

Navigating the AI Frontier in Higher Education: An Experimental Bibliometric Analysis of Pedagogical Innovations in Education (2014-2024)

Dr Wong Su Cheong

School of Communication and Creative Arts, UOW University Malaysia, Selangor, Malaysia

DOI: <https://dx.doi.org/10.47772/IJRISS.2025.903SEDU0143>

Received: 14 February 2025; Accepted: 28 February 2025; Published: 06 April 2025

ABSTRACT

Artificial intelligence (AI) is a branch of computer science designed to improve humans' productivity creatively with the help of intelligent computers and big data. Recently, the use of AI technology has been growing rapidly in many disciplines to improve task efficiency and accuracy, educational research is among the beneficial scholarly activities. With the help of AI technology in education, AI-Based robotic applications simulate human intelligence to make accurate predictions and decision making to solve complex issues. Through the assistance of AI-based learning tool, individual learner able to learn effectively with satisfactory positive experiences. However, education experts are worried that the level of AI integration depends on the adaptability of stakeholders. AI technology alone can't make a significant impact to improve education quality. AI technology integration will only happen when learners are equipped with the ability to choose information with creativity. Since the beginning of the 21st century, AIEL (Artificial Intelligence in Education) has become significantly important with rapidly developing technologies. Artificial Intelligence (AI) and Big Data Analytic (BDA) are among the two most crucial inventions to improve task productivity. This study aims to conduct a comprehensive bibliometric analysis of the impact of AI technology on higher education from 2014 to 2024.

Keywords: Artificial Intelligence (AI), Education Pedagogy, Bibliometric Analysis, Artificial Intelligence in Education (AIEL)

INTRODUCTION

Background of Study

The use of artificial intelligence (AI) technology has been growing popular in the many areas to improve efficiency and accuracy, particularly in educational research. According to Hwang et al. (2020), AIED (Artificial Intelligence in Education) refers to the use of AI (Artificial Intelligence) technologies in educational settings to facilitate teaching, learning, or decision making. With the assistance of AI technology, human intelligence stimulation helped to make inferences, judgments, or predictions, computer systems which were able to provide personalized guidance, support, or feedback to learners, as well as instructional delivery and operational decision making for our policymakers.

One of the prominent objectives of AI in education is the provision of personalized learning guidance or support to individual students based on their learning status, preferences, or personal characteristics (Hwang, 2014). Whereas Begum (2024) revised the claim that the future of higher education is closely related to the development of new technologies and the computing power of new intelligent machines. According to Begum (2024), advances in artificial intelligence open new opportunities and challenges for teaching and learning especially in higher education, as well as the possibility of fundamentally changing management and the internal architecture of higher education. Education is meant to improve human skills and mindsets in respective fields, and the invention of AI enables the learning process to become easy and productive. However, AI technology alone can't create immediate impact to improve students' performance and learning

satisfaction. Stakeholders must work together to address challenges to ensure responsible AI deployment in higher education while enjoying the benefits. The research aimed to take advantage of the opportunity of the absence of bibliometric review in AI technology integration research to provide a comprehensive publication report from the past 10 years.

Problem Statement

Traditional research methods for reviewing literature to read global research patterns and trends were too time consuming. Bibliometric analysis is a popular and rigorous method for exploring and analysing large volumes of scientific data for the past 10 years. It enables researchers to unpack the evolutionary nuances of a specific field, while shedding light on the emerging areas in that field. Yet, its application in AI-based educational research is relatively rare, and in many instances, unavailable.

Bibliometric analysis has gained immense popularity in business research in recent years (Donthu et al., 2020b, Donthu, Kumar, Pattnaik, & Lim, 2021, Khan et al., 2021), and its popularity can be attributed to the advancement, availability, and accessibility of bibliometric software such as Gephi, Leximancer, VOSviewer, and scientific databases such as Scopus and Web of Science, and the cross-disciplinary pollination of the bibliometric methodology from information science to business research. Numerous scholarly works investigate the applications of AI and BDA in various fields. Researching the application of AI Technology integration research analysis still numbered. Consequently, it is essential to evaluate the state of AI Technology integration research themes and trends for the global impacts. This bibliometric study intends to examine influential and well-cited bibliometric reviews on AI Technology integration research analysis written by eminent researchers from various fields.

Research Objective

1. To identify research gaps from the evolution of AI Technology at higher education through comprehensive bibliometric analysis.
2. To evaluate the trendy patterns of Bibliometric statistical data in AI Technology at higher education that involves publication and researchers' background.
3. To conduct an experimental bibliometric analysis focusing on pedagogical innovations

Research Question

RQ1 What are the dominant research themes and trends in the study of AI technology in higher education from 2014 to 2024?

RQ2 Who are the most influential authors, institutions, and countries contributing to the research on AI technology in higher education, and how have their collaborative networks evolved from 2014 to 2024?

RQ3 What are the most significant pedagogical innovations and best practices in integrating AI technology into higher education curricula and instructional design?

Significance of the Study

First, this research paper able to provide an overview to educators on how to integrate AI technologies into teaching, addressing challenges and benefits perceived in educational settings. The themes, prominent authors and global research patterns for the past 20 years will be served as a framework for instructional technology integration and implementation for faculty for the best decision on AI integration. Second, stakeholders are given a bibliometric analysis in statistical patterns about AI technology integration in higher education worldwide as reference to making decisions on education policies and institutional strategy by future development. Higher education institutions are well-prepared in addressing the need to prepare students for AI technology integration. Third, the government and education stakeholders can use this bibliometric analysis to discover a valid research topic that has not been done yet.

LITERATURE REVIEW

AI in Higher Education: An Overview

It is important to follow the developments of AIeL from the past. Tang et al. (2021) study aimed to review publication patterns for AIeL research with a focus on leading journals, countries, disciplines, and applications. In addition, a co-citation network analysis was conducted to explore the invisible relationships among the core papers of AIeL to reveal directions for future research. The meaning of AI-supported e-learning (AIeL) refers to the use of AI techniques like fuzzy logic, decision tree, Bayesian networks, neural networks, genetic algorithms, and hidden Markov models in e-learning (Colchester et al., 2017). However, Villardón-Gallego et al. (2018) reconfirmed AIeL impact that enables effective learning possible to improve individual professional skills and enhancing the quality of teaching and learning in education. AIeL contribution significantly impacted on average and low achiever groups in learning effectively. According to Tang et al. (2021), AIeL has become increasingly important with rapidly developing of AI technologies and the widespread use of technology in various educational settings (Colchester et al., 2017; Hinojo-Lucena et al., 2019; Hwang, 2014), such as medical education (Winkler-Schwartz et al., 2019), language learning (Kose et al., 2015), science courses (Iyanda et al., 2018), mathematics (Mandal & Naskar, 2019) and general discipline courses (Brittain & Norris, 2000). This phenomenon has opened a new chapter for the 21st Century of teaching and learning in education. Meanwhile, Tang et al. (2021) shared that researcher focused on the exploration of AIeL from several perspectives, such as the effectiveness of AIeL for students with different personal characteristics (Conde et al., 2020), and the impacts of AIeL on students' learning performances (Chang et al., 2018; Hooshmandja et al., 2019). Meanwhile, few research scholars have further aimed to develop more efficient AIeL systems by proposing new algorithms (Segal et al., 2019) and new models (Colchester et al., 2017). Not to mention the pedagogical revised study for AI technology adaptability, the advancements of AIeL research have not been certain yet, due to insufficient research directions and systematic way in data analysis. Therefore, researchers were concerned about the importance of systematic data analysis accordingly. Researchers have recognized the importance of a systematic review of AIeL with the help of technologies. It has been found that there has been no systematic review of AIeL study yet.

