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CORE COMPONENTS FOR AN AI LITERACY CURRICULUM: PROPOSING THE METAMORPHIC FRAMEWORK FOR AUGMENTED INTELLIGENCE

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Introduction. In an era, where artificial intelligence (AI) increasingly permeates education, work environments, and daily life, developing systematic approaches to AI literacy has become essential. Despite the urgency, a significant gap persists between theoretical approaches to AI literacy and practical implementation strategies. This paper proposes an enhanced, evidence-based framework for artificial intelligence literacy curriculum development, namely, the METAMORPHIC framework. This proposed framework integrates six core components: technological fluency, transformative awareness, ethical intelligence, augmented partnership, metacognitive agility, and dynamic equilibrium. This framework addresses the critical distinction between literacy (knowledge and skills) and competency (confidence and effective application) [1] and emerges at a critical juncture in AI education research, aligned with emerging regulatory standards for an increasingly AI-mediated world.

Aim. Drawing from recent research and implementation data, the proposed framework aims to provide structured guidance for educational contexts from early education to organizational settings.

Materials and methods. By synthesizing the recent academic research [1-4], European Union regulatory guidance [5], implementation data from the AI Literacy Institute [6], and suggesting additional approaches, a six-component curriculum framework was developed, that bridges this theory-practice divide (Fig. 1).

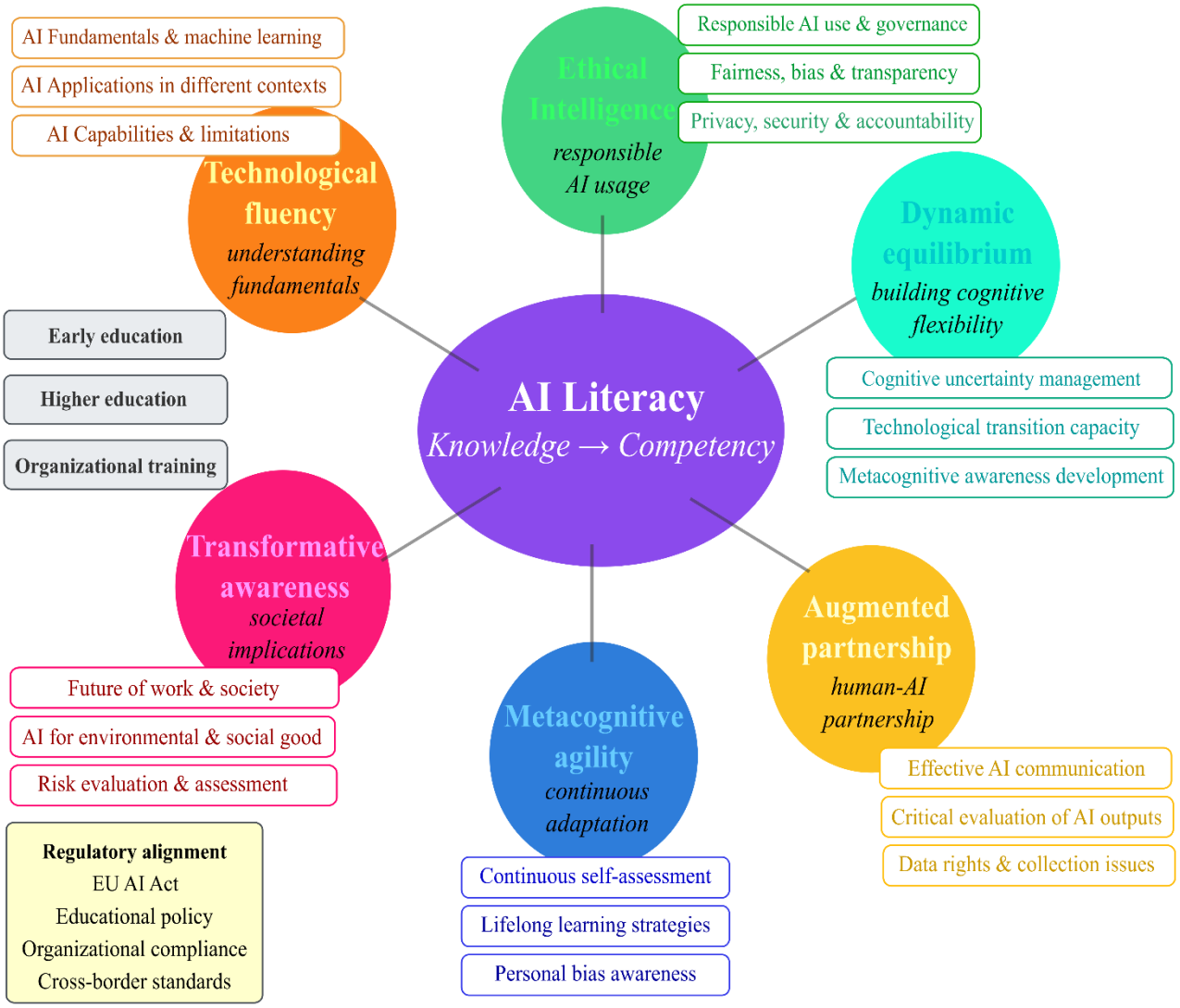

Fig. 1. The proposed METAMORPHIC framework for AI literacy: six core components and potential implementation contexts

The name METAMORPHIC represents the framework's transformative approach to AI literacy and stands for: Metacognitive agility, Ethical intelligence, Technological fluency, Augmented partnership, transforMative awareness, cOgnitive adaptation, Reflective practice, Progressive learning, Human-AI synergy, Impact understanding, and Critical evaluation. While the core framework focuses primarily on the six main components, this broader conceptualization reflects the multifaceted

nature of comprehensive AI literacy.

