



## AI Literacy in Information Technology Education: Challenges, Competency Frameworks, and Curriculum Implications

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### ABSTRACT

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The rapid development of Artificial Intelligence (AI) requires educational systems to integrate new competencies that extend beyond basic technical skills. In the context of Information Technology Education (ITE), AI literacy emerges as a strategic competency encompassing conceptual understanding, applied skills, and ethical awareness in the use of AI-based technologies. Although various AI literacy frameworks have been developed globally, studies that systematically integrate competency dimensions, implementation challenges, and curricular implications within the ITE context remain limited, particularly in Indonesia. This study aims to synthesize the literature on the conceptual construction of AI literacy, identify challenges in its educational implementation, and outline implications for the development of an adaptive ITE curriculum. The research employs a Systematic Literature Review of national and international articles published between 2018 and 2026, sourced from indexed academic databases using structured selection criteria. The findings indicate that AI literacy is multidimensional, encompassing conceptual, applicative, and ethical dimensions that must be integrated with the strengthening of computational thinking and critical digital literacy. The primary challenges in implementation include limited teacher competencies, the rapid evolution of AI technologies, and infrastructural disparities. The novelty of this study lies in integrating global competency frameworks with the implementation context of ITE in Indonesia into a unified conceptual model. These findings provide a strategic foundation for the development of a competency-based ITE curriculum that is responsive to AI-driven digital transformation.

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### INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) over the past decade has transformed various sectors, including industry, public services, the digital economy, and education (Russell & Norvig, 2021; UNESCO, 2021). The integration of AI into recommendation systems, chatbots, facial recognition, and automated data analytics demonstrates that this technology is no longer experimental but has become an integral component of global digital infrastructure. This transformation requires educational systems not only to teach technological usage skills but also to equip learners with conceptual

understanding, evaluative capabilities, and ethical awareness regarding AI applications (Holmes et al., 2022; Long & Magerko, 2020).

Literacy is increasingly understood as a set of competencies that develop through contextual and interdisciplinary practices rather than merely basic reading and writing skills. In various professional and educational fields, literacy reflects the ability to apply knowledge, collaborate, and adapt within specific domains (Ahmad et al., 2024). In the context of Information Technology Education, AI literacy therefore requires not only conceptual knowledge but also practical and ethical competencies.

In the context of Information Technology Education (ITE), AI literacy has become an essential component of 21st-century competencies. AI literacy extends beyond technical skills such as programming or data processing; it includes understanding the principles of machine learning algorithms, analyzing system bias, and recognizing issues related to privacy and data security (Ng et al., 2021; Touretzky et al., 2019). UNESCO (2021) emphasizes that AI education should integrate contextual, technical, and ethical dimensions in a balanced manner. This perspective aligns with the framework of critical digital literacy, which stresses reflective and evaluative capacities in engaging with technology (Gilster, 1997; Belshaw, 2014).

In Indonesia, strengthening digital literacy has become a national priority through various digital education transformation policies (Kemendikbudristek, 2022). However, the integration of AI literacy into the ITE curriculum remains at an early stage. Several national studies indicate that teachers' readiness to integrate AI-based technologies is still limited, both in terms of technical competence and pedagogical capacity (Wibowo et al., 2022; Prasetyo & Sutopo, 2023). Other research highlights a gap between the needs of the digital industry and the competencies of graduates in information technology fields (Suryadi & Santoso, 2021; Lestari, 2023).

Theoretically, AI literacy can be explained through competency-based education frameworks, which emphasize the mastery of measurable skills relevant to workforce demands (Mulder, 2017). Additionally, the computational thinking approach (Wing, 2006) provides an important foundation for understanding how AI concepts can be integrated into ITE through algorithmic problem-solving. In Indonesia, computational thinking has begun to be incorporated into the informatics curriculum; however, the explicit integration of AI literacy remains insufficiently structured (Rahmawati & Nugroho, 2022).