AI technologies are transforming teaching and learning methodologies, curriculum design, student engagement, and assessment practices in Science, Technology, Engineering and Mathematics (STEM) education. AI technologies have proven to contribute to a positive learning experience, and personalized learning experience for 21st Century. However, data privacy issues and algorithmic bias are among the challenges apart from positive impacts. With the AI integration in education, particularly at higher institutions, there was a significant grow in number for research publications, productivity and learning satisfactory levels. The integration of AI in higher education is rapidly evolving when students are saving time on searching and connecting information needed with key words to execute their idea proposal. With the efficient use of AI technology, students able to allocate more time to thinking, analyzing information and developing ideas. One of the prominent emerging challenges in education is how to integrate AI into teaching and learning with a system, based on solid didactic and pedagogical principles. Students of the 21st century do not learn in the same way as those of the 20th century. Whilst this phenomenon has occurred at all stages of history and society's educational development, this has become even more prominent considering the irruption of technology and the Internet in human daily life. Nowadays, what is substantial is not what is known, but "how it is known" and "how to put AI into practice" (Competency-based Curriculum). Glänzel (2003) reviewed about Pritchard discovery in 1969 that research performance and bibliometric mapping are the two fundamental analytical purposes of bibliometrics. The contribution of new knowledge maps can be used to forecast the structure and evolution of science in an area, whereas research performance assessment evaluates scientific research and its effects. With a robust user graphical interface and mapping visualization. VOS viewer is a software created in 2009 by Van Eck and Waltman of the Centre for Scientific and Technological Research at Leiden University in the Netherlands. On the other hand, Professor Chaomei Chen of Drexel University, USA has developed CiteSpace, a visual scientific data analysis tool with the purpose of mining and summarizing data on various study findings in the literature. Deep Learning, data mining and marketing are among the most popular fields in bibliometric analysis. Intelligent Tutoring Systems are used to provide personalized feedback and guidance to students. These systems can identify areas where students struggle and

provide additional learning materials to overcome them. Educational Data Analysis Tools allow us to identify patterns and trends in student learning. Whereas Adaptive Learning Platforms use artificial intelligence to adapt learning to the individual needs of each student (Ocaña-Fernández et al., 2019). These platforms can offer personalized materials and adjust the learning pace to meet each student's needs. Finally, Virtual Assistants are programs to answer questions and help students (Jara & Ochoa, 2020). This AI technology integration can be beneficial for students who need help for questions that cannot be answered online.

Ethical Implications of AI in Higher Education

While AI offers unprecedented opportunities for innovation in education, stakeholders must navigate challenges with diligence and ethical foresight to create equitable, inclusive, and effective educational environments. Eden et al. (2024) commented about AI holds promise in facilitating the creation of immersive learning environments through virtual reality and augmented reality applications, enriching the educational experience. Nevertheless, the integration of AI in education presents ethical considerations that warrant careful examination. Concerns regarding data privacy and security arise as educational institutions collect and analyse vast amounts of student data. Moreover, there are apprehensions about the potential for AI algorithms to perpetuate biases or reinforce inequalities if not implemented with conscientious oversight. Furthermore, questions surrounding the ethical use of AI in assessing student performance and making consequential decisions underscore the importance of establishing transparent and accountable practices (Eden et al., 2024). By addressing these challenges thoughtfully, stakeholders can harness the full potential of AI to cultivate equitable, inclusive, and effective educational environments. According to experts, articles and audiovisual content produced by AI can be easily accessible and persuasive, even if it may be biased, offensive or misleading (Illia et al. 2023; Jackson and Latham 2022), implying trust issues as well as related concerns over authorship and verifiability. The outputs of current AI services are between 50 and 70% accurate, while they also produce false or invented things, so-called “hallucinations” (Lin et al. 2021). Therefore, behind all these positive impacts, AI technology could possibly create ethical dilemmas and academic integrity. Stakeholders will be questioned if students’ performance has been assessed fairly with AI technology integration. Since AI technology happened worldwide about years ago, many traditional academic rules and enforcement have not been able to be revised yet. Therefore, it is important to note that AI integration implementation needs to ensure transparency with equal opportunity among stakeholders, and institution managers need to ensure teachers and students are possessed with necessary skills and knowledge for the AI technology switches, and ethical issues like cheating and plagiarism need to be minimized. This research aimed to compile systematically all statistical information regarding ethical implications with AI technology integration at higher education.

