https://doi.org/10.15625/2615-8965/22510403

Key Skills and Competences for Lifelong Learners in the Artificial Intelligence Era

Doan Thi Hue Dung[1]✉, **Nguyen Nhat Quang**[2]

[1] doanthihuedung@siu.edu.vn
Saigon International University (Vietnam)
[2] nguyennhatquang@siu.edu.vn
Saigon International University (Vietnam)
✉ Corresponding author

ABSTRACT: *This article identifies and conceptualizes key competences essential for lifelong learners to engage critically, ethically, and effectively within AI-mediated environments. In the age of artificial intelligence (AI), lifelong learning must be reimagined to meet the demand for multi-dimensional competences. This study moves beyond traditional skill-based frameworks by highlighting critical awareness, relational intelligence, and future-oriented responsibility as key competencies. Grounded in connectivism, affordance theory, and transformative learning, this study conceptualizes Human-AI learning interaction across three interconnected domains including grounding personal agency, navigating human-AI relationships, and envisioning transformative futures. Methodologically, the study is informed by a comprehensive synthesis of theoretical literature, policy documents, and recent empirical research across education, technology, and lifelong learning. The article contributes a theoretically grounded and forward-looking model to inform lifelong learning policy, pedagogy, and learner development in the AI era.*

KEYWORDS: **Lifelong learning, skill development, competence development, AI-mediated learning, lifelong learner**

Received 04/07/2025 → Revised manuscript received 09/09/2025 → Published 12/2/2026.

1. Introduction

The rapid evolution of artificial intelligence (AI) is transforming not only the labour market and knowledge production but also the very foundations of how people learn, interact, and define themselves as learners. While the integration of AI into education at all levels has generated optimism about personalization, automation, and efficiency, it also raises deeper pedagogical and ethical questions. This article narrows its scope to higher education and adult learning contexts. These sectors are undergoing rapid digital transitions and face evolving professional demands (Eliza, 2023). At the same time, adult learners demonstrate a cognitive readiness and life experience that enable more effective engagement in self-directed, technology-enhanced learning and continuous upskilling (Kizilcec *et al*., 2017).

Traditional models of competence development focused primarily on cognitive skills or job-specific proficiencies no longer suffice. The AI era demands multidimensional competences that are not only technical but also ethical, relational, and future-oriented. Learners must develop the ability to critically engage with AI systems, reflect on their roles within sociotechnical ecosystems, and take responsibility for shaping more equitable and humane futures. This view challenges narrow definitions of learning outcomes and calls for a broader rethinking of what lifelong learning entails in an age of intelligent machines and algorithmic mediation. These cultural and cognitive shifts highlight the urgency of moving beyond technical fluency toward more life-deep and life-beyond dimensions of learning. In other words, competence development should be rooted in values, identity, and ethical reasoning.

Grounded in contemporary learning theories and global policy perspectives, this article explores how lifelong learning must be reconceptualized to meet these demands, offering a theoretical and pedagogical framework that centers on layered competence development, ontological responsibility, and the active role of learners in co-shaping AI-mediated futures. It aims to contribute a holistic vision for lifelong competence development. Specifically, the study investigates this major research question: What types of competences are essential for lifelong learners to thrive in AI-mediated environments?

2. Literature Review

2.1 Historical Foundations and Shifting Dimensions of Lifelong Learning

The idea of lifelong learning has its intellectual roots in the early 20th century, notably in the influential work Lifelong Education by Basil Yeaxlee (1929). He argues that education is not confined to formal schooling but must be seen as a continuous and holistic process throughout life. Yeaxlee emphasized the importance of lifelong education in fostering moral and social development, framing learning as a deeply human pursuit essential to democratic life and spiritual growth.

This vision gained momentum in the post-war era through landmark UNESCO reports. The Faure Report first published in 1972 conceptualized lifelong learning as a human right and a central element of personal and societal advancement (Faure *et al*., 1972). It advocated for education systems that support human emancipation in an increasingly complex and interconnected world. Later, the Delors Report submitted in 1996 advanced this notion by proposing four pillars of learning: learning to know, learning to do, learning to live together, and learning to be. These pillars reinforced a vision of education as integral to peace, social cohesion, and personal fulfilment (Delors, 1996).

