articles. In the data cleaning and formatting step, full records of the results were exported as an Excel file and duplications and mispresented (such as conference papers) records were removed from the list. Ultimately, 436 records were narrowed down for a more thorough examination as in Table 2.

Table 2. *Study Selection Criteria.*

Criteria	Value
1. Data Source	Web of Science Core Collection
2. Search Query	"artificial intelligence" AND "assessment" OR "assess*" (All Fields)
3. Number of Results	91270
4. Filters	Article or Review Article or Early Access (Document Types) and Education Educational Research or Education Special or Psychology Educational or Education Scientific Disciplines (Web of Science Categories) and English (Languages) and English (Languages)
5. Number of Selected Articles	436

Following the refinement of the dataset to 436 articles, an in-depth analysis of publications was conducted using the "analyze results" feature on the Web of Science platform. The examination encompassed parameters such as year of publication, country of origin, authorship, affiliations, journals, and micro-level citation topics.

Various approaches emerged for examining bibliographic data sourced from databases, including methods like citation analysis, co-author analysis, co-citation analysis, and co-word analysis (Gülmez et al., 2021).

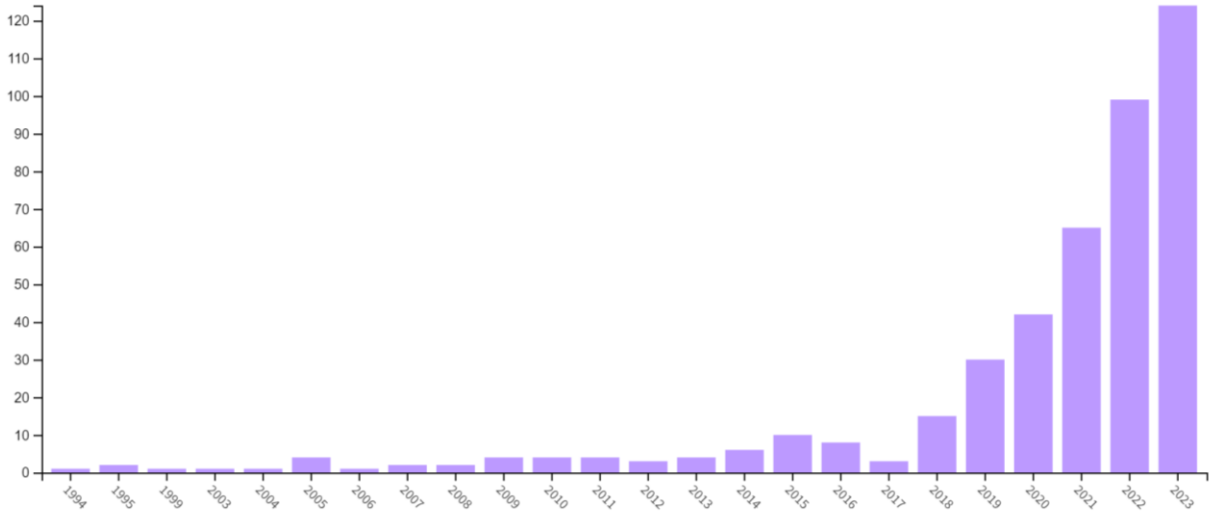
For the scientific mapping step, the maps were created to gain insights into the research topics and the various structures in the dataset (Cobo et al., 2011). Vos Viewer is used to create the co-occurrence of the keywords maps and to identify the clusters within the topic of the study. In the process of scientific mapping using VOS Viewer, various threshold values were tested to assess their influence on the outcomes. Ultimately, a minimum occurrence threshold of 5 was set to focus on significant contributions and core themes, reducing irrelevancy, enhancing interpretability, ensuring robustness, and balancing specificity and generality. This process is designed to pinpoint high-impact studies and prominent authors, as well as to scrutinize research themes that offer valuable insights for future investigations in the field.

3. RESULTS

3.1. Performance Analysis

Figure 2 provides a visual representation of the yearly distribution of articles within the chosen dataset. The trend in article productivity over the analyzed period exhibits a noticeable increase especially from 2018 to 2023. Significantly, 2019 marked a noteworthy turning point, witnessing a doubling of publications, with the release of 30 articles, thus establishing a substantial body of work. Subsequent years have consistently maintained this level of productivity, surpassing the initial threshold of 30 articles per year. It is noteworthy that more than %50 of the articles were published in 2022- 2023 and that since the year 2023 has not yet concluded, the final numbers are anticipated to exceed this current count.