Although research on AI in education has grown rapidly, most studies focus on AI as a learning support tool, such as adaptive learning systems or learning analytics (Zawacki-Richter et al., 2019; Holmes et al., 2022). Research that specifically addresses AI literacy as a core competency within Information Technology Education remains relatively limited and fragmented. In Indonesia, existing studies are generally descriptive or limited to institutional case studies, lacking comprehensive conceptual synthesis (Wibowo et al., 2022; Prasetyo & Sutopo, 2023).

Despite the growing number of studies on AI in education, most research still examines AI primarily as a technological tool rather than as a structured literacy competency within Information Technology Education. Furthermore, previous studies often focus on isolated aspects such as teacher readiness, AI-based learning tools, or curriculum design, without integrating these dimensions into a comprehensive framework. Therefore, a

systematic synthesis that connects competency frameworks, implementation challenges, and curriculum implications is still limited, particularly within the Indonesian ITE context.

This gap indicates the absence of systematic integration between AI literacy competency frameworks, implementation challenges, and curriculum alignment within the ITE context. Without structured synthesis, the integration of AI in education risks becoming reactive to technological trends rather than grounded in deliberate and adaptive curriculum design.

Based on this background, this study seeks to address the following questions: How does the literature define and construct AI literacy competency frameworks in education? What are the primary challenges in implementing AI literacy within Information Technology Education in Indonesia? And how can adaptive curriculum implementation be developed to integrate AI literacy effectively in ITE?

Accordingly, this research aims to conduct a systematic literature review to synthesize AI literacy competency frameworks, identify implementation challenges in ITE, and formulate competency-based curriculum implications that are adaptive to AI technological developments.

The novelty of this study lies in integrating global perspectives on AI literacy with the implementation context of Information Technology Education in Indonesia. Unlike previous research that positions AI primarily as a learning support tool, this study conceptualizes AI literacy as a core curricular competency in ITE that requires systematic and contextual design. Therefore, this research is expected to contribute conceptually to policy development and curriculum reform in ITE that is responsive to the era of AI-driven digital transformation.

## **METHOD**

This study employs a Systematic Literature Review (SLR) approach to obtain a comprehensive understanding of Artificial Intelligence (AI) literacy within the context of Information Technology Education (ITE), particularly concerning competency frameworks, implementation challenges, and curriculum development implications. The SLR approach was selected because it enables a structured, transparent, and replicable review process, thereby producing findings with greater objectivity and validity compared to conventional narrative reviews (Tranfield, Denyer, & Smart, 2003; Kitchenham & Charters, 2007). Furthermore, this method aligns with the study's objective of integrating diverse perspectives, conceptual frameworks, and empirical findings into a unified analytical framework.

The literature search was conducted through international and national academic databases to ensure balanced representation between global and Indonesian contexts. The databases included Scopus, Web of Science, Google Scholar, as well as Indonesia's nationally indexed journal portals SINTA and Garuda. The selection of these databases was based on considerations of academic credibility and broad publication coverage in the fields of education and information technology. The publication period was limited to 2018–2026, reflecting the rapid advancement of AI over the past decade and the increasing attention to AI literacy in education.

The search strategy employed combinations of keywords in both English and Indonesian, including “AI literacy,” “Artificial Intelligence education,” “AI competency framework,” “AI curriculum,” “literasi kecerdasan buatan,” “Pendidikan Teknologi Informasi,” and “kurikulum AI Indonesia.” These keywords were combined using Boolean operators (AND and OR) to ensure comprehensive yet focused results, specifically targeting AI literacy as a competency rather than merely the use of AI as an instructional tool.

The inclusion criteria comprised peer-reviewed scholarly articles published within the specified timeframe that explicitly addressed one or more of the study’s three primary dimensions: AI literacy competency frameworks, implementation challenges in education, or curriculum development implications. Articles that discussed AI solely as a learning technology without conceptual engagement with AI literacy or competencies were excluded. Additionally, sources unavailable in full text or consisting of popular opinion pieces without scientific methodology were not included.

