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# Editorial: From Policy to Pedagogy – Building Human-Centered AI Literacy Across Educational Contexts

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**Abstract.** This editorial connects policy framework suggestions for AI literacy in elementary and secondary schools and the papers published in this special issue. The suggested framework emphasizes a human-centered vision for AI education, encompassing four domains for students – Human-Centered Mindset, AI Ethics, AI Technology and Application, and AI System Design – and five dimensions for teachers, including AI-Empowered Pedagogy and Professional Development, aligning with UNESCO AI Competency Frameworks for Students and for Teachers. Collectively, the featured papers illustrate how this policy vision can be enacted through evidence-based practice: a systematic review of AI in primary education highlights pedagogically grounded, equity-driven approaches; an empirical study on an ethical reasoning curriculum demonstrating how responsible AI thinking can be taught and assessed; a constructionist review showcases hands-on, design-based strategies that foster active learning and creativity; a qualitative study on generative AI in the applied arts reveals new professional literacies for an AI-augmented creative economy; a GenAI-integrated data-science course illustrates how usability, reliability, privacy, and ethics can be woven into disciplinary learning; a survey of preservice STEM teachers identifies affective and experiential predictors of AI self-efficacy for educators; a Structured Controversy platform shows how debate and case-based reasoning can cultivate nuanced ethical judgment in computer science students; and a problem-based mathematics course demonstrates how we can teach students to discern which types of AI tools can better support different problem-solving tasks in real-world business contexts. Together, these studies illuminate a coherent pathway from policy to practice – one that advances human-centered, ethical, and sustainable AI literacy across lifelong learning and development.

**Keywords:** AI literacy, human-centered education, ethics in AI, constructionist learning, generative AI, policy and practice.

## 1. Introduction

Many regions like Taiwan have recently outlined a forward-looking blueprint for AI literacy in elementary and secondary schools, positioning education as a catalyst for cultivating human-centered, ethical, and innovative engagement with artificial intelligence. The framework emphasizes AI literacy for both students and teachers, structured around four dimensions for students – Human-Centered Thinking, AI Ethics, AI Technology and Application, and AI System Design – and five parallel dimensions for teachers, extending to AI-Empowered Pedagogy and AI in Professional Development (Hsu *et al.*, 2026). This vision resonates with global movements toward responsible and inclusive AI education, as championed by the UNESCO AI Competency Frameworks for Teachers and Students and similar frameworks by other international organizations (Miao and Cukurova, 2024; Miao, Shiohira and Lao, 2024).

The UNESCO AI Competency Framework for Students, published in 2024, presents a globally applicable framework intended to help education systems prepare young people to engage responsibly, creatively, and critically with artificial intelligence. The framework is built on the premise that AI is increasingly integrated into all dimensions of society, economy and culture, and that students should not merely be passive users but empowered co-creators of AI environments. It is grounded in UNESCO's core values of human rights, inclusion, sustainability and dignity. The framework is also designed to embed AI-related competencies across curricula rather than confining it to isolated technology modules (Miao and Cukurova, 2024; Miao, Shiohira and Lao, 2024).

The UNESCO framework defines four inter-related competency aspects, or domains, for students:

(1) Human-centered mindset: emphasizing the student's understanding of their own agency, the social and cultural dimensions of AI, human-machine collaboration, accountability, and citizenship in the AI era.
(2) Ethics of AI: addressing the moral, legal, and sociotechnical implications of AI systems.
(3) AI techniques and applications: foundational knowledge of AI (i.e. data, models, algorithms), understanding how AI is applied in society, and the ability to use AI tools appropriately.
(4) AI system design: scoping problems, designing AI solutions, iterating through feedback loops, and understanding the life-cycle of AI systems in the real world (Miao, Shiohira and Lao, 2024).

These four aspects are arranged across three progressive levels of mastery: Understand, Apply, and Create. The framework also emphasises that infrastructure, teacher professional development, and equity considerations (i.e. access, diversity, and representation) are foundational to successful implementation (Ireland Department of Education, 2022).

Yet translating policy frameworks into classroom realities requires empirical grounding, pedagogical creativity, and cross-disciplinary insight (Hsu and Hsu, 2025). The ar-

ticles featured in this issue – ranging from systematic reviews and design-based studies to constructionist and creative industry analyses – offer concrete pathways for realizing the human-centered aspirations of these frameworks. Together, they illustrate how AI literacy education can evolve from conceptual aspiration to pedagogical practice across diverse learners and contexts.

