Designing AI Literacy Curricula for Higher Education: A Comparative Framework

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ABSTRACT

Artificial Intelligence (AI) has become a defining force in education, transforming how knowledge is created, evaluated, and shared. However, universities still face challenges in integrating AI literacy effectively into their curricula. Current efforts, opinions, and ideas vary widely. Some concentrate on technical skills, while others emphasise ethics or social impacts, often without pedagogical alignment or supporting research. This study offers a **Structured Literature Review (SLR)** of **87 peer-reviewed sources** (2018–2025) from Scopus-indexed journals, including Computers & Education, AI & Society, British Journal of Educational Technology, Nature Machine Intelligence, and the International Journal of Artificial Intelligence in Education. The SLR synthesises conceptual, pedagogical, and governance perspectives to create the **AI Literacy Design Matrix (AILDM).** This matrix serves as a comparative framework identifying four interconnected curriculum design dimensions: conceptual, ethical, productive, and participatory. The review reveals that, although higher education worldwide acknowledges the importance of AI literacy, most programmes remain fragmented, with limited integration of ethics or civic aspects. The AILDM proposes a framework for designing balanced curricula that foster understanding, creativity, and responsibility. The paper concludes that AI literacy should be regarded as a civic and epistemic infrastructure, and therefore integrated across disciplines rather than confined to computer science.

Keywords: AI literacy; higher education; curriculum design; structured literature review; comparative framework; digital transformation; ethics in AI.

INTRODUCTION

Artificial Intelligence is not a peripheral technology. It has become a pervasive condition of academic life that can't be ignored or eliminated. Algorithms increasingly shape research discovery, administrative decision-making, and pedagogical interaction (Selwyn 2022; Williamson 2023). Higher education faces an epistemic shift as a result of this. Consequently, students and faculty now inhabit an ecosystem where knowledge is co-constructed with intelligent systems. The capacity to understand, critique, and co-create with these systems defines a new form of literacy, namely **AI literacy** (Long & Magerko 2020; Ng et al. 2021). However, no AI system operates without a human prompt. Whilst enthusiasm for AI integration in universities is strong, conceptual coherence is weak. Governments and professional bodies have begun issuing frameworks—UNESCO (2023), OECD (2021), European Commission (2022). Notwithstanding, the different local implementations vary dramatically. Some institutions embed AI ethics into general-education modules (Holmes et al. 2019), whilst others launch coding boot camps, and many remain in exploratory stages. Without alignment between philosophical values, technical capability, ethical reflection, and civic engagement, "AI literacy" risks becoming a buzzword detached from learning outcomes.

The objective of this paper is therefore to **clarify and operationalise AI literacy** for curriculum design in higher education and to add at least a window of clarity in the evolving schools of thought surrounding AI literacy. It does so through a **Structured Literature Review (SLR)** analysing 87 academic sources published between 2018 and 2025 across leading education and technology journals.

Three questions guide the study:

1. How is AI literacy conceptualised in recent higher-education scholarship?

2. What pedagogical and ethical models underpin existing curricula?
3. How can comparative analysis inform a coherent framework for curriculum design?

The review synthesises these findings into the **AI Literacy Design Matrix (AILDM)**—a tool that helps educators balance conceptual, ethical, productive, and participatory learning goals. By articulating these dimensions, the paper extends current scholarship beyond fragmented perspectives toward an integrative, actionable framework.

LITERATURE REVIEW

From Digital to AI Literacy

The genealogy of AI literacy can be traced through the evolution of digital and data literacies. Early theorists such as Gilster (1997) and Bawden (2008) defined digital literacy as the capacity to locate, evaluate, and create information using digital technologies. As big data emerged, attention shifted to "**data literacy". Data Literacy** is the ability to interpret and communicate with data critically (Wolff et al. 2016; Prado & Marzal 2013). AI literacy extends this trajectory into systems that *learn and act*, demanding epistemic understanding of algorithms and their societal consequences (Long & Magerko 2020; Ng et al. 2021).

