A Systematic Review on Teachers' Digital Competencies on the Adoption of Artificial Intelligence in Enhancing Learning Experiences

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ABSTRACT

Artificial intelligence (AI) has the potential to revolutionize education by providing personalized learning experiences, adaptive assessments, and improved teaching and learning experiences. However, the adoption of AI-driven learning environments is hindered by several challenges, including ethical concerns, lack of teacher training, and insufficient infrastructure and resources.

This literature review explores the digital competencies needed by teachers to navigate AI-driven learning environments effectively. It begins by providing a brief overview of AI in Education, followed by a discussion of the key digital competencies required for teachers to successfully implement and use AI-powered tools and technologies. The review then explores the challenges and opportunities associated with integrating AI into the classroom and concludes for supporting teachers in developing the digital competencies they need to thrive in AI-driven learning environments.

Keywords: Artificial Intelligence in Education, Digital Competencies for Teachers, AI-driven Learning Environments, Systematic Review

INTRODUCTION

Artificial intelligence (AI) is revolutionizing education, offering unprecedented opportunities for personalized learning, increased student engagement, and enhanced instructional efficacy. However, the integration of AI in education (AIED) presents challenges for educators, necessitating the development of digital competencies to navigate evolving ecosystems (Zawacki-Richter et al., 2019). These challenges encompass ethical, social, and pedagogical dimensions, requiring educators to responsibly use AI technologies and address issues of equity, access, and learner-instructor interaction in online learning.

The ethical dimension involves ensuring responsible AI use, addressing issues of data privacy, and mitigating algorithmic biases. Social challenges include promoting equity in AI-driven learning environments and understanding the impact of AI on online interactions. Pedagogical challenges involve designing effective learning environments that foster student-AI collaboration and integrating AI into educational leadership. Teachers' digital competencies are crucial for leveraging AI systems to enhance teaching, learning, and assessment, as highlighted by Ng et al. (2023).

However, concerns persist, including fears of job displacement, ethical implications, and a lack of technical expertise. To address these concerns, a holistic approach is needed. Professional development programs can alleviate fears, transparent AI practices can address ethical concerns, and training resources can bridge technical gaps.

Despite challenges, AI-driven learning environments offer opportunities for personalized learning, adaptive

assessments, and enhanced teaching experiences. To fully harness AI's potential in education, it is crucial to strike a balance between transformative power and associated challenges. Equipping teachers with digital competencies, fostering trust in AI, and addressing ethical concerns can revolutionize education, creating a personalized, engaging, and effective learning experience for all.

The purpose of this literature review is to examine the digital competencies needed by teachers to navigate AI-driven learning environments effectively. This review will begin by providing a brief overview of AI in Education, followed by a discussion of the key digital competencies required for teachers to successfully implement and use AI-powered tools and technologies. The review will then explore the challenges and opportunities associated with integrating AI into the classroom, and conclude with recommendations for supporting teachers in developing the digital competencies they need to thrive in AI-driven learning environments.

This review is timely and relevant, given the growing adoption of AIED tools and technologies in schools and educational institutions around the world. By providing a comprehensive overview of the digital competencies needed by teachers to leverage AI effectively, this review aims to inform and support educators in their efforts to create more personalized, engaging, and effective learning experiences for all students.

METHODOLOGY

This literature review was conducted using a systematic approach and follows the PRISMA Statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) to answer specific questions about the Teachers' Digital Competencies on the Adoption of Artificial Intelligence in Enhancing Learning Experiences (Page et al., 2021).

Research objective and search

The questions that define the research problem presented in this work are:

1. What are the key developments and applications of AI-driven learning environments in recent years between 2019 to 2023?
2. What are the benefits and challenges associated with the adoption of AI technologies in education, and what factors contribute to educators' hesitancy in embracing these technologies?
3. What digital competencies are required for educators to effectively utilize AI-driven learning environments, and what strategies can be employed to develop these competencies?
4. How can educators be equipped with the necessary skills and knowledge to overcome the challenges associated with AI integration in education, and what support strategies can be implemented to facilitate this process?