## 2. Rethinking Foundations: Systematic Insights from Primary Education

The article "*Artificial Intelligence in Primary Education: A Systematic Literature Review 2020–2025*" provides the empirical foundation for policy realization in early schooling. Synthesizing 94 studies from eleven countries, it identifies four major domains shaping AI in primary education – student learning, teacher development, ethical inclusion, and learner agency. Its findings reinforce the call for human-centered AI education: AI is most effective when it augments teacher decision-making, scaffolds metacognition, and supports diverse learners rather than replacing human judgment.

This evidence echoes the policy emphasis on AI as a tool for self-realization and ethical engagement, revealing that successful implementation depends less on technological access and more on pedagogically grounded, equity-driven, and teacher-mediated practices (Department for Education and Youth, 2025). By connecting global research with local policy aims, the review highlights that sustainable AI literacy must begin in the primary years – through inquiry, collaboration, and contextual sensitivity.

## 3. Ethics at the Core: Measuring Responsible AI Thinking

The second paper, "*Ethical Thinking: Integration and Measurement in an AI Curriculum for Middle–High School Students*," delves into AI Ethics, a pillar of many AI education frameworks, including those of Taiwan's and UNESCO's. Through the Responsible AI for Computational Action (RAICA) curriculum, it demonstrates how ethical reasoning can be embedded and empirically assessed within AI project-based learning. Students engage in identifying stakeholders, evaluating societal impacts, and reflecting on design values such as fairness, transparency, and accountability (European Commission, 2022).

Importantly, the study advances the field by developing scalable instruments to measure ethical reasoning, bridging a critical policy gap between conceptual advocacy and classroom assessment. This aligns with equipping youth not only with technical understanding but also the moral imagination to deliberate on AI's societal roles. By foregrounding ethical reflection as a continuous process – rather than an add-on – the study exemplifies how adolescent learners can evolve from passive consumers of AI to reflective, responsible co-creators.

## 4. Learning by Making: Constructionism and Hands-On AI Literacy

The third contribution, "*Constructing AI Literacy: A Hands-On Approach for School Children*," links directly to the policy's AI System Design and AI Technology and Application strands. Through a narrative synthesis of studies spanning 2009–2024, it proposes a constructionist framework for AI literacy, grounded in Papert's learning-by-making philosophy. The review identifies five pedagogical pillars – hands-on experimentation, project-based inquiry, ethical integration, age-appropriate scaffolding, and teacher support.

This emphasizes design thinking and learner agency, suggesting that AI education flourishes when students actively build, test, and iterate their own intelligent systems (Hsu and Lin, 2025). From block-based programming to embodied AI simulations, constructionist environments empower children to move from abstract understanding to creative application. The paper thus bridges AI literacy with computational thinking 2.0, offering teachers tangible strategies for humanizing AI learning through creation and reflection.

## 5. Extending AI Literacy Beyond Schools: Generative AI in the Applied Arts

"*Generative AI in the Applied Arts: Workflow Transformations, Evolving Professional Roles, and Emerging Skill Sets*," extends the conversation into lifelong and professional AI literacy. Through interviews with creative professionals, it reveals how generative AI reshapes authorship, identity, and ethical responsibility in design, film, and digital media. Participants describe AI as a co-creator that accelerates ideation while simultaneously provoking tensions around authenticity, bias, and cultural representation.

These insights parallel the global frameworks' emphasis on teacher and professional development, emphasizing that AI literacy extends beyond technical competence to include critical awareness, cultural sensitivity, and ethical stewardship. The study also underscores the importance of cultivating adaptive mindsets – trust, reflective practice, and interdisciplinary collaboration – which are essential for educators guiding students into AI-augmented creative futures (Organisation for Economic Co-operation and Development, 2025).

## 6. Integrating Generative AI into Inter-Disciplinary Learning: A Data-Science Based Model for GenAI Literacy

"*GenAI-Assisted Data Science Course to Promote GenAI Literacy for Non-Computing Students*" advances the discussion of AI literacy in higher education by presenting a fully integrated approach to GenAI literacy within a data science course for non-computing students. Rather than treating AI literacy as an add-on, the course design embeds generative AI across assessments, lectures, and reflective tasks to cultivate competencies in usability, reliability, privacy, and ethics–a structure closely aligned with UNESCO's

student competency aspects. The study seeks to demonstrate how scaffolded exposure to GenAI tools can promote a nuanced understanding of AI's strengths and limitations. Students used AI to generate code, validate data, refine explanations, and critique outputs while being required to acknowledge AI use and align outputs to their own reasoning and programming style. Complementing these AI-enabled tasks, certain assessments prohibited GenAI assistance to prevent over-reliance and support accurate measurement of individual competence.

Findings from 113 students show substantial gains in students' understanding of GenAI behaviors, enhanced ability to critique and adapt AI-generated code, and reduced tendencies toward AI misuse. The course design also offers a replicable model for other institutions seeking to integrate GenAI literacy across non-computing disciplines while tying the course to the students' disciplines of origin. By positioning generative AI as both a learning partnership tool and an object of critique, the study illustrates how higher education can cultivate practical and ethical fluency to expand data science education to a broader student base.

