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The Role of Artificial Intelligence in Education: A Systematic Literature Review

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ABSTRACT

The rapid advancement of computing technology has facilitated the implementation of AIED (Artificial Intelligence in Education) applications. AIED refers to the use of AI (Artificial Intelligence) technologies or application programmes in educational settings to facilitate teaching, learning or decision-making. This research aims to identify the role of AI in education. This research utilises a Systematic Literature Review (SLR) using PRISMA analysis to identify AI's role in education. An important finding of this research is that with the help of AI technology, which simulates human intelligence to make inferences, judgements, or predictions, computer systems can provide personalised guidance, support, or feedback to students as well as assist teachers or policymakers in making decisions. These findings indicate the important role AI can play in education to improve the efficiency and effectiveness of learning. However, it is important to note that AI is not a substitute for teachers. The role of teachers as facilitators and supporters of learning remains important in the context of AI use.

Keywords: *Artificial Intelligence (AI), Education, Systematic Literature Review (SLR).*

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INTRODUCTION

Current technological developments have a huge influence in various aspects of life (Albana and Sujarwo 2021). This can be seen in the last few decades, the development of artificial intelligence (AI) technology has created a significant impact in various scientific fields (Johri et al. 2021). AI's ability to quickly process big data, recognise complex patterns and make accurate predictions is changing the way scientists conduct research, analyse data and generate new knowledge (Ara Shaikh et al. 2022). One of the main benefits of AI in education is its ability to analyse data on student progress (Ahmad et al. 2021). AI systems can collect and analyse data from various sources, such as tests, homework, and exams, to understand each student's strengths and weaknesses. With this understanding, AI can generate learning recommendations that are customised to the skill level and needs of the student

(Bokhari and Myeong 2022). This is intended in order to produce creative individuals (Surya and Arty 2020).

The development of AI has opened up new opportunities in education and personalised learning. By analysing student data, providing customised content, and providing real-time assistance, AI can help improve learning effectiveness and efficiency. In healthcare, the use of AI has made significant contributions to the diagnosis, treatment, and management of diseases (Kaplan et al. 2021). In the field of machine learning, AI has brought about significant changes in learning and teaching methods (Friedrich et al. 2022).

Under the traditional system, teaching methods are often generalised and do not take into account individual differences between students (Nugrahani et al. 2019). However, with the advent of AI, a more personalised approach can be adapted to meet the needs of the scientific community (Allen 2019; Rahayu, 2023). AI also supports the development of a more objective evaluation system (Ng et al. 2022) and eases the teacher's task as a facilitator in the learning process (Fauziyah and Triyono 2020). The AI system can correct and grade student assignments by using pre-programmed algorithms (Kannan et al. 2020). This helps to reduce human error in assessment and provides more objective and consistent feedback to students.

Therefore, AI acts as a partner in the evaluation process and provides a more accurate insight into the progress of the field (Ng et al. 2022). However, while AI brings many benefits in education, it is important to maintain a balance between technology and human interaction (Alexander, Romito, and Çobanoğlu 2020). AI can also provide personalised learning, interpersonal relationships between teachers and students remain important for students' social and emotional development (Bokhari and Myeong 2022). AI should be used as a tool that supports the learning process, not a substitute for human interaction (Ayling, Lewis, and Cotter 2019).

The essentiality of conducting this research stems from the burgeoning influence and impact of AI in educational contexts. This study was critical to comprehensively document and analyze the multifaceted roles of AI in education, which includes its function as an intelligent tutor, learner, learning tool/partner, and policy-making advisor. With AI rapidly penetrating various educational domains, this research aimed to explore and synthesize the existing knowledge, providing insights into AI's profound implications for educational practices. The systematic literature review aimed to highlight the evolving roles and applications of AI within educational settings, underscoring the need for a detailed understanding of how AI can effectively transform and optimize the learning process, contribute to pedagogical innovations, and assist in policymaking within educational frameworks.

