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DIGITAL LITERACY, IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE INTO THE EDUCATION SYSTEM: CONCEPTUAL ANALYSIS AND THEORETICAL BASIS

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Abstract: *The rapid proliferation of generative artificial intelligence (AI) tools has fundamentally reshaped how individuals interact with digital information, creating an urgent need to align technological capability with digital literacy competencies. This article presents a conceptual narrative review and theoretical framework paper examining the integration of responsible AI use within digital literacy education in higher education and professional development contexts. Drawing on peer-reviewed literature indexed in Scopus and Web of Science (2014–2024), supplemented by normative documents from UNESCO, the European Union AI Act, and leading educational technology bodies, the study pursues four guiding questions: (1) What competencies constitute responsible AI literacy in higher education? (2) How do existing frameworks inadequately address legal literacy, prompt literacy, and human oversight? (3) How can responsible AI principles be operationalized in digital literacy curricula? (4) How must AI literacy frameworks be adapted for emerging economies and multilingual contexts? The article identifies critical limitations in existing AI literacy frameworks and proposes a novel multilayered framework comprising three concentric layers — foundational understanding, applied competency, and critical governance — integrated with prompt literacy, legal literacy, human oversight, and governance dimensions absent from prior models. Critical analysis addresses epistemic dependency, AI-induced deskilling, environmental costs of large language models, Global South inequalities, and corporate concentration of AI ecosystems. Implementation guidance includes sample learning outcomes, assessment rubrics, and a beginner–intermediate–advanced progression model. Implications for higher education institutions, policymakers, and curriculum designers are discussed, with particular attention to Uzbekistan and other emerging economies.*

Keywords: *artificial intelligence; digital literacy; AI literacy; responsible AI; generative AI; prompt literacy; legal literacy; higher education; ethics; emerging economies.*

Annotatsiya. *Generativ sun'iy intellekt (SI) vositalarining jadal sur'atlarda rivojlanishi va keng tarqalishi insonlarning raqamli axborot bilan o'zaro munosabatlarini tubdan o'zgartirdi hamda texnologik imkoniyatlarni raqamli savodxonlik kompetensiyalari bilan uyg'unlashtirish zaruratini yuzaga keltirdi. Mazkur maqolada oliy ta'lim va kasbiy rivojlanish jarayonlarida sun'iy intellektdan mas'uliyatli foydalanishni raqamli savodxonlik ta'limiga integratsiya qilish masalalariga bag'ishlangan konseptual narrativ sharh hamda nazariy model taqdim etilgan. Tadqiqot Scopus va Web of Science ma'lumotlar bazalarida indekslangan 2014–2024-yillarga oid taqrizdan o'tgan ilmiy adabiyotlar, shuningdek, UNESCO, Yevropa Ittifoqining Sun'iy intellekt to'g'risidagi qonuni (EU AI Act) va yetakchi ta'lim texnologiyalari tashkilotlarining me'yoriy*

hujjatlari tahliliga asoslangan. Tadqiqot quyidagi to‘rtta asosiy savolga javob izlaydi: (1) oliy ta’limda mas’uliyatli SI savodxonligini tashkil etuvchi kompetensiyalar nimalardan iborat; (2) mavjud modellar huquqiy savodxonlik, prompt savodxonligi va inson nazoratini qay darajada yetarlicha qamrab olmayapti; (3) mas’uliyatli SI tamoyillarini raqamli savodxonlik o‘quv dasturlariga qanday tatbiq etish mumkin; (4) SI savodxonligi modellari rivojlanayotgan iqtisodiyotlar va ko‘p tilli ta’lim muhitlari uchun qanday moslashtirilishi lozim. Maqolada mavjud SI savodxonligi modellarining muhim cheklovlari aniqlanib, uchta konsentrik qatlamdan iborat yangi ko‘p bosqichli model taklif etiladi. Ushbu qatlamlar: bazaviy tushuncha, amaliy kompetensiyalar va tanqidiy boshqaruvdan iborat bo‘lib, ular prompt savodxonligi, huquqiy savodxonlik, inson nazorati va boshqaruv komponentlari bilan boyitilgan. Mazkur elementlar avvalgi modellarda yetarli darajada aks ettirilmagan. Tanqidiy tahlilda epistemik qaramlik, sun’iy intellekt ta’sirida kasbiy ko‘nikmalarning susayishi, katta til modellari bilan bog‘liq ekologik xarajatlar, Global Janub mamlakatlari duch kelayotgan tengsizliklar hamda sun’iy intellekt ekotizimlarining yirik korporatsiyalar qo‘lida markazlashuvi kabi muammolar ko‘rib chiqilgan. Amaliy tavsiyalar sifatida o‘quv natijalari namunalarini, baholash mezonlarini hamda boshlang‘ich, o‘rta va ilg‘or darajalarni qamrab oluvchi kompetensiyalar rivojlanish modelini o‘z ichiga oladi. Shuningdek, taklif etilgan modelning oliy ta’lim muassasalari, ta’lim siyosatini ishlab chiquvchilar va o‘quv dasturlari dizaynerlari uchun ahamiyati muhokama qilinib, O‘zbekiston va boshqa rivojlanayotgan iqtisodiyotlarga alohida e’tibor qaratilgan.

Kalit so‘zlar: *sun’iy intellekt; raqamli savodxonlik; SI savodxonligi; mas’uliyatli sun’iy intellekt; generativ sun’iy intellekt; prompt savodxonligi; huquqiy savodxonlik; oliy ta’lim; etika; rivojlanayotgan iqtisodiyotlar.*

