

Teachers' AI Literacy: Core Components and Systematic Training Framework

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Abstract: The rapid advancement of artificial intelligence (AI), particularly generative AI (GenAI), has significantly reshaped education, offering opportunities for personalized learning and instructional efficiency while posing challenges such as ethical concerns and algorithmic biases. Teachers must transition from passive users to strategic participants in AI integration, necessitating the development of comprehensive AI literacy. This study addresses gaps in existing research by proposing a systematic framework for teachers' AI literacy, identifying four core components: technical literacy (understanding AI fundamentals and tools), pedagogical literacy (integrating AI into teaching practices), ethical and societal literacy (navigating AI's ethical implications), and reflective and adaptive literacy (continuous learning and adaptation). A structured training framework is designed to cultivate these competencies through modular, hands-on, and ethically grounded professional development. Challenges such as resistance to change, institutional barriers, and resource disparities are analyzed, alongside mitigation strategies like flexible training models and policy advocacy. The paper underscores the urgency of fostering teachers' AI literacy to ensure equitable, responsible, and pedagogically sound AI adoption in education.

Keywords: AI Literacy; Teacher Professional Development; Pedagogical Integration; Systematic Training Framework

1. Introduction

The rapid development of artificial intelligence (AI), particularly generative AI (GenAI), has profoundly transformed the global educational landscape. Recent advancements in AI applications for education highlight its ability to revolutionize instructional approaches, learning

strategies, and school management while enriching educational experiences and supporting educators [1]. AI offers opportunities for facilitating personalized learning and teaching efficiency. However, the application of AI in education also brings critical challenges such as data privacy and security risks, algorithmic bias and discrimination, and inappropriate or wrong output [2]. With the growing integration of AI in education, teachers are expected to transition from passive users to strategic participants in developing instructional applications of AI tools. Therefore, it should be prioritized to promote teachers' AI literacy.

Despite increasing scholarly attention to teachers' AI literacy, current research fails to establish systematic frameworks for integrating AI literacy into teacher professional development programs [3]. To fill this gap, this study is guided by the following three questions:

1. What are the core components of teachers' AI literacy?
2. How can teachers' AI literacy can be developed?
3. What are the challenges and barriers hindering AI literacy development among teachers?

2. Core Components of Teachers' AI Literacy

The term "AI literacy" can be defined as a series of competencies by which individuals are enabled to evaluate AI technologies critically, communicate with AI systems effectively, and apply AI as a tool in diverse domains [4]. As for teachers, AI literacy refers to a collection of knowledge, competencies, and critical discernment, which enables individuals to progressively comprehend, assess, and pedagogically engage with artificial intelligence (AI) in a manner that is informed, reflective, and anchored in ethical principles [5]. What distinguishes AI from other digital technologies is its autonomous operational capacity and context-dependent adaptability. Therefore,

understanding what AI is and does is insufficient when detached from discussions of AI ethics, data bias, surveillance, labor market effects, and sustainability [6]. Based on the AI Competency Framework proposed by United Nations Educational, Scientific and Cultural Organization (UNESCO) and other studies, this paper identifies four core components of teachers' AI literacy (Table 1).

Table 1. Four Core Components of Teachers' AI Literacy

Dimension	Content	Educational Significance
Technical Literacy	Understanding AI fundamentals and related tools	Comprehending AI system operations, proficiently using AI tools in education
Pedagogical Literacy	Integrating AI technologies into teaching practices and evaluating the effectiveness of AI tools.	Meeting diverse student needs, promoting effectiveness of AI integration
Ethical and Societal Literacy	Recognizing ethical issues in AI use in education selecting fair, inclusive AI tools.	Protecting student data, mitigating algorithmic bias, and fostering students' critical thinking about AI's societal impacts
Reflective and Adaptive Literacy	Continuously learning and adapting to rapidly evolving AI technologies	Encouraging teachers to embrace AI challenges, improving teaching practices

2.1 Technical Literacy

Technical literacy forms the foundation of AI literacy, providing teachers with the necessary knowledge to comprehend AI technologies and their further educational applications. Teachers are supposed to grasp basic AI concepts such as machine learning, neural networks, and natural language processing [4]. This kind of knowledge enables them to appreciate how AI systems function and make informed decisions about their use in educational settings. Moreover, technical literacy involves familiarity with specific AI tools and platforms relevant to education, such as intelligent tutoring systems, automated assessment tools, and AI-driven educational software [7]. Proficiency in these tools allows teachers to leverage AI to enhance instructional delivery and student engagement.

