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Application of AI in Education. A Bibliometric Analysis

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Abstract

The primary objective of this study is to contribute to the existing literature concerning the utilization of AI in education. It achieves this by introducing four distinct research clusters that offer directions for scholars to expand their investigations into AI-based learning. The study's focus centers on student-centric literature related to AI-based learning from 2000 onwards, employing established bibliometric techniques to yield comprehensive insights. Through the application of these techniques, a comprehensive analysis was conducted on 722 articles published within the last decade This assessment encompassed the identification of key research domains, influential authors, countries contributing significantly, influential journals, and prominent organizations involved in AI-based learning research. Additionally, a scrutiny of the most influential studies was conducted based on their citation counts. The study acknowledges the transformation of AI-based learning from an emerging field to a robust tool for both teaching and research. Given this progression, the investigation is designed to explore and delineate the evolving trends in the application of AI within the realms of learning and research. By conducting a meticulous examination of relevant literature and employing bibliometric methodologies the study provides a valuable resource for researchers, educators, and stakeholders keen on understanding and contributing to the dynamic field of AI-based learning.

Keywords: *Artificial Intelligence. Education, Bibliometric Analysis, Educational Institutions Co-citation Analysis, Collaborative Learning, Augmented Reality, Teaching Methods, E-learning, Digital Learning*

INTRODUCTION

Artificial Intelligence (AI) is triggering rapid transformations across global industries, and the field of education has witnessed massive changes. This transition is characterized by the deployment of innovative AI applications, poised to completely revolutionize the conventional pedagogical approaches. These changes are marked by personalized learning experiences, data-driven decision-making processes, and a heightened quality of educational interactions (Liu et al.,2017)

The advent of AI indicates the rise of adaptive learning systems, a progressive development that is fundamentally changing the educational trajectory for every individual student. (Roberts et al., (2016)At the core of these systems lies a deep analysis of each student's unique learning patterns, strengths, and areas that require further development. This leads to the creation of bespoke lessons, exercises, and assessments, precisely tailored to cater to the distinctive needs of each learner. (Kelley et al.,2020)

This personalized approach promotes optimal learning outcomes by enabling students to learn at their own pace, receive robust support, and engage with relevant content

Upgraded and improved Intelligent tutoring systems is another benefit that AI offers on education platform These systems perform the role of human tutors, offering one-to-one personalized guidance. Leveraging natural language processing and machine learning, AI tutors solve queries, clarify doubts, and furnish supplemental resources, nurturing a contextual approach towards subjects. Consequently, this technology stands as a beacon, capable of bridging learning disparities and supplementing classroom instruction.

The integration of AI in education extends to analytics and data mining, which have triggered a paradigm shift in the acquisition and interpretation of information. (Luan et al., 2020) AI's prowess in sifting through vast data repositories allows institutions to unearth trends, forecast student performance, and suggest timely

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interventions. This data-centric approach facilitates the timely identification of struggling learners, permitting educators to render personalized support before challenges compound. (Lukarov. 2019)

AI-powered assessment tools have fundamentally transmuted the evaluative landscape. Automated grading systems deftly appraise objective assignments and assessments, affording educators more time to dedicate to intricate aspects of teaching. Additionally, AI's natural language understanding capabilities enable the assessment of subjective assignments like essays, offering profound insights into students' analytical and writing proficiencies

AI's reach in education transcends the confines of the classroom, contributing to its inclusivity and accessibility. (Finn 2021). Language translation technologies driven by AI surmount language barriers, rendering educational content accessible to linguistically diverse students. Furthermore, AI-driven assistive technologies embolden students with disabilities, delivering real-time transcriptions and text-to-speech functionalities, thus fostering an equitable learning environment