Eligibility criteria

In this research, the eligibility criteria are established to ensure the inclusion of relevant materials that pertain to the study on Digital Competencies and the Adoption of Artificial Intelligence in Education. These criteria encompass research papers published between the years 2019 and 2023 and are particularly focused on studies conducted in the English language. Furthermore, the criteria for inclusion or exclusion of studies are detailed in Table 1.

Criteria	Inclusion	Exclusion
Publication year	2019-2023	Before 2019
Language	English	Not in English

Focus on Digital Competencies and AI	Yes	Not relevant to digital competencies and AI
Education Level	Primary/Secondary/College	Not relevant to teachers

Table 1. Criteria for including/excluding research papers

Search Strategy

A systematic literature search was conducted using a variety of search engines and databases, including Google Scholar, ERIC, and Scopus. The search was limited to peer-reviewed articles published in English between January 2019 and November 2023. The following search terms were used: "artificial intelligence and education," "AIED," "digital competencies," "teacher education," and "teaching and learning" were used in various combinations to ensure a comprehensive search.

Study Selection

The search results were screened to identify relevant studies that addressed the research question. Studies were excluded if they were not peer-reviewed, not in English, or not published within the past five years. The findings from the selected studies were synthesized and reported clearly and concisely.

RESULTS

Search Outcomes

The initial search yielded 40 records, of which 9 were duplicates. After screening the titles and abstracts of the remaining 31 records, 5 were excluded because they were not relevant to the topic of the review. This left 26 records to be retrieved and assessed for eligibility. Of these, 8 were excluded because they did not focus on digital competencies and AI in education. This left 18 studies to be included in the review. The workflow of this process is shown in Figure 1.

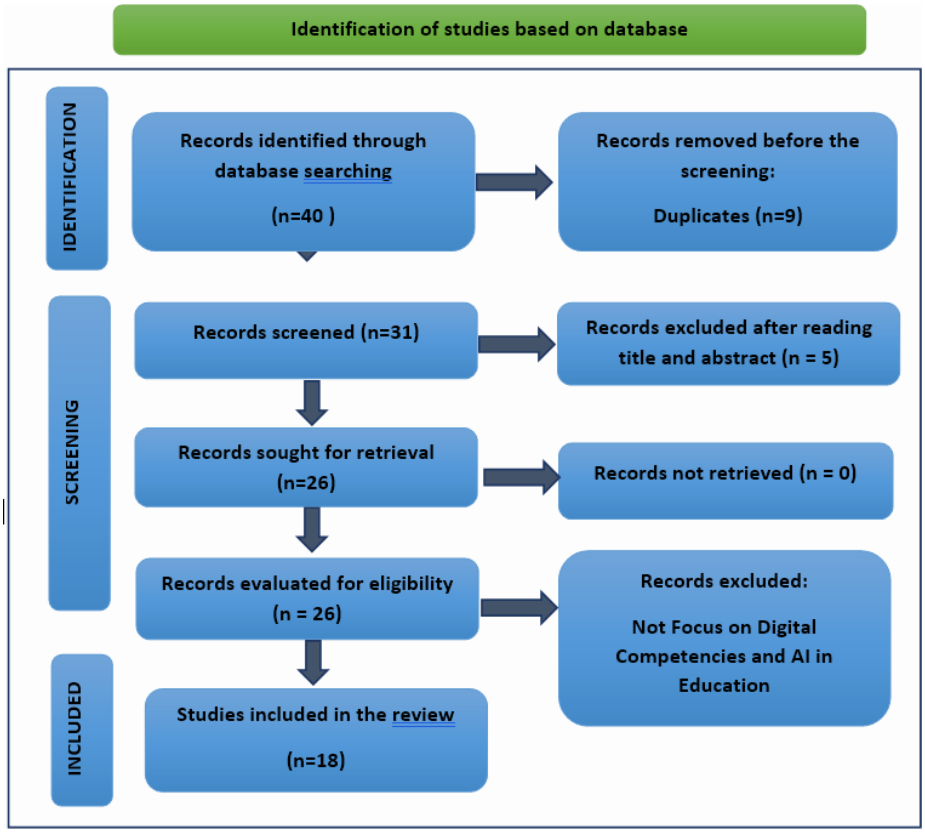

Figure 1. Flowchart of Identification of Study databases based on PRISMA

Table 2. Summary of the selected studies, considering the year of publication, and their characterization.