Figure 2. *Distribution of publications related to AI and assessment by year*.



In Figure 3, the distribution of papers published by different countries is presented. The United States has been the most prolific country in addressing the topics of the study. Specifically, over a quarter of the articles originate from the USA. Additionally, noteworthy contributions come from countries such as the People's Republic of China, England, Spain, and Australia. This data underscores the global collaboration and collective involvement in advancing the field of AI utilization in educational assessment.

Figure 3. *Distribution of publications related to AI and assessment by country*.

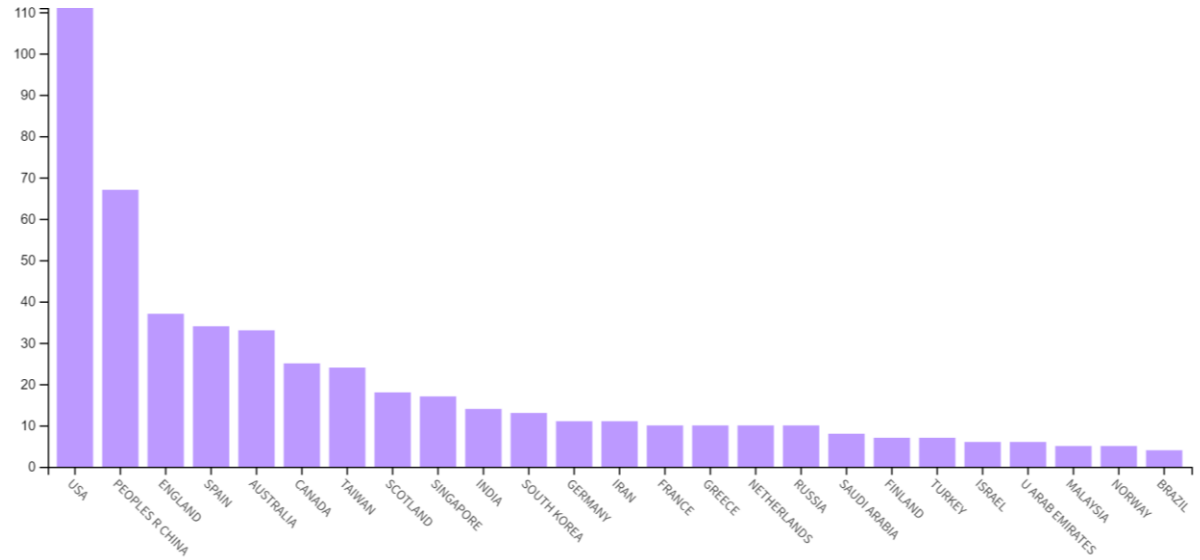


Figure 4 and Figure 5 provide insights into the authors and institutions with the highest productivity in contributing to these journals. Figure 4 reveals that the most prolific author was A.C. Graesser with 11 articles, closely followed by Z.L. Pi and J.M. Yang with 10 articles. However, it is noteworthy that 21 researchers had 9 articles each, equally contributing to the field. In Figure 5, we can observe that the institution with the highest productivity was Central China Normal University, followed by the University System of Georgia and Harvard University. It's worth noting that universities in China and the USA appear to dominate the contributions in terms of the country of origin.

Figure 4. *Distribution of publications related to AI and assessment by authors.*