However, as AI continues to weave itself into the educational fabric, ethical and privacy concerns loom large. Safeguarding student data, ensuring algorithmic transparency, and preserving the human element in education stands as paramount considerations, guiding the responsible and beneficial integration of AI into the educational ecosystem.(Marachi & Quill 2020) . In essence, AI's burgeoning presence in education holds the promise of revolutionizing conventional paradigms, ushering in an era of personalized, data-informed, and inclusive learning experiences. The subsequent exploration will delve deeper into the multifaceted applications of AI within the realm of education, elucidating its potential to reshape the learning landscape

LITERATURE REVIEW

The integration of Artificial Intelligence (AI) into the field of education has attracted considerable attention in recent times, ushering in novel avenues for enriching learning experiences, personalizing instructional approaches, and optimizing educational outcomes. This literature review seeks to offer a comprehensive perspective on the manifold applications of AI in education, delving into both the potential benefits and the inherent challenges

Among the foremost applications of AI in education is the creation of personalized learning systems. These systems harness the power of machine learning algorithms to scrutinize student data, learning preferences, and performance trends. Subsequently, they curate and provide bespoke educational content and activities. Vygotsky's Zone of Proximal Development underpins the pivotal role of personalized instruction in scaffolding the learning journey of students. Echoing this notion, Van & Waltman (2007) explore how AI-driven adaptive learning platforms offer students content that aligns with their skill levels, pacing, and preferred learning styles.

Another significant aspect of AI's influence on education involves enhancing Intelligent Tutoring Systems (ITS). By harnessing AI technologies, these systems can be upgraded to simulate and replicate the functions of a human tutor, providing instant guidance and feedback in real-time. These systems integrate natural language processing and cognitive modeling to scrutinize student inputs and furnish customized explanations. The upshot is a heightened level of comprehension and a more profound grasp of underlying concepts.

AI-driven data analytics have ushered in a paradigm shift in the way educational institutions collect and harness student data. Baker and Yacef (2009) underscore the critical role of data mining methodologies in unraveling patterns, prognosticating student performance, and facilitating prompt interventions. By dissecting academic data, AI offers educators insights into identifying students who may be struggling, thereby enabling the timely delivery of support and tailored interventions.

The symbiotic relationship between AI and education is thus poised to reshape pedagogical paradigms. The ensuing sections of this review will expound upon these applications, examining their potential to redefine the educational landscape while also considering the potential challenges and ethical considerations that arise in the wake of this technological transformation. The implementation of AI for automated assessment and feedback has revolutionized traditional grading methods. Siemens and Long (2011) discuss the potential of AI to evaluate both objective and open-ended assignments, providing consistent and timely feedback to students. This

application not only enhances efficiency in grading but also allows educators to focus on more nuanced aspects of teaching and learning.

AI technologies have contributed to making education more accessible and inclusive. Translation services powered by AI, as explored by Sykes et al. (2016), break down language barriers, enabling students from diverse linguistic backgrounds to access educational content. Assistive technologies, such as text-to-speech and speech-to-text tools, offer support to learners with disabilities, aligning with principles of universal learning design (UDL).

METHODOLOGY

The provided text describes the methodology and approach used for conducting a bibliometric analysis in the field of the application of AI in education. Bibliometrics refers to the systematic analysis and management of bibliographic information derived from scholarly publications. The study aimed to investigate the evolution of research in the domain of mobile learning, with a focus on high-quality publications and the use of specific databases and search strategies.

The study's methodology encompassed both general descriptive statistics and more complex techniques like document co-citation analysis. It started with the adoption of suitable search terms and an iterative process of literature search and analysis to ensure reliable results. Journals with high impact factors, as indicated by Clarivate Analytics Journal Citation Reports (JCR), were considered indicative of high-quality publications.

To ensure the inclusion of top-tier publications, the study relied on the Web of Science (WoS) database for data collection. This choice was made due to WoS's strong coverage, particularly in the social sciences and humanities, and its comprehensive citation and bibliographic records. The study focused on articles from 2000 to December 2020, as these years were deemed relevant for the analysis.