Authors and Year Published	**Objectives**	**Key Insights**	**Practical Implication**
Hwang et al., 2020	Explore AI-driven learning environments and tools.	Surge in interest in AI-driven learning environments, and development of personalized tools.	Transform education by improving learning outcomes and enhancing teaching methods.
Williamson & Eynon, 2020	Investigate AI applications in specific subject areas and decision-making.	Development of AI-based tools for subject areas and assessments.	Enhance educational decision-making through AI applications.
González-Calatayud et al., 2021	Explore AI applications in education.	AI applications in subject areas, assessments, and decision-making.	Address challenges for successful AI implementation in learning environments.
Ng et al., 2023	Examine opportunities for educators in AI-driven learning environments.	AI offers personalized support, seamless communication, and valuable learning analytics.	Improve teaching effectiveness and facilitate meaningful communication through AI tools.
Seo et al., 2021	Investigate practical implications of AI technologies in education.	Ethical and practical implications of AI, including data privacy and algorithm bias.	Carefully examine ethical and practical implications for effective AI implementation.
Slimi, 2021	Examine the development of AI education curricula.	Development of AI education curricula as a priority.	Prioritize the development of AI education curricula for schools.
Zawacki-Richter et al., 2019	Explore challenges in AI-driven learning environments.	Ethical, social, and pedagogical challenges in AI-driven learning environments.	Address ethical, social, and pedagogical challenges for successful AI implementation.
Nazaretsky et al., 2022	Investigate educators' perceptions and concerns regarding AI.	Reluctance is influenced by uncertain added value, confirmation bias, and fear of replacement.	Address factors influencing educators' reluctance for successful AI integration.
Holmes & Tuomi, 2022	Examine the impact of AI on human relations in education.	Fear of AI replacing teachers and challenges in human relations.	Address challenges in human relations and potential job displacement concerns.
Alnaqbi & Yassin, 2021	Explore challenges in the adoption of AI-based e-learning systems.	The lack of human relations between teachers and students is a major challenge.	Address challenges in human relations for successful AI-based e-learning adoption.

Alenezi, 2023	Investigate institutional support for AI-based education.	Institutional support as a driving force for educators' acceptance of AI-based education.	Emphasize the importance ofinstitutional support for successful AI integration.
Chou et al., 2022	Examine teachers' trust and attitudes toward AI-EdTech.	Trust in AI-EdTech is an essential, professional development strategy to increase trust.	Provide professional development opportunities to enhance teachers' trust in AI-EdTech.
Zhao et al., 2022	Focus on developing AI literacy for teachers.	Equipping teachers with AI literacy to use emerging technologies ethically.	Develop AI literacy to guide teachers in using AI technologies responsibly.
Dobey, 2023	Explore the impact of AI on teaching methodology, pedagogy, and curriculum design.	Teachers need knowledge and skills for interaction with AI systems.	Foster discussions on AI's impact on teaching methodology, pedagogy, and curriculum design.
Alasadi & Baiz, 2023	Discuss potential opportunities and challenges of AI-powered pedagogy.	AI-powered pedagogy as an opportunity to transform traditional teaching methods.	Explore the potential of AI-powered pedagogy for improved teaching methods.
Chen, 2022	Examine challenges faced by college teachers in the era of AI.	Identifying challenges and capacities needed by college teachers for AI integration.	Address challenges and enhance capacities for successful AI integration in higher education.
Barakina et al., 2021	Focus on improving college teachers' information-based teaching ability in the era of AI.	Improve college teachers' information-based teaching ability for effective AI integration.	Enhance college teachers' information-based teaching ability for successful AI integration.
Wang, 2023	Explore the central role of teachers in the introduction of AI technologies in education.	The correct choice of training tools and effectiveness of AI use depend on teachers.	Emphasize the central role of teachers in successful AI integration in education.