Research on the role of Artificial Intelligence has been carried out by previous studies such as The Role of Machine Learning and Artificial Intelligence for Making a Digital Classroom and its sustainable Impact on Education during Covid-19 (Ara Shaikh et al. 2022), Vision, challenges roles and research issues of Artificial Intelligence in Education (Hwang et al. 2020) , Teaching Artificial Intelligence to K-12 Through a Role-Playing Game Questioning the Intelligence Concept (Henry, Hernalesteen, and Collard 2021), dan The role of artificial intelligence and machine learning in harmonization of high-resolution post-mortem MRI (virtopsy) with respect to brain microstructure (O'Sullivan et al. 2019). Based on the review and search for previous studies presented above, substantive differences can be seen. So that this paper will focus on aspects of the role of artificial intelligence in the field of education.

Research on artificial intelligence is interesting to discuss. Many studies assume artificial intelligence as a tool to carry out educational activities. This research aims to conduct a systematic literature review on the role of artificial intelligence in education. By conducting a thorough review of AI-related research in education, we can understand the latest developments in the use of this technology and identify emerging trends. The results of this research are expected to help the continuity of activities in education, which is an important knowledge that artificial intelligence has a good impact and is very beneficial for the continuity of the knowledge transfer process. In addition, this paper can be a reference for future research to find out the role of artificial intelligence.

METHOD

This research is descriptive qualitative research using a literature review or Systematic Literature Review (SLR). The literature used is journals/articles that are relevant to the problem or research objectives. A systematic literature review selects, identifies and evaluates research to answer clearly formulated research questions. Because this research aims to explore the application of Artificial Intelligence in education. In this systematic literature review, the research began by identifying articles related to Artificial Intelligence in the Scopus and Google Scholar databases through the publish and perish tool. There are four phases involved in literature mapping, namely identification phase, screening phase, eligibility phase and inclusion phase.

Research Questions on Systematic Literature Review

Research Question	Motivation
What is the Role of Artificial Intelligence in Education?	To identify the role of Artificial Intelligence in education.

First Phase (Identification)

Determination of articles that fulfil the set criteria. First, the database sources used for this systematic literature review are Scopus and Google Scholar. With the criteria of articles published between 2014 and 2023. The Scopus database uniquely combines various scientific literature in education. The Google Scholar database is a free and accessible search engine that covers most peer-reviewed literature across multiple disciplines. Articles were identified through related keywords based on the two search engines required for the review as shown in Table 1.

Table 1. Keywords used to search for relevant articles

Databases	Keywords
Scopus	The Role Artificial Intelligence in Education
Google Scholar	The Role Artificial Intelligence in Education

Table 1 shows that the keyword used in searching for relevant articles is The Role Artificial Intelligence. The focus determined in this literature leads to research related to the role of Artificial Intelligence. The next step is to determine the criteria for articles that include and exclude from the focused theme according to the framework required for the review as shown in Table 2.

Table 2. Inclusion and Exclusion Criteria

Inclusion Criteria	Exlusion Criteria
Journal Article	Book chapters, book, proceedings, review
Articles published 2014-2023 (last 10 years)	Unpublished articles in 2014-2023.
Article on Artificial Intelligence	Article out on Artificial Intelligence
Articles related to the role of Artificial Intelligence in education	Articles unrelated to the role of Artificial Intelligence in education
English Articles	Non-English articles

Table 2 illustrates the articles selected for follow-up based on the inclusion and exclusion criteria. The full text of each article was downloaded, and articles that met the exclude criteria were excluded. In other words, the included articles were reviewed and analysed in depth to answer the research questions. Thus, the determination of inclusion and exclusion criteria is very important for creating high-quality research studies.

Second Phase (Screening)

Literature results from Scopus and Google Scholar databases were filtered through Mendeley software to separate articles that were identified as duplicate. Next was the title and abstract screening process, which mapped articles based on their titles and abstracts. Titles were screened for relevance and match with the keywords used. Then, the abstracts of each article were screened and scanned according to the predetermined inclusion and exclusion criteria.