As global shifts accelerated in the late 20th and early 21st centuries, lifelong learning evolved beyond its humanistic origins. Policymakers and scholars began to frame it as an imperative for workforce adaptability and knowledge economies. The focus expanded from formal adult education to include informal, non-formal, and experiential learning across multiple contexts. The notion of life-wide learning emerged to capture how learning takes place not only in educational institutions but also in the workplace, home, and community (Jackson, 2011). Later interpretations incorporated life-deep learning, emphasizing the development of ethical sensibilities, critical consciousness, and spiritual depth (UNESCO, 2021).

2.2. Traditional Skill Domains and Their Limitations

Historically, core competences in education have been categorized into three domains: cognitive, affective, and social. Cognitive skills include critical thinking, reasoning, and problem-solving abilities, which are traditionally emphasized in formal education. The affective domain covers emotional intelligence, motivation, and ethical judgment, while the social domain involves interpersonal skills such as empathy, collaboration, and communication (Aspin & Chapman, 2001). These domains laid the foundation for curriculum development and assessment frameworks in both general and vocational education.

However, these categories often treated competences as isolated traits rather than interconnected and evolving capacities. In practice, many education systems prioritized cognitive mastery, particularly literacy and numeracy, while neglecting emotional, ethical, and socio-political dimensions of learning. This reductionist approach has been increasingly criticized for its inability to prepare learners for the complexities of 21st-century life, particularly in an era shaped by rapid technological change and social uncertainty.

2.3. Global Frameworks and the Policy Evolution of Competence

In response to the inadequacies of traditional models, global organizations have developed more comprehensive frameworks to redefine core competences. The European Commission's Key Competences for Lifelong Learning (2018) outlines eight transversal competences, including digital literacy, civic responsibility, cultural awareness, and learning to learn. These competences represent a shift toward a more holistic and life-relevant vision of education, integrating knowledge, skills, and attitudes.

Similarly, the OECD's Learning Compass 2030 articulates a vision of education that empowers learners to cope with complexity and shape future societies. Central to this framework is the idea of "transformative competences", the ability to create new value, reconcile tensions and dilemmas, and take responsibility for collective well-being (OECD, 2019). These competences move beyond the technical or utilitarian to

encompass ethical, reflective, and ecological dimensions of learning.

UNESCO's Futures of Education Report (2021) complements this perspective by arguing that education must not only prepare learners for employment but also for reimagining the future itself. It calls for education systems that are anticipatory, inclusive, and grounded in principles of sustainability, solidarity, and human dignity.

The World Economic Forum (WEF) has also contributed to the discourse through its Future of Jobs Reports, which identify trends in labour markets and project the skills in demand for the coming decades. The WEF 2020 report emphasizes resilience, flexibility, creativity, digital collaboration, and emotional intelligence as essential for thriving in dynamic, AI-augmented workplaces.

Collectively, these frameworks signal a profound reorientation of lifelong learning from a system primarily concerned with transmitting knowledge to one focused on cultivating adaptable, self-directed, and ethically responsible individuals.

2.4. Rethinking Competence Frameworks for the AI Era

Despite their progressive orientation, existing global competence frameworks face criticism for lagging behind the pace and depth of technological change, particularly the rise of artificial intelligence. Scholars have highlighted that most current models do not adequately incorporate competences specific to AI-mediated environments. Long and Magerko (2020), for instance, argue that AI literacy, i.e., understanding how AI systems work and impact society, is a fundamental civic and professional skill that remains largely absent from educational standards.

Moreover, as AI systems increasingly mediate decision-making, labour, and communication, there is a growing need for algorithmic awareness and data ethics. Howard and Choudhury (2022) note that most educational systems remain structurally unprepared to foster such competences, which require not only technical understanding but also critical inquiry and moral reasoning. Another point of critique is the rigidity of formal education systems, which tend to rely on standardized curricula and slow credentialing mechanisms. These structures are insufficient for addressing the dynamic and continuous learning needs of individuals operating within rapidly evolving labour markets.

The accelerating diffusion of artificial intelligence has not only altered the landscape of work and education but also exposed fundamental limitations in existing competence frameworks. While global policy models have increasingly embraced holistic and future-oriented visions, integrating cognitive, social, and emotional dimensions, they have struggled to keep pace with the speed, scope, and systemic impact of AI technologies.