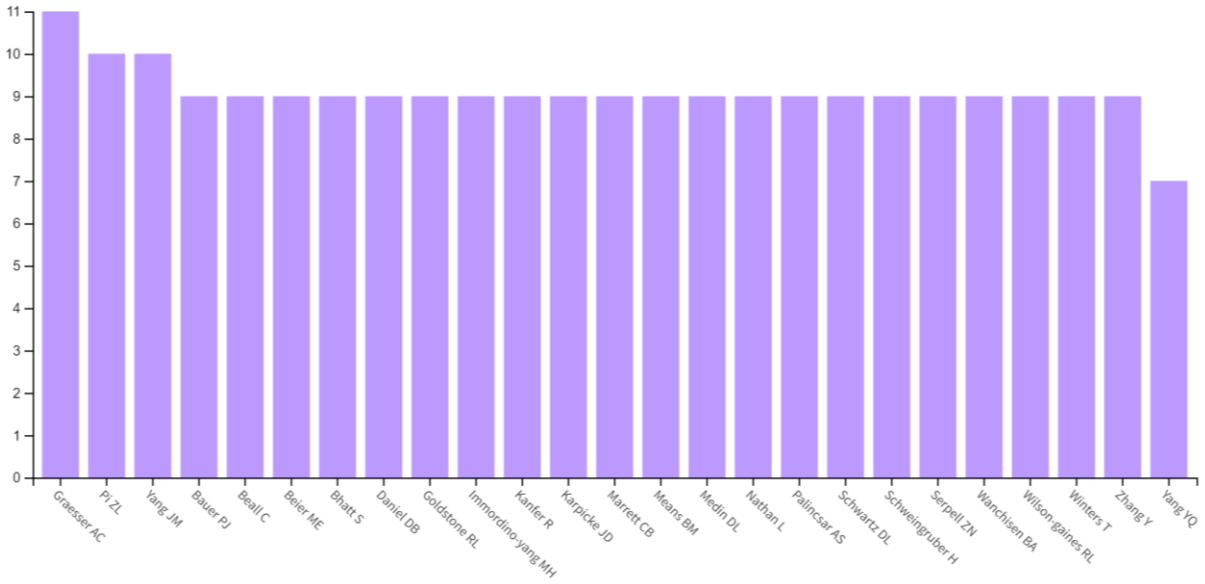


Figure 5. *Distribution of publications related to AI and assessment by affiliations.*

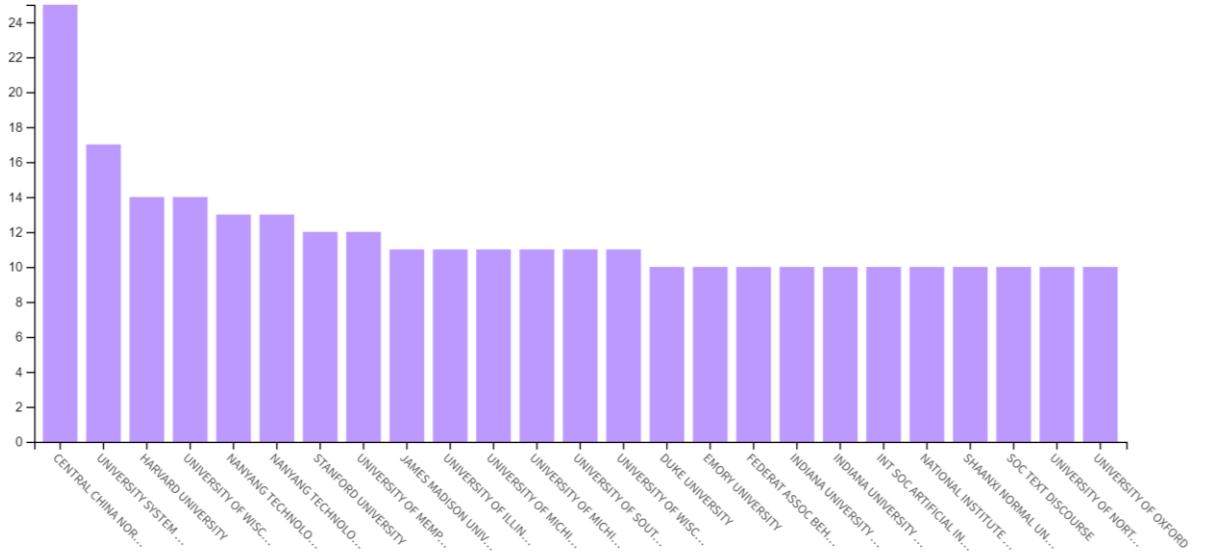


Figure 6 provides a visual representation of the journals that have published the selected articles. The figure indicates that the *Education and Information Technologies Journal and* leads with over 20 articles, followed closely by the *Education Sciences Journal and International Journal of Emerging Technologies in Learning*.

Figure 6. *Distribution of publications related to AI and assessment by publication journals.*