The initial search query in the WoS database used the terms "Artificial Intelligence " OR "AI-based learning," resulting in a collection of 1,192 articles. This initial set of results was then refined to focus on articles related to students as learners, resulting in 781 articles. The refinement process also involved excluding non-research articles and those not in English. The final search string yielded 722 articles that were utilized for the subsequent bibliometric analysis.

In summary, the study employed a systematic approach to bibliometric analysis utilizing specific research terms, databases, and inclusion criteria to investigate the evolution of research in mobile learning with particular emphasis on high-quality publication and a focus on student learners

DATA ANALYSIS

The study utilized data sets obtained from the Web of Science (WoS) database, containing information in PlainText format. This data included details such as the publication year, publication title, author name, journal, citation information, and keywords. The data covered the period from 2000 to December 2020 and was then subjected to analysis using the VOSviewer software version 1.6.15.

VOSviewer, a software tool developed by Van Eck and Waltman (2010), was employed for both analysis and the creation of visual maps. The software leveraged VOS clustering and mapping methods to achieve these objectives. This method allows for the assessment of relationships and frameworks within the prescribed dataset.

In the study conducted by Van Eck and Waltman (2007), a more precise and suitable technique for normalizing co-occurrence frequencies was introduced. This advancement holds paramount significance, as VOSViewer incorporates this technique into its framework. By doing so, VOSViewer aims to heighten the accuracy and meaningfulness of the resultant maps and visual representations. This technique essentially enhances the fidelity of the insights gleaned from the data, rendering the generated visualizations more faithful to the inherent relationships and patterns within the dataset.

In consonance with the insights presented by Appio et al. (2016), the study under consideration leveraged the LinLog/modularity normalization method. By harnessing the visualization capabilities furnished by VOSViewer, the team of researchers embarked on an illuminating journey to uncover intricate patterns grounded in mathematical relationships latent within the dataset. This comprehensive process encompassed a suite of analyses, spanning the terrain of keyword co-occurrence analysis, citation analysis, and co-citation analysis

Keyword co-occurrence analysis, as highlighted by Zhao (2017), proved invaluable for understanding the evolution of the research area over a specific timeframe. This technique effectively identifies prevalent topics across diverse fields, as evidenced by Li et al. (2016). On the other hand, citation analysis offers a means to identify pivotal research themes, emerging trends, and methodologies. Additionally, it aids in tracing the historical significance of a discipline's primary focus, as emphasized by Allahverdiyev and Yucesoy (2017).

Among the commonly utilized bibliometric methods, document co-citation analysis stands out as a frequently employed approach. This technique has been discussed by various scholars, including Appio et al. (2016), Fahimnia et al. (2015), and Verma et al., (2023). The outcome of document co-citation analysis is reliant on network theory, a concept illustrated by Liu et al. (2015), which assists in identifying the inherent structure and relationships within the data, leading to the generation of informative maps

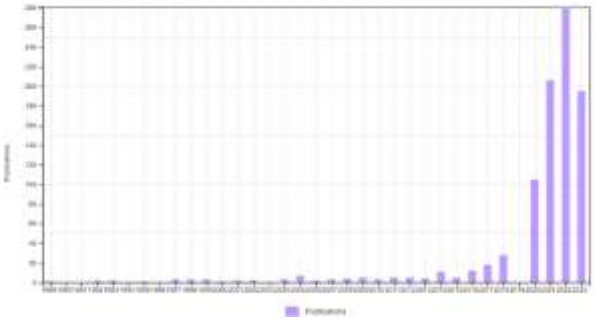

Figure 1 Distributing Chart of Articles Published

Figure 2- Research areas with more than 47 published articles.

General Statistics

The distribution of the application of AI in education as per citations per year and publications per year are represented in Figure 1. The graphs clearly show that the number of citations is increasing every year and more citations are being added every year. This shows that the field is evolving rapidly which adds to the novelty and relevance to its study. Further examination of data revealed that publications relating to the application of AI in education covered 73 different countries mainly China, the USA, the UK, Taiwan, Canada, Brazil, South Korea, and Germany

Figure 2 investigates the research areas with more than 47 published articles education educational research, computer science artificial intelligence, computer science information systems, and computer science interdisciplinary applications are the main areas that cover the relevance of AI in education.

