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From tools to co-learners: entangled humanism and the co-evolution of intelligence in AI education

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Introduction: reframing intelligence in education

Suppose that most groundbreaking change in education is, instead, philosophical rather than technological? In an era increasingly defined by artificial intelligence and intelligent systems, teachers are challenged to not just embrace new tools, but to rethink the very definition of intelligence, learning, and knowledge. This is to suggest “entangled humanism” as a post-human and pedagogic paradigm that redefines AI as an epistemic partner—in an ecology of learning that blurs categorical divisions between humans, machinery, and surroundings.

In an era where students move seamlessly within intelligent systems, adaptive simulations, and international crowds, learning needs to break beyond anthropocentric presuppositions and hierarchical frameworks (Zheng, 2024). We advocate for moving toward co-learning in collaboration with AI, prioritizing decentralized, fluid, and ethically sensitive knowledge creation made possible by machine-human collaboration.

Deconstructing human-centered paradigms

Education has long functioned based on an assumption that it is possible to deliver knowledge from expert to student in a hierarchical, top-down framework (Biggs, 2002; Schmitt, 2016). This Enlightenment rationalist and Cartesian dualist framework imagines learners as abstractions, independent of context and technological environment. But in an era where cognition is increasingly supported by intelligent systems, this framework is no longer sufficient (Cukurova, 2024; Schmitt, 2016). Paradigms of old need to be rethought against emergent digital and AI ecosystems.

In spite of technological innovation, most educational institutions still cling to antiquated buildings. Formal hierarchies encase learning within static surroundings and timetables, stifling adaptability. Artificial intelligence is viewed more as an add-on than as an agent for collaboration, and gatekeeping within institutions still holds sway over the creation of knowledge, displacing other ways of learning (Han et al., 2024). This contradiction that exists between students’ interactive, intuitive learning and formal learning’s static frameworks points to an urgent need for paradigm change.

Entangled humanism: a post humanist educational framework

Entangled humanism provides an account that is moving beyond autonomous, rational notions of learners (Pulkki and Keto, 2023). In contrast to constructivist and socio-cultural theories that privilege meaning-making centered upon humans (Bodomo, 2019), entangled humanism prioritizes humans and intelligent systems as co-agents in learning (Herrenkohl et al., 2022). Intelligence is conceptualized as hybrid, networked, and co-evolving. Based on post-humanist philosophy, Deweyan pragmatism, and critical knowledge theories, this paradigm highlights that learning is constructed as an interactive process of dynamically engaged minds, machines, and socio-technical contexts (Snaza, 2018).

AI as co-learner: reimagining machine agency in pedagogy

In an ecology of learning, AI evolves from an instrumental tool to an engaged co-learner. Such systems deliver immediate feedback, adjust to learners' preferences, and synthesize rich information, enhancing human cognitive abilities (Luo, 2024). AI systems, as epistemic partners, work together with learners to build meaning, especially within exploratory, information-dense contexts.

Empirical evidence supports this potential. Studies discovered that learning systems adapted to specific learners exceeded traditional approaches in more than, particularly for support-seeking learners (Fu et al., 2025). A randomized controlled trial of an AI-powered tutoring system for secondary students in Spain demonstrated significant gains in standardized math scores (+0.26 SD) and improved end-of-year grades, particularly in disadvantaged populations (Gortázar et al., 2024). A recent study found that generative AI tools, when integrated into collaborative STEM learning, significantly enhanced reflective thinking, problem-solving, and conceptual clarity. Learners using a GPT-based summarization tool (GASA) performed better than peers in traditional group settings (Lin et al., 2024).

Such findings are supported by cognitive science evidence as well. Adaptive real-time feedback can alleviate unnecessary cognitive load and optimize working memory (Blayney et al., 2015). AI's ability to personalize learning is also what is supported by dual-process cognitive theories, which contrast analytical and intuitive learning habits (Zhang et al., 2025). But caution is needed. Over-reliance on AI tools can subtly downplay emotional engagement, mentoring, and pedagogical improvisation—the aspects of teaching that don't lend well to machine imitation.

Hybrid modalities: learning across physical and digital realms

Learning today increasingly takes place in hybrid environments that combine physical and digital modalities. Experiential and embodied learning is supported by immersive technologies like virtual and augmented reality (Crogman et al., 2025). Intrinsic motivation and mastery of concepts is enhanced by gamification

(Ruble et al., 2021). In one study using a gamified system in higher education, researchers observed statistically significant gains in engagement, test scores, and course satisfaction, particularly when leaderboards and point-based systems were implemented (Ruiz-Alba et al., 2016). A systematic review on gamification in MOOCs found that elements like badges, leaderboards, and challenges significantly increased student motivation and engagement, and led to notable improvements in completion rates across multiple platforms (Zakaria, 2024). Moreover, online communities allow for peer learning and intercultural collaboration.