Аннотация: *Стремительное распространение инструментов генеративного искусственного интеллекта (ИИ) кардинально изменило способы взаимодействия людей с цифровой информацией, что обусловило острую необходимость согласования технологических возможностей с компетенциями цифровой грамотности. В данной статье представлен концептуальный нарративный обзор и теоретическая модель, посвящённые вопросам интеграции ответственного использования искусственного интеллекта в обучение цифровой грамотности в системе высшего образования и профессионального развития. Исследование основано на анализе рецензируемых научных публикаций, индексируемых в базах данных Scopus и Web of Science за период 2014–2024 гг., а также нормативных документов ЮНЕСКО, Закона Европейского Союза об искусственном интеллекте (EU AI Act) и материалов ведущих организаций в области образовательных технологий. Работа направлена на поиск ответов на четыре ключевых вопроса: (1) какие компетенции формируют ответственную ИИ-грамотность в высшем образовании; (2) каким образом существующие модели недостаточно учитывают правовую грамотность, грамотность составления запросов (prompt literacy) и человеческий контроль; (3) каким образом принципы ответственного ИИ могут быть интегрированы в учебные программы по цифровой грамотности; (4) каким образом модели ИИ-грамотности должны быть адаптированы к условиям развивающихся экономик и многоязычных образовательных сред. В статье выявлены существенные ограничения существующих моделей ИИ-грамотности и предложена новая многоуровневая структура, включающая три концентрических уровня: базовое понимание, прикладные компетенции и критическое управление. Данная структура дополнена компонентами грамотности составления запросов, правовой грамотности, человеческого контроля и управления, отсутствующими в ранее разработанных моделях.*

Критический анализ охватывает проблемы эпистемической зависимости, снижения профессиональных навыков под влиянием ИИ, экологических издержек больших языковых моделей, неравенства между странами Глобального Юга и Севера, а также концентрации ИИ-экосистем в руках крупных корпораций. Практические рекомендации включают примеры ожидаемых результатов обучения, оценочные рубрики и модель поэтапного развития компетенций от начального до продвинутого уровня. Рассматриваются последствия внедрения предложенной модели для высших учебных заведений, разработчиков образовательных программ и лиц, принимающих решения в сфере образовательной политики, с особым акцентом на Узбекистан и другие страны с формирующейся экономикой.

Ключевые слова: *искусственный интеллект; цифровая грамотность; ИИ-грамотность; ответственный искусственный интеллект; генеративный искусственный интеллект; грамотность составления запросов; правовая грамотность; высшее образование; этика; развивающиеся экономики.*

INTRODUCTION. The emergence of large-scale generative AI systems — most notably large language models (LLMs) such as GPT-4, Gemini, and Claude — has reshaped how knowledge workers, educators, and citizens engage with information. Unlike prior automation waves that primarily displaced routine manual tasks, generative AI produces complex written, visual, and analytical content at unprecedented scale and speed, bringing AI tools from specialist laboratories into everyday educational, professional, and personal practice.

In parallel, research communities and policymakers have intensified focus on digital literacy — the capacity to locate, evaluate, use, and create information in digital environments. Digital literacy is not merely a technical skill set; it encompasses sociocultural, critical, communicative, creative, and civic dimensions (Gilster, 1997; van Laar et al., 2017; Vuorikari et al., 2022). In contemporary scholarship, this concept has expanded to encompass the ability to critically engage with AI-generated content, a specialization frequently termed AI literacy (Long & Magerko, 2020; Ng et al., 2021).

Despite the theoretical richness of existing frameworks, significant gaps persist between principle and practice. Educators frequently lack structured guidelines for integrating AI tools into curricula responsibly (Michel-Villarreal et al., 2023). Learners face challenges in distinguishing AI-generated content from human-authored material. Organizations encounter difficulties translating high-level ethical principles into operational governance mechanisms. These gaps are particularly acute in emerging economies and non-English-speaking contexts, where AI literacy resources remain underdeveloped.

Crucially, existing AI literacy frameworks — including those of Long and Magerko (2020), Ng et al. (2021), and UNESCO (2024) — inadequately address three emerging dimensions: (1) prompt literacy as a distinct pedagogical competency grounded in learning theory; (2) legal literacy as a response to binding regulatory frameworks such as the EU AI Act; and (3) human oversight as both a technical and civic responsibility. The proposed multilayered framework addresses these gaps through systematic conceptual integration.

This article addresses these challenges through four guiding questions:

1. What competencies constitute responsible AI literacy in higher education contexts?
2. How do existing frameworks inadequately address legal literacy, prompt literacy, and human oversight?
3. How can responsible AI principles be operationalized within digital literacy curricula?
4. How must AI literacy frameworks be adapted for emerging economies and multilingual contexts?

The review draws on peer-reviewed literature indexed in Scopus and Web of Science, supplemented by normative documents from UNESCO, the EU AI Act, and leading universities. The article is positioned as a conceptual narrative review and theoretical framework paper, not a systematic review.

METHODOLOGY. This article constitutes a conceptual narrative review and theoretical framework paper. The review methodology followed a structured, though non-exhaustive, thematic synthesis approach, consistent with the narrative review typology described by Grant and Booth (2009).

Literature was retrieved from two primary databases: Scopus and Web of Science (WoS). Supplementary searches were conducted in ERIC and IEEE Xplore for education-specific literature. Policy documents were retrieved from the UNESCO website, the Official Journal of the European Union, and institutional repositories of leading universities.

The following Boolean search strings were applied:

- ("AI literacy" OR "artificial intelligence literacy") AND ("higher education" OR "university")
- ("responsible AI" OR "ethical AI") AND ("digital literacy" OR "curriculum")
- ("prompt engineering" OR "prompt literacy") AND ("education" OR "pedagogy")
- ("AI governance" OR "EU AI Act") AND ("education" OR "digital competence")
- ("emerging economies" OR "Global South" OR "Uzbekistan") AND ("AI literacy" OR "digital education")

Articles were included if they: (a) were published in peer-reviewed journals indexed in Scopus or WoS; (b) were published between January 2014 and December 2024; (c) addressed AI literacy, digital literacy, responsible AI, prompt engineering, or AI governance in educational contexts; and (d) were available in English. Articles were excluded if they focused exclusively on technical AI development without educational relevance, or if they were conference abstracts without full-text availability.

An initial search returned approximately 840 candidate articles. After title and abstract screening for relevance to the four guiding questions, 112 articles were retained for full-text review. Thematic synthesis (Thomas & Harden, 2008) was applied to identify recurring conceptual categories across the literature. Six thematic clusters emerged: foundational AI literacy competencies; responsible AI principles; prompt engineering pedagogy; governance and legal frameworks; implementation in higher education; and AI literacy in emerging economies. Policy documents and normative frameworks were analysed using document analysis methods.