Results and discussion. Fig. 1 illustrates the proposed conceptual model of how the components would connect with the central concept of AI literacy as the bridge between knowledge and competency, while highlighting their key elements and showing potential implementation across various educational contexts. This distinction serves as a cornerstone for the proposed curriculum framework, which, informed by recent implementation data, encompasses six interconnected components forming what designated as the METAMORPHIC framework. This enhanced framework is presented as follows:

1. Technological fluency

Technological fluency extends beyond basic understanding to active mastery of AI tools, creating the cognitive scaffolding, upon which broader literacy development depends. This component addresses:

- Progressive mastery of AI fundamentals and machine learning principles through age-appropriate demonstrations, emphasizing active implementation over passive knowledge
- Development of computational thinking and pattern recognition specific to different AI applications in daily life
- Exploration of human-AI interaction paradigms through experiential learning tools, that illuminate both AI capabilities and fundamental limitations

The centrality of technological fluency is consistently supported by empirical evidence. Lintner's [4] review identified it as a core factor in most validated AI literacy scales, aligning with the EU AI Act's emphasis on AI literacy as equipping "providers, deployers and affected persons with the necessary notions to make informed decisions regarding AI systems" (Article 4).

2. Transformative awareness

Beyond technical knowledge, learners must develop a sophisticated comprehension of AI's broader societal implications through cultivating transformative awareness:

- Anticipatory thinking and future scenario planning regarding AI's

influence on evolving work environments, careers, and societal structures

- Methodologies for measuring both quantitative and qualitative impacts of AI applications for social good through engagement with environmental and public health challenges
- Contextual understanding of how AI impacts vary across different domains, with domain-specific impact assessment frameworks

This transformative awareness component directly supports the EU AI Act's recognition, that "AI literacy should equip providers, deployers and affected persons with the necessary notions to make informed decisions regarding AI systems" (Art. 4).

3. Ethical intelligence

Ethical intelligence represents the moral compass guiding responsible AI usage across contexts, transcending basic awareness to develop sophisticated ethical reasoning:

- Structured decision-making frameworks for navigating ethical dilemmas in AI development and deployment
- Systematic examination of fairness, biases, trust, transparency, accountability, social benefit, privacy, and security through case-based learning
- Cross-cultural ethical reasoning skills, that address gender gaps in AI usage and diverse cultural perspectives on AI governance

The ethical intelligence component resonates strongly with the EU AI Act's approach, particularly in Article 27, which requires certain deployers to "perform an assessment of the impact on fundamental rights" prior to using high-risk AI systems.

4. Augmented partnership

Effective interaction with AI systems requires specific collaborative skills, that enable productive human-AI synergies rather than mere tool usage:

- Development of structured frameworks for human-AI complementary capabilities, emphasizing reciprocal learning systems
- Training in communication protocols optimized for AI systems, including nuanced prompt engineering and feedback mechanisms

- Collective intelligence principles for working in human-AI teams with appropriate boundary-setting practices

The complexity of this augmented partnership is illuminated by research indicating, that experts actually use more cognitive effort, when working with generative AI than novices – suggesting, that meaningful collaboration requires deeper engagement, rather than passive acceptance. It directly supports Article 14 of the EU AI Act on "Human oversight", which requires high-risk AI systems to be "designed and developed in such a way, that they can be effectively overseen by natural persons."

5. Metacognitive agility

The rapidly evolving nature of AI technologies necessitates ongoing self-assessment and adaptation through metacognitive processes:

- Systematic feedback mechanisms for continuous improvement of one's AI understanding and usage patterns
- Development of robust lifelong learning skills with specific cognitive bias recognition techniques for AI interactions
- Monitoring practices for identifying knowledge gaps with learning transfer strategies across different AI contexts

Chiu *et al.* [1] emphasize, that these metacognitive abilities are essential for AI competency in a dynamic technological landscape. Implementation data shows a significant percentage of students believe overreliance on AI impedes independent problem-solving abilities, underscoring the necessity of cultivating metacognitive skills, and aligning with the EU AI Act's recognition, that AI systems continue to evolve after deployment, requiring vigilant monitoring and assessment.