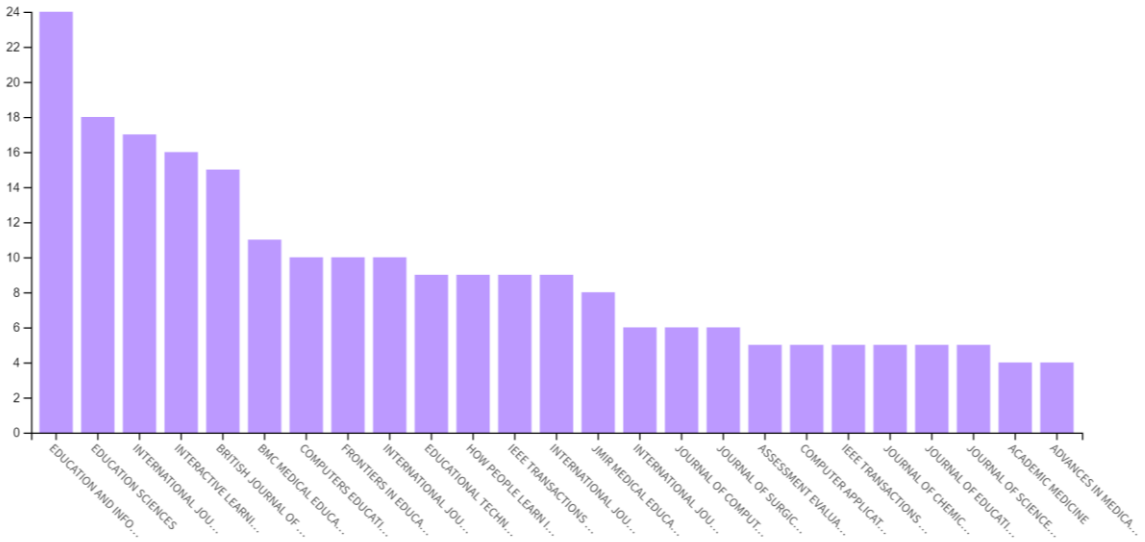
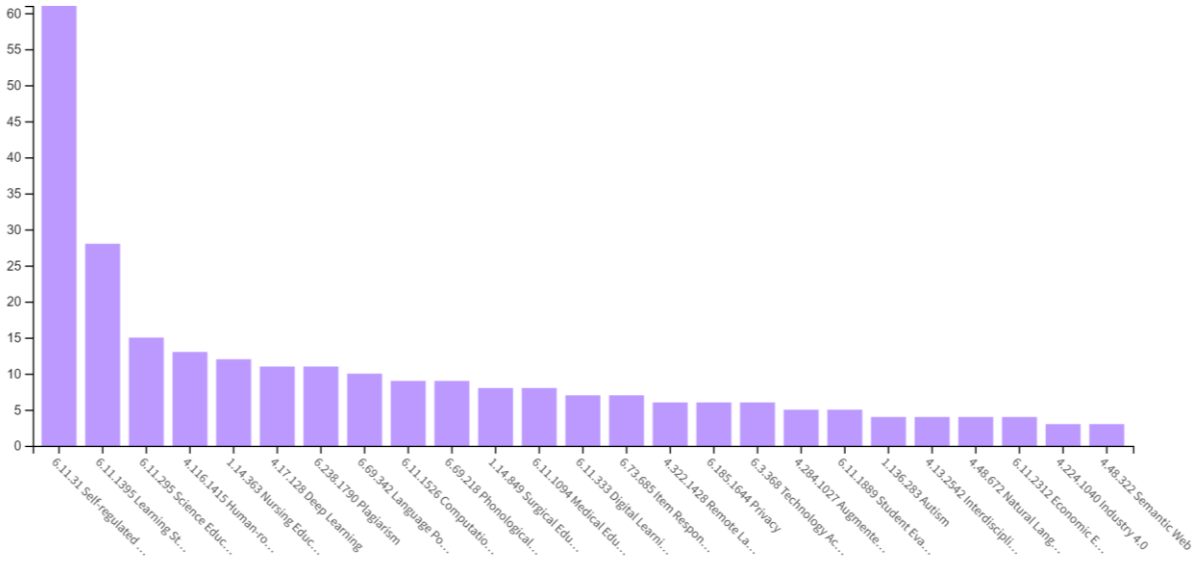


Figure 7 showcases the distribution of publications on AI and assessment, categorized by citation topics that encompass groups of related papers connected through citations. In this study, micro-topics were employed, utilizing an algorithmic tool to label each category based on the most prominent keyword. The figure reveals that the most frequently occurring citation topics revolve around *self-regulated learning*, followed by *learning styles* and *science education*. From the data, it can be inferred that the articles in the field of educational assessment and AI have had a substantial impact, particularly on research studies utilizing these keywords.

Figure 7. *Distribution of publications related to AI and assessment by citation topics (micro).*



3.2. Scientific Mapping

As noted in the methods section, scientific network maps allow for the exploration of relevant terms, research trends, and interrelationships among various concepts. These networks facilitate the detection of emerging patterns in research and the identification of areas where further investigation is needed. Figure 8 displays the keywords employed by the articles within the selected dataset, with a minimum occurrence threshold set at 5, and out of 1363 keywords, 39

meet the threshold. One prominent observation in the figure is that frequently used keywords appear larger compared to less frequently used ones.