This table provides a concise overview of the objectives, key insights, and practical implications of the main studies on AI-driven learning environments and related topics.

DISCUSSION

In this section, the researcher provides answers to the research questions through the analysis of the selected articles to provide insights and findings aligned with the identified themes, thus presenting the outcomes of the systematic literature review (SLR).

Main Studies on AI-Driven Learning Environments (2019-2023)

Recent years have witnessed a surge in interest in AI-driven learning environments, leading to the development of various AI-based tools, such as intelligent tutoring systems and recommendation engines (Hwang et al., 2020; Williamson & Eynon, 2020). These tools offer personalized guidance to students, tailoring learning materials, diagnosing strengths and weaknesses, and identifying at-risk learners. Furthermore, studies have explored the applications of AI in specific subject areas, assessments, and

educational decision-making (González-Calatayud et al., 2021).

AI technologies present educators with opportunities to enhance their instructional methods, offering personalized support, seamless communication, and valuable learning analytics (Ng et al., 2023). By incorporating AI-based tools, teachers can improve their effectiveness, foster student self-regulation, and facilitate meaningful communication (Seo et al., 2021).

While the potential benefits of AI in education are evident, there is also a need to address challenges and considerations related to AI implementation in learning environments. For instance, the ethical and practical implications of AI technologies in education, including issues related to data privacy, algorithm bias, and the impact on the role of educators, require careful examination (Seo et al., 2021; Slimi, 2021). Additionally, the development of AI education curricula and learning materials has been identified as a priority to expand AI education in schools (Kim, 2021).

The studies on AI-driven learning environments have highlighted the potential of AI to transform education by improving learning outcomes, enhancing teaching methods, and personalizing learning experiences. However, there is a need for further research to understand the implications of AI on learner-instructor interaction, employee learning behavior, and the ethical considerations of AI implementation in educational settings.

Digital Competencies, Challenges, Opportunities, and Support Strategies

Artificial intelligence (AI)-driven learning environments have gained significant attention in the literature due to their potential to revolutionize education and provide personalized learning experiences (Ng et al., 2023). Several aspects have been identified in the literature on AI-driven learning environments.

Digital Competencies

In the dynamic landscape of AI-driven learning environments, teachers play a pivotal role in harnessing the transformative power of technology to enhance students' learning experiences. To effectively navigate this evolving educational paradigm, teachers need to cultivate a comprehensive set of AI digital competencies, empowering them to seamlessly integrate AI tools into their pedagogical practices (Ng et al., 2023).

A cornerstone of AI digital competencies lies in the ability to comprehend and utilize AI technologies, encompassing a range of innovative tools that can revolutionize teaching and learning. Intelligent learning environments, for instance, provide adaptive learning pathways tailored to each student's unique needs and learning styles. Interactive narrative generation tools foster immersive learning experiences, captivating students' imaginations and fostering deeper engagement with the subject matter. User modeling techniques enable teachers to gain valuable insights into students' learning patterns, preferences, and potential challenges, facilitating personalized instruction and targeted support.

Beyond technological proficiency, AI digital competencies encompass a broader understanding of the pedagogical implications of AI-driven learning environments. Teachers should recognize the potential of these environments to foster personalized learning experiences, catering to the diverse needs and learning styles of all students. By leveraging AI-powered tools for individualized instruction, teachers can effectively address the unique learning trajectories of each student, promoting inclusive and equitable learning experiences.

Furthermore, teachers equipped with AI digital competencies can seamlessly integrate AI-driven learning environments into their existing teaching practices, enhancing their instructional repertoire without disrupting established pedagogical frameworks. By strategically incorporating AI tools into traditional

lesson plans and classroom activities, teachers can augment their teaching methods, introducing new dimensions of engagement, interaction, and personalized learning.