The literature selection process was conducted in stages, following the principles of transparency and accountability recommended by the PRISMA guidelines (Moher et al., 2009). The initial stage involved identifying all articles retrieved from the database searches. This was followed by title and abstract screening to assess relevance to the research focus. Articles meeting the preliminary criteria underwent full-text review to ensure substantive alignment with AI literacy competency frameworks, implementation challenges, and curriculum implications within ITE. Articles that passed this stage were designated as primary sources for analysis.

Data analysis was conducted using a thematic analysis approach aligned with the research questions. Each selected article was categorized into three main analytical dimensions. The first dimension addressed the conceptual construction of AI literacy, including definitions, competency models, and theoretical frameworks. The second dimension focused on implementation challenges, encompassing teacher readiness, institutional capacity, infrastructural disparities, and educational policy dynamics. The third dimension examined curriculum design implications for ITE, including competency-based approaches, cross-disciplinary integration, and adaptive curriculum models responsive to technological advancements.

During the synthesis process, cross-study comparisons were conducted to identify consistent patterns, divergent approaches, and existing research gaps. The analysis was not merely descriptive but also critical, taking into account research contexts, methodological approaches, and the limitations of individual studies. This approach enabled the development of a conceptual model of AI literacy tailored to the context of Information Technology Education in Indonesia, as outlined in the study’s objectives.

Through this methodological procedure, the study seeks to produce a systematic, comprehensive, and contextualized literature synthesis capable of providing a strong conceptual foundation for the development of AI literacy-based curricula in Information Technology Education.

## **RESULT AND DISCUSSION**

The synthesis of the selected literature indicates that Artificial Intelligence (AI) literacy

in Information Technology Education (ITE) is constructed as a multidimensional competency that extends beyond purely technical skills. This finding aligns with the definition of AI literacy proposed by Long and Magerko (2020) and the AI4K12 framework (Touretzky et al., 2019), which conceptualize AI literacy as a combination of conceptual understanding, applied capabilities, and ethical-social awareness. Across the reviewed literature, these three dimensions consistently emerge, albeit with varying emphases.

In the conceptual dimension, the literature highlights the importance of understanding fundamental machine learning principles, data structures, model training processes, and the limitations of AI systems. This perspective is consistent with the computational thinking framework (Wing, 2006), which emphasizes problem decomposition, pattern recognition, abstraction, and algorithm design. Within the ITE context, integrating AI literacy not only expands curricular content but also deepens computational thinking as a foundation for analyzing intelligent systems. Thus, AI literacy functions as an extension of existing computational competencies rather than as a standalone subject.

The second dominant dimension in the literature concerns applied capabilities. Several studies emphasize the importance of hands-on experience in building simple data-driven models or interpreting AI system outputs (Holmes et al., 2022; Ng et al., 2021). This approach aligns closely with competency-based education principles (Mulder, 2017), which stress the mastery of measurable skills through authentic practice. In ITE, project-based and problem-based learning approaches are considered effective in simultaneously integrating contextual and applied aspects. The literature suggests that when students not only understand theoretical foundations but also engage in data experimentation and model simulations, deeper conceptual understanding is achieved.

The third dimension receiving increasing attention is the ethical and social aspect. Both global and national literature indicate that issues such as algorithmic bias, data privacy, information security, and system accountability are integral components of AI literacy (UNESCO, 2021; Holmes et al., 2022; Wibowo et al., 2022). From the perspective of critical digital literacy (Belshaw, 2014), the ability to critically analyze and evaluate technological implementation is a crucial educational objective. The synthesis shows that without integrating this dimension, AI literacy risks being reduced to technical training that neglects social responsibility. Therefore, AI instruction within ITE should be accompanied by reflective discussions on the social and policy implications of technology.