BIBLIOMETRIC ANALYSIS

Analysis of Keywords

In the data set of 722 publications total of 1892 keywords were used. Co-occurrence analysis was conducted with a minimum number of occurrences of a keyword kept at a threshold of 5. A total of 106 keywords met the criteria and formed seven different clusters. On further examination of the co-occurrence network visualization map, it was found that these keywords act as guidance for the topics that are connected in this area of research. The `olive green color comprises of artificial intelligence, big data, medical education, radiology, survey, data science, perceptions, and attitude. The brown color includes words like machine learning, computational thinking, robotics, school, curriculum, and self-efficacy, the light blue color consists of words like artificial intelligence, systems, algorithm, bias, trust, fairness, ethics, privacy, framework, optimization, and explainable ai, the dark blue colour has words like models, systems, framework, algorithm, bias, predictions and optimization, the green color includes ai, chatbot, teaching, chatgpt, adoption, as in education and technology, the purple colour has words like management, virtual reality, neural networks, medicine, augmented reality and visualization and finally the red colour had words like bibliometric analysis, tutoring systems, designs, students, language, robots, trends, and evolutions. From Figure 3, it is evident that clusters are related closely to each other which exhibits that researchers are most likely to be cited in studies of a similar nature.

The key research topics are in trend and can be identified by a visualization map of keyword co-occurrence analysis Figure 4. It has been found that trends in the application of AI in education are shifting towards words like chatgpt, chatbot, big data, bibliometric analysis, and artificial intelligence in education. These topics have played a major role in attracting researchers in the present era. (Burden et al., 2019; Hwang et al., 2011; Wu et al., 2013).

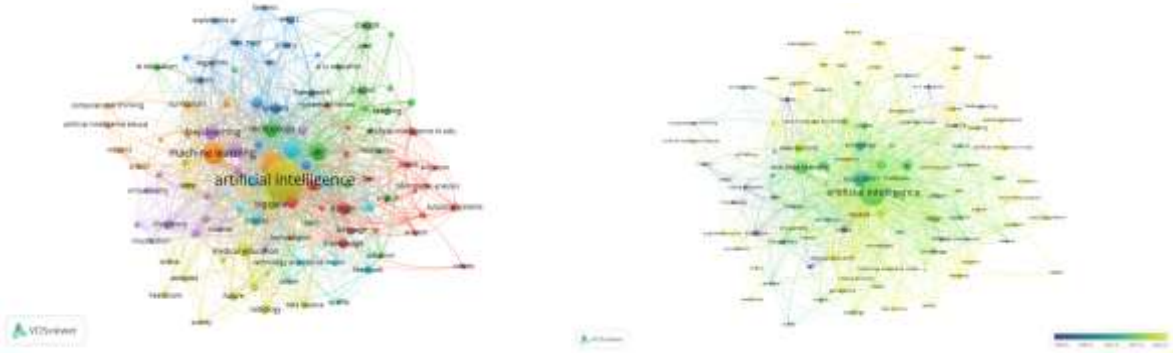

Figure 3 : Keyword co -occurrence network visualization map

Figure 4 : Overlay Visualisation Map (Yearly)

Citation Analysis

This analysis helps to identify the authors who have contributed majorly to this field of research. Table 1 shows the list of top contributing authors. Richter et al. contributed 302 citations and Karp et al.,253 citations. Richter's paper titled Systematic Review of Research on Artificial Intelligence Applications in Higher Education - Where Are the Educators" aims to provide a review of the application of AI in higher education. According to Santos et al.,2019 students in the field of medicine are well aware of the usage of AI in medical sciences and its implications for their career growth. Chen et al, 2020 revealed that AI is deeply entrenched and has been well-adopted in the field of education. It has helped the instructors to deliver their courses effectively and also machine learning has led to more customization of courses and teaching pedagogy.