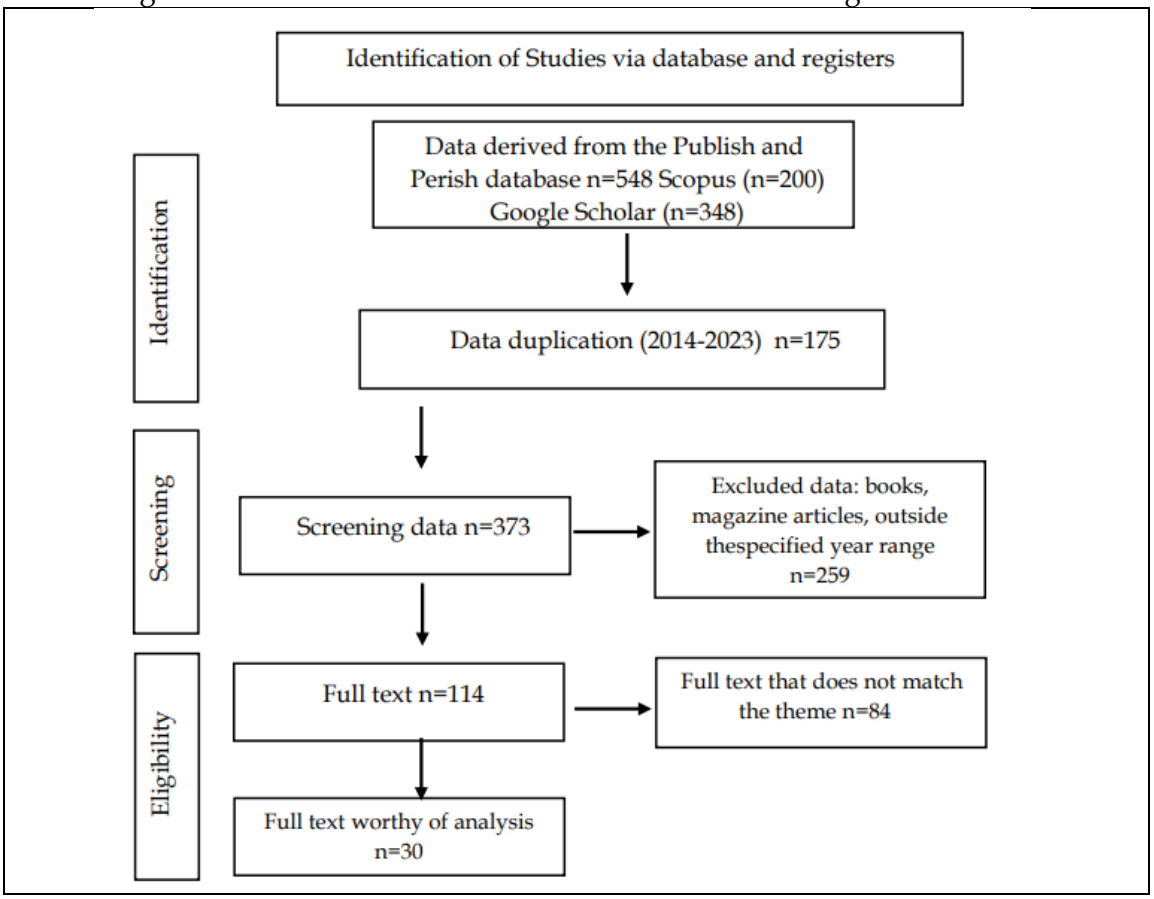
Third Phase (Eligibility)

At this stage, articles were analysed and checked for eligibility through Mendeley software. The articles were selected by adjusting the inclusion and exclusion criteria in Table 2. After the articles were identified as eligible, the next step was to download the full text of the articles and separate the articles that were included in the exclude criteria. In this phase, articles that are determined to be eligible must be able to map the answers to the questions in the study.

Fourth Phase (Extraction)

After checking the eligibility of articles based on the include and exclude criteria. Eligible articles in the include criteria will be extracted and analysed according to the statements that will be used as guidelines, namely Participant, Intervention, Comparatos conditions, Outcomes, Studies (PICOS). The data extraction process uses the Joanna Briggs Institute (JBI) model and continues on the study quality of the extracted literature using the JBI model. The following is the article search process using the PRISMA diagram.

Figure 1. Prisma Search Flow for The Role Artifial Intelligence Literature



As the flow of the prism chart above, there are 548 databases from Scopus and google scholar accessed through publish and perish software. A total of 175 databases were identified as duplicates. Then the remaining databases are mapped according to the include and exclude criteria. A total of 259 databases are included in the exclude criteria because the data is in the form of books, proceedings and not in English. A total of 84 databases were also included in the exclude criteria because they did not match the keyword criteria specified in the research. There are 30 databases in the form of articles that are included in the include criteria. In the next stage, the articles will be analysed and deepened by using the predetermined PICOS statements.