What AI introduces is not simply a new set of technical requirements, but a profound shift in how knowledge is produced, applied, and valued. In this context, the distinction between static content knowledge and dynamic, adaptive competence becomes more critical than ever. Learners today must go beyond conventional digital literacy to cultivate capacities for interacting meaningfully and responsibly with intelligent systems.

Recent scholarship and policy reviews have emphasized the urgency of this shift. Core areas such as AI literacy, algorithmic awareness, and data ethics are emerging as essential dimensions of civic and professional life (Long and Magerko, 2020; OECD, 2023). These competences entail not only understanding how AI operates but also how it shapes decisions, mediates relationships, and reinforces or disrupts structures of power. Equally vital are human-centric capacities that position learners to complement, question, and guide AI systems rather than merely operate within them.

The 2025 Education Testing Service (ETS) Human Progress Report provides compelling evidence that individuals around the world are increasingly aware of this transformation. Its findings indicate a strong global demand for verified, demonstrable competences, what the report terms "evidential currency." This shift

toward skill-based validation reflects growing scepticisms about the sufficiency of traditional qualifications. At the same time, it reveals a disconnect between learners' aspirations and the institutional mechanisms currently available to support ongoing, adaptive learning.

The implications are obvious that the existing architecture of lifelong learning must be redesigned to align with the evolving demands of an AI-mediated society. This means not discarding but reconfiguring established frameworks to integrate technical, ethical, and human competences more fluidly and responsively.

3. Methodology

This study adopts an integrative theory synthesis design (Jaakkola, 2020), which aims to generate new conceptual frameworks by integrating existing theories with emerging empirical evidence to investigate and reframe the core competences required for lifelong learning in the AI era. Connectivism, affordance theory, and transformative learning are mainly explored to address a novel phenomenon of lifelong learning in the AI era. The study specifically draws on a comprehensive body of international policy reports, empirical surveys, and academic literature, selected for their relevance to future skill demands and lifelong learning strategies. To construct the framework, a purposeful sampling strategy was employed to select documents across three distinct streams. The selection criteria focused on high-impact policy guidance, theoretical relevance, and recent empirical insights into AI adoption.

- Stream 1 includes global policy frameworks from 2018 and 2025. Documents were selected based on their influence on global education policy and their focus on future skill demands. This includes the *OECD Learning Compass 2030* and *Skills Outlook* , *UNESCO's Futures of Education* , and the *European Commission's Key Competences*. The inclusion of the *2025 ETS Human Progress Report* ensures the analysis reflects the most current global sentiment regarding "evidential currency" and credentialing.
- Stream 2 covers theoretical foundations. Foundational texts were selected to provide the ontological and pedagogical grounding for the new model. This includes seminal works on Connectivism (Siemens, 2005) Affordance Theory (Gibson, 1979; Norman, 1999; Nguyen, 2025) , and Transformative Learning (Mezirow, 1991), and peer-reviewed academic studies on skill and competence formation, AI literacy, self-regulated learning, and human-AI interaction (Panadero, 2017; Zimmerman, 2002; Long and Magerko, 2020).
- Stream 3 is sectoral and labour market analysis. Reports such as the *World Economic Forum's Future of Jobs Report 2023* were included to identify shifting labour market demands, to ensure the framework addresses practical realities. Based on the synthesized insights, a framework of core competences is developed. The framework is intended as a heuristic to inform curriculum reform, pedagogical design, and policy direction in lifelong learning ecosystems.

The analysis proceeded in three phases. Phase 1 (thematic analysis) involved coding the policy and labour market documents to identify recurring competence gaps, specifically the lack of "AI literacy" and "ethical foresight" in traditional frameworks. Phase 2 (Theoretical Mapping) involved mapping these gaps against the three selected theories (Connectivism, Affordance, Transformative) to determine how each theory could address specific challenges of the AI era. Phase 3 (Conceptual Modelling) integrated these insights to construct the "Human–AI Learning Arc" (Figure 1), differentiating between competences for *agency* (internal), *interaction* (relational), and *transformation* (future-oriented). This phase represents the study's original conceptual contribution, moving beyond synthesis to model generation. A methodological limitation is, however, also acknowledged. Because documents were purposively selected for their influence and then thematically coded, the synthesis inevitably relies on researchers' judgement.