The proposed multilayered framework was constructed deductively-inductively. The three-layer architecture (foundational understanding, applied competency, critical governance) was informed

deductively by existing AI literacy competency models (Long & Magerko, 2020; Ng et al., 2021; UNESCO, 2024). The novel integrations — prompt literacy, legal literacy, and human oversight — were derived inductively from thematic patterns in the reviewed literature and from gaps identified in existing frameworks. The framework was subsequently mapped against five benchmark models (Table 2) to validate differentiation.

Previous studies have highlighted significant challenges in assessing practical skills among medical students, particularly in the context of digital transformation and AI integration (Abdumanonov, 2026; Abdumanonov, 2025).

THEORETICAL FOUNDATIONS. Digital literacy evolved from basic computer skills in the 1990s through successive expansions: information literacy (Gilster, 1997), data literacy, media literacy, privacy literacy, and now AI literacy. Van Laar et al. (2017) synthesized 21st-century digital skills into seven core components: technical, information, communication, collaboration, creativity, critical thinking, and problem-solving. Vuorikari et al.'s (2022) DigComp 2.2 framework operationalizes digital competence across five areas and three proficiency levels, establishing the most widely adopted European standard.

Generative AI does not replace these established digital literacy dimensions; rather, it reconfigures them. Information literacy, for instance, now requires evaluating AI-generated content alongside human-authored material. Communication literacy must incorporate the ability to disclose AI assistance transparently. Critical thinking must extend to evaluating AI reasoning chains and identifying hallucinations. Understanding these continuities and discontinuities is essential for positioning AI literacy as an extension, specialization, and reconfiguration of existing digital competencies — not a wholesale replacement.

Long and Magerko (2020) offered a foundational definition now widely adopted: AI literacy comprises the competencies to critically evaluate AI technologies, communicate and collaborate effectively with AI, and use AI as a tool in online, home, and workplace environments. This tripartite structure — critical evaluation, communicative collaboration, and applied use — aligns closely with broader digital literacy frameworks.

Subsequent scholarship differentiated generic AI literacy, targeting non-specialist users and focusing on societal understanding and responsible use, from domain-specific AI literacy, which integrates technical and contextual knowledge for professional practice in fields such as medicine, engineering, and law (Almatrafi et al., 2024; Laupichler et al., 2023). This distinction is significant for curriculum design: a medical professional requires technical understanding of AI-assisted diagnostics, while a public administrator primarily requires critical and ethical competencies.

Gao et al. (2025), in a bibliometric analysis of 335 articles published between 2014 and 2024, identified four developmental pathways in AI literacy research: technical foundations, educational applications, ethical and societal dimensions, and assessment methodologies. The field's interdisciplinary nature is evidenced by intersections with information literacy, media literacy, data literacy, and algorithm literacy. Kabudi et al. (2025), in a systematic literature review of 87 high-quality studies, found that AI literacy extends well beyond technical proficiency to encompass ethical considerations, societal impacts, and practical applications.

The ethical dimensions of AI use have attracted substantial attention from international governance bodies. UNESCO's Recommendation on the Ethics of AI (2021), applicable to all 194 member states, identifies four foundational values: respect for human rights and dignity, living in peaceful and interconnected societies, environmental and ecosystem flourishing, and the conditions for knowledge and creativity. These values are operationalized through eleven policy action areas.

The European Union's AI Act (Regulation EU 2024/1689), which entered into force in August 2024, constitutes the first comprehensive legal framework for AI governance. It establishes a risk-based regulatory hierarchy and explicitly mandates the promotion of AI literacy among users and developers. The Act's emphasis on transparency, accountability, and human oversight directly complements educational frameworks for AI literacy by providing the legal infrastructure within which responsible AI use must occur.

Drawing on a Delphi consensus procedure with sixteen international experts, Knöchel et al. (2025) identified eight sequentially ordered principles for responsible generative AI use in research contexts: (1) regulatory compliance, (2) data security, (3) quality control, (4) originality, (5) bias mitigation, (6) accountability, (7) transparency, and (8) broader societal impact. Table 1 translates these principles into educational competencies, teaching practices, and institutional policies.

Table 1. Responsible AI Principles Translated into Educational Contexts

Principle	Student Competency	Teacher Practice	Institutional Policy
Regulatory Compliance	Understand and apply institutional AI use policies	Model transparent AI disclosure in assignments	Publish clear AI use guidelines aligned with EU AI Act
Data Security	Avoid entering sensitive personal data into public AI tools	Demonstrate secure AI use practices	Implement data governance policies for AI platforms
Quality Control	Cross-verify AI outputs against primary sources	Teach source triangulation methods	Require AI-output verification in assessment rubrics
Originality	Disclose AI assistance; maintain independent reasoning	Design tasks requiring original analysis beyond AI output	Update academic integrity policies to address generative AI
Bias Mitigation	Identify potential cultural and demographic bias in AI outputs	Incorporate bias detection exercises into curricula	Audit AI tools for equity implications before deployment
Accountability	Document AI tool use and decisions made	Maintain audit trails for AI-assisted teaching materials	Establish clear accountability chains for AI deployment
Transparency	Explain AI tool selection and limitations in submitted work	Communicate AI use rationale to students and colleagues	Publish AI governance reports and usage statistics
Societal	Analyse environmental	Integrate	Adopt sustainable AI

Principle	Student Competency	Teacher Practice	Institutional Policy
Impact	and social consequences of AI use	sustainability into AI literacy discussions	procurement and usage policies

Note. Principles adapted from Knöchel et al. (2025); Floridi et al. (2018); UNESCO (2021).

PROMPT LITERACY AS A PEDAGOGICAL COMPETENCY. The term prompt engineering entered public discourse primarily through practitioner documentation (e.g., OpenAI, 2024) and tends to connote a technical, developer-oriented skill. For educational contexts, the construct of prompt literacy is more appropriate: it denotes the capacity to formulate, evaluate, and iteratively refine instructions to generative AI systems, grounded in subject-matter knowledge, communicative intent, and critical awareness of model limitations. This reframing positions prompt literacy as a learnable, teachable, and assessable competency within digital literacy curricula rather than a specialist technical skill.