Pedagogical Innovations Driven by AI Technology

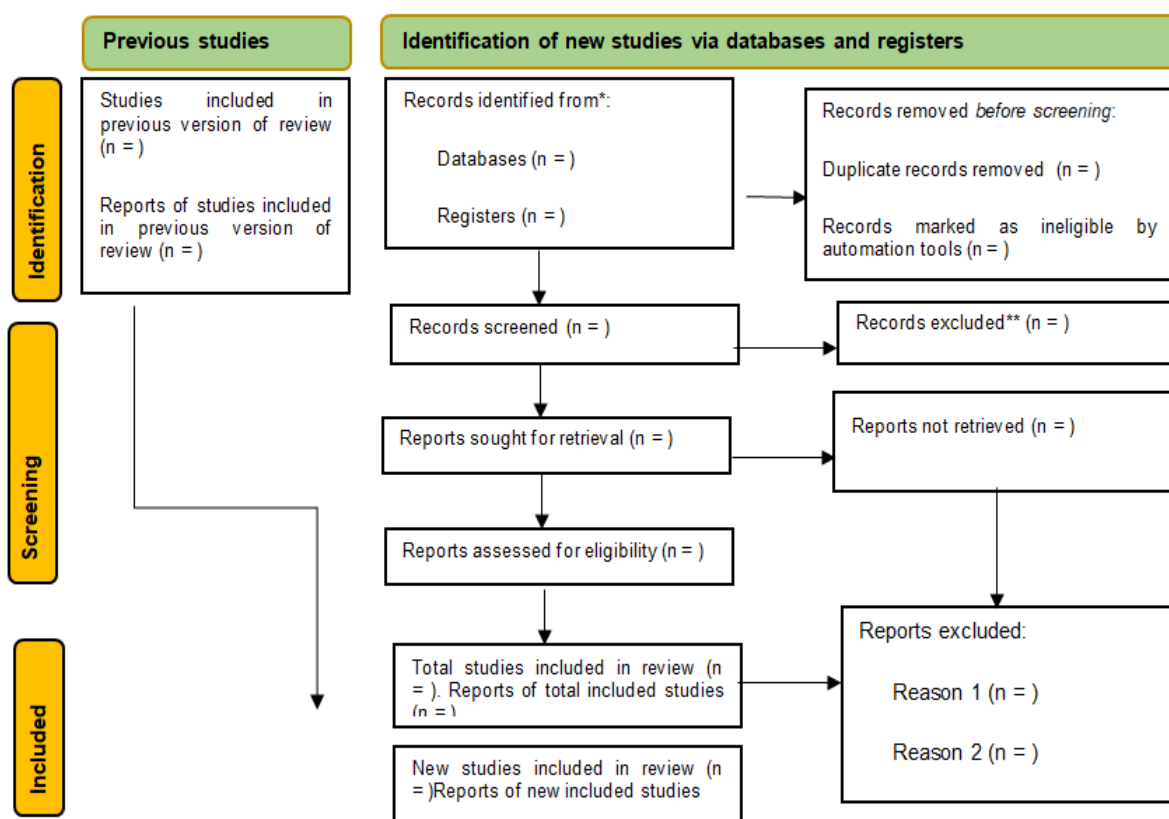
Eden et al. (2024) mentioned that the most significant opportunities offered by integrating AI into education is the ability to provide personalized learning experiences for students (Qusheh, et al., 2021; Chen, et al., 2022; Ahmad, et al., 2020). Traditional one-size fits-all approaches to education often fail to accommodate the diverse learning styles and paces of individual students (Lopez, and Schroeder, 2008; Mustafa, 2015). To prepare for AI integration in teaching, pedagogical innovation is crucial to teachers and students for smooth adaptation. Dole, Bloom, & Kowalske (2016) have discovered the importance of instruction pedagogy to switch from teacher-centered to learner-centered for 21st Century classroom. According to them, Problem-Based Learning (PBL) and Project-Based Learning (PjBL) among those instructional strategies that meeting the requirement of deeper learning, including content mastery, critical thinking and problem solving, effective communication, self-directed learning, and academic mindsets (Hewlett Foundation, n.d.). Students are acquire and retain knowledge when they are engaged in their learning and when they can apply what they are learning to the real world. When students have growth mindsets as opposed to fixed mindsets, they believe in themselves and their own abilities and they will persist in the face of obstacles (Dweck, Walton, & Cohen, 2014; Farrington, 2013). A key element in PBL and PjBL is student choose and connecting to information; students exhibit increased motivation by planning their learning and organizing their own research in solving real-world problems (Bell, 2010). In the process, students develop skills needed for the 21st century, such as the ability to frame, investigate, and solve problems; the ability to acquire and evaluate information; the ability

to collaborate effectively with others; the ability to work with a variety of technologies; and the ability to develop new ideas and products (Bell, 2010; BIE, n.d.; Darling-Hammond, 2010; The Secretary's Commission on Achieving Necessary Skills, 1991; Wagner, 2012; Zhao, 2012). Pedagogical innovations are among the most crucial fundamental aspects to ensure a well-organized and smooth transmission of AI technology integration in higher education.

METHODOLOGY

This study uses bibliometric analysis to conduct a systematic literature review of research on Artificial Intelligence (AI) in AI-based learning tools to provides future research directions. It also aims to identify the most influential and productive contributors and progression of research on AI-based learning tools. The bibliographic data documents on artificial intelligence in AI-based learning tools research was extracted from the Scopus database. The bibliometric analysis is performed to comprehensively understand the most influential and productive articles, authors, sources, and the top contributing countries and institutions towards the discipline of AI in learning tool research. To analyse the keyword co-occurrence analysis, literature co-citation and other data, and construct the corresponding scientific knowledge map, we combine the research methodologies of bibliometrics and knowledge structure visualization with two information collation software, and VOSviewer. After delving deeper into the knowledge map and statistical results, this paper can be understood intuitively. To learn more about the broad trends and advancements in the field to which the literature belongs, one might mine the knowledge map and statistical findings.

Table 1: Flowchart according to the PRISMA declaration

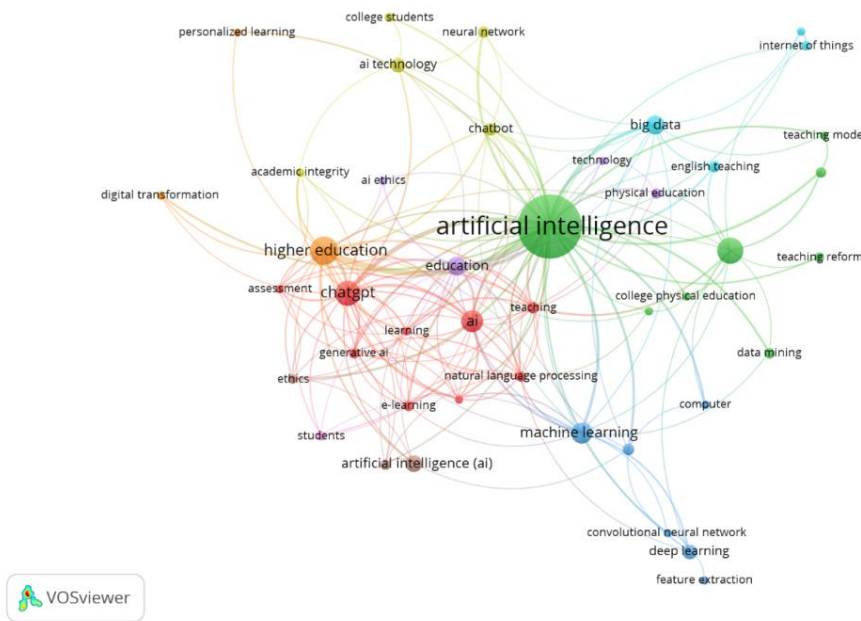


RESULTS AND FINDINGS

Dominant Research Theme on Trends

RQ1 What are the dominant research themes and trends in the study of AI technology in higher education from 2014 to 2024, particularly in the areas of ethical implications, pedagogical innovations, and institutional challenges?

Figure 1: VOSviewer Visualisation of A Term Co-Occurrence Network-based on Title and Abstract Fields



The VOS map provided visualizations relationships and clusters of various terms related to artificial intelligence (AI) in education. Here are some general observations:

Central Theme: The term "artificial intelligence" is centrally located and is the largest node, indicating it is the most influential or frequently occurring term in the dataset.

Clusters: There are several distinct clusters, each representing a thematic grouping of related terms.

Green Cluster: This cluster is centered around terms like "big data," "chatbot," "teaching mode," and "internet of things," indicating a focus on the application of AI technologies in various educational contexts.