Figure 8. *Co-occurrence of keywords in the selected dataset.*

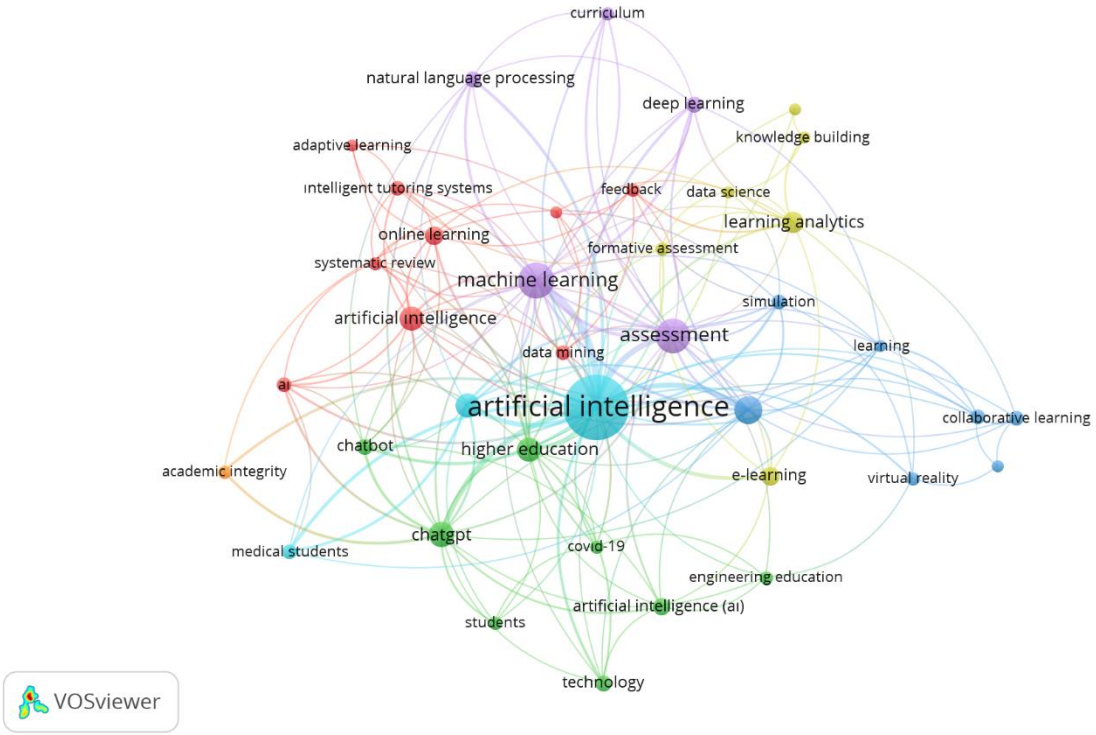
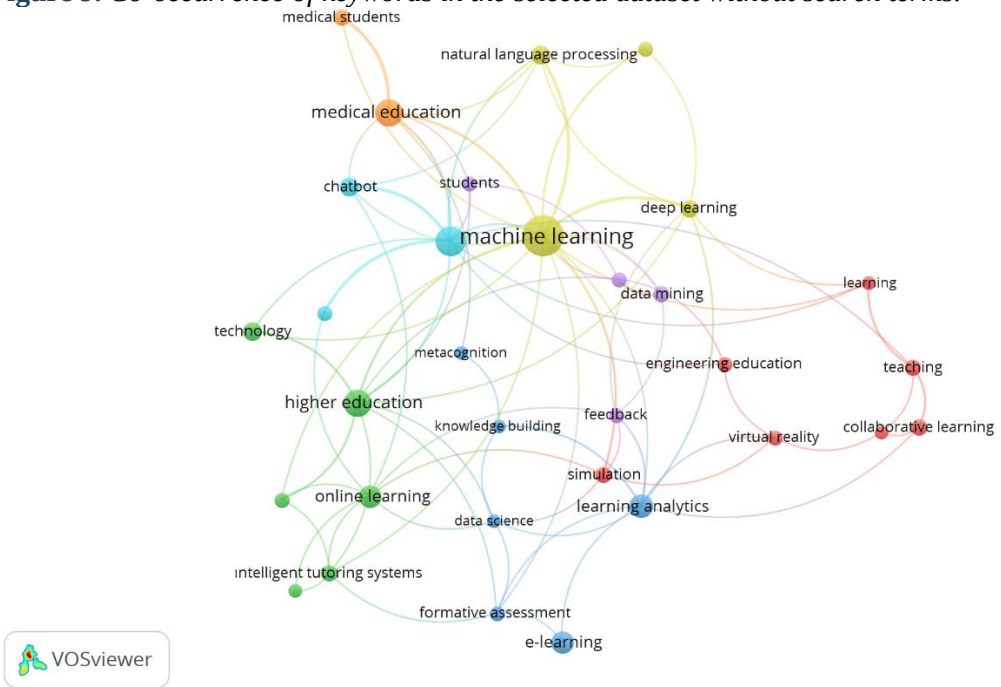