Prompt literacy can be theoretically grounded in at least three established learning-science traditions. First, cognitive load theory (Sweller, 1988; Mayer, 2021) suggests that poorly designed prompts impose extraneous cognitive load by producing ambiguous or irrelevant output, forcing learners to engage in unproductive reprocessing. Teaching structured prompt design reduces this load and redirects cognitive resources toward evaluative and creative tasks.

Second, metacognition research (Flavell, 1979; Chi & Wylie, 2014) indicates that effective prompt construction requires self-regulatory monitoring: learners must represent their information need accurately, anticipate potential model misunderstandings, and evaluate output quality against criteria. These metacognitive processes are precisely those that educational AI literacy frameworks should cultivate.

Third, active learning frameworks (Chi & Wylie, 2014) demonstrate that iterative, generative engagement with learning materials produces deeper understanding than passive consumption. Prompt iteration — in which learners revise and refine prompts in response to AI output — constitutes a form of generative learning activity with strong theoretical backing.

Drawing on educational design principles and peer-reviewed research on prompt-based learning (Chiu, 2024), a well-structured prompt for educational or professional purposes comprises five elements:

5. Role or context specification: defining the persona or expertise level the AI should adopt.
6. Task description: clearly articulating what must be accomplished.
7. Format specification: indicating desired structure, length, or stylistic conventions.
8. Constraints: delineating what should be excluded or avoided.
9. Evaluation criteria: describing what a successful output looks like.

This five-part structure aligns with established instructional design principles and can be taught systematically at all educational levels. Studies on prompt-based learning in educational contexts indicate that explicit instruction in prompt structure often improves the specificity and reliability of AI-generated outputs and increases learner confidence in critically evaluating AI-generated content (Chiu, 2024). Crucially, prompt literacy also encompasses awareness of model limitations: prompts

cannot fully compensate for training data biases, factual hallucinations, or version-specific instability across model releases.

Table 3 presents a prompt evaluation rubric for formative and summative assessment of prompt literacy at the applied competency layer. The rubric operationalizes six dimensions aligned with the cognitive load, metacognition, and active learning foundations described above.

Table 3. Prompt Literacy Evaluation Rubric

Criterion	Exemplary (4)	Proficient (3)	Developing (2)	Beginning (1)
Task Clarity	Task is precisely defined; scope is unambiguous	Task is clear with minor ambiguity	Task is somewhat clear but vague in parts	Task is unclear or too broad
Contextual Richness	Full context provided; role, domain, and purpose specified	Adequate context; minor gaps	Limited context; key information missing	No meaningful context provided
Constraints & Exclusions	Clear exclusions stated; format and length specified	Most constraints identified	Few constraints mentioned	No constraints included
Ethical Appropriateness	Demonstrates awareness of bias, privacy, and harm risks	Generally ethical; minor oversight	Limited ethical consideration	No ethical consideration
Iterative Revision	Multiple revision cycles documented with rationale	At least one documented revision	Revision attempted but undocumented	No revision attempted
Output Evaluation	Critically evaluates AI output against sources; identifies limitations	Evaluates output with some critical analysis	Superficial evaluation only	No evaluation of AI output

Note. Rubric informed by Chi & Wylie (2014); Sweller (1988); Chiu (2024).

AI LITERACY IN EDUCATIONAL CONTEXTS. Gao et al. (2025) identified a rapidly expanding field of AI literacy research, with four distinct developmental pathways: technical foundations, educational applications, ethical and societal dimensions, and assessment methodologies. Kabudi et al. (2025) found significant contextual variation in how AI literacy is conceptualized: definitions developed in North American and European contexts tend to emphasize critical evaluation and ethical reasoning, while frameworks from East Asian contexts may foreground technical mastery and application.

Nazaretsky et al. (2024), in a scoping review of teacher education literature, identified that AI literacy remains almost entirely absent from teacher education programmes globally. This finding is particularly concerning given that educators constitute the primary mediators of AI literacy at scale: without AI-literate teachers, institutional efforts to embed AI competencies in curricula will encounter a fundamental human capital deficit.

UNESCO's AI Competency Framework for Teachers (2024) provides a structured approach across five key dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional development. These dimensions encompass fifteen competencies achievable at three progressive levels — acquire, deepen, and create — providing a model that the proposed curriculum progression (Section 8) adapts for student AI literacy development.

Moreira-Choez et al. (2024), in a large-sample study of 1,103 Hungarian university teachers across 13 disciplines, found a significant positive relationship between digital competence and AI literacy, with notable variation across age groups, disciplines, and levels of teaching experience. Educators in STEM fields demonstrated higher technical AI literacy but not necessarily greater ethical or regulatory awareness, suggesting that comprehensive AI literacy education must integrate technical, ethical, and legal dimensions rather than privileging any single component.

The AI Literacy Heptagon, recently proposed in higher education scholarship (Knöchel et al., 2025), extends existing frameworks by incorporating legal and regulatory knowledge as an explicit competency domain. This addition reflects the operationalization of the EU AI Act and similar legislation, which create concrete legal obligations for AI users and developers that cannot be addressed by purely technical or ethical education alone. The current study follows this direction and argues that legal literacy — understanding binding regulatory frameworks, liability implications, and institutional compliance obligations — constitutes a non-negotiable component of AI literacy in the post-AI-Act educational environment.

Table 2 maps the proposed multilayered framework against five benchmark models. The framework's core theoretical contribution is threefold. First, it integrates prompt literacy as a theory-grounded pedagogical competency — distinct from practitioner-level prompt engineering — informed by cognitive load theory, metacognition, and active learning. Second, it incorporates legal literacy as a distinct layer within the critical governance dimension, responding to binding regulatory frameworks that existing AI literacy models predate. Third, it provides a curriculum sequencing architecture — foundational, applied, and governance competencies mapped to beginner, intermediate, and advanced progression levels — which prior frameworks address insufficiently. Together, these three integrations constitute the framework's novel scholarly contribution beyond existing models.