2.2 Pedagogical Literacy

In the context of AI, pedagogical literacy refers to the ability to integrate AI technologies into teaching practices in ways that promote students' effective learning. This includes understanding how AI can be used to support personalized students' learning experiences, provide real-time feedback, and support differentiated instruction [1]. In this way, the diverse learning needs and styles of students can be met when teachers with strong pedagogical literacy incorporate AI tools into curricula design. Furthermore, pedagogical literacy also involves evaluating the effectiveness of AI integration. In other words, teachers are expected to evaluate whether AI tools are fulfilling their intended educational objectives and make necessary modifications when required.

2.3 Ethical and Societal Literacy

Ethical and societal literacy is crucial for teachers to navigate the complicated impacts of AI in education. This component encompasses the acknowledgement of issues such as data privacy, security, and the potential for algorithmic bias [6]. Teachers must be aware of how AI systems collect and use data, ensuring that student information is protected and used in an ethical way. Additionally, ethical literacy involves recognizing and mitigating biases in AI systems. Since AI algorithms can perpetuate existing societal biases, teachers need to be vigilant in selecting and using AI tools that are fair and inclusive [8]. This could be fostering critical thinking among students about the societal impacts of AI.

2.4 Reflective and Adaptive Literacy

Reflective and adaptive literacy emphasizes the importance of continuous learning and adaptation in the face of rapidly evolving AI technologies. Teachers need to be proactive in seeking out professional development opportunities to stay abreast of the latest advancements in AI and education. This might be staying abreast of new developments in AI technology and pedagogy. Reflective practices, such as keeping a journal of their experiences with AI or participating in peer observations, can help teachers critically assess their use of AI and identify areas for improvement. Moreover, building self-efficacy in learning AI is crucial; teachers who believe they can master AI technologies are more likely to engage with

them and integrate them into their teaching. Encouraging a growth mindset towards technology can help teachers embrace the challenges and opportunities presented by AI.

3. Construction and Implementation of a Systematic Training Framework for Teachers' AI Literacy

To foster teachers' AI literacy, a systematic training framework is essential. This framework should be designed to address the core components of AI literacy through structured modules and diverse training approaches.

3.1 Design Principles

There are several principles which should be considered for designing a professional learning program for teachers' AI literacy. The first one is comprehensive coverage, which means that ensuring all core components of AI literacy are addressed. The second principle is practical application, so hands-on activities and real-world case studies should be included. The third principle is ethical integration, which emphasizes ethical considerations throughout the training. The fourth principle is continuous learning, which promotes teachers' ongoing professional development.

The fifth principle is inclusivity, which caters to teachers with varying levels of technological proficiency.

3.2 A Systematic Training Framework for Teachers' AI Literacy

Based on the four core components of teachers' AI literacy, this paper develops a systematic training framework for teachers' AI literacy (Table 2).

Table 2. A Systematic Training Framework for Teachers' AI Literacy

Targeted dimension	Module
Technical Literacy	AI Fundamentals & Tools
Pedagogical Literacy	AI in Teaching & Learning
Ethical and Societal Literacy	Navigating AI Challenges
Reflective and Adaptive Literacy	Lifelong AI Learning

The first module targets at technical literacy. The AI Fundamentals and Tools module establishes foundational knowledge by introducing key AI concepts such as machine learning, neural

networks, and natural language processing. Teachers engage in interactive lectures and guided workshops to explore AI-powered educational tools, including intelligent tutoring systems and automated assessment platforms. A critical component of this module involves hands-on experimentation with accessible AI applications (e.g., Google Teachable Machine, ChatGPT for lesson planning), enabling educators to assess their potential classroom utility. Mastery is evaluated through a combination of quizzes and practical demonstrations, ensuring participants can confidently navigate basic AI functionalities.

Building upon technical literacy, the second module is designed for Pedagogical Literacy. This Integrating AI into Teaching and Learning module focuses on the strategic incorporation of AI to enhance instructional practices. Educators analyze case studies of successful AI implementations, such as adaptive learning platforms like Khan Academy, and participate in role-playing exercises to simulate AI-supported classroom scenarios. Key emphasis is placed on designing personalized and differentiated learning experiences using AI-driven feedback mechanisms (e.g., Turnitin's automated grading, Duolingo's adaptive exercises). Teachers collaborate to redesign traditional lesson plans with AI enhancements, followed by peer reviews and reflective essays to evaluate pedagogical effectiveness.