Luckin et al. (2016) argued that education must move from *learning with* AI to *learning about* AI. Holmes, Bialik and Fadel (2019) later proposed four pillars: knowledge, skills, character, and meta-learning, contending that AI literacy must cultivate ethical and adaptive reasoning alongside technical ability. Floridi (2019) and Dignum (2019) positioned AI literacy as a moral and epistemological competence, suggesting an awareness of how information systems shape human agency. Druga et al. (2023) found that students frequently anthropomorphise AI, attributing autonomy where none exists. Such misconceptions underline the need for curricula that teach not only *what AI does* but *how it knows*. In this sense, AI literacy merges cognitive insight with philosophical reflexivity.

Pedagogical Models and Learning Theories

AI literacy education draws upon constructivist and socio-cultural pedagogies that emphasise active, contextual learning (Vygotsky 1978; Bruner 1966). Students learn effectively when they engage with AI tools to solve authentic problems, reflect on outcomes, and iterate, thus mirroring AI's own learning processes (Holmes et al. 2019). Design-based research demonstrates that project-centred approaches encourage deeper conceptual understanding (Chan et al. 2021; Nørgård 2022). For example, Amershi et al. (2019) recommend *human-AI collaboration projects* where learners co-design interfaces or evaluate model outputs. Such experiential strategies bridge abstract theory with ethical application.

However, pedagogy must address the *affective* dimension as well. Students often experience both fascination and anxiety toward AI (Henrickson 2021). Educators must therefore foster emotional resilience and moral reasoning, guiding learners to see AI as a tool for empowerment rather than a threat (Shneiderman 2022; Selwyn 2022). Integrating reflection journals, ethical debates, and peer evaluation helps balance technical confidence with ethical sensitivity.

Curriculum Frameworks and Institutional Responses

International frameworks increasingly specify AI literacy goals for education systems. The **UNESCO Guidance for Generative AI in Education and Research (2023)** highlights human-centred design and equitable access. The **OECD Digital Education Outlook (2021)** supports lifelong learning policies that incorporate AI literacy across different disciplines. The **European Commission's DigComp 2.2 (2022)** integrates AI-related skills into the wider digital-skills framework, connecting them with critical thinking and citizenship.

At the institutional level, initiatives such as the **MIT Teaching Systems Lab's AI Literacy Initiative** (2020) and **UCL Knowledge Lab's AI for Education project** (Luckin 2021) demonstrate cross-disciplinary curriculum design. In Asia, the **National University of Singapore's AI Innovation Programme** integrates

ethics and entrepreneurship (Lim et al. 2021). Meanwhile, Nordic universities emphasise transparency and explainability, reflecting regional commitments to participatory governance (Hakkarainen & Hietajärvi 2022).

Despite these advances, gaps still exist. Williamson (2023) and Selwyn (2022) point out that many universities treat AI ethics as optional, separate from core curricula. Professional-development gaps among faculty further impede adoption (Chan & Yuen 2023). The literature consistently advocates for a holistic approach, where AI literacy is embedded within institutional culture, assessment design, and teacher training (Chan et al. 2021; OECD 2023).

Ethical and Societal Perspectives

Beyond pedagogy, AI literacy encompasses ethical awareness and civic and academic engagement. Scholars such as Rahwan (2018), Benjamin (2019), Noble (2018), and Buolamwini & Gebru (2018) emphasise algorithmic bias and systemic inequality, arguing that critical literacy must involve an understanding of power. Ruha Benjamin's Race After Technology (2019) and Safiya Noble's Algorithms of Oppression (2018) demonstrate how AI systems perpetuate social hierarchies. These insights expand literacy from individual skills to collective responsibility. Floridi (2019) introduces the notion of the **infosphere**, in which human and artificial agents co-create informational realities; here, literacy implies ethical navigation within this shared environment. Similarly, Crawford's *Atlas of AI*(2021) exposes the environmental and labour costs of AI, linking literacy to sustainability ethics. Scholars agree on three key principles: transparency, accountability, and participation (Whittlestone et al. 2019; Jobin et al. 2019). In higher education, this means developing curricula that enable students to challenge datasets, critique algorithmic decisions, and participate in policy discussions.