Red Cluster: This cluster includes terms such as "higher education," "ChatGPT," "generative AI," and "learning," suggesting a focus on AI's impact on higher education and the use of generative AI tools in educational settings.

Blue Cluster: Terms like "machine learning," "convolutional neural network," and "deep learning" are present here, highlighting the technical aspects of AI that are being discussed in the context of education.

Orange Cluster: This includes terms like "digital transformation," "personalized learning," and "academic integrity," which point to broader educational reforms and ethical considerations related to AI.

Possible Reasons: The distribution and clustering of terms can be attributed to several factors:

Interdisciplinary Nature of AI: AI's applications span multiple fields, from technical aspects (machine learning, neural networks) to practical applications in education (personalized learning, chatbots), resulting in a diverse range of topics that naturally form distinct clusters.

Emergence of Generative AI Tools: The presence of terms like "ChatGPT" and "generative AI" indicates the growing interest and research in using these advanced AI tools in educational settings, influencing learning and teaching methods.

Focus on Ethical and Societal Impact: Clusters involving terms like "ethics," "academic integrity," and "AI ethics" reflect the ongoing discussions about the ethical implications of using AI in education, ensuring that its deployment does not compromise academic standards or integrity.

Technological Integration in Education: The cluster with terms like "big data," "internet of things," and "digital transformation" highlights the integration of various advanced technologies in the educational sector, aiming to enhance learning experiences and administrative efficiency.

Research Trends and Collaboration: The map also indicates collaborative research trends where different aspects of AI and education are being studied together, leading to overlapping clusters and interconnected terms.

In summary, the VOS map shows a comprehensive landscape of AI in education, highlighting key areas of focus, technological advancements, and the importance of ethical considerations. The clustering and connections between terms reflect the multifaceted impact of AI and its evolving role in transforming educational practices. To compare the given VOS map with findings from previous studies on AI in education, we need to consider the general trends and focus areas that have been identified over time.

General Trends in Previous Studies:

Initial Focus on Technical Aspects: Early studies on AI in education often emphasized the technical components of AI, such as machine learning algorithms, neural networks, and data mining. The focus was largely on developing and refining these technologies.

Integration with Educational Practices: As AI technologies matured, research started exploring their integration into educational practices. This included the use of intelligent tutoring systems, adaptive learning platforms, and AI-driven assessments.

Emphasis on Personalized Learning:

A significant trend in past studies was the potential of AI to personalize learning experiences. This involved tailoring educational content to individual learners' needs, preferences, and learning styles, aiming to improve student engagement and outcomes.

Ethical and Societal Concerns:

Recent years have seen an increasing focus on the ethical implications of AI in education. Concerns about data privacy, bias in AI algorithms, and the impact of AI on academic integrity and fairness have become prominent topics of discussion.

Comparison with Current VOS Map:

Central Theme Consistency: Both the current VOS map and previous studies identify "artificial intelligence" as the central theme. This indicates a consistent recognition of AI's importance in the educational domain.

Expansion into Broader Applications: The current map shows an expanded focus on practical applications like "big data," "chatbots," and "internet of things," reflecting a broader integration of AI technologies into educational practices compared to earlier studies.

Emergence of Generative AI: The presence of terms like "ChatGPT" and "generative AI" in the current map highlights a new trend. This was not prominent in earlier studies, indicating a recent surge in interest and research on the use of generative AI tools in education.

Continued Ethical Focus:

Ethical concerns remain a significant cluster in the current map, consistent with recent trends in past studies. Terms like "AI ethics," "academic integrity," and "ethics" underscore ongoing discussions about the responsible use of AI in education.

Diverse Research Themes:

The current map displays a diverse range of research themes, from technical aspects (e.g., "machine learning," "deep learning") to educational practices (e.g., "personalized learning," "digital transformation"). This diversification reflects an evolution from earlier studies that were more narrowly focused.

Possible Reasons for Differences:

Technological Advancements: The rapid development of AI technologies, particularly in generative AI and big data analytics, has opened new avenues for research and application in education.

Increased Adoption in Education: The growing adoption of AI tools and technologies in educational settings has prompted more research into practical applications and their impact on teaching and learning.

Heightened Ethical Awareness:

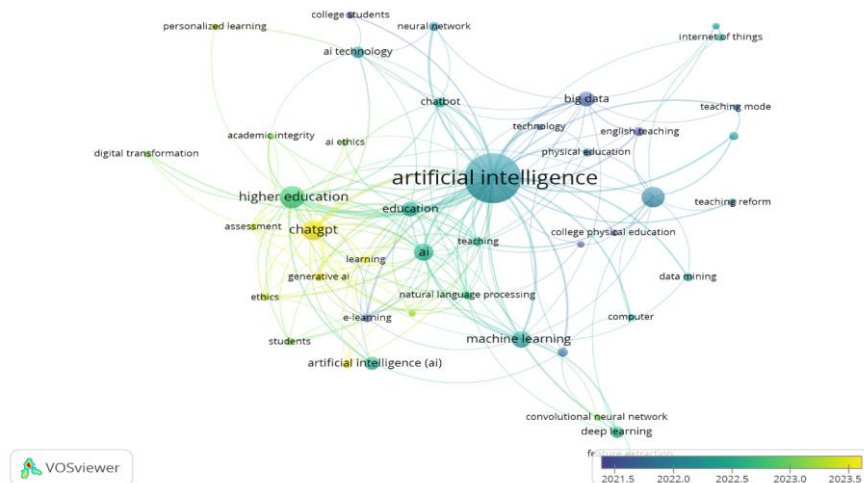
As AI becomes more pervasive, there is increased awareness and concern about its ethical implications, driving more research into ensuring responsible use.

Interdisciplinary Collaboration:

The intersection of AI with various educational disciplines has led to more collaborative and interdisciplinary research efforts, resulting in a broader range of topics being explored.

In summary, the current VOS map reflects both continuity and evolution in the research on AI in education. While core themes like the centrality of AI and ethical concerns remain consistent, there is a noticeable expansion into new applications and technologies, highlighting the dynamic nature of this field.

Figure 2. VOSviewer visualisation of A Term Co-Occurrence Network-based on Title Fields



Ethical Implications: The integration of AI in education presents significant ethical concerns, which are prominently reflected in the research. Keywords like "ai ethics," "ethical use of AI," and "trustworthy algorithms" are central to the discussion. These terms illustrate the critical focus on ensuring AI technologies are deployed responsibly and equitably in educational contexts. The visualization shows strong connections between "artificial intelligence," "ethics," and "higher education," indicating that ethical considerations are a major theme intertwined with broader AI applications in education.

Pedagogical Innovations: AI's impact on educational practices is another dominant theme, underscored by keywords such as "learning," "teaching," "personalized learning," and "e-learning." The visualization highlights the role of AI in enhancing learning experiences through personalized education and administrative

streamlining. The term "chatgpt," closely linked with "learning" and "assessment," reflects the growing interest in AI-driven tools for educational purposes, particularly in improving teaching methods and student evaluation processes.

