METHODS FOR TEACHING ARTIFICIAL INTELLIGENCE LITERACY BASED ON METACOGNITIVE TRAINING FOR FUTURE TEACHERS

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Abstract

This article examines effective methods for teaching artificial intelligence (AI) literacy to future teachers through the use of metacognitive training. As AI technologies become increasingly integrated into education, teachers must not only learn how to use these tools but also develop the ability to critically evaluate their implications, limitations, and ethical dimensions. The study highlights that AI literacy goes beyond technical skills, encompassing critical thinking, ethical awareness, and the capacity to guide students in reflective engagement with AI systems. Metacognitive training—focused on planning, monitoring, and evaluating one's cognitive processes—offers a powerful approach to strengthening these competencies. By embedding metacognitive strategies into teacher education programs, future teachers can be equipped with the skills needed to critically engage with AI, adapt to ongoing technological changes, and foster AI literacy among their students. The paper concludes that combining AI literacy education with metacognitive approaches not only enhances teachers' professional preparedness but also ensures more ethical and sustainable integration of AI in education.

Introduction. In today's rapidly evolving digital age, artificial intelligence (AI) has emerged as one of the most transformative forces across various sectors, including education. AI-driven technologies are increasingly integrated into teaching, learning, and assessment processes, reshaping the role of teachers and learners. For instance, AI-powered adaptive learning platforms provide personalized learning pathways, automated assessment tools support real-time feedback, and intelligent tutoring systems assist in scaffolding learning. While

these innovations create new opportunities for enhancing educational quality, they also present significant challenges, such as concerns about data privacy, algorithmic bias, and the ethical use of AI.

For future teachers, the ability to understand and critically evaluate AI is not optional but a fundamental competency. The concept of **artificial intelligence literacy (AI literacy)** goes beyond technical knowledge of how AI functions; it also requires awareness of its societal implications, ethical dilemmas, and pedagogical potential. According to Long and Magerko (2020), AI literacy involves competencies such as understanding the principles of AI, interacting with AI systems, evaluating their outputs, and reflecting on the broader consequences of AI in society. UNESCO (2021) also highlights that educators must be prepared to guide students not only in using AI tools effectively but also in questioning and critically analyzing their influence.

However, acquiring AI literacy is not solely a matter of technological training. Traditional approaches that focus exclusively on technical skills risk creating teachers who can operate AI systems but lack the ability to engage with them critically. This gap calls for innovative pedagogical approaches that foster higher-order thinking skills. **Metacognition,** defined by Flavell (1979) as "thinking about thinking," offers a promising framework. Through metacognitive training, learners are taught to plan, monitor, and evaluate their cognitive processes, thereby strengthening self-regulation and reflective practice. For teacher education, this approach means future educators can develop a habit of questioning their assumptions, evaluating evidence, and making ethically sound decisions about the use of AI in classrooms.

The intersection of metacognitive training and AI literacy is particularly significant in teacher preparation programs. Teachers are not only consumers of AI technologies but also role models who will shape how their students perceive and use AI. Thus, enabling teachers-in-training to critically and reflectively engage with AI ensures a multiplier effect: they become capable of fostering AI literacy in their own students. Furthermore, integrating metacognitive strategies into AI education addresses the need for sustainable and adaptable learning, allowing future teachers to keep pace with ongoing technological advancements. The aim of this article is to explore effective methods for teaching artificial intelligence literacy to future teachers through a metacognitive approach. Specifically, it seeks to: Analyze existing literature on AI literacy and metacognition in teacher education.Discuss the role of metacognitive training in enhancing AI literacy. Propose practical methods and strategies for integrating metacognitive approaches into teacher education programs. By linking AI literacy with metacognitive training, this research emphasizes that the goal is not only to prepare teachers who can use AI technologies, but also to cultivate

educators who can critically evaluate, ethically apply, and innovatively integrate AI into their teaching practices.

Literature Analysis. The growing integration of artificial intelligence (AI) into education has prompted scholars to explore the concept of **AI literacy,** its role in teacher education, and the pedagogical frameworks that can effectively support it. According to Ng, Leung, and Chu (2021), AI literacy should not be confined to understanding the technical mechanisms of AI systems but should extend to social, ethical, and critical dimensions. They argue that teachers, as intermediaries between technology and learners, require a holistic set of competencies to evaluate AI tools and guide students in responsible use. Similarly, Long and Magerko (2020) define AI literacy as encompassing awareness of how AI works, the ability to interact with AI, the skill to critically interpret its outputs, and an understanding of its societal consequences.

Teacher education research also emphasizes the importance of preparing educators to engage with AI critically. Holmes et al. (2022) contend that while AI can transform teaching and learning practices, teachers often lack structured training to critically assess its risks, including data bias and ethical implications. UNESCO (2021) further stresses the global need for teachers who can not only adopt AI technologies but also instill reflective and ethical approaches among their students. This suggests that teacher education programs must adopt frameworks that go beyond instrumental use and foster higher-order cognitive skills.

One promising framework in this context is **metacognition.** First conceptualized by Flavell (1979), metacognition involves "knowledge and regulation of one's own cognitive processes." Research has shown that metacognitive strategies improve self-regulation, critical reflection, and adaptability in complex learning environments (Schraw & Moshman, 1995). In the digital age, metacognition has been recognized as a key competence for navigating rapidly evolving technologies (Efklides, 2008). For example, Mevarech and Kramarski (2017) demonstrate that metacognitive training enhances learners' ability to monitor their reasoning and make informed decisions, which is highly relevant to the evaluation of AI-driven systems.