4. Results

4.1. Theoretical Foundations for Developing a Conceptual Framework of the Human-AI Learning Interaction

The Human-AI learning framework is underpinned by three interrelated theoretical perspectives: connectivism, affordance theory, and transformative learning theory. Connectivism views learning as a networked and distributed process. As first proposed by Siemens (2005) and expanded by Downes (2012), connectivism reframes learning for a digital age, where knowledge is increasingly externalized across networks of people, machines, and platforms. Unlike earlier learning theories that focus on internal cognitive processes, connectivism asserts that the capacity to develop and maintain connections across distributed knowledge sources is central to learning success. In connectivism environments, learners are not isolated actors but nodes within dynamic knowledge ecologies. They learn from and with both human agents and algorithmic systems. Moreover, it supports the notion of learning as co-agency, a theme echoed in the OECD's Learning Compass 2030, where students are seen as active participants in shaping shared futures through their interactions with socio-technical systems (OECD, 2019).

In other direction, affordance theory views learning through situated possibilities. First introduced by Gibson (1979) and later expanded in educational contexts by Norman (1999), Conole and Dyke (2004), Bower (2008), and Nguyen (2025), affordance theory offers a useful lens for understanding how learners interact with tools and environments. In this view, learning occurs not merely by acquiring knowledge, but by perceiving and acting upon the affordances or action possibilities presented by a given context, especially technological systems. In AI-enhanced learning environments, affordances are not neutral or static, they are situational, mediated, and often asymmetric. Recognizing and critically reflecting on these affordances is thus a necessary competence in itself.

Additionally, transformative learning theory emphasizes learning as a process of critical reflection and deep personal change. Initially developed by Mezirow (1991), this theory posits that significant learning occurs when individuals question and revise their existing frames of reference such as beliefs, assumptions, and worldviews, through dialogic engagement and reflective thinking. In the context of AI-mediated environments, where ethical ambiguities, technological disruption, and rapid social shifts are commonplace, transformative learning equips individuals to reorient their understanding of self, society, and technology.

The conceptual framework proposed in this study refers to a three-phase model of competence development that helps lifelong learners build agency, interact with AI responsibly, and imagine future possibilities. To clarify its internal structure, it is helpful to distinguish between two overarching domains of competence. The first includes competences that support lifelong learning itself such as self-regulated learning, critical thinking, metacognitive reflection, and AI or data literacy. These foundational skills enable individuals to navigate learning environments with autonomy and awareness. The second domain encompasses competences required for adaptation to broader societal, ethical, and occupational challenges. These include adaptability, intercultural collaboration, ethical reasoning, and systems thinking. Together, these two domains form a cohesive developmental arc that spans internal learning agency, human–AI collaboration, and transformative engagement with future possibilities. The framework, thus, bridges learning processes with real-world adaptation and ethical responsibility (Fig.1).

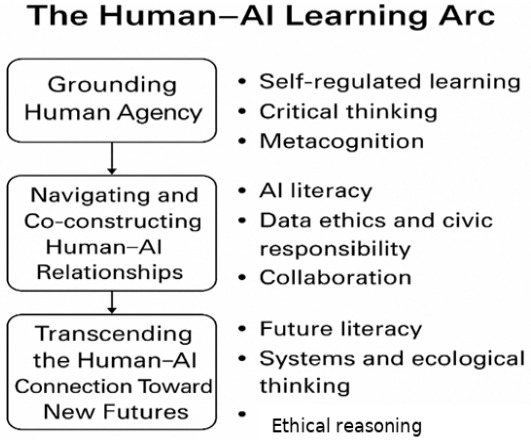

Figure 1. The framework of Human-AI co-learning

4.2. Essential Skills and Competences for Lifelong Learners

The three-layered framework conceptualizes learning in the age of artificial intelligence as a dynamic and recursive interaction across three interrelated domains: grounding personal agency, navigating human–AI relationships, and envisioning transformative futures. These domains reflect how learners engage with intelligent systems not merely as users, but as ethical and reflective agents embedded in evolving socio-technical environments.