Beyond the conceptual construction of AI literacy, the literature also reveals several significant implementation challenges. The first challenge relates to teacher readiness. Several studies indicate that many information technology educators lack sufficient competence to systematically teach AI concepts (Chiu & Chai, 2020; Prasetyo & Sutopo, 2023). This gap is not only technical but also pedagogical, particularly in designing meaningful AI-based project learning activities. These findings suggest that strengthening AI literacy cannot be separated from professional teacher development.

The second challenge concerns curriculum dynamics. The rapid evolution of AI technologies causes learning materials to become outdated quickly, while formal curriculum structures tend to adapt more slowly (Holmes et al., 2022). In Indonesia, some studies indicate that AI integration in the ITE curriculum remains partial and lacks clearly defined competency standards (Wibowo et al., 2022; Lestari, 2023). This situation creates

misalignment between digital industry demands and graduate competencies.

The third challenge involves infrastructure disparities and foundational digital literacy gaps. National literature indicates that access to computing devices and AI-based learning resources remains uneven across regions (Kemendikbudristek, 2022). Without inclusive integration strategies, this condition risks widening educational inequalities.

Based on the synthesis of these challenges, the literature emphasizes the importance of adaptive and modular competency-based approaches. The integration of AI literacy into ITE should be implemented progressively – beginning with strengthening fundamental concepts of data and algorithms, followed by exploration of simple applications, and culminating in ethical and social reflection. A modular curriculum model allows periodic content updates without fundamentally restructuring the entire curriculum. This approach is consistent with competency-based education principles emphasizing relevance and sustainability.

Furthermore, the literature highlights the importance of collaboration between educational institutions and the technology industry to ensure alignment between competencies and labor market needs (Suryadi & Santoso, 2021). Integrating AI literacy into ITE aims not only to produce graduates capable of using technology but also individuals able to critically participate in the development and evaluation of AI systems.

Based on the synthesis, this study proposes a conceptual model of AI literacy in Information Technology Education that integrates three primary components: conceptual understanding, applied competencies, and ethical awareness (Long & Magerko, 2020; Ng et al., 2021; Laupichler et al., 2022; El-dosuky, 2024; Kong et al., 2021). These components interact within curriculum design, teacher capacity, and institutional readiness, reflecting the need for systematic integration of AI literacy within educational ecosystems and curriculum innovation (Mahmud et al., 2025); Chiu et al., 2021).

Overall, the synthesis indicates that AI literacy in Information Technology Education should be understood as an integrative competency encompassing conceptual, applied, and ethical dimensions. Implementation challenges require strengthening teacher capacity, developing adaptive curricula, and ensuring equitable infrastructure. By integrating global competency frameworks with national implementation contexts, this study emphasizes that AI literacy integration in ITE requires a systemic approach rather than merely adding new content to existing curricula.

## **CONCLUSION**

This systematic literature review demonstrates that Artificial Intelligence (AI) literacy in Information Technology Education (ITE) constitutes a multidimensional competency encompassing conceptual understanding of AI principles, applied skills in developing and evaluating data-driven systems, and ethical and social awareness regarding technological implications.

The study also identifies several major challenges in implementing AI literacy, including limitations in teachers' pedagogical and technical competencies, insufficiently adaptive curriculum structures, and digital infrastructure disparities. These challenges indicate that integrating AI literacy into ITE requires a systemic approach involving professional capacity development for educators, competency-based curriculum reform, and

sustained policy support.

The primary implication for ITE curriculum development is the need for an adaptive and modular model that integrates conceptual, applied, and ethical dimensions in a structured and progressive manner. Through competency-based and authentic practice-oriented approaches, AI literacy can become a core competency that enhances the relevance of ITE in the era of digital transformation. Contextually, this study underscores that strengthening AI literacy is not merely a response to technological trends but a strategic necessity to prepare graduates who are competent, critical, and responsible participants in the AI-driven ecosystem.

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