Summary of Gaps

Across these studies, two persistent issues emerge:

1. **Fragmentation**: AI literacy initiatives often address only one dimension (technical or ethical) without integrating others.
2. **Lack of comparative analysis**: Only a few frameworks systematically examine cross-regional curricular differences.

The present review addresses both aspects by analysing 87 peer-reviewed studies through an integrative comparative lens, resulting in the AI Literacy Design Matrix (AILDM) as a unified model.

METHODOLOGY

Structured Literature Review Design

This study employed a **Structured Literature Review (SLR)** to ensure transparency and replicability (Denyer & Tranfield, 2009; Snyder, 2019). The SLR synthesised findings from **87 peer-reviewed articles and reviews** published between 2018 and 2025 in Scopus-indexed journals. Following Torraco (2005) and Boell & Cecez-Kecmanovic (2015), the process combined systematic search strategies with interpretive synthesis to integrate theoretical, empirical, and pedagogical insights.

Search Strategy and Data Sources

Searches were conducted across **SpringerLink, Scopus, ERIC, ScienceDirect, Taylor & Francis Online, and Wiley Online Library** using combinations of the keywords: "AI literacy," "artificial intelligence education," "curriculum design," "higher education," "ethical AI," and "learning analytics." The corpus included studies from journals such as *Computers & Education*, *AI & Society*, *British Journal of Educational Technology*, *Educational Technology Research & Development*, *Computers in Human Behaviour*, *Ethics and Information Technology*, and *Nature Machine Intelligence*.

Inclusion and Exclusion Criteria

Inclusion:

- Peer-reviewed articles focusing on AI literacy, higher education, or curriculum development.
- Studies offering theoretical frameworks, empirical analyses, or pedagogical interventions.
- Publications in English between 2018 and 2025.

Exclusion:

- Non-academic commentaries or media pieces.
- Papers limited to K-12 education unless transferable to tertiary contexts.
- Technical AI research without educational relevance.

Screening and Analysis

Initial search results (n = 1,142) were screened by title and abstract. Duplicates and irrelevant studies were removed, leaving 132 for full-text review. After quality appraisal using the Critical Appraisal Skills Programme (CASP 2020) checklist, 87 studies met the inclusion criteria. Data were coded inductively with NVivo, resulting in four thematic clusters—conceptual, ethical, productive, and participatory. These clusters informed the AILDM framework. Cross-comparison by geographic region (Europe, North America, Asia-Pacific, Africa) revealed contextual patterns and pedagogical trends.

Limitations and Trustworthiness

The SLR is interpretive rather than comprehensive; its strength lies in conceptual integration. An English-language bias and focus on peer-reviewed literature may under-represent regional initiatives documented in grey sources. Nonetheless, triangulation across 87 academic studies improves robustness and validity. The inclusion of multiple journals and methodologies ensures a balanced synthesis across technical, ethical, and pedagogical dimensions.

FINDINGS: THE AI LITERACY DESIGN MATRIX (AILDM)

The synthesis of 87 peer-reviewed sources resulted in the **AI Literacy Design Matrix (AILDM)**—a comparative framework that outlines four interconnected curriculum design dimensions: **conceptual, ethical, productive, and participatory literacy**. Each dimension represents a distinct yet overlapping area of learning outcomes, pedagogical strategies, and assessment methods.