As AI continues to transform education, work, and society, lifelong learning must extend beyond technical know-how to encompass a broad set of cognitive, ethical, relational, and future-oriented competences. This section identifies the core capabilities lifelong learners need across three interrelated domains to learn with, through, and beyond AI.

4.2.1. Grounding Human Agency

The foundation of lifelong learning lies in cultivating self-directed, reflective, and ethical agency. In increasingly automated and personalized learning environments, such agency is vital for resisting passive consumption and maintaining control over one's learning landscapes. Key competences in this layer include:

Self-Regulated Learning (SRL): The ability to plan, monitor, and evaluate one's own learning is fundamental in AI-enhanced environments such as adaptive platforms or MOOCs. According to Zimmerman (2002), SRL enables learners to set goals, manage time, and apply self-assessment, and critical skills. SRL even enhances learners' autonomy and efficacy in the AI mediated environment (Nguyen & Doan, 2025).

Critical thinking and information evaluation: In algorithmically filtered environments, learners must critically assess content, detect bias, and reason with evidence. These skills are crucial for evaluating machine-generated outputs, resisting misinformation, and making informed decisions. The World Economic Forum (2020) and OECD (2019) identify critical thinking as a core competence for democratic resilience and responsible digital citizenship.

Reflective and metacognitive thinking: Lifelong learners must engage in reflective inquiry about their strategies, emotional states, and the influence of technology on learning. Dewey (1933) emphasized that experience becomes educational only through reflection. Nguyen (2022) further highlights the need for affordance-aware reflection, a sensitivity to how digital tools shape the possibilities and constraints of learning. Together, these competences empower learners to maintain autonomy, self-awareness, and ethical judgment in increasingly AI-mediated contexts.

4.2.2. Navigating and Co-constructing Human-ai Relationships

This layer addresses how learners engage with AI not just as users but as co-participants in hybrid learning systems. As AI systems increasingly generate feedback, mediate interaction, and influence outcomes, learners must cultivate competences for ethical and effective human–AI collaboration. Key competences include:

AI and data literacy: Beyond basic digital skills, learners need to understand how AI systems function, recognize their limitations, and interact with them critically. Ng & Chu (2021) describe AI literacy as the capacity to evaluate, use, and interpret AI outputs across contexts. This includes algorithmic awareness, data ethics, and transparency. UNESCO (2021) affirms AI literacy as essential to inclusive and equitable digital citizenship.

Civic responsibility: Learners must assess the societal impacts of AI in terms of fairness, accountability, privacy, and sustainability. Biesta (2006) describes this as subjectification, the development of individuals as moral agents capable of critique, care, and civic engagement in an algorithmically influenced world.

Intercultural collaboration and empathy: Globalized digital environments demand the ability to work across cultural and disciplinary boundaries. Learners must engage diverse perspectives with empathy, practice ethical dialogue, and co-construct knowledge in virtual and mixed human–AI teams. The OECD (2018) highlights global competence as vital for both collaboration and inclusive citizenship.

Adaptability and learning agility: As technologies evolve rapidly, learners must be able to learn, unlearn, and relearn. Nguyen (2022, 2025) consistently link this to learners' ability to adapt strategies based on technological affordances and feedback loops. These competences position learners as active, ethical participants in human–AI ecologies capable of shaping interactions rather than being shaped by them.

4.2.3. Envisioning and Shaping Transformative Futures

The third layer extends learning into the moral, ecological, and imaginative domains. As AI becomes embedded in societal infrastructures, lifelong learners must be equipped not only to adapt but also to envision and create alternative, more just futures. Key future-facing competences include:

Future literacy and ethical foresight: Learners need the ability to anticipate, interpret, and act upon emerging trends. UNESCO (2021) defines future literacy as essential to adaptive citizenship, enabling learners to question assumptions and co-imagine equitable and sustainable alternatives to dominant technological world.

Systems and ecological thinking: Understanding the interconnectedness of technological, social, and ecological systems is vital for addressing complex global challenges. According to the OECD (2023), systems thinking fosters integrative reasoning, humility, and the capacity to navigate uncertainty in AI-mediated environments.