6. Dynamic equilibrium

In rapidly evolving AI environments, individuals must develop cognitive flexibility and adaptive capacity to maintain a dynamic equilibrium between human and machine capabilities:

- Cognitive uncertainty management strategies with practical exercises for effectively processing unpredictable AI outputs

- Technological transition capacity building through structured approaches to mitigate "innovation fatigue"
- Stress management techniques specific to technological change with practical approaches for maintaining human agency during rapid AI evolution

Current research suggests, that traditional educational paradigms often emphasize static knowledge acquisition rather than the adaptive cognitive frameworks necessary for AI-mediated environments. This dynamic equilibrium component directly supports Article 14.4.d of the EU AI Act regarding the ability "to decide, in any particular situation, not to use the high-risk AI system or otherwise disregard, override or reverse the output of the high-risk AI system."

Pedagogical implementation and assessment approaches

Effective implementation of AI literacy curricula requires tailored approaches for different educational contexts:

Early education

For younger learners, a scaffolded introduction to AI concepts builds a foundation for future development:

- Age-appropriate AI literacy resources like engaging high school lessons, that progressively develop all six components
- Parent-guided exploration of basic AI tools with structured discussions about appropriate use and ethical considerations
- Interactive classroom exercises designed to improve student prompting and evaluation skills through experiential learning

Recent census data indicates, that a significant percentage of children under 8 are already using AI for school-related material, often with limited guidance — highlighting the need for structured early education approaches.

Higher education

Collegiate settings require more sophisticated approaches:

- Cross-disciplinary frameworks, that conceptualize AI as "a fourth world" after physical, biological, and social domains
- Innovative train-the-trainer models like professional learning

communities with disciplinary specializations

- Strategic institutional partnerships with AI developers focusing on co-creation rather than adoption
- Comprehensive first-year experience programs, that prepare both students and faculty for AI integration with differentiated learning paths

Recent research from higher education reveals majority faculty support for AI tool use in classrooms, indicating institutional readiness for structured implementation approaches.

Organizational implementation

Workplace AI literacy requires structured approaches, that align with business objectives:

- Role-based tiered training programs, that address specific competency needs across organizational structures
- Seamless integration with AI governance frameworks and organizational learning systems
- Diverse multi-channel learning approaches demonstrated by the European Commission's repository of best practices
- Context-specific applications for specialized domains like legal work, healthcare, and creative industries

The organizational implementation recommendations directly support the EU AI Act's Article 26 on "Obligations of deployers of high-risk AI systems".

Assessment methods and implementation strategies

Measuring AI literacy presents unique challenges, that require carefully designed assessment approaches. Lintner's [4] systematic review provides valuable guidance, that could be adapted for the proposed framework:

- Performance-based assessment: only three validated objective instruments currently exist, necessitating the development of new assessment tools, that could be aligned with the proposed METAMORPHIC framework
- Self-report measures: thirteen validated self-report scales assess perceived AI literacy, which could potentially be adapted to reflect the six proposed

components

- Target-specific assessment: different tools would need to be strategically deployed based on audience and educational context
- Consistent dimensions: most validated instruments measure similar components, that could potentially be mapped to the proposed framework components

The scarcity of validated performance-based assessments represents a significant gap, that future research must address to better evaluate actual AI competency rather than merely self-perceived literacy.

Aligning the proposed educational framework with regulatory developments

The proposed METAMORPHIC framework could align with and support emerging policy directions:

The EU AI Act (2024) [8] establishes specific requirements for AI literacy within educational institutions and professional training programs. The framework's six components directly address the Act's emphasis on ethical understanding, critical evaluation, and responsible application of AI technologies.

Educational policy integration. The framework provides educational policymakers with structured components, that can be adapted to national educational standards and assessment frameworks. Research indicates, that jurisdictions with structured AI literacy frameworks demonstrate higher rates of successful implementation.

Organizational compliance frameworks. For organizations implementing AI systems, regulatory requirements increasingly include workforce training components. The framework's organizational implementation strategies align with emerging compliance requirements.

Contextual cross-border adaptability as a design feature. The framework's implementation across specific populations has allowed for targeted refinement, enabling precise calibration of educational approaches to different learning environments.

Evolutionary design for technological advancement. The modular, component-based approach intentionally separates foundational concepts from specific technological implementations, creating an inherently flexible structure.

Conclusions. As AI continues its transformative march across society, developing effective literacy and competency will be essential for ensuring that humans retain agency in an increasingly AI-augmented world. We propose the METAMORPHIC framework as an approach that, by integrating current research on both curriculum design and practical implementation, could provide a foundation for developing AI literacy programs. If implemented, this framework could help prepare individuals to understand, critically evaluate, and responsibly engage with AI systems across educational and professional contexts.

The proposed reconceptualization of adaptive resilience as dynamic equilibrium addresses what is a critical dimension of AI literacy: the cognitive and psychological capacities, that are necessary for navigating rapidly evolving technological environments, while maintaining human agency. As AI systems continue to advance at accelerating rates, the ability to maintain cognitive flexibility and effectively manage technological transitions will likely become increasingly essential for meaningful human participation in AI-mediated contexts.

By attempting to bridge theoretical foundations with practical implementation strategies through the proposed METAMORPHIC framework, this work aims to offer a potential roadmap for navigating the complex terrain of AI literacy development. If this framework were to be implemented and tested, ongoing research and adaptation would be essential to ensure, that these approaches remain relevant and effective in a rapidly evolving technological landscape.

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