Challenges of AI-driven learning environments

The incorporation of artificial intelligence (AI) into education holds the promise of revolutionizing teaching practices and fostering personalized learning experiences. However, alongside these potential benefits, AI-driven learning environments also present a range of challenges that need to be carefully considered and addressed to ensure equitable and effective implementation.

Ethical considerations

The ethical dimension of AI in education centers on the responsible and ethical use of AI technologies to promote the well-being and safety of learners (Zawacki-Richter et al., 2019). This includes safeguarding student privacy, preventing data misuse, and ensuring that AI algorithms are free from bias. Teachers and educational institutions must establish clear guidelines and protocols for the ethical use of AI in the classroom, ensuring that these technologies are used responsibly and in alignment with educational values.

Social implications

AI-driven learning environments introduce a range of social challenges that need to be addressed to promote equity and access for all learners. One key concern is the potential for AI to exacerbate existing educational inequalities, particularly for students from marginalized communities or those with limited access to technology. Additionally, the increasing use of AI in online learning raises questions about the impact on learner-instructor interaction and the potential for AI to replace human teachers. It is crucial to ensure that AI is used to supplement, not replace, human interaction in the learning process, preserving the essential role of teachers in guiding, motivating, and supporting students.

Pedagogical considerations

Effective implementation of AI in education requires careful consideration of pedagogical design and integration strategies. Educators need to design learning experiences that effectively utilize AI technologies to support student-AI collaboration and enhance learning outcomes. This includes creating opportunities for students to interact with AI tools in meaningful ways, fostering critical thinking skills and promoting deep understanding of the subject matter. Additionally, integrating AI into educational leadership requires a holistic approach that addresses the impact of AI on school administration, teacher training, and curriculum development.

While AI offers immense potential to transform education, it is essential to acknowledge and address the challenges that accompany its integration into learning environments. By carefully considering the ethical, social, and pedagogical dimensions of AI, educators can harness the power of this technology to create equitable, inclusive, and effective learning experiences for all students.

Opportunities

Opportunities in AI-driven learning environments include personalized learning, adaptive assessments, and improved teaching and learning experiences. AI technologies can personalize learning for students by adapting content and activities to their individual needs and preferences. Adaptive assessments powered by AI can provide real-time feedback and support to students, enhancing their learning outcomes. AI can also improve teaching and learning experiences by automating routine tasks for instructors and providing data-driven insights for decision-making.

Support strategies

Educators play a pivotal role in harnessing the transformative power of AI-driven learning environments. To effectively navigate this evolving educational paradigm, teachers need to cultivate a comprehensive set of AI digital competencies, empowering them to seamlessly integrate AI tools into their pedagogical practices. Providing professional development opportunities for teachers is crucial to developing these competencies. Furthermore, the integration of AI in education requires the development of appropriate teaching strategies and the consideration of ethical and pedagogical issues.

Teachers' Perceptions and Concerns

The reluctance of educators to embrace AI in educational settings is influenced by various factors. One of the prominent hindering factors is the uncertain added value to practice, leading to low acceptance of AI applications among adopters and complicating the acquisition of funds for AI applications by Strohm et al. (2020). Additionally, educators' trust in AI-based educational technology is influenced by confirmation bias and the expectation for AI to be infallible, especially in situations where absolute truth may not exist, such as grading open-ended questions (Nazaretsky et al., 2022). Furthermore, there is a lack of established tools for measuring educators' perceptions of AI and its impact on their trust and adoption of AI tools in their teaching practices (Nazaretsky et al., 2022).

Moreover, some teachers fear that AI will replace them, undermining their professional roles (Holmes & Tuomi, 2022). The lack of human relations between teachers and students is reported as a major challenge in the adoption of AI-based e-learning systems (Alnaqbi& Yassin, 2021). Additionally, the seamless integration of AI across different aspects of the curriculum is essential for its successful introduction in educational settings (Paranjape et al., 2019). Achieving high-quality STEM education requires careful consideration of complex social, pedagogical, and environmental factors, rather than merely applying AI technologies to education (Xu & Ouyang, 2022).