The third module is intended for Ethical and Societal Literacy. The Navigating AI's Impact module addresses the critical challenges associated with AI adoption in education. Through structured debates and scenario-based discussions, teachers examine issues of algorithmic bias, data privacy (e.g., GDPR, COPPA compliance), and the broader societal implications of AI. Guest lectures from ethics experts or policymakers provide real-world insights, while analytical tasks require educators to critique AI tools for fairness and inclusivity. This module culminates in a case study report, encouraging teachers to develop actionable guidelines for ethical AI use in their institutions. Finally, the fourth module, Reflective and Adaptive Literacy: Continuous Professional Growth, fosters a culture of lifelong learning and self-assessment. Educators maintain reflective journals documenting their AI integration experiences and participate in peer feedback sessions to share successes and challenges. A

forward-looking webinar on emerging AI trends ensures teachers remain informed about technological advancements. The module concludes with a personalized AI integration roadmap, empowering educators to set measurable goals for ongoing professional development.

To reinforce learning, the framework incorporates community-driven engagement through digital forums (e.g., Slack, Discord) where educators exchange resources and troubleshoot implementation barriers. Micro-credentials (e.g., digital badges) are awarded upon module completion to incentivize participation and validate competency. Program efficacy is assessed via pre- and post-training knowledge tests, classroom implementation portfolios, and iterative feedback surveys to refine content based on teacher needs.

This framework tends to develop teachers' AI literacy by emphasizing applied learning, ethical vigilance, and adaptive pedagogy. By equipping teachers with technical skills, pedagogical strategies, ethical awareness, and a growth mindset, the training ensures sustainable and responsible AI integration in diverse educational contexts.

4. Challenges and Mitigation Strategies

4.1 Challenges in Developing Teachers' AI Literacy

The integration of AI literacy into teacher professional development programs faces several significant challenges that hinder its adoption and effectiveness. One of the primary obstacles is resistance to technological change among educators. Teachers with traditional educational philosophies might be relatively resist to technological change and show low level of digital literacy [9]. Such resistance also exists for teachers' AI literacy. Additionally, time constraints pose a major challenge, as teachers already face heavy workloads, leaving little room for additional training in AI technologies. Without dedicated professional development time, efforts to enhance AI literacy may be difficult.

Another critical challenge is the lack of institutional support and resources. Some schools and educational institutions might lack the necessary infrastructure [1], such as high-speed internet, updated hardware, or access to AI-powered educational tools, which are

essential for hands-on training. Furthermore, limited funding for AI-related professional development programs restricts the availability of high-quality training opportunities. Even when resources are available, unequal access exacerbates disparities, with educators in rural areas being disproportionately disadvantaged [10].

Ethical and privacy concerns also present substantial barriers. Teachers may be hesitant to use AI tools due to uncertainties about data security, algorithmic bias, and the potential misuse of student information. Without clear policies or guidelines on AI ethics in education, educators may struggle to navigate these concerns effectively. Additionally, rapid technological advancements create a moving target for AI literacy training. The fast-paced evolution of AI tools means that training programs must be continuously updated, making it difficult for educators to stay current without ongoing support.

Finally, pedagogical misalignment can hinder effective AI integration. Some AI tools may not align with existing curricula or teaching philosophies, leading to superficial adoption rather than meaningful integration. Teachers may also lack the pedagogical knowledge to effectively incorporate AI into their instructional strategies, resulting in underutilization or misuse of these technologies. Addressing these challenges requires a multifaceted approach that combines policy support, institutional investment, and targeted professional development strategies.

4.2 Strategies to Mitigate Challenges

To overcome these barriers, a comprehensive and sustainable approach is necessary to support teachers in developing AI literacy. One key strategy is providing structured and flexible professional development programs. Training should be designed in modular formats, allowing teachers to engage at their own pace while accommodating their schedules. Blended learning models—combining online self-paced courses with in-person workshops—can enhance accessibility and reduce time constraints. Additionally, micro-credentialing (e.g., digital badges or certifications) can incentivize participation by offering tangible recognition of competency.

Institutional and policy support is crucial for fostering AI literacy. Educational leaders must

advocate for dedicated funding and resources to ensure equitable access to AI training. Governments and school districts should establish AI integration grants to subsidize professional development programs and provide schools with necessary technological infrastructure. Furthermore, clear ethical guidelines on AI use in education should be developed to address concerns about data privacy and algorithmic bias. These guidelines should be incorporated into teacher training to ensure responsible AI adoption.