Citation analysis was also performed to identify the top contributing journals that have been published in this field refer to Table 2. The minimum number of publications by any journal is above 5 papers. Further citation analysis was carried out to identify the top institutions that have contributed to this field of research. Out of 919 organizations that had a minimum number of 12 citations, 100 met the threshold limit.., Beijing Normal Univ, National Taiwan University of Science and Technology, and Imperial College of London were the top three contributing organizations. Refer to Table 3. The top 30 countries that have contributed specifically towards research in this field have been represented in figure 5. The USA, China, England, and Taiwan figure prominently on the list of top countries working on AI and its application in the educational field.

Table 1 - Top contributing Publications

Author	Article Title	Journal	Citations
Richter et al., 2019	Systematic review of research on artificial intelligence applications in higher education - where are the educators?	International Journal of Educational Technology in Higher Education	302
Karp et al., 2002	The Metacyc Data base	Nucleic Acid Research	253
Santos et al.,2019	Medical students' attitude towards artificial intelligence: a multicentre survey	European Radiology	194
Gulwani et al .,2017	Program Synthesis	Foundations and Trends in programming Language	183
Schwendicke et al., 2020	Artificial Intelligence in Dentistry: Chances and Challenges	Journal of Dental Research	165
Chen et al., 2020	Artificial Intelligence in Education: A Review	IEEE ACCESS	145
Car et al .,2020	Conversational Agents in Health Care: Scoping Review and Conceptual Analysis	Journal of Medical Internet Research	130
Yigitcanlar et al., 2020	Contributions and Risks of Artificial Intelligence (AI) in Building Smarter Cities: Insights from a Systematic Review of the Literature	Energies	122
Perrotta et al., 2021	Automation, APIs and the distributed labour of platform pedagogies in Google Classroom	Critical Studies in education	71

Table 2 Top contributing Journals

Journals	No of Published articles	Citations
Computational Intelligence and Neuroscience	7	2
Education and Information technologies	13	115
Educational Technology & Society	12	83
Engineering	6	286
Frontiers in Artificial Intelligence	5	29
Frontiers in Psychology	8	62
Ieee Access	7	184
Interactive Learning Environments	8	89
International Journal of Emerging Technologies in Learning	5	62
Journal of Dental Education	5	36
Sustainability	18	148

Table 3 Top contributing Organizations

Organization	Documents	Citations	Country
Beijing Normal Univ	10	50	China
Educ Univ Hong Kong	6	55	China
Imperial Coll London	6	24	UK
MIT	7	34	USA
Natl Taiwan Univ sci & Technol	7	155	Taiwan
Tsinghua Univ	7	76	China
UCL	8	71	UK
Univ British Columbia	6	42	UK
Univ Michigan	6	41	USA
Univ Toronto	11	64	Canada
Zhejiang Univ	7	178	China

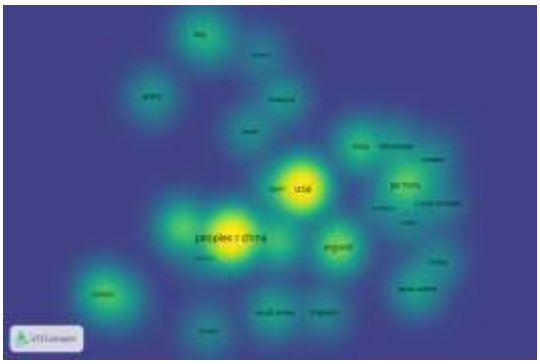

Figure 5 Top Contributing Countries

DISCUSSION

The present research significantly contributes to the scientific literature concerning the utilization of Artificial Intelligence (AI) in the education sector. It builds upon and extends existing viewpoints put forth by scholars such as Camilleri and Camilleri (2020), Hamidi and Chavoshi (2018), Hu et al. (2020), and Kuhnel et al. (2018). The study employs a bibliometric analysis to identify the most influential studies based on factors like citations and co-citations. This analysis culminates in the identification of four distinct clusters that delve into different aspects of AI, ranging from its conceptualization to methods and its practical application within the education system.