Institutional support for providing resources, facilities, and services is a driving force behind educators' acceptance of AI-based education (Alenezi, 2023). Lack of training and support, as well as the absence of radiologists' involvement in AI development, are factors attributed to the non-use of AI-based applications in clinical practice (Alsharif et al., 2022).

In conclusion, educators' reluctance to embrace AI in educational settings is influenced by various factors, including uncertainty about its added value, confirmation bias, lack of established tools for measuring trust in AI, and challenges in integrating AI across the curriculum. Addressing these factors is crucial for the successful integration of AI into educational settings.

Equipping Teachers with AI Digital Competencies

Equipping teachers with AI digital competencies is crucial, as there is a growing need for teachers to have adequate digital competencies to effectively use and teach AI in their classrooms (Ng et al., 2023). However, little research has been conducted on the trust and attitudes of K-12 teachers regarding the use and adoption of AI-based Educational Technology (EdTech) (Nazaretsky et al., 2022). Teachers' trust in AI-EdTech is essential, and effective professional development strategies can increase teachers' trust and willingness to apply AI-EdTech in their classrooms (Nazaretsky et al., 2022). Furthermore, it is important to identify teachers' cognitive efficacy regarding the need for AI application in teaching and their awareness of the AI technology development trends (Chou et al., 2022).

To achieve this, it is crucial to focus on developing AI literacy for teachers, guiding them on how to use

emerging technologies in a disciplined and ethical manner, and fostering their ethical values and responsibility (Zhao et al., 2022). Additionally, teachers need to be equipped with knowledge and skills for their interaction with AI systems, and discussions on how AI itself can impact methodology, pedagogy, engagement with students, assessment, and curriculum design are essential (Dobey, 2023). Moreover, the integration of AI in education presents both unparalleled opportunities and complex challenges, and it is crucial to explore the potential of AI-powered pedagogy in transforming traditional teaching methods (Alasadi & Baiz, 2023).

In the context of higher education, AI technologies will change the shape of education completely, and it is important to discuss the potential challenges faced by college teachers in the era of AI and the capacities they should possess to deal with these challenges (Chen, 2022). Furthermore, the central place in the introduction of AI technologies in education is occupied by teachers, as the correct choice of training tools and the effectiveness of the use of AI depend on them (Barakina et al., 2021). Therefore, it is essential to improve college teachers' information-based teaching ability in the era of AI to lay the foundation for talent training in colleges and universities (Wang, 2023).

Equipping teachers with AI digital competencies is essential for the effective integration of AI in education. This involves building teachers' trust in AI-EdTech, developing their AI literacy, and addressing the potential challenges and opportunities associated with the integration of AI in teaching and learning.

CONCLUSION

This systematic literature review extensively examined key studies, digital competencies, challenges, opportunities, and support strategies related to AI-driven learning environments. The findings underscore the transformative potential of AI in revolutionizing education, offering personalized learning experiences, adaptive assessments, and improved teaching and learning dynamics. Despite these benefits, widespread adoption faces hurdles such as ethical concerns, inadequate teacher training, and insufficient infrastructure and resources.

To overcome these challenges, it is essential to empower educators with the requisite AI digital competencies for the pedagogically sound integration of AI. This involves developing learning tasks that leverage AI capabilities and ensuring responsible and ethical AI usage, transcending traditional technology integration skills. Continuous professional development opportunities, along with clear guidelines on data privacy and ethical use, are vital to support teachers in acquiring these competencies. Adequate funding for resources and infrastructure is equally crucial.

Furthermore, fostering collaboration between governments and private organizations can play a pivotal role in promoting the widespread adoption of AI-driven learning environments. By working together, these entities can contribute to addressing the challenges and ensuring a more seamless integration of AI in education.

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