To combat resistance to AI adoption, building teacher self-efficacy is essential. Training programs should include hands-on, experiential learning opportunities where educators can experiment with AI tools in low-stakes environments. Peer mentoring and communities of practice can also foster collaboration, allowing teachers to share best practices and troubleshoot challenges collectively. Showcasing success stories of AI integration in classrooms can help alleviate fears and demonstrate the tangible benefits of AI in education.

Another important strategy is ensuring pedagogical relevance in AI training. Professional development should emphasize AI's alignment with curriculum goals and demonstrate how AI can enhance, rather than replace, traditional teaching methods. Case studies and scenario-based learning can help teachers visualize practical applications of AI in their subject areas. Additionally, ongoing support mechanisms, such as AI help desks or online forums, can provide continuous assistance as teachers implement AI tools in their classrooms. Finally, addressing the digital divide is imperative to ensure equitable AI literacy development. Policymakers and institutions must prioritize funding for underserved schools, providing access to AI tools and training. Partnerships with technology companies and non-profit organizations can also help bridge gaps by offering subsidized or free AI resources. By implementing these strategies, educational stakeholders can create an enabling environment for teachers to develop AI literacy effectively and sustainably.

5. Conclusion

The rapid advancement of artificial intelligence has ushered in transformative possibilities for education, necessitating that teachers develop comprehensive AI literacy to navigate this

evolving landscape effectively. This paper has outlined the four core components of teachers' AI literacy—technical literacy, pedagogical literacy, ethical and societal literacy, and reflective and adaptive literacy—each of which plays a critical role in ensuring that educators can harness AI's potential responsibly and effectively. A systematic training framework has been proposed to address these dimensions through structured modules, emphasizing hands-on learning, ethical considerations, and continuous professional growth.

However, the path to widespread AI literacy among teachers is fraught with challenges, including resistance to change, lack of institutional support, ethical concerns, and rapid technological evolution. These barriers underscore the need for targeted mitigation strategies, such as flexible professional development models, policy advocacy, peer collaboration, and equitable resource distribution. Without such interventions, the benefits of AI in education risk being unevenly distributed, exacerbating existing disparities in access and quality.

Moving forward, collaboration among stakeholders—including policymakers, school administrators, teacher educators, and technology developers—is essential to create an ecosystem that supports AI literacy development. Future research should explore longitudinal studies on the impact of AI literacy training on teaching practices and student outcomes, as well as best practices for scaling these initiatives across diverse educational contexts. By prioritizing AI literacy in teacher professional development, the education sector can ensure that AI serves as a catalyst for innovation, equity, and enhanced learning experiences rather than a source of disruption or inequality.

Finally, fostering teachers' AI literacy is not merely about technological proficiency but about empowering educators to critically engage with AI, adapt to its advancements, and guide students in becoming informed and ethical users of AI. As AI continues to reshape education, investing in teachers' AI literacy will be a cornerstone of building a future-ready education system that leverages technology to its fullest potential while safeguarding ethical and pedagogical integrity.

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References

- [1] UNESCO. AI Competency Framework for Teachers. Paris: UNESCO, 2024.
- [2] U.S. Department of Education. Artificial Intelligence and the Future of Teaching and Learning. Washington, DC: U.S. Department of Education, 2023.
- [3] Sperling K, Stenberg J C, McGrath C , et al. In search of artificial intelligence (AI) literacy in teacher education: A scoping review. *Computers and Education Open*, 2024, 6100169-.
- [4] Kit T D N ,Lok K J L ,Wah K S C , et al. Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*,2021,2.
- [5] Carl M L, Alexandra A, Jana S , et al. Artificial intelligence literacy in higher and adult education: A scoping literature review. *Computers and Education: Artificial Intelligence*,2022,3.
- [6] Holmes, W., & Porayska-Pomsta, K. (Eds.). 2022. *The Ethics of Artificial Intelligence in Education: Practices, Challenges, and Debates* (1st ed.). New York: Routledge.
- [7] Lorena O C, Alejandro C, Carmen M F , et al. AI literacy in K-12: a systematic literature review. *International Journal of STEM Education*,2023,10(1).
- [8] Carl M L, Alexandra A, Jana S , et al. Artificial intelligence literacy in higher and adult education: A scoping literature review. *Computers and Education: Artificial Intelligence*,2022,3.
- [9] Alanoglu, M., Aslan, S., & Karabatak, S. (2022). Do teachers' educational philosophies affect their digital literacy? The mediating effect of resistance to change. *Education and Information Technologies*, 27, 3447-3466.
- [10] He C, Feng X Y. What kind of intelligent literacy do teachers need?—An analysis based on a survey of 33,800 teachers nationwide. *Primary and Secondary School Management*, 2025(04):23-27.