Table 2. Comparative Mapping of Proposed Framework Against Existing Models

Framework	Core Dimensions	Limitations Addressed by Proposed Framework
Long & Magerko (2020) – AI Literacy	Critical evaluation, communication, use	No legal literacy; no prompt literacy; no curriculum sequencing
DigComp 2.2 (Vuorikari et al., 2022)	Information, communication, safety, problem-solving	Insufficient AI governance; no generative AI competencies
UNESCO Teacher AI Competencies (2024)	Mindset, ethics, foundations, pedagogy, PD	Teacher-only scope; no student progression model
Knöchel et al. (2025) – 8	Compliance, security,	Research-context focus; not adapted

Framework	Core Dimensions	Limitations Addressed by Proposed Framework
Principles	quality, originality, bias, accountability, transparency, societal impact	for educational curricula
Proposed Multilayered Framework (this study)	Foundational understanding + Applied competency + Critical governance + Prompt literacy + Legal literacy + Human oversight	Integrates all dimensions; curriculum-sequenced; adaptable to emerging economies

Note. DigComp 2.2 = Vuorikari et al. (2022); UNESCO Teacher Framework = UNESCO (2024); Knöchel et al. (2025).

A MULTILAYERED FRAMEWORK FOR RESPONSIBLE AI LITERACY. Based on the thematic synthesis of reviewed literature, the proposed multilayered framework organizes AI literacy competencies around three concentric layers — foundational understanding, applied competency, and critical governance — integrated with four cross-cutting dimensions: prompt literacy, legal literacy, human oversight, and governance integration (Figure 1).

The foundational layer encompasses conceptual knowledge required to understand how AI systems function, including basic familiarity with machine learning, natural language processing, and data-driven decision-making. This layer aims to demystify AI for non-specialist users by providing accurate mental models of AI capabilities and limitations. Research consistently indicates that inflated perceptions of AI capabilities are associated with uncritical over-reliance, while deflated perceptions produce resistant non-adoption (Long & Magerko, 2020). Both outcomes impede responsible use. Competencies at this layer include: explaining how LLMs generate text; identifying major types of AI bias (training data bias, algorithmic bias, output bias); and describing the risk-tier architecture of the EU AI Act.

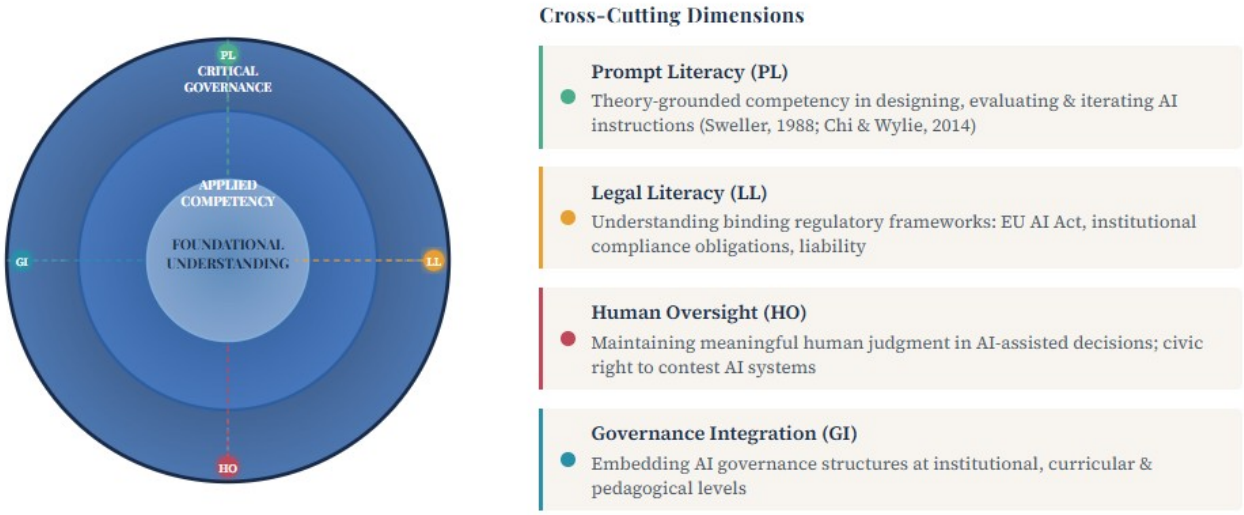

Figure 1. Multilayered Responsible AI Literacy Framework

Three concentric layers (foundational understanding, applied competency, critical governance) integrated with four cross-cutting dimensions: prompt literacy, legal literacy, human oversight, and governance integration. Outer layers build on inner layers; cross-cutting dimensions permeate all three layers. [Note: Graphical rendering to be produced at production stage per journal specifications.]

The applied competency layer focuses on practical skills needed to use AI tools responsibly in specific domains. It encompasses prompt literacy (as theorized in Section 4), output evaluation, iterative refinement, and transparent integration of AI tools into existing workflows. Applied competency training should be embedded in disciplinary contexts rather than delivered as a standalone module, as transfer of generic AI skills to domain-specific practice is limited without contextual scaffolding (Mishra & Koehler, 2006). Assessment at this layer should evaluate process (documented prompt iteration) alongside product (quality of AI-assisted outputs).

The critical governance layer encompasses ethical, legal, and societal dimensions of AI use. It includes understanding of the EU AI Act's binding obligations, awareness of algorithmic bias and its societal consequences, data privacy and security considerations, and the capacity to critically evaluate the broader impacts of AI deployment on equity, labour markets, and democratic accountability. Democratic accountability — the capacity of citizens, professionals, and institutions to interrogate, contest, and govern AI systems deployed in consequential decision-making contexts — is the ultimate civic competency that this layer targets. Without it, AI literacy risks becoming a purely instrumental skill that optimizes AI use without questioning the power structures it reinforces.

Prompt literacy (Section 4) permeates all three layers: foundational learners acquire basic prompt structure; intermediate learners apply disciplinary prompt design; advanced learners evaluate prompts for ethical appropriateness and bias risk. Legal literacy similarly evolves from awareness of regulatory frameworks (foundational) through compliance in professional practice (applied) to critical policy analysis (governance). Human oversight — the capacity and disposition to maintain

meaningful human judgment in AI-assisted decisions — is the integrating principle: it is simultaneously a technical competency (knowing when to override AI outputs), an ethical commitment (accepting responsibility for AI-assisted decisions), and a civic right (demanding transparency from AI systems in public life).