Dimension	Core Aim	Illustrative Learning Outcomes	Curricular Strategies
1. Conceptual Literacy	Develop fundamental understanding of how AI systems operate.	Explain algorithmic reasoning; identify dataset bias; describe learning types (supervised, unsupervised, reinforcement).	Cross-disciplinary theory modules; case studies linking AI to disciplinary contexts; data visualisation tasks.
2. Ethical Literacy	Cultivate reflective and moral awareness of AI's societal implications.	Evaluate ethical dilemmas; debate fairness and accountability; apply ethical frameworks to real-world cases.	Ethics workshops; simulation of policy decisions; reflective essays and scenario-based discussions.
3. Productive Literacy	Enable creative and competent use of AI tools for problem-solving and innovation.	Build or adapt AI systems responsibly; use generative tools critically; interpret AI outputs accurately.	Project-based labs; hackathons; interdisciplinary design challenges.
4. Participatory Literacy	Empower engagement in governance and public discourse on AI.	Critique AI policy; propose institutional guidelines; collaborate in citizen-AI governance projects.	Policy simulations; community-based research; debate forums and stakeholder dialogues.

Conceptual Literacy

Conceptual literacy encompasses what AI is and how it functions. It includes knowledge of computational logic, model architectures, and the epistemological assumptions underpinning machine reasoning (Mitchell 2019; Jordan 2019). Higher education should view AI understanding as part of overall epistemic competence, akin to scientific literacy (Chin et al. 2023).

Interdisciplinary teaching is essential: social science students should grasp the basics of algorithmic decision-making, while computer science students should explore the philosophical foundations of cognition and bias. This reciprocity helps bridge the cognitive divide between technical and humanistic disciplines (Nørgård 2022; Holmes et al. 2019).

Ethical Literacy

Ethical literacy broadens understanding into the moral domain. According to Dignum (2019) and Floridi (2019), this involves not only following ethical codes but also developing moral imagination. Students must analyse AI's role in perpetuating or reducing inequity (Benjamin 2019; Noble 2018; Buolamwini & Gebru 2018). Curricula should incorporate a **dialogic pedagogy**, enabling learners to debate, empathise, and reflect. Approaches such as "ethics sandboxes" (Borenstein et al. 2021) and structured moral reasoning frameworks (Lau & Wong 2023) allow students to engage with complex scenarios without fixed answers. Ethical literacy, therefore, transforms AI from a technical topic into a humanistic inquiry—grounding decision-making in empathy, justice, and social context.

Productive Literacy

Productive literacy refers to agency through practice—the ability to engage AI tools critically and creatively (Amershi et al. 2019; Shneiderman 2022). Unlike digital skills training, it emphasises reflexivity: using AI to enhance human capability while maintaining interpretive control (Chan et al. 2021). Hands-on, project-based learning closely aligns with this dimension. For instance, media students might use generative AI to analyse bias in content production; engineering students could apply machine learning to sustainable energy modelling. Productive literacy bridges *knowing* and *doing*, ensuring that creative experimentation is guided by ethical awareness.

Participatory Literacy

Participatory literacy relates to AI's civic dimension—the ability to understand and influence governance, policy, and cultural narratives (Rahwan 2018; West et al. 2019). It corresponds with Freire's (1970) idea of critical consciousness: education as a tool for empowerment through dialogue. Universities can foster this through policy debates, hackathons, and community engagement projects that focus on local AI concerns, such as surveillance or algorithmic hiring. Participatory literacy also connects academic research to public discussion, enabling graduates to act as informed citizens who co-govern technology rather than passively consume it.

Example 1: "AI and Society" Interdisciplinary Course

Application of AILDM dimensions:

- **Conceptual Literacy:** Students can examine the fundamentals of algorithmic reasoning and dataset bias through brief, accessible modules delivered collaboratively by computer science and sociology lecturers.
- **Ethical Literacy:** Case studies on algorithmic discrimination (e.g., biased facial recognition systems) can be utilised for structured debates and reflective essays.
- **Productive Literacy:** Students can employ open-source AI tools to analyse real-world datasets and apply their learning to social-impact issues.
- **Participatory Literacy:** The class can end with a simulated policy hearing during which students present recommendations to a mock ethics board.