RESULT AND DISCUSSION

Article Mapping on The Role Artificial Intelligence

From the findings of the Scopus and Google Scholar databases, there are 548 databases according to the keyword "The Role Artificial Intelligence". After the identification process through mendeley software, 20 articles were found to be included in the criteria with predetermined conditions. The mapping of 20 articles will be explained based on author, year of publication, journal (journal name, volume, edition, year), publication, scopus accredited, and relevance to the research question (RQ), namely (RQ1). The following is a table of mapping articles that are included in the criteria:

Table 3. Article Mapping on The Role Artificial Intelligence

No	Author & Date	Title	Publication	Scopus Accredited
1	Ma, Wenting et al 2014	*Intelligent Tutoring Systems and Learning Outcomes: A Meta-Analysis*	*Journal of Educational Psychology*	*Q1*
2	Steenbergen-Hu et al 2014	*A meta-analysis of the effectiveness of intelligent tutoring systems on college students' academic learning*	*Journal of Educational Psychology*	*Q1*
3	Heffernan et al 2014	*The ASSISTments Ecosystem: Building a Platform that Brings Scientists and Teachers Together for Minimally Invasive Research on Human Learning and Teaching*	*International Journal of Artificial Intelligence in Education*	*Q1*
4	Macfadyen et al 2014	*Embracing Big Data in Complex Educational Systems: The Learning Analytics Imperative and the Policy Challenge*	*Research & Practice in Assessment*	*Q1*
5	Gasser et al 2017	*A Layered Model for AI Governance*	*IEEE Internet Computing*	*Q1*
6	Tsai, Yi-Shan et al 2017	*Complexity leadership in learning analytics: Drivers, challenges and opportunities*	*British Journal of Educational Technology*	*Q1*
7	Chi, Yang et al 2018	*Knowledge Graph in Smart Education: A Case Study of Entrepreneurship Scientific Publication Management*	*Sustainability*	*Q1*
8	Chen, Penghe et al 2018	*KnowEdu: A System to Construct Knowledge Graph for Education*	*IEEE Access*	*Q1*
9	Wang, Quan et al 2017	*Knowledge Graph Embedding: A Survey of Approaches and Applications*	*IEEE Transactions on Knowledge and Data Engineering*	*Q1*
10	Wolf, M J et al 2017	*Why We Should Have Seen That Coming: Comments on Microsoft's Tay "Experiment," and Wider Implications*	*The ORBIT Journal*	*Q1*
11	Topol, Eric J 2019	*High-performance medicine: the convergence of human and artificial intelligence*	*Nature Medicine*	*Q1*

12	Duan, Yanqing Edwards, John S Dwivedi, Yogesh K 2019	*Artificial intelligence for decision making in the era of Big Data – evolution, challenges and research agenda*	*International Journal of Information Management*	*Q1*
13	G.J. Hwang 2022	*Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective*	*Computers and Education: Artificial Intelligence*	*Q1*
14	S.F. Ahmad 2021	*Artificial intelligence and its role in education*	*Sustainability (Switzerland)*	*Q2*
15	A. Ara Shaikh 2022	*The Role of Machine Learning and Artificial Intelligence for making a Digital Classroom and its sustainable Impact on Education during Covid-19*	*Materials Today: Proceedings*	*Q2*
16	D.A. Winkler 2020	*Role of Artificial Intelligence and Machine Learning in Nanosafety*	*Small*	*Q1*
17	L. Bayliss 2019	*The role of artificial intelligence and machine learning in predicting orthopaedic outcomes*	*Bone and Joint Journal*	*Q1*
18	J. Henry 2021	*Teaching Artificial Intelligence to K-12 Through a Role-Playing Game Questioning the Intelligence Concept*	*KI - Kunstliche Intelligenz*	*Q2*
19	X. Gao 2021	*Role of 5G network technology and artificial intelligence for research and reform of english situational teaching in higher vocational colleges*	*Journal of Intelligent and Fuzzy Systems*	*Q2*
20	G.-J. Hwang 2020	*Vision, challenges roles and research issues of Artificial Intelligence in Education*	*Computer and Education*	*Q1*
21	Xieling Chen, Haoran Xie, Gwo-Jen Hwang 2020	*A Multi-Perspective Study on Artificial Intelligence in Education: Grants, Conferences, Journals, Software Tools, Institutions, and Researchers*	*Computers and Education: Artificial Intelligence*	*Q1*
22	Selena Nemorin et. al 2023	*AI hyped? A horizon scan of discourse on artificial intelligence in education (AIED) and evelopment*	*Learning, Media and Technology*	*Q1*
23	Garima Malik et. al 2019	*An Analysis of the Role of Artificial Intelligence in Education and*	*Advances in Intelligent Systems and*	*Q4*

