Pedagogical Framework for AI Literacy: Bridging theory and practice.

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In the rapidly evolving landscape of education, Artificial Intelligence (AI) is significantly reshaping teaching and learning, preparing the next generation for 21st-century challenges (Dwivedi et al., 2021; Ng et al., 2023). The increasing influence of AI in schools necessitates that teachers possess the essential knowledge and skills to effectively use, design with, and integrate AI literacy into their curriculum (Kreinsen & Schulz, 2023). As AI-powered experiences and applications become integral to everyday personal and professional life, AI literacy is increasingly crucial as a component of K-12 digital literacy and digital citizenship.

This theoretical analysis introduces a pedagogical framework for integrating AI literacy (Lyublinskaya & Du, 2025) into teaching and learning across disciplines in K-12 education. Moving beyond traditional, programming-centric approaches, this framework offers educators practical strategies for incorporating AI literacy across grade levels and subject areas, fostering interdisciplinary connections. The framework is built upon three key theoretical foundations: the Five Big Ideas in AI (AAAI & CSTA, n.d.), which define core AI concepts; the human-centered design process (IDEO, 2015), providing a structured methodology for teaching with AI; and the Science of Learning and Development (SoLD) framework (https://soldalliance.org/), ensuring inclusivity and accessibility.

The Five Big Ideas in AI, developed by the AI for K-12 initiative as national guidelines for K-12 AI education in the United States, are: perception, representation and reasoning, learning, natural interaction, and social impact (Touretzky et al., 2022). Perception refers to how computers perceive the world by gathering data from various sensors. Representation and reasoning refer to how agents construct representations using data structures, and how these representations support reasoning algorithms that derive new information from what is already known. Learning (or machine learning) refers to how computers learn from data and make predictions. Natural interaction refers to communication between humans and machines that feels intuitive, effortless, and similar to how people interact with each other. Finally, societal impact refers to how AI can impact society in both positive and negative ways.

Human-centred design is an iterative problem-solving approach that prioritizes the needs and experiences of the end-user. It involves in-depth understanding through empathy, user involvement throughout the design process, and the creation of tailored solutions through cycles of research, ideation, prototyping, testing, and refinement (IDEO, 2015).

The SoLD framework synthesizes evidence from learning sciences and educational research on effective strategies that foster essential relationships and learning experiences to enhance students' health, development, and transferable skills (Darling-Hammond et al., 2020). It outlines five fundamental principles for optimal learning environments: positive developmental

relationships; safe and belonging environments; rich learning experiences and knowledge development; the development of skills, habits, and mindsets; and integrated support systems.

The development of this pedagogical framework for AI literacy integration followed Jabareen's (2009) multi-phase iterative process, which included: identifying and mapping literature; initial categorization of sources to identify core AI concepts; deconstructing and categorizing these concepts; integrating foundational AI concepts with design thinking and learning science principles; and synthesizing core AI concepts and literacy indicators into an initial framework. The framework was then refined through iterative cycles of expert validation and pilot testing to ensure alignment with learning science principles and real-world applications. This process resulted in a practical, evidence-based model with three fundamental processes: Design, Create, and Reflect (DCR model). The Design process positions students as designers and encourages student-led initiatives within student-centered, authentic learning experiences. The Create process emphasizes learning experiences where students become active problem-solvers, applying knowledge to real-world challenges. Finally, the Reflect process fosters students' critical awareness of AI's societal impacts and provides basis for discussing its ethical and societal implications.

Through concrete examples, this paper bridges the gap between theory and practice and demonstrates how to design lessons that integrate core AI concepts into existing K-12 curriculum across different grade bands. This empowers educators to cultivate AI literacy, preparing students to become informed, responsible, and innovative contributors in the age of AI.

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