Curricular Adaptations in Higher Education: The dynamic network shows terms like "education," "higher education," and "digital transformation," signifying a focus on how curricula are adapting to integrate AI technologies. The keyword "academic integrity" is notably connected with "higher education," pointing to ongoing concerns about maintaining ethical standards in an AI-driven academic environment. The visualization indicates that educational institutions are increasingly embedding AI competencies into their curricula to prepare students for a future dominated by AI technologies.

AI Competencies and Future Workforce Readiness: Keywords such as "ai technology," "machine learning," and "deep learning" suggest a strong emphasis on equipping students with relevant AI skills. These competencies are crucial for future workforce readiness, as indicated by the connections between "artificial intelligence" and "students." The visualization shows that there is a concerted effort to align educational outcomes with industry needs, ensuring that graduates are well-prepared for careers in AI and related fields.

Gaps and Challenges in Higher Education: Visualization also highlights several gaps and challenges in the integration of AI in higher education. Keywords like "assessment," "digital transformation," and "ai ethics" suggest areas where further research and development are needed. The term "students" connected with "ethics" and "learning" indicates ongoing challenges in ensuring that AI technologies are used ethically and effectively in student learning environments. The keyword 'chatgpt' also points to emerging issues related to the deployment of AI tools and their implications for academic integrity and quality of education.

Conclusion: The bibliometric analysis of AI technology in higher education from 2014 to 2024 reveals several dominant themes and trends. Ethical implications, pedagogical innovations, curricular adaptations, AI competencies, and future workforce readiness are the key areas of focus. The visualization maps provide a clear picture of how these themes are interconnected and evolving over time. As AI continues to transform higher education, addressing the highlighted gaps and challenges will be crucial for maximizing its benefits while mitigating potential risks.

Influential Contributions and Collaborations Networks

RQ2 Who are the most influential authors, institutions, and countries contributing to the research on AI technology in higher education, and how have their collaborative networks evolved from 2014 to 2024?

Figure 3: A co-authorship network analysis depicting collaborative patterns among the most productive authors, institutions, and countries, alongside a timeline showing the evolution of these networks.

Figure 3.1: By Author (Minimum Documents – 3, Citation 5, Author - 3)

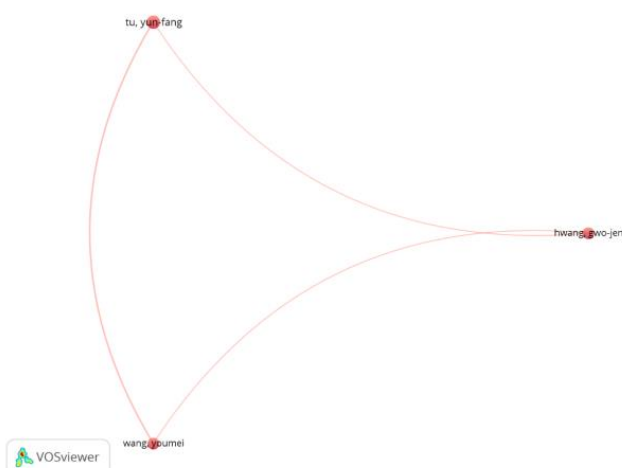
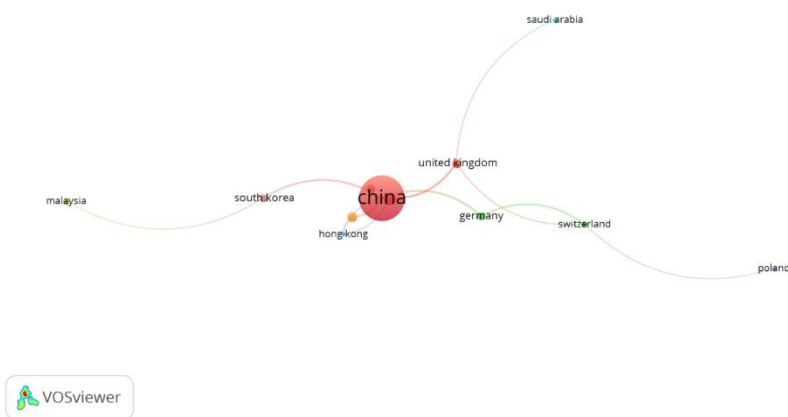


Figure 3.2: By Institutions (Minimum Documents – 2, Citation - 5, Institutions - 11) By Documents



Figure 3.3: By Countries (Minimum Documents – 5, Citation 25, Countries – 16)



Based on the bibliometric analysis results, the most influential authors, institutions, and countries contributing to AI technology research in higher education can be identified, along with the evolution of their collaborative networks from 2014 to 2024:

1. S. Slade and P. Prinsloo are highly effective researchers in AI technology in higher education, receiving the most citations, by author that contributing the most.
2. The Chinese Academy of Sciences plays a pivotal role in connecting institutional collaboration groups in the field of AI, by institution that contributing the most.
3. Universities, particularly in the United States and China, play a crucial role in promoting and carrying out AI research, by country that contributing the most.

China and the United States are the most influential countries in AI research in higher education, with a significant increase in research output. The co-authorship network primarily comprises the United States, Saudi Arabia, the United Kingdom, and China, indicating evolving collaborative patterns (refer to figure 3.3). The US, the UK, France, and Spain lead global collaboration research in the field of AI at the country level, with high degrees of international participation from Vietnam, Saudi Arabia, and the United Arab Emirates

Based on the bibliometric analysis results, most dominant emerging themes in AI research in higher education were 'Machine Learning', 'Convolutional Neural Networks', 'Curriculum and Higher Education System', and 'Co-occurring with AI'. AI research primarily leverages technologies such as machine learning, decision trees, deep learning, speech recognition, and computer vision in higher education. Overall, the collaborative networks in AI technology research in higher education have evolved, with China and the United States emerging as the most influential countries, and key researchers and institutions playing significant roles in advancing the field.

Pedagogical Innovations and Challenges

RQ3 What are the most significant pedagogical innovations and best practices in integrating AI technology into higher education curricula and instructional design?

Based on the bibliometric analysis results in pedagogical innovations, best practices in integrating AI technology into higher education curricula and instructional design was a study of faculty members' readiness to integrate AI into teaching practices and the factors influencing that readiness provides insights into the perceived benefit of AI in higher education, attitudes towards AI, and behavioural intentions to use AI. However, while the abstracts offer valuable insights into the integration of AI technology into higher education, they do not explicitly outline the most significant pedagogical innovations and best practices. The abstracts provide information on the readiness of faculty, practical steps for technology selection, and AI's impact on learning experiences, but a comprehensive overview of the most significant pedagogical innovations and best practices is not directly addressed in the available abstracts. Therefore, a direct answer to the query regarding the most significant pedagogical innovations and best practices in integrating AI technology into higher education curricula and instructional design cannot be provided based on the available abstracts. Research Trends: The use of bibliometric analyses and visualization software has been employed to identify trends and hotspots in AI-driven pedagogy research.