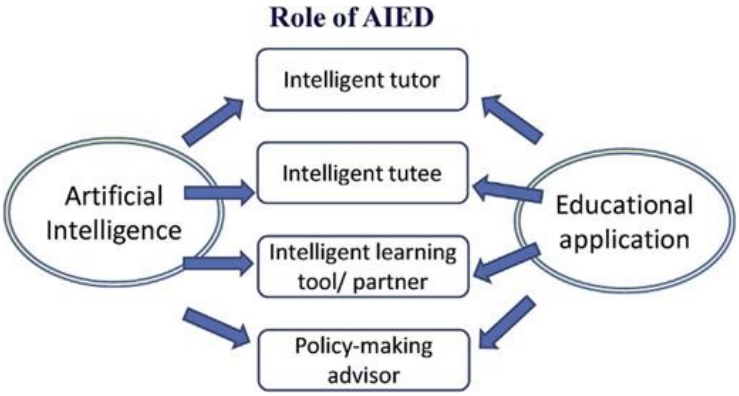
		Teaching	*Computing*	
24	Margaret A et. al 2020	*Artificial intelligence and sustainable development*	*The International Journal of Management Education*	*Q2*
25	Gromyko et. al 2018	*Artificial Intelligence as Tutoring Partner for Human Intellect*	*Advances in Intelligent Systems and Computing*	*Q4*
26	Fan Ouyang et. al 2021	*Artificial intelligence in education: The three paradigms*	*Computers and Education: Artificial Intelligence*	*Q1*
27	Jinyu Yang and Bo Zhang 2019	*Artificial Intelligence in Intelligent Tutoring Robots: A Systematic Review and Design Guidelines*	*Applied Science*	*Q2*
28	Chong Guan et. al 2020	*Artificial intelligence innovation in education: A twenty-year data-driven historical analysis*	*International Journal of Innovation Studies*	*Q2*
29	Ashraf Alam 2022	*Employing Adaptive Learning and Intelligent Tutoring Robots for Virtual Classrooms and Smart Campuses: Reforming Education in the Age of Artificial Intelligence*	*Advanced Computing and Intelligent Technologies*	*Q4*
30	Hassan Khosravi et.al 2022	*Explainable Artificial Intelligence in education*	*Computers and Education: Artificial Intelligence*	*Q1*

The articles present a variety of contributions on the role of Artificial Intelligence (AI) in the realm of education. Articles from various journals such as the Journal of Educational Psychology, IEEE Internet Computing, Nature Medicine, and several other high-quality journals address topics like the use of intelligent tutoring systems, learning analytics, employing big data in education, educational policy development, and the concept of the metaverse in education from an artificial intelligence perspective. Additionally, the articles discuss the implementation of artificial intelligence in data management, risk analysis, prediction of medical outcomes, development of digital classrooms, and the sustainability of education during the Covid-19 pandemic. Many articles delve into the concept of AI in learning, teaching, and the development of AI models in the context of sustainable education.

DISCUSSION

Rapid advances in computing and information processing have accelerated the advancement and use of Artificial Intelligence (AI), which aims to enable computers to perform tasks through simulating intelligent human behaviour, such as inferring, analysing, and making decisions, and decision-making in various fields (Duan et al., 2019; Topol, 2019). In the context of education, the application of artificial intelligence (AI) offers great potential in enhancing the learning experience and improving the efficiency of the education system. From an educational application perspective, there are several roles of AI in education as main finding of this research (Khosravi et al. 2022; Nemorin et al. 2023; Ouyang and Jiao 2021), namely as an intelligent tutor, learner, learning tool/partner, or policy-making advisor, as shown in Figure 2.(Hwang et al. 2020).

Figure 2. Framework of the AIED role (O'shea and Self 1986)



In the past few decades, many studies on Artificial Intelligence In Education (AIED) have been reported by researchers. These studies can be generally categorised into four roles. Firstly, AI as an intelligent tutor. This could be the largest category of AIED roles. Intelligent tutoring systems, adaptive/personalised learning systems, or recommendation systems fall into this category.