Figure 2. Responsible AI Governance Model for Higher Education Institutions

A three-tier governance model showing: (Tier 1) Institutional AI policy and compliance infrastructure; (Tier 2) Curricular and pedagogical governance structures; (Tier 3) Student and staff AI literacy competencies. Each tier identifies responsible actors, governance mechanisms, and accountability channels. [Note: Graphical rendering to be produced at production stage.]

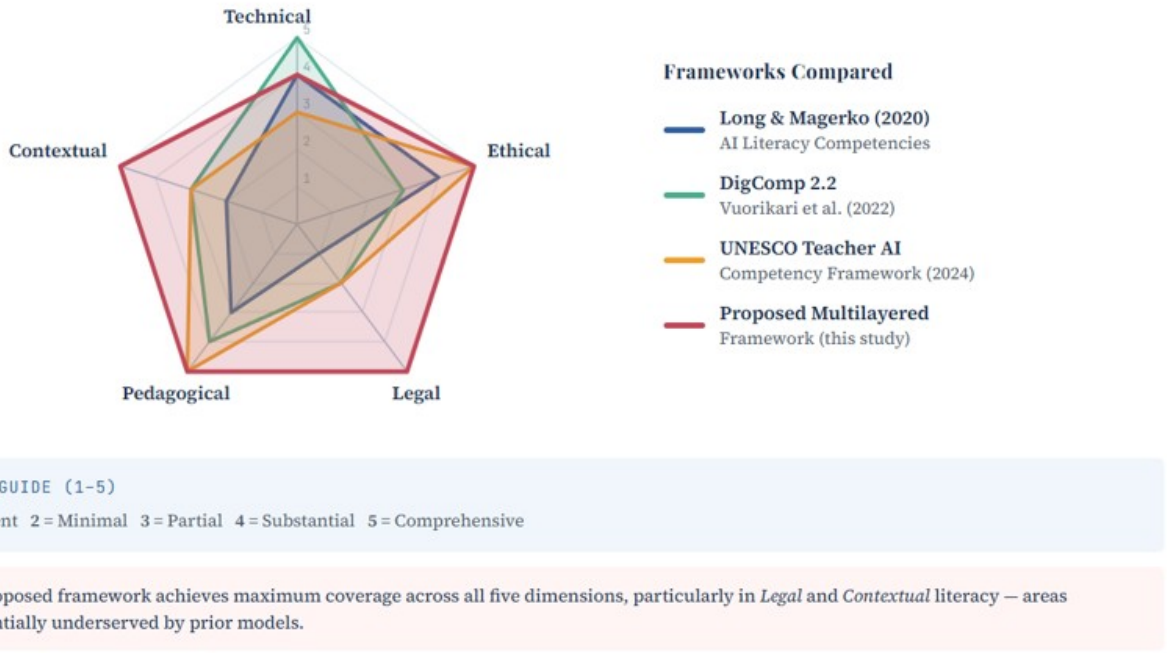

Figure 3. AI Literacy Competency Comparison: Existing Models vs. Proposed Framework
Radar chart comparing five dimensions (technical, ethical, legal, pedagogical, contextual) across four frameworks: Long & Magerko (2020), DigComp 2.2, UNESCO Teacher AI Competency Framework, and the proposed Multilayered Framework. The proposed framework demonstrates the most balanced coverage across all five dimensions. [Note: Graphical rendering to be produced at production stage.]

CRITICAL PERSPECTIVES: RISKS, INEQUALITIES, AND CONTESTED DIMENSIONS. A robust AI literacy framework must engage critically with contested dimensions of AI deployment — not merely summarize existing ethics literature but analytically examine tensions and trade-offs that affect educational and professional practice.

The productivity gains of generative AI are empirically real: AI tools can reduce time-on-task for content generation, translation, coding, and data analysis. However, uncritical over-reliance on AI-generated outputs risks eroding the deliberative processes through which learners develop domain expertise. When AI produces adequate outputs quickly, learners may forgo the cognitive effort required to develop original frameworks, arguments, or solutions. AI literacy frameworks must therefore not only teach how to use AI tools effectively but also when not to use them — preserving cognitive engagement for tasks where generative AI substitution impedes rather than enhances learning.

Epistemic dependency refers to the gradual outsourcing of knowledge-generation and reasoning to AI systems, resulting in diminished capacity for independent epistemic activity (Floridi et al., 2018). In educational contexts, this manifests as students who can prompt AI to generate sophisticated analyses but lack the underlying knowledge to evaluate those analyses critically. AI-induced deskilling is a related phenomenon documented in professional contexts: when AI routinely

performs tasks previously requiring human expertise, practitioners may lose the skills necessary to perform those tasks independently — a significant concern in high-stakes fields such as medicine, law, and engineering. Responsible AI literacy education must explicitly address these risks by designing assessment tasks that cannot be completed through AI substitution alone.

The deployment of AI-powered monitoring tools in educational settings — automated plagiarism detection, learning analytics, proctoring systems — raises significant surveillance risks that AI literacy frameworks frequently underemphasize. Students and educators must develop critical awareness of how institutional AI systems collect, analyse, and act on behavioural data. Power asymmetries between institutions deploying surveillance AI and individuals subject to it must be addressed explicitly in the critical governance layer, not merely treated as a data privacy compliance issue.

The training and operation of large language models consume substantial energy and generate non-trivial carbon emissions (Strubell et al., 2019). Responsible AI literacy should include awareness of these environmental costs and encourage users to calibrate AI use to genuine informational need rather than defaulting to AI generation as a matter of convenience. This dimension aligns with UNESCO's sustainability pillar within its AI ethics framework but remains almost entirely absent from current AI literacy curricula. Future curriculum frameworks should incorporate AI sustainability literacy as a component of the critical governance layer.