Ethical reasoning and ontological reflection: Ethical reasoning is the ability to identify ethical issues, weigh relevant values and consequences, and justify a responsible decision. Lifelong learning should foster reflection on values, purpose, and what it means to be human amid technological transformation. Biesta (2006) and Selwyn (2019) argue for learning that is ontologically grounded, inviting learners to engage not only with what they can do but with who they want to become in relation to others and the planet. Ontological reflection in this context refers to a learner's deliberate examination of their underlying assumptions about being and identity.

Creative inquiry and design thinking: Learners must be capable of reframing problems, synthesizing interdisciplinary insights, and prototyping novel solutions. Rooted in transformative learning theory (Mezirow, 1991; Cranton, 2006), these competences promote innovation, resilience, and democratic agency. These transformative competences reposition lifelong learning as more than a path to employment. It becomes a moral and civic endeavour, empowering learners to co-create futures they may not inhabit but feel responsible for shaping.

In sum, the essential competences of lifelong learners in human–AI contexts are not static skills, but dynamic capabilities that evolve with shifting technological, ethical, and ecological conditions. Across all three layers, agency, co-agency, and transformation, learners must cultivate the ability to think critically, act ethically, collaborate responsibly, and imagine boldly. This demands pedagogies that nurture autonomy, reflection, and collective imagination for futures beyond the algorithm. The core skills and competencies are summarised in Table 1 below.

Table 1: Core skills and competences of lifelong learners

Layer	Core Skill / Competence	Key Objectives
Grounding Human Agency	Self-Regulated Learning (SRL)	Enable autonomous and self-directed learning in diverse contexts
	Critical Thinking and Knowledge Evaluation	Evaluate information, detect bias, and support informed decision-making
	Reflective and Metacognitive Thinking	Reflect on learning strategies, emotions, and technology affordances

Layer	Core Skill / Competence	Key Objectives
Navigating Human–AI Relationships	AI and Data Literacy	Understand, engage with, and critique AI systems and data platforms
	Ethical Reasoning and Civic Responsibility	Assess social and ethical impacts of AI and act with responsibility
	Intercultural Communication and Collaboration	Collaborate ethically in global and AI-mediated environments
	Adaptability and Learning Agility	Adapt to rapid change and navigate shifting learning environments
Transcending the Human–AI Connection	Future Literacy and Anticipatory Thinking	Imagine and prepare for multiple futures with critical foresight
	Systems and Ecological Thinking	Understand interdependence of systems and global challenges
	Ethical reasoning and Ontological Reflection Creative Inquiry and Design Thinking	Reflect on human identity, purpose, and future possibilities

5. Discussions

5.1. Supporting Self-regulated and Reflective Learning

In AI-saturated environments, the central challenge is less about accessing information than sustaining attention, judgment, and purposeful learning. Pedagogy should therefore prioritise learner agency through self-regulated learning, metacognitive awareness, and reflective judgment. Learners need to set goals, monitor progress, evaluate quality, and adjust strategies as conditions change. In open, online, or AI-enhanced contexts, these capacities are strengthened when courses and platforms embed simple structures such as goal trackers, progress dashboards, and short reflective prompts that make learning decisions visible. A further step is affordance-aware reflection, where learners identify opportunities and make deliberate decisions about when and how to use AI, rather than defaulting to uncritical reliance.

5.2. Cultivating AI Literacy and Co-agency

Beyond self-management, learners must develop the competence to participate responsibly in human–AI interaction. AI literacy should be treated as both functional understanding and critical engagement such as interpreting outputs, recognising uncertainty and limitations, and identifying ethical risks. This is best developed through guided, hands-on use of AI systems where learners are expected to compare sources and justify decisions. Practical strategies include small-scale "algorithmic audits," design-thinking tasks, and scenario-based ethical discussions that surface how AI systems embed assumptions and distribute advantages and harms.

5.3. The Active Role of Learners in the AI Era

Many educational systems and AI-driven platforms prioritize surface-level metrics such as task completion, engagement time, or performance scores, often overlooking or undervaluing subtler but crucial competences like reflective thinking, ethical reasoning, or systems awareness. As Selwyn (2019) notes, this data-driven paradigm often reduces learners to behavioural profiles, marginalizing internal dispositions that resist easy quantification. Consequently, youth may be conditioned to chase algorithmic approval or gamified rewards, undermining the development of more durable and transformative capacities.