Figure 9 shows the map when artificial intelligence, AI, assessment, and education keywords were excluded. Figure 9 and Table 3 reveal the presence of seven main clusters, denoted by colors (red, green, blue, khaki, purple, turquoise, and orange), indicating interrelated words. The occurrence of these associated words and concepts within these clusters is further detailed in Table 3.

Figure 9. *Co-occurrence of keywords in the selected dataset without search terms.*



The terms that prominently feature in the analyzed papers are as follows: "machine learning" with a frequency of 40 occurrences, followed by "ChatGPT" (f=21), "higher education" (f=19), "medical education" (f=18), “online learning” (12) and e-learning (12). It can be inferred from the map that the breakdown and scientific production trends of artificial intelligence in educational assessment focused on machine learning, ChatGPT, higher education, medical education, online learning, and e-learning.

Table 3. *Clusters and co-occurrence of the keywords.*

Clusters	Co-occurrence of keywords (*f*)
Cluster 1 (7 items) (red)	Collaborative learning (7), Improving classroom Teaching (5), Learning (7), Simulation (7), Teaching (7), Virtual reality (6), engineering education (6)
Cluster 2 (6 items) (green)	Higher education (19), Online learning (12), Technology (9), Intelligent tutoring Systems (7), Systematic review (6), Adaptive learning (5)
Cluster 3 (6 items) (blue)	Learning analytics (14), E-Learning (12), Formative assessment (6), Data science (5), Knowledge building (5), Metacognition (5)
Cluster 4 (4 items) (khaki)	Machine learning (40), Deep learning (8), Natural language Processing (9), Curriculum (6)
Cluster 5 (4 items) (purple)	Data mining (7), Feedback (6), Covid-19 (6), Students (6)
Cluster 6 (3 items) (turquoise)	Chatgpt (21), Chatbot (9), Academic integrity (6)
Cluster 7 (2 items) (orange)	Medical education (18), Medical students (7)

As can be inferred from Table 3 **Cluster 1** revolves around the concept of collaborative learning, virtual reality, and improving classroom teaching. It suggests that collaborative and immersive learning experiences are integral to AI in educational assessment. The inclusion of keywords like simulation and engineering education indicates a focus on practical and hands-on learning experiences (e.g. Winkler-Schwarz et al., 2019). The emphasis on teaching and learning in this cluster suggests a commitment to enhancing the educational experience through AI-driven methods.

Cluster 2 centers on higher education and online learning, emphasizing the importance of AI in these contexts. It includes terms like technology, intelligent tutoring systems, and systematic review, highlighting a scholarly approach to incorporating AI into higher education (Sharma & Harkishan, 2022; Zawacki-Richter et al., 2019). The cluster's focus on adaptive learning underscores the desire to tailor education to individual student needs (Sharma et al., 2019).

Cluster 3 focuses on learning analytics, e-learning, and formative assessment, indicating a strong emphasis on data-driven educational practices. Keywords like data science and metacognition suggest a rigorous analytical approach to educational assessment (Wood et al., 2021). The presence of terms like knowledge building reflects a community dedicated to advancing pedagogy through AI and data.

Cluster 4 centers on machine learning, deep learning, and natural language processing are foundational to this cluster, highlighting the centrality of advanced AI techniques in educational assessment. The curriculum is a critical keyword, indicating the integration of AI into educational curricula. The prevalence of machine learning-related terms suggests a community of researchers and practitioners focused on AI's potential in education.