AI literacy as currently theorized and practiced reflects primarily North American and Western European contexts, reinforcing structural inequalities in global knowledge production. Infrastructure inequalities — unreliable electricity, limited bandwidth, high device costs — constrain AI tool access in low- and middle-income countries. Language inequalities — the overwhelming dominance of English in training data and evaluation benchmarks — disadvantage non-English-speaking populations and produce systematically inferior outputs in non-Western languages. Corporate concentration — the control of frontier AI development by a small number of companies in the United States and China — creates dependency relationships that constrain the policy autonomy of other nations. AI literacy frameworks designed for global adoption must acknowledge these structural dimensions and offer adaptation guidance for resource-constrained, multilingual, and institutionally varied contexts.

AI LITERACY IN EMERGING ECONOMIES: THE CASE OF UZBEKISTAN AND THE GLOBAL SOUTH. While AI literacy frameworks developed in high-income, English-speaking contexts provide valuable conceptual foundations, their direct application in emerging economies — including Uzbekistan and comparable Central Asian, African, and South Asian contexts — encounters structural barriers that require explicit analysis.

Uzbekistan's higher education system has undergone significant reform since the early 2000s, with substantial investment in digital infrastructure since 2018. Nevertheless, persistent gaps remain in reliable broadband access outside major urban centres, device availability for students, and institutional subscriptions to premium AI tools. Many frontier generative AI systems (GPT-4, Gemini Ultra, Claude 3) are either unavailable in local-language interfaces or require payment methods inaccessible to most students. These infrastructure barriers mean that AI literacy education in Uzbekistan cannot simply adopt Western curriculum models predicated on universal tool access.

Uzbek, Tajik, and Russian — the primary languages of higher education in Uzbekistan — are significantly underrepresented in LLM training data. This produces systematically lower-quality outputs in these languages compared to English, creating a compounding disadvantage: students learning to critically evaluate AI outputs must first work with outputs that are less reliable, less fluent, and less culturally appropriate than those available to English-speaking peers. AI literacy curricula in multilingual contexts must explicitly address output quality variation across languages and develop learner competencies for cross-linguistic AI output evaluation.

The significant relationship between teacher digital competence and AI literacy (Moreira-Choez et al., 2024) implies that AI literacy education in Uzbekistan faces a compounding challenge: many faculty members lack foundational digital competencies upon which AI literacy can be built. Systematic teacher training programmes — not single-session workshops — are required. Abdumanonov (2025), examining intelligent educational management systems in Uzbekistan's higher education institutions, found that structured digital competency training significantly improved both faculty and student outcomes, suggesting that investment in foundational digital literacy is a prerequisite for AI literacy interventions.

The proposed multilayered framework can be adapted for emerging economy contexts through four modifications: (1) substituting inaccessible frontier AI tools with locally available alternatives (e.g., open-source models such as LLaMA or Mistral); (2) beginning foundational layer instruction with language-agnostic AI concepts before tool-specific competencies; (3) prioritizing the critical governance layer early in the curriculum given the policy urgency of AI governance in rapidly digitalizing contexts; and (4) incorporating national AI policy frameworks (e.g., Uzbekistan's Digital Uzbekistan 2030 strategy) alongside EU and UNESCO standards in legal literacy instruction.

IMPLEMENTATION FRAMEWORK. Effective implementation of the proposed multilayered framework in higher education requires institutional, curricular, and pedagogical changes at multiple levels. This section provides an actionable implementation model with sample learning outcomes, assessment tasks, and a progression structure.

Table 4 presents sample learning outcomes for each of the three layers, mapped to assessment tasks. Learning outcomes use measurable action verbs consistent with Bloom's revised taxonomy and the UNESCO acquire–deepen–create progression model.

Table 4. Learning Outcomes and Assessment Tasks by Framework Layer

Layer	Sample Learning Outcomes	Assessment Task
Foundational Understanding	Explain how LLMs generate text; identify types of AI bias; describe the EU AI Act risk tiers	Short-answer quiz; concept map of AI system components
Applied Competency	Construct, evaluate, and iteratively refine prompts for specific disciplinary tasks; document AI-assisted workflows transparently	Documented prompt iteration log; AI-output critique report
Critical Governance	Analyse an AI ethics case study; evaluate an institutional AI policy against UNESCO/EU	Ethical case analysis (1,500 words); governance audit rubric

Layer	Sample Learning Outcomes	Assessment Task
	standards; propose governance improvements	

Note. Progression levels adapted from UNESCO (2024) acquire–deepen–create model.

Consistent with UNESCO's (2024) acquire–deepen–create structure, the implementation model organizes competency development across three progression levels:

- Beginner (Acquire): Students identify AI system types, explain LLM generation processes, apply basic five-element prompt structure, and recognize common AI output errors. Assessment: short-answer quiz; single-cycle prompt task with reflection.
- Intermediate (Deepen): Students design discipline-specific prompt sequences, evaluate AI outputs against primary sources, document AI-assisted workflows transparently, and analyse a given AI ethics case using the eight responsible AI principles. Assessment: documented prompt iteration log; AI-output critique report (800–1,000 words).
- Advanced (Create): Students design an AI literacy learning activity for a specified professional context, audit an institutional AI policy against EU AI Act standards, propose governance improvements, and critically analyse the power dynamics embedded in a specific AI deployment. Assessment: ethical case analysis (1,500 words); governance audit with policy recommendations.

AI-Output Critique Task. Students are provided with an AI-generated response to a discipline-specific prompt (e.g., a medical case summary, a legal analysis, or a historical interpretation). They must: (a) identify factual claims in the output; (b) verify each claim against at least two primary or secondary sources; (c) identify instances of hallucination, bias, or oversimplification; (d) document the original prompt and propose a revised prompt likely to produce a more reliable output; and (e) reflect on what this exercise reveals about appropriate reliance on AI tools in their discipline.

Ethical Case Analysis. Students analyse a real or composite AI deployment case (e.g., AI-assisted hiring, automated student assessment, AI in clinical diagnosis) using the eight responsible AI principles (Knöchel et al., 2025). They must identify which principles are violated or upheld, evaluate the adequacy of existing governance mechanisms, and propose concrete improvements. Cases from Uzbekistan and Central Asian contexts should be incorporated where available to develop locally relevant analytical competencies.