Several meta-analytic studies have shown the effectiveness of intelligent tutoring systems to promote learning outcomes. (Alam 2022; Ma et al. 2014; Steenbergen-Hu and Cooper 2014);. Examples of intelligent tutoring systems include cognitive tutors developed to support tutoring in maths and science and Auto Tutor (Ahmad et al. 2021; Chen, Xie, and Hwang 2020) is a dialogue-based tutor that supports physics learning, computer literacy, and critical thinking. A more recent example is an assessment that combines intelligent tutoring features with grading to provide real-time feedback to students while working on assignments and offers data-driven reports for teachers on each assignment (Heffernan and Heffernan 2014; Malik, Tayal, and Vij 2019; Yang and Zhang 2019). Second, AI as an intelligent student. Studies in this category are rarely seen because most AI-based education systems generally focus on assisting learners rather than providing opportunities to encourage learners to serve as tutors or advisors. Nevertheless, engaging learners in the context of helping others (i.e., AI students) understand complex concepts can be an excellent approach to promote their higher-order thinking competencies and knowledge levels(Hwang et al. 2020). Although there is no research aimed at developing intelligent learners intentionally and explicitly, many AI models and techniques are capable of learning knowledge and experience from interactions with humans. The learning capabilities of AI models and methods may facilitate the development of intelligent learners in the

future. For example, smart pupils could become chatbots like Microsoft's Tay (Wolf, Miller, and Grodzinsky 2017) with natural language processing interfaces and artificial neural networks. Members of the public made inappropriate comments on topics such as racism and sexism while chatting with Tay. Tay mimicked these comments and produced inappropriate expressions, and thus, Microsoft decided to shut it down. Ideally, if ethics modules can be embedded in the architecture of robots or chatbots then intelligent learners can be developed, learners can interact with a well-developed chatbot or robot and teach it by providing training examples related to a particular topic. The chatbot or robot can then respond to questions regarding the topic after the training process. Third, AI as an intelligent learning tool or partner. From the perspective of constructivism and student-centred learning, the provision of intelligent learning tools or partners is an important issue (Guan, Mou, and Jiang 2020). These tools can help learners collect and analyse data in an effective and powerful way, allowing them to focus on critical points or high-level thinking (e.g., inference and prediction), rather than low-level tasks (e.g., editing and calculation)(Gromyko et al. 2018). Some tools can even analyse and present data in clever ways to help learners think deeply and discover valuable implications underlying the data. For example, traditional Mindtools, such as concept mapping tools, help learners to organise knowledge by passively connecting relationships between concepts. In contrast, intelligent concept mapping tools can advise or provide hints to learners as well as evaluate the concept maps developed during the concept mapping process. Recently, knowledge graph, as a popular field in AI recently, can establish relationships among different entities from large volumes of related data based on AI models (Wang et al. 2017). There are several knowledge graph projects for educational purposes that would be promising research sub-areas for building smart learning tools or partners (Chen et al. 2018; Chi et al. 2018). Fourth, AI as a policymaking advisor. AI techniques have been used in informing and guiding the development of policies or laws in recent years (Gasser and Almeida 2017). Therefore, it is possible and feasible to develop a policy-making advisor for policy development in education. With the help of AI technology, policymakers can more precisely understand the trends and issues in educational settings from a macro and micro perspective, which can help them build and evaluate effective educational policies (Goralski and Tan 2020; Macfadyen et al. 2014; Tsai et al. 2019).

The difference between the current research and several other studies lies in the distinct focus and research objectives. The current study aims to identify the role of AI within the educational context, employing the Systematic Literature Review method. Conversely, the majority of other studies concentrate on various specific topics related to artificial intelligence and technology within the realm of education (Heffernan and Heffernan 2014; Ma et al. 2014; Steenbergen-Hu and Cooper 2014). Other research highlights different facets of AI, such as the effectiveness of intelligent tutoring systems (Gromyko et al. 2018; Yang and Zhang 2019), big data, learning analytics (Khosravi et al. 2022; Macfadyen et al. 2014), the development of Knowledge Graph (Chen et al. 2018; Chi et al. 2018; Wang et al. 2017), the use of AI in the digital classroom (Ara Shaikh et al. 2022), AI in the reform of English teaching in higher education (Gao 2021), and the paradigms of AI in education (Ouyang and Jiao 2021). The main gap in this study is that the "Role of Artificial Intelligence in Education" study focuses more broadly on exploring the general role of AI within educational contexts, whereas other research delves deeper into specific AI-related topics in teaching and learning.