Cluster 5 includes data mining, feedback, and mentions of COVID-19, highlighting the importance of data-driven decision-making and adaptability in the face of challenges (Yang et al., 2023). The presence of keywords related to students suggests a student-centered approach to AI in education. The focus on feedback indicates a concern for enhancing the learning

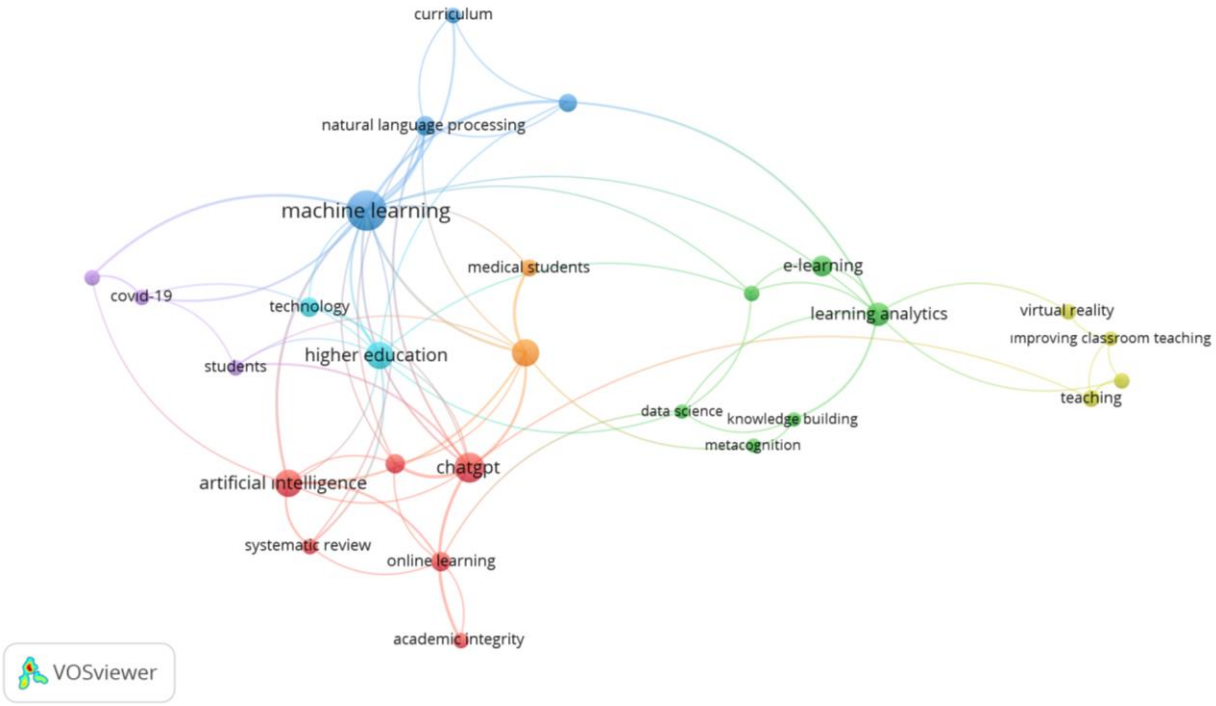
experience through assessment and improvement.

Cluster 6 focuses on ChatGPT and chatbots, emphasizing the role of conversational AI in educational assessment. Academic integrity is a key term, suggesting a focus on ethical considerations in AI-driven assessment (Lancaster, 2023). The prominence of chatbot-related keywords implies the existence of communities exploring AI-driven chat systems in education.

Cluster 7 includes medical education and medical students as the core themes, highlighting the application of AI in the medical field. This cluster reflects a specialized area of research (e.g., Civaner et al., 2022; Tolsgaard et al., 2023; Winkler- Schwarz et al., 2019) within AI in education, focusing on medical training. The emphasis on medical education suggests a dedicated community of researchers and educators in this domain.

Since the field showed a breakdown in 2018, the articles from the beginning of 2018 until September 2023 were also examined as a network map in Vos Viewer. Figure 10 presents this map. The depicted figure highlights the dominance of certain keywords such as "machine learning," "ChatGPT," "higher education," "medical education," and "learning analytics" within the field of artificial intelligence in educational assessment.

Figure 10. *Co-occurrence of keywords between 2018 and 2023.*



4. DISCUSSION and CONCLUSION

The present article tried to thoroughly investigate contemporary topics in AI and assessment in education with a bibliometric review, aiming to delineate its evolving scope. In conclusion, this study's findings have illuminated the remarkable growth and global collaboration within the field of artificial intelligence in educational assessment in recent years. The surge in publications, the prominence of specific keywords, and the interconnected clusters of terms collectively underscore the dynamic and evolving nature of research in this domain. As highlighted by Latif et al. (2023), the study affirms that Artificial Intelligence (AI) has firmly established itself as an integral element of educational practice and assessment. This evolving landscape suggests that educators and researchers should continuously adapt to the changing educational technology environment to harness the potential of AI effectively.