AI-Use Disclosure Statement. For all assessed work where AI tools were used, students submit a structured disclosure statement specifying: the AI tools used; the prompts submitted; the outputs received; how the outputs were evaluated, modified, or rejected; and how the final submission reflects the student's own independent reasoning. This assessment develops accountability, transparency, and documentation competencies aligned with responsible AI principles.

Figure 4. AI Literacy Curriculum Integration Roadmap

A four-year undergraduate curriculum integration roadmap showing: Year 1 — foundational understanding (all disciplines); Year 2 — applied competency in disciplinary context; Year 3 — critical governance and professional ethics; Year 4/Postgraduate — governance design, policy analysis, and AI leadership. Cross-cutting prompt literacy and legal literacy threads span all four years. [Note: Graphical rendering to be produced at production stage.]

DISCUSSION. This conceptual narrative review set out to address four guiding questions. The discussion returns to each in turn before addressing broader implications.

Regarding the first question — what competencies constitute responsible AI literacy in higher education — the review identifies a tripartite architecture of foundational understanding (AI concepts, system types, regulatory awareness), applied competency (prompt literacy, output evaluation, transparent documentation), and critical governance (ethical reasoning, legal compliance, democratic accountability). No single existing framework adequately encompasses all three layers, necessitating the integrated model proposed here.

Regarding the second question — how existing frameworks inadequately address legal literacy, prompt literacy, and human oversight — the comparative mapping (Table 2) demonstrates that prior models predate binding regulatory frameworks such as the EU AI Act, conceptualize prompting as a practitioner skill rather than a theory-grounded pedagogical competency, and underspecify human oversight as a civic and institutional responsibility rather than merely a technical fail-safe.

Regarding the third question — how responsible AI principles can be operationalized in digital literacy curricula — the implementation framework (Section 9) provides sample learning outcomes, assessment tasks, and a progression model. The responsible AI principles table (Table 1) translates abstract ethical principles into concrete student competencies, teacher practices, and institutional policies for the first time in integrated form.

Regarding the fourth question — how AI literacy frameworks must be adapted for emerging economies — Section 8 provides analysis of infrastructure, language, teacher training, and institutional barriers specific to Uzbekistan and comparable contexts, and offers four concrete adaptation recommendations.

A critical observation arising from this review concerns the relationship between AI literacy and academic integrity. The rapid adoption of generative AI in higher education has prompted widespread concern about AI-assisted plagiarism. However, framing AI primarily as an integrity risk misses the deeper pedagogical opportunity: when AI tools are used responsibly and transparently, with critical evaluation of outputs, they can function as powerful learning tools that develop higher-order thinking skills. Assessment redesign — moving from product to process, from knowledge recall to critical evaluation — is as important as AI literacy instruction itself.

The environmental and resource dimensions of AI use represent an emerging area that current frameworks inadequately address. Large language models consume substantial computational resources and generate non-trivial carbon emissions. Responsible AI literacy should include awareness of these costs and encourage learners to calibrate AI use to genuine informational need, aligning with UNESCO's sustainability pillar.

LIMITATIONS. This study is subject to several important limitations that qualify the scope and confidence of its findings.

- Database and language bias: The review drew primarily on Scopus and Web of Science and included only English-language literature. AI literacy scholarship published in Uzbek, Russian, Chinese, Arabic, and other languages was not systematically included, potentially underrepresenting perspectives from emerging economies.
- Absence of systematic screening protocol: Unlike a formal systematic review, this review did not employ dual-coder reliability checks, PRISMA-compliant screening, or inter-rater agreement measures. The thematic synthesis reflects the authors' interpretive judgments and may not be fully reproducible.
- Rapidly changing AI tools and literature: Generative AI tools and the research literature surrounding them are evolving at exceptional speed. Some frameworks reviewed may already be superseded by subsequent empirical findings or regulatory developments; the review captures the state of the field as of December 2024.

- Lack of empirical validation: The proposed multilayered framework is conceptual and has not been empirically validated through curriculum implementation studies, expert consensus methods, or longitudinal competency assessments. Future research should pilot the framework in educational settings and evaluate its effectiveness.
- Conceptual scope limitation: The framework is designed primarily for higher education contexts in countries with developing or emerging AI regulatory environments. Its applicability to primary and secondary education, informal learning, or highly regulated professional contexts may require substantial adaptation.

CONCLUSION. This conceptual narrative review has argued that responsible use of artificial intelligence constitutes an emerging and essential dimension of digital literacy in the twenty-first century. The convergence of increasingly capable generative AI tools, binding regulatory frameworks, and growing evidence of competency gaps creates both the impetus and the intellectual foundation for integrating responsible AI use within digital literacy education at all levels.

The proposed multilayered framework — encompassing foundational understanding, applied competency, and critical governance, integrated with prompt literacy, legal literacy, and human oversight — addresses three theoretical gaps absent from prior models: (1) a theory-grounded conception of prompt literacy as a pedagogical competency; (2) legal literacy as a binding requirement in the post-EU-AI-Act regulatory environment; and (3) curriculum sequencing adapted for diverse institutional and resource contexts including emerging economies.

The critical analysis demonstrates that AI literacy education cannot be reduced to tool use instruction. Epistemic dependency, AI-induced deskilling, surveillance risks, environmental costs, and Global South inequalities demand analytical engagement — not merely ethical awareness — from educators and learners alike. Democratic accountability, the capacity of citizens and institutions to interrogate and govern AI systems deployed in consequential decision-making, is the ultimate civic competency that AI literacy education must cultivate.

Four priorities for future research emerge from this analysis. First, longitudinal studies are needed to assess the effectiveness of AI literacy interventions over time. Second, comparative research across national and cultural contexts would illuminate how frameworks must be adapted for non-Western environments. Third, empirical validation of the proposed framework through curriculum implementation studies is urgently needed. Fourth, the intersection of AI literacy with academic integrity, creative authorship, and professional ethics warrants systematic investigation.

As AI systems become increasingly embedded in consequential decision-making — healthcare, education, criminal justice, public administration — the question of who is empowered to use, evaluate, and govern these systems becomes a matter of democratic accountability. Digital literacy, in its most expansive and socially responsible form, must rise to meet this challenge.

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