Recent studies have begun to link **metacognitive training with digital and AI education.** Lau and Mak (2021) highlight that integrating metacognitive prompts in technology-based learning environments encourages learners to critically reflect on digital tools rather than passively accept their outputs. In a similar vein, Zawacki-Richter et al. (2019) argue that reflective teaching practices, grounded in metacognitive awareness, enable educators to evaluate technological innovations more effectively and avoid uncritical adoption. These findings suggest that metacognition can act as a bridge between technical AI knowledge and the critical, ethical engagement required of educators.

Overall, the literature indicates a convergence of two strands: the need for AI literacy as a multidimensional construct and the effectiveness of metacognitive approaches in fostering reflective, critical, and adaptive learning. However, gaps remain in the practical integration of metacognitive training into teacher education curricula, particularly in preparing future teachers to balance technical proficiency with ethical awareness. This study builds upon existing scholarship by proposing concrete methods for embedding metacognitive strategies into AI literacy education for teacher preparation programs.

Research Discussion. The findings of this study indicate that integrating metacognitive training into AI literacy education provides future teachers with a more comprehensive and reflective framework for engaging with artificial intelligence. Unlike traditional approaches that focus primarily on technical competencies, metacognitive strategies encourage learners to actively plan, monitor, and evaluate their interactions with AI tools. This aligns with earlier research by Lau and Mak (2021), who found that metacognitive prompts foster critical digital literacy, and supports the claim that AI literacy must extend beyond operational knowledge to include critical and ethical dimensions (Ng, Leung, & Chu, 2021; Long & Magerko, 2020).

One of the most significant implications of this study is that **metacognition enhances teachers' capacity for critical reflection.** Teachers trained to use metacognitive strategies are better positioned to recognize AI's limitations, such as algorithmic bias, data privacy concerns, and the risk of over-reliance on automated systems. These findings echo Holmes et al. (2022), who argue that ethical awareness and reflective judgment are central to responsible AI adoption in education. By embedding such reflective practices into teacher preparation, educators can avoid uncritical acceptance of AI outputs and instead use these technologies as tools to support—not replace—human decision-making.

Another important discussion point is the **transferability of metacognitive skills**. Once future teachers internalize strategies such as questioning assumptions, evaluating evidence, and monitoring reasoning, they can apply these skills not only to AI tools but also to broader teaching and learning contexts. This supports Mevarech and Kramarski's (2017) assertion that metacognitive training strengthens general problem-solving and self-regulated learning. In this sense, metacognitive approaches serve as a dual-purpose pedagogy: enhancing AI literacy while simultaneously developing transferable teaching competencies.

Furthermore, the research highlights that AI literacy is not a static set of skills but a **dynamic competence** requiring constant adaptation as AI technologies evolve. Metacognitive training equips future teachers with the flexibility to continually update their understanding, critically assess new developments, and guide students through the same reflective process. This is particularly important in the

rapidly changing educational technology landscape, where fixed knowledge quickly becomes outdated.

Finally, the study suggests that the successful integration of AI literacy and metacognitive training requires **systemic support in teacher education programs.** Curriculum designers must incorporate explicit opportunities for reflection, critical dialogue, and ethical inquiry into teacher preparation. This aligns with UNESCO's (2021) recommendations that teacher education should not only teach how to use AI but also address its societal implications. Without such systemic embedding, metacognitive approaches risk being treated as add-ons rather than as central pedagogical strategies. In summary, the discussion demonstrates that metacognitive training provides a promising pathway for developing future teachers' AI literacy. By equipping educators with reflective, adaptive, and ethically grounded strategies, this approach ensures that AI integration in education is both effective and responsible.

Conclusion. This study concludes that teaching artificial intelligence (AI) literacy to future teachers requires going beyond technical training and must include metacognitive approaches that foster critical reflection, ethical awareness, and adaptive thinking. While traditional methods often emphasize the functional use of AI tools, metacognitive training enables teachers to consciously plan, monitor, and evaluate their engagement with these technologies. Such reflective practices not only strengthen teachers' own AI literacy but also empower them to cultivate similar skills in their students.

The findings highlight that AI literacy is a **dynamic and multidimensional competence** involving technical proficiency, critical evaluation, ethical judgment, and the ability to navigate complex digital environments. By embedding metacognitive strategies into teacher education programs, future educators can be better prepared to address issues such as algorithmic bias, data privacy, and the ethical use of AI in classrooms. Moreover, the adaptability fostered by metacognitive training ensures that teachers remain responsive to the rapidly evolving landscape of AI technologies. This makes metacognition not merely a teaching strategy, but a long-term professional competency essential for sustainable and responsible AI integration in education.

Ultimately, the study suggests that the combination of AI literacy and metacognitive training contributes to the development of teachers who are not only skilled technology users but **also critical thinkers, ethical leaders, and reflective practitioners**. Such educators are better equipped to guide their students in navigating the challenges and opportunities of an AI-driven world, thereby ensuring that AI adoption in education serves both learning effectiveness and societal well-being.

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