The findings of the study underscored the significance of global collaboration, with

contributions from various countries and institutions. As the field continues to evolve, likely, emerging technologies and innovative approaches will likely further shape the landscape of AI in educational assessment, providing valuable insights and tools for educators and researchers alike. A vast amount of research on the field (e.g., Baker & Yacef, 2009; Siemens & Baker, 2012; Baker & Inventado, 2014) covers various aspects of AI in education, including design-based research, learning analytics, cognitive tutors, stealth assessment, and ethical considerations. They also highlight the contributions from different countries and institutions, emphasizing the collaborative nature of the field. This collaborative spirit can lead to more comprehensive and effective AI applications in education.

Prominent trends identified in the study encompass a concentrated emphasis on machine learning, ChatGPT, and their application in higher education and medical education. This reflects a concerted endeavor to harness AI's capabilities within these specific domains. Reinforcing these observations, Zawacki-Richter et al. (2019) conducted a systematic review that delved into the research on artificial intelligence applications in higher education. Their findings underscore the potential transformative impact of AI on higher education institutions. Moreover, they shed light on the substantial investments and keen interest in AI from both private companies and public-private partnerships. This corroborates the study's assertion that AI's influence in higher education remains a significant focal point, further emphasizing the importance of AI in this sector. Sapci & Sapci (2020) also contributed to the understanding of AI in education, particularly in the context of medical and health informatics. The systematic review explores the integration of AI training into medical and health informatics curricula, indicating a growing recognition of the importance of AI education in these fields. In addition, Bozkurt et al. (2021) provided a comprehensive review of AI studies in education over the past half-century. The authors used a systematic review approach and employed social network analysis and text-mining approaches to identify key research clusters and themes. The study identified three research clusters, one of which is focused on artificial intelligence. Within this cluster, the study highlights the theme of adaptive learning and personalization of education through AI-based practices, which aligns with the present study. Educators and researchers should stay informed about these developments to leverage the latest tools and insights for improved teaching and assessment.

The prevalence of citation topics such as self-regulated learning, learning styles, and science education underscores a substantial focus on pedagogical aspects within the field. This emphasis is in line with the recognition of how learning styles can significantly influence a variety of assessment methods and practices, as discussed by Calatayud et al. (2021). Additionally, it aligns with the potential for artificial intelligence to bring about transformative changes in the delivery and evaluation of education, which holds the promise of enhancing educational outcomes for students, as articulated by Owan et al. (2023). Consequently, the integration of artificial intelligence into this educational domain is not only a logical step but also an expected and prominent development. Future research and implementations should prioritize pedagogical effectiveness.

The clusters created by Vos Viewer collectively represent the multifaceted nature of AI in educational assessment (Baker & Yacef, 2009; Siemens & Baker, 2012; Luckin et. al., 2016), with each cluster contributing to the broader knowledge base necessary to advance the field. They underscore the diverse applications of AI, from collaborative and immersive learning experiences to data-driven decision-making and personalized education. Moreover, they emphasize the importance of ethical considerations and the potential for AI to revolutionize education in various domains (Zhai & Nehm, 2023), including medicine. Understanding these clusters is crucial for researchers, educators, and policymakers seeking to leverage AI's potential in educational assessment effectively.

Regarding the study's limitations, it should be noted that the research relies on data available up to a specific point in time. Since then, new publications and emerging trends may have surfaced, potentially escaping the scope of this analysis. Furthermore, the study predominantly concentrates on bibliometric analysis and the tracking of keyword trends. It does not delve into the qualitative dimensions of research or provide an in-depth exploration of the specific applications of AI in education. It is also important to recognize that while the study does identify prevailing trends, it may not comprehensively capture the full spectrum of AI applications in education across diverse contexts and regions. Consequently, caution should be exercised when attempting to generalize the findings to all educational settings. Lastly, the study offers insights into potential future developments in AI in education. However, it is essential to acknowledge that the actual trajectory of AI's role in education may be subject to a multitude of unpredictable influences, including advancements in technology, alterations in policy, and shifts in societal dynamics.

In conclusion, as indicated by Zawacki-Richter et al., (2019) the complete outcomes of AI progress remain unpredictable at this time. However, it appears probable that AI applications will emerge as a prominent concern in the realm of educational technology for the next two decades. Moreover, the influence of AI within education continues to broaden and deepen, promising innovative solutions and insights for the field.

Declaration of Conflicting Interests and Ethics

The author declares no conflict of interest. This research study complies with research publishing ethics. The scientific and legal responsibility for manuscripts published in IJATE belongs to the author.

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