Key Themes: Emerging themes in AI-driven pedagogy include AI tools in education, transformation of teachers' roles, and AI applications in academic support services. **Global Influence:** China and the United States are identified as leading contributors to AI research in higher education.

An investigation delves into the integration of AI technologies within elearning platforms, uncovering AI's potential to tailor learning experiences, cultivate student engagement, and refine content dissemination

Table 2: Pedagogical innovations and best practices in integrating AI technology into higher education

Author(s) & Year	Title	Journal/ Conference	Objective	Methodology	Key Findings	Implications for Higher Education	Total Citation
Bin et al. (2019)	English teaching practice based on artificial intelligence technology	Journal of Intelligent & Fuzzy Systems	Explore application of AI in English teaching to improve quality and effectiveness.	Literature analysis, field investigation, system design and implementation.	-AI can provide interactive English teaching environment -Enables personalized teaching and optimizes results -Can evaluate students' knowledge mastery and provide guidance	-AI can enhance English teaching and learning processes -Allows for more individualized instruction and assessment - Provides new tools for teachers to improve course delivery	78
Chu et al.	Roles and research trends of	Australasian Journal of Educational	Review research	Systematic review of 50	-Most common AI applications were for	-AI can provide personalized	32

(2022)	artificial intelligence in higher education: A systematic review of the top 50 most-cited articles	Technology	trends in AI applications in higher education by analyzing the top 50 most-cited articles.	most-cited articles on AI in higher education from Web of Science database.	<p>predicting student performance/dropout</p> <ul style="list-style-type: none"> □ Engineering was the most frequent application domain -AI mostly used for profiling/prediction and intelligent tutoring systems -Research focused on learning behaviors, accuracy/precision, and cognitive/affective factors 	<p>learning support and predictions - Need to develop AI literacy among educators and students</p> <p>-Should explore AI applications across more disciplines</p> <p>-Consider ethical issues in AI implementation</p>	
Chang et al. (2023)	Educational Design Principles of Using AI Chatbot That Supports Self-Regulated Learning in Education: Goal Setting, Feedback, and Personalization	Sustainability	Propose pedagogical principles for integrating AI chatbots in education to promote self-regulated learning.	Conceptual analysis drawing on Zimmerman's Self-Regulated Learning framework and Judgment of Learning theory.	<p>-Three key principles proposed: goal setting, feedback/self-assessment, and personalization -AI chatbots should support learner goal setting, provide feedback, and adapt to individual needs</p> <p>-Bidirectional interaction between learners and chatbots is important for developing self-regulation</p>	<p>-Educators should teach students how to effectively use AI tools to support learning</p> <p>-AI chatbots can facilitate self-regulated learning if designed with pedagogical principles</p> <p>-Collaboration needed between educators and AI developers to create effective educational chatbots</p>	24
Yuan (2021)	Design of College English Teaching Information Platform Based on Artificial Intelligence Technology	Journal of Physics: Conference Series	Design college English teaching information platform using AI technology.	Literature analysis, questionnaire surveys, experimental design and evaluation.	<p>-AI enables personalized and interactive English teaching</p> <p>-Students prefer micro-classes and English movies for learning</p> <p>-High satisfaction with AI-based online teaching systems</p>	<p>-AI can enhance English teaching methods and student engagement - Promotes reform of traditional English teaching approaches - Enable development of hybrid online-offline teaching models</p>	19
Chen et al. (2020)	Design and implementation of bilingual digital reader based on artificial intelligence and	Journal of Computational Methods in Sciences and Engineering	Develop a bilingual digital reading system with AI and big	Designed and implemented an Android-based bilingual reading platform with features	<p>-System allows seamless bilingual reading with real-time language switching</p> <p>-AI enables features</p>	<p>-Facilitates bilingual language learning and teaching</p>	18

	big data technology		data capabilities for language learning and teaching.	like real-time language switching, sentence translation, and user behavior analysis.	like sentence translation and personalized recommendations -Big data analysis of reading behaviors provides insights for teaching	-Provides data-driven insights to improve teaching quality -Increase accessibility of bilingual reading materials	
Asakura et al. (2020)	A Call to Action on Artificial Intelligence and Social Work Education: Lessons Learned from A Simulation Project Using Natural Language Processing	Journal of Teaching in Social Work	Explore the use of AI-based simulation using Natural Language Processing (NLP) in social work education.	Case study of developing an NLP-based virtual simulation platform called "Chris Jones".	-NLP simulation can increase access to practice opportunities for beginner students -Current NLP technology is limited for teaching advanced practice skills -AI simulation needs to be used as a tool within a collaborative learning environment, not as a standalone pedagogy	-Educators should engage in critical discussions about risks and benefits of AI -More interdisciplinary collaboration needed between social work and technology fields -Rigorous research required on effectiveness of AI-based simulation in social work education	18
McGrath et al. (2023)	University teachers' perceptions of responsibility and artificial intelligence in higher education - An experimental philosophical study	Computers and Education: Artificial Intelligence	Investigate university teachers' views on adopting AI technologies in higher education, focusing on responsibility and equity.	Online survey with experimental philosophy approach, presenting different student case scenarios to teachers.	-Teacher's support using AI for equitable outcomes, especially for first-generation and disabled students -Many teachers report low knowledge of AI but believe it could improve equity -Gender differences in reported AI knowledge and views on equity	-Need to enhance teachers' AI literacy and provide resources for implementation -Consider equity issues when deploying AI tools for different student groups -Address teachers' concerns about fairness and responsibility in AI adoption	14
Li et al. (2021)	The effectiveness of physical education teaching in college based on Artificial	Journal of Intelligent & Fuzzy Systems	Explore using artificial intelligence to improve effectiveness of college	Experimental study comparing AI-assisted and traditional PE teaching	-AI-based PE teaching significantly improved students' strength, speed, endurance and	-AI can help make PE classes more effective and engaging for students	12

	intelligence methods		physical education teaching.	methods.	agility -AI methods more effective than traditional methods in developing physical qualities -AI tools like sensors and video analysis enhanced teaching and student engagement	-AI tools allow for more personalized and data-driven physical training -PE teachers should incorporate AI technologies to improve teaching outcomes	
Liu et al. (2022)	A Method for Predicting the Academic Performances of College Students Based on Education System Data	Mathematics	Develop a model to predict student academic performance using educational data.	Feedforward spiking neural network model trained on student and course data from university systems.	-Proposed model achieved 70.8% prediction accuracy, outperforming other algorithms -Model effective at predicting low-performing students -Student factors like entrance exam scores and demographics impact performance	-Can help identify at-risk students early for intervention -Allows more targeted student management and learning supervision - Demonstrates value of analyzing educational data to improve outcomes	9
Heugh et al. (2022)	Multilingualism, translanguaging and transknowledging: Translation technology in EMI higher education	AILA Review	Explore use of human language technology (HLT) to support diverse students in English-medium instruction.	Surveys, interviews, focus groups with students and staff; classroom interventions using HLT.	-HLT supports academic reading, writing, and knowledge exchange for all students -Multilingual students benefit from using home languages alongside English -HLT can enhance inclusion and confidence when used purposefully	-Develop policies to guide appropriate use of HLT -Train staff and students on academic use of HLT -Leverage diverse linguistic resources to enrich learning for all	8

AI Integration in Higher Education:

AI has been explored to integrate flexible adaptations in higher education, with a focus on practical examples and insights into AI-driven practices.