The research unveils diverse implications in leveraging Artificial Intelligence (AI) in education, establishing it as a catalyst in enhancing the learning process and bolstering educational system efficiency. The pivotal findings by (Khosravi et al. 2022; Nemorin et al. 2023; Ouyang and Jiao 2021) categorize AI's role in education into four major dimensions. Firstly, as an intelligent tutor, it encompasses systems such as intelligent tutoring systems, adaptive learning platforms, and recommendation systems, proving their efficacy in improving learning outcomes. Secondly, there's the concept of AI as an intelligent student, albeit an underexplored dimension, with potential to foster higher-order thinking skills and knowledge levels. In the context of an intelligent learning tool or partner, AI could assist in collecting and analyzing data, focusing learners on critical thinking rather than mundane tasks. Finally, AI can serve as a policymaking advisor, contributing to precise policy development and evaluation by offering macro and micro perspectives on trends and issues within educational settings, fostering the creation of effective educational policies. Through these roles, AI's integration into education signifies transformative potential in refining the learning experience, teacher support, learning tools, and policy evolution, ultimately revolutionizing the education sector.

The research bears several limitations and constraints. Firstly, the scope of the study might be too broad due to the vastness of the AI in education landscape, potentially leading to some aspects being overlooked or not thoroughly analyzed within the review. Secondly, reliance solely on published literature might result in publication bias, disregarding significant ongoing or unpublished research. Additionally, given the rapid evolution of technology, there could be constraints in capturing the most recent advancements or emerging trends in the field. Methodological limitations, such as challenges in the search process or setting inclusion criteria, may hinder the review from including all relevant papers or considering essential sources. A focus on breadth rather than depth might also limit the review, possibly overlooking in-depth analysis of specific areas within AI in education. Furthermore, the review's conclusions might depend on the quality and integrity of the studies included, potentially impacting the overall comprehensiveness and accuracy of the review's findings.

There are several aspects require deeper exploration as expanding on the research. One crucial area for further investigation involves the real-world implementation and effectiveness of various roles that AI assumes in education, such as its role as a smart tutor, a learning tool, a policy advisor, or a facilitator in the educational process. By scrutinizing how these roles are practically integrated into educational settings, understanding their usability, challenges, and effectiveness in diverse environments becomes an essential pathway for further research. This exploration can provide valuable insights into how AI technologies can best serve the educational landscape and contribute to improved learning outcomes.

CONCLUSION

Advances in AI have brought computer-supported education into a new era. By incorporating human intelligence, computer systems can serve as intelligent tutors, tools or students and facilitate decision-making in educational settings. The integration of AI and education will open up new opportunities to improve the quality of teaching and learning. Teachers can benefit from intelligent systems that assist in assessment, data collection, improving learning progress, and developing new strategies. Students can benefit from intelligent tutors and asynchronous learning in advancing learning

outcomes. Moreover, the integration of AI and Education is not only the transformation of education but also the transformation of human knowledge, cognition, and culture. Thus, AI in Education is becoming a major research focus in the field of computing and education. Research directions stemming from the integration of AI into education involve several key areas. These include investigating the ethical use of AI in educational settings, exploring the effectiveness of intelligent tutoring systems on student learning outcomes, optimizing AI to support educators in assessment and personalized instruction, studying adaptive learning strategies for diverse student needs, examining the dynamics of human-AI collaboration in the classroom, understanding the broader impact of AI integration on human knowledge and culture, and assessing the long-term sustainability of AI implementation in education. These research pathways aim to deepen our understanding of the implications, challenges, and transformative potential of AI in education, seeking to enhance teaching and learning practices for the future.

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AUTHOR CONTRIBUTION STATEMENT

In the writing of the article, Imam and Zul focused on research, data collection, and analysis. Ayu and Rusdi was responsible for the theoretical framework, introduction, and conclusion. Syaifudin and Hammis led the editing, wrote the methodology, and coordinated the overall writing of the article.

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