Moreover, cultural patterns in digital life present further difficulties. A vivid example is the Brain Rot trend, a term popularized by youth

themselves to describe excessive exposure to short-form, hyper-stimulating, often absurdist content on platforms like TikTok or YouTube Shorts. Although often expressed with irony or self-awareness, the term reflects a broader concern, which is the erosion of attention, curiosity, and reflective capacity due to the constant barrage of algorithmically optimized media. Huang (2023) shows that frequent exposure to such content can impair cognitive control and reduce motivation for sustained or complex learning. The normalization of such patterns raises urgent questions for educators seeking to foster competences in metacognition, critical inquiry, or systems thinking.

In fact, the learner's role is central to the realization of human–AI co-learning. Self-regulated learning, for example, is not just a skill to be taught but a disposition to be cultivated through practice, reflection, and purposeful design. AI literacy cannot be imposed, it must emerge from active interaction, questioning, and even playful experimentation with AI tools and systems. Ethical reasoning demands that learners engage in dialogue, imagination, and judgment. These activities require a sense of ownership and co-authorship in the learning process. Transformative learning theory supports this view of learners as autonomous meaning-makers who can critically reflect on their assumptions and co-create new perspectives. Even in environments saturated with algorithmic mediation, learners can develop affordance awareness, the ability to discern how technologies shape possibilities and to choose how they respond. As UNESCO (2021) emphasizes, equitable learning futures depend not only on institutional reform but on creating spaces where learners can practice autonomy, dialogue, and collective inquiry. Educational models must, therefore, not only instruct but entrust learners with the responsibility and capacity to direct their own learning across the lifespan.

6. Conclusion and Recommendations

This article has argued that traditional models, often rooted in static, discipline-bound, or narrowly cognitive frameworks, are insufficient for preparing individuals to thrive in AI-mediated environments. Instead, it introduced the three layered human–AI co-learning framework that conceptualizes competence development as a dynamic continuum.

Drawing on connectivism, affordance theory, and transformative learning theory, the framework emphasizes that lifelong learning in the AI era is not merely a matter of acquiring technical fluency. Rather, it requires learners to engage with evolving socio-technical realities in reflective, relational, and future-oriented ways. The article further outlined how specific pedagogical strategies such as self-regulated learning scaffolds, AI literacy practices, and future thinking approaches can support the development of multidimensional competences across the learning arc. Yet the transformation of lifelong learning is not solely pedagogical, it is also ontological. Learners must be seen not just as knowledge workers but as ethical agents, future-makers, and co-creators of AI-augmented worlds. In this light, the proposed model advances a vision of education that is inclusive, anticipatory, and deeply human, even as it embraces the capacities of intelligent machines.

Ultimately, the development of life-deep and life-beyond competences offers a new imperative for lifelong learning: not only to adapt to technological change, but to guide it responsibly and reimagine the futures it enables. This redefinition of core competences will be essential to building equitable, sustainable, and meaningful learning ecologies in the AI era.

References

Aspin, N., & Chapman, D. (2001). *Lifelong learning: Concepts and conceptions*. Routledge.

Binns, R. (2018). Algorithmic accountability and public reason. *Philosophy and Technology*, 31(4), 543–556.

Biesta, G. (2006). *Beyond learning: Democratic education for a human future*. Paradigm Publishers.

Bower, M. (2008). Affordance analysis - Matching learning tasks with learning technologies. *Educational Media International,* 45(1), 3–15.

Conole, G., & Dyke, M. (2004). What are the affordances of information and communication technologies? *ALT-J*, 12(2), 113–124.

Cranton, P. (2006). *Understanding and promoting transformative learning: A guide for educators of adults* (2nd ed.). Jossey-Bass.

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. D.C. Heath and Company.

Doan, T. H. D. (2025). Deep learning for school-age children in the artificial intelligence era: An educational imperative. *Journal of Research and Method in Education*, 15(3), 24–29. https://doi.org/10.9790/7388-1503012429

Delors, J., Al Mufti, I., Amagi, I., Carneiro, R., Chung, F., Geremek, B., & Nanzhao, Z. (1996). *Learning: The treasure within: Report to UNESCO of the International Commission on Education for the Twenty-first Century.* UNESCO Publishing.