The need for significant reform in higher education, with AI being a primary factor in providing individuals with adapted personalized information, has been emphasized

Research Trends and Impact:

A structured bibliometric study revealed a significant increase in AI related research output in higher education, particularly in machine learning, data mining, and learning analytic.

The study highlighted the evolving role of AI in transforming higher education and the need for multidisciplinary research approaches to address emerging challenges and opportunities

AI Applications in Higher Education:

AI applications in higher education include profiling and prediction, assessment and evaluation, adaptive systems and personalization, and intelligent tutoring systems.

Successful applications of AI technologies in higher education were highlighted in areas such as student learning experience, student support, and enrolment management Science, AI Research). Certain critical skills like Python Programming, Natural Language Processing, and Deep Learning show a supply but no apparent demand, suggesting a potential mismatch.

CONCLUSION AND FUTURE STUDY

According to Chan-Olmsted (2019), there have only been a few studies which aimed to review the trends of AI in specific applications. At the same year, Zawacki-Richter et al. (2019) reported that the use of AI for specific learners in selected publications without considering a theoretical framework or the relationships between the publications. Compared to other fields of educational technology, such as gamification and blended learning, AIED research is more scattered and less organized. The impact of AI on education remains unclear (Holmes et al., 2021), and more research is needed to understand whether and how these emerging technologies benefit education. A lack of familiarity with the technologies makes it challenging to introduce or integrate them into schools and universities (Hussin, 2018). Therefore, more review studies are needed to organize the literature, provide an overview of the opportunities and challenges of AIED, and thereby suggest future research directions. Differing from these previous review studies that had narrow research focus on AI in education, this study provides a co-citation network analysis using dynamic citation data of a large amount of the follow-up research to elucidate the trends of AIEL research. The co-citation analysis measures how often the two more core papers were cited together, and the social network analysis can help researchers transform complex relationships such as co-citation or cross-citation structure into a form of visualization. Drawing on cross-referenced citation relationships, the co-citation analysis aims to extract relational patterns representing the invisible community of AIEL research to provide citation-based evidence of how most of the literature is concentrated. The visualization of a research network will help researchers identify core papers in the focal network and highlight networking relationships among core papers for future research directions.

Literature review is one of the most important reading activities in traditional research. From the past, researchers have been reading for new knowledge and potential citation, it usually takes months and years before finding a valid research topic. According to Thayyib et al. (2023) academicians and practitioners have recently begun to accord Artificial Intelligence (AI) and Big Data Analytics (BDA) significant consideration when exploring emerging research trends in different fields. The technique of bibliometric review has been extensively applied to the AI and BDA literature to map out existing scholarships. Bibliometric analysis is one of the latest options to reverse by checking the validity of proposed research topic through AI assistant. However, Shiferaw et al. (2022) described Bibliometric analysis as a scientific method that allows researchers to explore the current trend in a certain research area using citation information. Shiferaw et al. (2022) explained that the number of studies published in peer reviewed academic journals and suggesting customized models for predictions based on Big Data is steadily increasing. Synthesizing evidence in this area of research will provide a comprehensive input for upcoming clinical and methodological guideline development and an indication for potential research areas. Therefore, bibliometric review is crucial to researchers as an indicator to read past patterns of publication from the world statistic in respective field. As an example, the research summary of Thayyib et al. (2023) has reported that USA was the most influential nation (101 documents; 5,405 citations), while China was the most productive nation (204 documents; 2,371 citations). The most productive institution was Symbiosis International University, India (32 documents; 4.5%). This information will help researchers to understand the latest statistic progression all around the world and be able to find new valid research activities in respective disciplines by systematic charts and figures. Thayyib et al. (2023) also provided the top five clusters of most popular disciplines in bibliometric review. There are: (a) Business &

Management, (b) Engineering and Construction, (c) Healthcare, (d) Sustainable Operations & IR4.0, and (e) Tourism and Hospitality Studies, the majority of which investigate the applications and use cases of AI and BDA to address real-world problems in the field. The keyword co-occurrence in the past bibliometric analyses indicates that BDA, AI, Machine Learning, Deep Learning, NLP, Fuzzy Logic, and Expert Systems will remain conspicuous research areas in these five diverse clusters of domain areas.

Identification of Existing Research and Potential Research Opportunity

Vázquez-Cano (2021) described 21st century education pedagogy like any other discipline, must adapt its principles to the new social and technological realities of the day, and look to provide solutions and proposals that ultimately aim to improve teaching-learning processes, and for the development of the skills and knowledge today's students need in order to succeed in their personal and professional life, and also in terms of their citizenship. Teachers in the 21st century face a series of challenges in relation to didactic and the method to be expanded in both face-to-face and online teaching environments, where borders are becoming increasingly blurred. In this sense, the incipient proposals from artificial intelligence may be seen as hopeful, but also perhaps worrying, with issues pertaining to data protection, emotions, and sustainability, etc. all needing due consideration. Since the tsunami of technological innovation in education, pedagogy and didactic have always been secondary to these events and to the plethora of digital resources. It is therefore necessary to rethink the didactic and pedagogical model in which to support the use of technology, both within and outside of the classroom. Technology alone does not offer improvement in education, not without a strong didactic component, and proposals based on AI will therefore require significant didactical modifications. AI refers to systems that use technologies such as data mining, computer vision, language recognition, natural language generation, machine learning, deep learning to gather or use data, and to predict, recommend or decide, with varying levels of autonomy, the best action to achieve (Eurostat, 2021). Artificial intelligence can be based on purely software systems like Chatbots and virtual assistants based on natural language processing; facial recognition systems based on visual or language recognition systems; software for machine translation; data analysis based on machine learning; and, Neural Nets for Deep Learning, etc. It seems that that "with all of these developments, the limits of artificial intelligence remain the limits of transposition of meaning into number" (Cope et al., 2020, p. 4). From our perspective, there are two key principles upon which artificial intelligence is based: (1) 'Autonomy': The ability to perform tasks in complex situations without constant guidance from the user, and (2) 'Adaptability': The ability to improve task execution by learning from experience. These two concepts are fundamental principles when defining a pedagogical paradigm that provides an adequate response to the different current and future proposals based on artificial intelligence. There is no doubt that the objective going forwards will be based on how to think of better ways to integrate AI into education, rather than just knowing where to "click."