## 7. Preparing Future Educators: AI Literacy and Self-Efficacy among Preservice STEM Teachers

"*Investigating preservice STEM teachers' AI literacy and self-efficacy beliefs: Are they ready for AI?*" extends AI literacy discourse into the crucial domain of teacher preparation, examining AI literacy, attitudes, and self-efficacy among 180 preservice STEM teachers in Türkiye. Using a performance-based AI literacy test by Hornberger *et al.* and validated psychometric scales, the study identifies both strengths and gaps in future educators' readiness to integrate AI meaningfully into instruction. Findings showed that preservice teachers' self-efficacy in AI is strongly predicted by interest in AI, positive attitudes, and frequency of AI use, rather than demographic, academic, or cognitive factors.

The study underscores the need for teacher education programs to move beyond basic conceptual exposure and offer hands-on, classroom-embedded opportunities to practice interacting with AI tools. The authors argue that strengthening preservice teachers' AI self-efficacy is essential for responsible AI integration in schools, positioning critical evaluations of hands-on experiences–not only technical skill or general knowledge about AI–as drivers of pedagogical innovation (Hsu *et al.*, 2026). This work contributes an important empirical foundation for shaping teacher-first AI literacy standards and professional development in teacher preparation (Miao and Cukurova, 2024).

## 8. Cultivating Ethical Reasoning for Real-World AI: Structured Controversy and Case-Based Learning

"*Real-World AI Ethics Preparation: A Debate and Case-Study Platform*" introduces EthicsDebateAI, an online platform that prepares computer science undergraduates for the ethical challenges of AI development through structured debate, authentic case studies,

and collaborative synthesis. Centered on the Structured Controversy model, the platform immerses students in multi-perspective ethical deliberation: researching opposing viewpoints, engaging in rebuttals, switching sides, and co-constructing shared recommendations. Students demonstrated gains in ethical reasoning, increased confidence in facing real-world AI dilemmas, and high satisfaction with the course. Qualitative analysis also showed growth in perspective-taking, analytical nuance, and recognition of AI's sociotechnical complexity.

The study exemplifies policy recommendations on AI ethics education by shifting ethics education from abstract principles to dialogic, situated, and decision-oriented practice. Particularly valuable is the platform's emphasis on professional identity development: students learn to reason not just about ethics generally, but as future practitioners shaped by organizational, societal, and technical constraints. In doing so, the intervention models a scalable, pedagogically rigorous approach to preparing ethically grounded AI professionals.

## 9. AI Integration in Applied Mathematics Education: Problem-Based Learning Using AI Tools

"*AI Literacy in the Classroom: Transforming Education through Educational Technologies*" explores a novel pathway into AI literacy by integrating AI tools into mathematics instruction for business students through problem-based learning. Situated in a Latin American educational context where traditional pedagogies have remained unchanged for decades, the study demonstrates how tools such as matrix calculators and large language models (LLMs) can modernize mathematics education while cultivating AI-related skills. The instructional design asked students to apply mathematics to real-world business decision-making tasks, use AI tools to generate and critique quantitative analyses, and ultimately create a digital magazine articulating their findings. This approach developed students' abilities to evaluate AI outputs, construct data-driven arguments, and understand the practical interplay between mathematical modeling and AI-assisted reasoning.

The findings highlight both possibilities and limitations of AI in STEM learning for non-STEM students: while the LLMs excelled in generating explanations and arguments, it was less reliable for precise computation, underscoring the need for combined tool ecosystems in computational use cases (Hsu and Lin, 2025). The study showcases an interdisciplinary and transferable model for embedding AI literacy into core subjects, enabling students to bridge numerical reasoning, computational tools, and authentic workplace applications in non-STEM disciplines.

## 10. Toward a Human-Centered Ecosystem for AI Literacy

Taken together, these studies offer a coherent roadmap for enacting a human-centered AI literacy policy across the educational continuum. From primary classrooms that introduce AI through inquiry and adaptive feedback, to secondary curricula embedding ethics and

responsible design, to hands-on maker pedagogies fostering creative agency, and finally to professional practices redefining creative literacy in the era of generative AI – each paper demonstrates that AI literacy is not a singular subject but an evolving ecosystem.

At its heart lies a human-centered ethos: ensuring AI serves learning, empathy, and societal well-being. Policymakers and educators alike must therefore focus not merely on adopting AI tools, but on nurturing reflective, ethical, and creative capacities among learners and teachers. Through research-driven practice, these models of AI literacy education can serve as a blueprint for global efforts to harmonize technological fluency with humanistic responsibility.

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