Impact: Demonstrates how AI ethics are practical and illustrates the connection between technical and moral reasoning.

Example 2: Engineering Capstone – "Designing Sustainable AI Systems"

Application of AILDM dimensions:

- **Conceptual literacy:** Teams can investigate model architectures for energy-efficient computing.
- **Ethical Literacy:** Each team can justify the environmental trade-offs of their chosen model using the EU's AI Ethics Guidelines.
- **Productive Literacy:** Students can develop prototype solutions that optimise power usage or data storage.
- **Participatory Literacy:** Results can be shared with local industry partners or municipal sustainability councils for feedback.

Impact: Linking AI design to sustainability and civic responsibility, illustrating how technical skill and ethical responsibility can coexist.

The AI Literacy Design Matrix (AILDM) is inherently adaptable and can evolve in response to emerging technologies that continue to reshape higher education. As generative AI, adaptive learning platforms, and multimodal systems become more widespread, the framework can include new literacies such as **meta-literacy. This is** the ability to reflect on one's interactions with intelligent systems and to develop **sustainability literacy**, connecting AI innovation to ethical, environmental, and social responsibility. Ongoing collaboration among educators, technologists, and policymakers will help ensure that the AILDM remains responsive to advances in artificial intelligence, keeping AI literacy education relevant, resilient, and future-proof.

COMPARATIVE ANALYSIS: REGIONAL PATTERNS

The structured review identified four global clusters demonstrating how AI literacy is conceptualised and implemented in higher education.

Europe: Policy Alignment and Ethical Integration

Europe leads in governance-led models. The European Commission's AI Act (2024) and Digital Education Action Plan (2021–2027) embed human-centred AI within higher education. Scandinavian universities exemplify ethical integration practices—embedding AI ethics into teacher training (Hakkarainen & Hietajärvi, 2022)—while Mediterranean systems lag in implementation (OECD, 2023). However, overemphasis on regulation risks bureaucratising creativity. Critics (Williamson 2023; Nørgård 2022) warn that compliance cultures may stifle innovation. The AILDM provides balance by linking ethical oversight with participatory learning.

United States: Innovation-Driven Decentralisation

The U.S. features a fragmented yet vibrant ecosystem. Institutions like MIT, Stanford, and Georgia Tech promote experiential, design-based learning (Amershi et al. 2019; Dede 2022). Ethical reasoning, however, remains inconsistently integrated outside elite contexts (Selwyn 2022). Federal initiatives such as *AI and the Future of Teaching and Learning* (U.S. Department of Education 2023) encourage responsible use but stop short of defining curriculum standards. This pluralism fosters innovation but undermines systemic coherence. Comparative synthesis reveals a need for national coordination and shared benchmarks.

Asia-Pacific: Capability and Competitiveness

Asian models emphasise technical mastery and innovation capacity. *China's AI Education Strategy (Zeng 2022)* and *Singapore's AI for Everyone* programme (Lim et al. 2021) highlight STEM integration and entrepreneurship. Ethical discourse, while emerging, remains secondary (Chan & Yuen, 2023). Korean and Japanese universities have begun introducing AI humanities modules, bridging cultural values of harmony with technical excellence (Lee 2023). The AILDM's participatory dimension could further localise ethics and governance in these contexts, enhancing public dialogue on AI's social effects.

Global South: AI Literacy as Empowerment

In Africa and Latin America, AI literacy is connected to development and inclusion. The African Union Digital Transformation Strategy (2020–2030) describes AI education as a key driver of equity. Case studies from South Africa (Goosen 2024) and Brazil (Ferreira 2023) show how universities adapt open-source AI tools to local languages and economies. These initiatives, although resource-limited, focus on community participation and building teacher capacity—aligning naturally with the AILDM's participatory ethos. The challenge is to scale such models without creating dependency on imported frameworks.