Future Recommendations

Future Directions: The need for multidisciplinary research approaches, ethical considerations, and robust scientific evidence in AI-driven pedagogy is emphasized. Given the insights from the abstracts, it is evident that impactful AI-driven pedagogical innovations and best practices in higher education are being extensively researched. The use of bibliometric analyses and visualization software has allowed for the identification of key research trends and themes in this area. Additionally, the global influence of countries like China and the United States underscores the significance of AI in higher education. However, the need for multidisciplinary research approaches and ethical considerations indicates the complexity of integrating AI into pedagogical practices. While the abstracts provide valuable insights into the research landscape of AI-driven pedagogy, they do not explicitly outline specific impact innovations or best practices. Therefore, it can be inferred that while there is extensive research on AI-driven pedagogy in higher education, the identification of specific impact innovations and best practices may require a more targeted review of the literature.

Conclusion

This is a meaningful experiment to explore new possibilities of bibliometric analysis in searching for a new potential research topic in post-graduate studies, as well as academic research methodology. By setting a clear

area of scientific investigation with research questions, bibliometric data able to provide a comprehensive direction for a new research proposal. As an academic researcher, I have learned a new alternative way to gain new information through AI technologies.

REFERENCES

1. Begum, I.U. (2024). Role of Artificial Intelligence in Higher Education- An Empirical Investigation. *International Research Journal on Advanced Engineering and Management (IRJAEM)*.
2. Chan-Olmsted, S. M. (2019). A review of artificial intelligence adoptions in the media industry. *International Journal on Media Management*, 21(3-4), 193–215. <https://doi.org/10.1080/14241277.2019.1695619>
3. Cheng, Y.-P., Huang, C.-H., Hsu, L.C. (2022). Research Trends in Educational Technology: A Review of Studies Published in Five Social Science. DOI: 10.4018/IJTHI.293191
4. Chen, Y., Jensen, S., Albert, L.J. et al. Artificial Intelligence (AI) Student Assistants in the Classroom: Designing Chatbots to Support Student Success. *Inf Syst Front* 25, 161–182 (2023). <https://doi.org/10.1007/s10796-022-10291-4>
5. Colchester, K., Hagrass, H., Alghazzawi, D. & Aldabbagh, G. (2017). A survey of artificial intelligence techniques employed for adaptive educational systems within E-learning platforms. *Journal of Artificial Intelligence and Soft Computing Research*, 7 (1) (2017), pp. 4764, 10.1515/jaiscr-2017-0004.
6. Collins-Nelsen, R., Koziarz, F., Levinson, B., Allard, E., Verkoeyen, S. & Raha, S. (2021). Social context and transferable skill development in experiential learning, *Innovations in Education and Teaching International*, DOI: 10.1080/14703297.2021.1886970
7. Dole, S., Bloom, L., & Kowalske, K. (2016). Transforming Pedagogy: Changing Perspectives from Teacher-Centered to Learner-Centered. *Interdisciplinary Journal of Problem-Based Learning*, 10(1). Available at: <https://doi.org/10.7771/1541-5015.1538>
8. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N. & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines, *Journal of Business Research*, Volume 133, 2021, Pages 285-296, ISSN 0148-2963, <https://doi.org/10.1016/j.jbusres.2021.04.070>. Retrieved from: <https://www.sciencedirect.com/science/article/pii/S0148296321003155>
9. Eden, C. A., Chisom, O. N. & Adeniyi, I. S. (2024). Integrating AI in education: Opportunities, challenges, and ethical considerations. *Magna Scientia Advanced Research and Reviews*, 2024, 10(02), 006–013. Article DOI: <https://doi.org/10.30574/msarr.2024.10.2.0039>
10. Glänzel, W. (2003). BIBLIOMETRICS AS A RESEARCH FIELD A course on theory and application of bibliometric indicators.
11. Holmes, W., Hui, Z., Miao, F. & Ronghuai, H. (2021). AI and education: A guide for policymakers, UNESCO Publishing (2021).
12. Hussin, A. A. (2018) Education 4.0 Made Simple: Ideas For Teaching. *International Journal of Education and Literacy Studies* 6(3):92. DOI:10.7575/aiac.ijels.v.6n.3p.92
13. Hwang, G. J., Xie, H., Wah, B. W., Gašević, D. (2020). Vision, challenges, roles and research issues of Artificial Intelligence in Education, *Computers and Education: Artificial Intelligence*, Volume 1, ISSN 2666-920X. <https://doi.org/10.1016/j.caeai.2020.100001>.
14. Jara, I., & Ochoa, J. M. (2020). Usos y efectos de la inteligencia artificial en educación. Sector Social división educación. Documento para discusión número IDB-DP-00-776. BID. doi: <http://dx.doi.org/10.18235/0002380>.
15. Ocaña-Fernández, Y., Valenzuela-Fernández, L. A., & Garro-Aburto, L. L. (2019). Artificial Intelligence and Its Implications in Higher Education. *Journal of Educational Psychology-Propósitos y Representaciones*, 7(2), 553-568.
16. Pritchard, A. 1969, Statistical bibliography or bibliometrics? *Journal of Documentation*. 24, 348-349.
17. Tang, K. U., Chang, C. Y. & Hwang, G. J. (2021): Trends in artificial intelligence-supported e-learning: a systematic review and co-citation network analysis (1998–2019), *Interactive Learning Environments*, DOI: 10.1080/10494820.2021.1875001 <https://doi.org/10.1080/10494820.2021.1875001>
18. Thayyib, P.V.; Mamilla, R.; Khan, M.; Fatima, H.; Asim, M.; Anwar, I.; Shamsudheen, M.K.; Khan, M.A. (2023). State-of-the-Art of Artificial Intelligence and Big Data Analytics Reviews in Five

Different Domains: A Bibliometric Summary. Sustainability 2023, 15, 4026.
<https://doi.org/10.3390/su15054026>

19. Shiferaw, K. B., Waltemath D., Zeleke, A. (2022). Disparities in Regional Publication Trends on the Topic of Artificial Intelligence in Biomedical Science Over the Last Five Years: A Bibliometric Analysis. *Stud Health Technol Inform.* 294:609-613. doi: 10.3233/SHTI220541. PMID: 35612161. Retrieved from: (PDF) Disparities in Regional Publication Trends on the Topic of Artificial Intelligence in Biomedical Science Over the Last Five Years: A Bibliometric Analysis (researchgate.net)
20. Vázquez-Cano, E. (2021). Artificial intelligence and education: A pedagogical challenge for the 21st century. *Educational Process International Journal.*
21. Villardón-Gallego, L., García-Carrión, R., Yáñez-Marquina, L., & Estévez, A. (2018). Impact of the interactive learning environments in children's prosocial behavior. *Sustainability*, 10(7), 2138. <https://doi.org/10.3390/su10072138>
22. Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education—where are the educators? *International Journal of Educational Technology in Higher Education*, 16(1), 39–66. <https://doi.org/10.1186/s41239-019-0171-0>