Moreover, the study underscores the interrelationships between these clusters, asserting that advancements in techniques will lead to improved applications of mobile learning (m-learning) within the education sector. The authors highlight the notable attention that the intersection of AI and the education sector has garnered over time. This attention, they argue, underscores the potential for collaboration among institutions and researchers, suggesting a collective endeavor to enhance the education sector

Additionally, the research brings attention to the burgeoning field of m-learning, present in both education and computer science journals. This observation underscores the need for interdisciplinary approaches in m-learning research and development, encouraging researchers to draw from both fields for comprehensive insights

The emergence of online communication platforms like Zoom, Google Meet, CISCO Webex, and Microsoft Teams has had a transformative impact on education, especially during the COVID-19 pandemic. Mandala et al., (2022), Verma et al., (2022) .These platforms, often utilizing a freemium model, have reshaped the way education is delivered and experienced. Research studies, such as those conducted by Luckin & Holmes (2016), Roll & Wylie (2016), and Kim (2020), underscore the essential role of online teaching and learning during the pandemic, shifting it from an optional approach to a necessary online teaching method. (Gulwani et al .,2017), (Timms 2016).

The concept of gamification has proven to be an effective strategy for motivating learners by integrating game elements and principles into educational contexts (Lin et al., 2013, Çera et al., 2020; Zeng et al., 2020). By employing gamification with AI, educational institutions can create engaging and enjoyable learning experiences for students, enhancing their overall learning journey. Additionally, incorporating social support network settings into the learning process, as suggested by Polson & Richardson (2013), can foster collaboration, interaction, and a sense of community among learners.

Augmented Reality (AR) has been highlighted as a potentially valuable tool for enhancing productivity among learners, as recommended by Wu et al., (2017). AR technology can provide immersive and interactive learning experiences that bridge the gap between theoretical concepts and real-world applications, ultimately enriching the learning process

However, for these technological innovations to yield positive and sustainable outcomes in student learning both educators and students must receive appropriate training and support in utilizing AI-based technologies effectively. Facilitating access to training and assistance can significantly reduce the time and effort required for adopting these technologies.

The responsibility to foster a conducive environment for integrating innovative AI-based technologies in education doesn't solely rest with educators and students. Administrators, governmental bodies, and policymakers can play a pivotal role by incentivizing, investing in, and providing necessary assistance to teachers. Encouraging proactive adoption of such technologies can lead to a more dynamic and effective educational landscape.

However, to realize the full potential of these advancements, a comprehensive approach involving educators, students, administrators, and policymakers is essential

CONCLUSION

In conclusion, this study conducted a comprehensive literature review spanning a decade (2010-2020) to examine the integration of AI in education, utilizing bibliometric analysis techniques.

The findings shed light on the significant contributions of scientific journals, academics, and institutions in advancing the understanding and adoption of AI-based education and instructional methods. The study not only provides valuable insights but also serves as a source of inspiration and direction for researchers in the field of education, encouraging them to explore existing gaps in information, knowledge, skills, and technology implementation.

Given the growing importance of digital access and equity, higher education administrators must take proactive measures to ensure the availability of electronic resources, thereby promoting inclusivity among learners. Educators, on their part, can enhance content delivery by making lectures and educational materials accessible through mediums like podcasts or recorded sessions, catering to both synchronous and asynchronous learning needs

As we look ahead, the study emphasizes the importance of offering diverse options to students in AI-based learning experiences. This involves addressing the three essential facets of AI mobility: focusing on devices for a seamless learning experience, emphasizing the learning process itself, and ensuring the adaptability of learners to evolving technological landscapes.

In summary, this study's findings underscore the evolution and potential of AI in education, urging researchers educators, and administrators to collaboratively drive advancements in this domain, enhance accessibility, and empower learners through a multifaceted approach to AI-based learning.

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