DISCUSSION

From Fragmentation to Integration

The global evidence shows that AI literacy efforts remain isolated—focused on technical aspects in the U.S. and Asia, ethical considerations in Europe, and development in the Global South. The AILDM unites these strands through a multi-dimensional integration approach: conceptual (knowledge), moral (values), productive (skills), and participatory (agency). Embracing this framework encourages universities to align course outcomes, assessments, and institutional policies. Similar integrated models have transformed education in sustainability and digital citizenship (Tilbury 2011; Redecker 2020); AI literacy now demands a comparable shift.

Implications for Curriculum Design

Practical execution requires integrating it into the curriculum rather than treating it as an add-on. Recommended approaches include:

- **Curricular mapping**: audit existing programs for implicit AI content and align to AILDM dimensions.
- **Cross-disciplinary teaching**: pair data-science faculty with humanities scholars to design integrative modules.
- **Assessment innovation**: use reflective portfolios and project outcomes rather than closed-book exams (Biggs & Tang, 2011).
- **Accreditation alignment**: institutions can link AI literacy indicators to graduate attributes or to professional body standards.

Faculty Development and Institutional Readiness

Faculty readiness remains a key challenge. Studies (Chan et al., 2021; OECD, 2023) show that many lecturers feel underprepared for AI pedagogy. Professional learning communities and mentorship models can develop capacity (Dede 2022). Finland's Elements of AI course illustrates scalable faculty training when paired with open-access resources. Institutional leadership must regard AI literacy as a strategic infrastructure. Creating AI education hubs and interdisciplinary chairs encourages sustainable innovation and cross-faculty dialogue (Holmes et al. 2019; Williamson 2023).

Ethical and Cultural Adaptation

AI ethics cannot be culturally neutral. Western frameworks emphasise autonomy and privacy; Asian traditions prioritise harmony and collective responsibility (Zeng 2022; Dignum 2019). The AILDM's flexible architecture allows weighting among dimensions according to cultural context, ensuring global applicability without moral imperialism.

Measuring AI Literacy

Assessment remains a frontier. Current tools assess technical skills but neglect ethics and participation (Ng et al. 2021). Multi-level evaluation should measure:

- **Cognitive outcomes** (conceptual tests, self-assessments),
- **Affective outcomes** (ethical reasoning rubrics), and

- **Civic outcomes** (policy proposals, community engagement).

Developing validated instruments, such as the *Digital Competence Framework (DigComp 2.2)* , could standardise evaluation while respecting contextual nuance.

CONCLUSION

This Structured Literature Review consolidates evidence from 87 peer-reviewed studies to propose the **AI Literacy Design Matrix (AILDM)** as a comprehensive framework for integrating AI literacy within higher education. The analysis shows that while global enthusiasm for AI education exists, its implementation remains fragmented. The AILDM addresses this by encompassing four key dimensions: conceptual, ethical, productive, and participatory. Each is crucial to fostering graduates who are informed, responsible, and empowered. Future research should implement the AILDM in pilot curricula and assess its impact on students' understanding, ethical judgment, and civic participation.

By translating its four dimensions into practical curriculum design, the AILDM moves beyond theory into concrete educational practice. Universities can use it to map current courses, identify gaps, and develop new modules that incorporate AI literacy across disciplines—from ethics-focused engineering projects to reflective AI-in-society seminars. Faculty can align assessments with each literacy dimension, while institutions can benchmark graduate competencies against them. In doing so, the framework not only guides curriculum reform but also fosters a culture of responsible innovation where students learn to create, question, and co-govern intelligent technologies.

Policymakers should encourage faculty development, interdisciplinary collaboration, and accreditation reforms to make AI literacy a core skill for all graduates. AI literacy is not merely about learning technology; it is about **learning to live intelligently with intelligence**.

Author Biography

Prof. Wynand Goosen is the Chief Executive Officer of the Infomage Rims Group and a researcher specialising in artificial intelligence, digital transformation, Business Incubation and education policy. His work explores the intersection of technology, ethics, and contextual awareness in post-school education and training systems.

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