Downes, S. (2012). *Connectivism and connective knowledge: Essays on meaning and learning networks*. National Research Council Canada.

ETS (2025), *2025 ETS Human Progress Report.* Educational Testing Service.

European Commission. Key Competences for Lifelong Learning. Basic skills - European Education Area

Eliza, M. (2023). Digital transformation in adult education: Empowering global understanding and sustainable development. *Journal of Educational Sciences*, 24(2), 46–63.

Faure, E., Herrera, F., Kaddoura, A.-R., Lopes, H., Petrovsky, A. V., Rahnema, M., & Ward, F. C. (1972). *Learning to be: The world of education today and tomorrow*. UNESCO.

Gibson, J. (1979). *The ecological approach to visual perception*. Houghton Mifflin.

Huang, L. (2023) Ethics of Artificial Intelligence in Education: Student Privacy and Data Protection. *Science Insights Education Frontiers*, 16, 2577-2587. https://doi.org/10.15354/sief.23.re202

Holmes, W., Bialik, M., & Fadel, C. (2019). *Artificial intelligence in education: Promises and implications for teaching and learning.* Center for Curriculum Redesign.

Howard, A., & Choudhury, M. (2022). Ethics in AI education. *AI and Ethics,* 2, 1–13.

Jackson, N.(Ed.) (2011). *Learning for a complex world: a lifewide concept of learning, education and personal development*. AuthorHouse Publishing.

Kizilcec, R. F., Pérez-Sanagustín, M., & Maldonado, J. J. (2017). Self-regulated learning strategies predict learner behaviour and goal attainment in Massive Open Online Courses. *Computers and Education*, 104, 18–33.

Long, D., & Magerko, B. (2020). What is AI literacy? Competencies and design considerations. In Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1–16). https://doi.org/10.1145/3313831.3376727

Mezirow, J. (1991). *Transformative dimensions of adult learning*. Jossey-Bass.

Milligan, C., & Littlejohn, A. (2015). Supporting professional learning in a massive open online course. *The International Review of Research in Open and Distributed Learning, 15*(5), 197–213. https://doi.org/10.19173/irrodl.v15i5.1855

Ng, D. T. K., & Chu, S. K. W. (2021). Motivating Students to Learn AI Through Social Networking Sites: A Case Study in Hong Kong. *Online Learning, 25(1), 195–208*.

Nguyen, Q. N. (2022). Postlesson affordance-based reflective discussion in ELT classes. *TESOL Journal*, 13(4), e677. https://doi.org/10.1002/tesj.677

Nguyen, Q. N. (2025). Affordance theory in language education: A multidimensional framework. *TESL-EJ*.

Nguyen, Q. N. & Doan, D. T. H (2025). ChatGPT's effects on EFL learners' autonomy and self-efficacy in self-regulated learning contexts. *The JALT CALL Journal, 21(2), 102968*. https://doi.org/10.29140/jaltcall.v21n2.102968

Norman, D. A. (1999). Affordance, conventions, and design. *Interactions,* 6(3), 38–43.

OECD. (2019). *OECD learning compass 2030: A series of concept notes.* OECD Publishing.

OECD. (2023). *Skills outlook 2023: Skills for a resilient green and digital transition.* OECD Publishing.

Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology,* 8, 422.

Siemens, G. (2005). Connectivism: A learning theory for the digital age. *International Journal of Instructional Technology and Distance Learning, 2(1), 3–10.*

Selwyn, N. (2019). *Should robots replace teachers? AI and the future of education*. Polity Press.

Taylor, E. W. (2009). Fostering transformative learning. In J. Mezirow and E. W. Taylor (Eds.), *Transformative learning in practice: Insights from community, workplace, and higher education* (pp. 3–17). Jossey-Bass.

UNESCO. (2021). *Reimagining our futures together: A new social contract for education.*

World Economic Forum. (2020). *The future of jobs report 2023*.

Yeaxlee, B. (1929). *Lifelong education*. Facsimile Publisher.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice*, 41(2), 64–70.