These changes require redefinition of the teacher's role. With AI systems increasingly taking up standard pedagogic functions, educators are transforming into learning designers, dialogue facilitators, and ethical guardians. Such repositioning not only demands professional upskilling but also requires changes within institutions to acknowledge and enable these evolving roles.

Decentralizing knowledge production

Humanism entangled also demands that creation and validation of knowledge be decentralized. Institutions no longer solely create and legitimate knowledge. Institutions like Coursera, edX, and Udemy disseminate expert content to any individual, while nondomain expertise is verified by systems like Stack Overflow and blockchain credentialing systems.

Students become more empowered to design learning pathways from open educational resources (OERs), peer-created content, and decentralized credentials. This is in accordance with Weller's (2020) promotion of open, collaborative learning environments that support learners having maximum agency and sharing epistemic power (Lane and Goode, 2021).

A successful example of this is Singapore's learning platform "Abacus," which offers real-time diagnosis and interactive math learning which contributed to "Singapore Math" (Ahmad et al., 2015). A study using the SAVI (Somatic, Auditory, Visual, and Intellectual) cooperative learning model showed significant gains in both metacognitive awareness and academic achievement among high school students, particularly when interactive group learning strategies were applied (Asri et al., 2016).

Equity, ethics, and governance in a human–AI learning ecology

Although entangled humanism holds immeasurable potential, it also presents underlying issues of concern. Algorithmic bias remains a perpetual problem, as AI systems can reinforce and magnify social prejudices based on poorly trained data or poorly designed algorithms (Baker and Hawn, 2022). Bender and Friedman (2018) expose that poorly audited AI systems can create biased learning outcomes. Solutions to counter these include adversarial debiasing, transparent algorithms, and explainable AI.

The digital divide also raises another problem, where uneven availability of technology can exacerbate educational imbalances, particularly in disadvantaged contexts (Li, 2023). Moreover, AI adoption in educational decision-making necessitates close regulation. Issues like AI grading of student assignments, as

seen in the case of AI grading in the UK during COVID-19, pose an example of taking discretion away from humans in high-stakes learning contexts (Ovchinnikov, 2020). Such examples illustrate the need for regulation by humans, transparency, and ethical responsibility.

The European Union (AI Act) and UNESCO (Morandín-Ahuerma, n.d.) and OECD (AI Principles) initiatives are beginning to create robust frameworks for integrating AI responsibly. Entangled humanism encourages educators to familiarize themselves with these standards and design AI-enabled systems to be equitable, inclusive, and transparent.

To support this, here, we propose four principles of AI-driven policy design: (1) transparent algorithms, (2) student data ownership, (3) equitable development of infrastructure, and (4) professional development AI literacy training of teachers. They provide an anchor for AI adoption in education that is ethical and practicable in the real world.

We also acknowledge increasingly salient cross-disciplinary critiques of AI's sociotechnical dimensions beyond its formal and technological properties. Algorithmic systems intertwine with social inequality and power imbalances. Integrating such critical perspectives into education policy and pedagogy is important to prevent perpetuating existing epistemic or social injustices in the name of entangled humanism.

Conclusion: toward a co-evolutionary model of learning

The future of learning is not one of substitution of artificial and human intelligence, but of co-evolving them. Entangled humanism recontextualizes intelligence as co-constructed, distributed, and relational within socio-technical assemblages of humans, objects, and media. It overturns traditional hierarchies and encourages educators to conceptualize AI as intellectual co-conspirator to augment, expand, even reconfigure what it means to be able to learn as a human being.

In order to achieve that, educational systems need to operationalize multimodality, ethical resilience, and decentralization. Learning environments need to facilitate real interaction, as humans, with AI, establish strong ethical norms, and overcome old digital divides. We push educators, policymakers, technologists, and researchers to confront that change as an abstraction in the distance, but as an imminent instructional mandate. In an AI-altered world where AI is increasingly shaping the ways that we think, learn, and relate, no longer is it a matter of if AI has any place in the classroom—but of how to reimagine learning as it does.

In coming years, AI integration could result in radically reconfigured learning organizations. Consider learning spaces where affective AI agents assist learners in managing anxiety and

becoming resilient, or where decentralized AI tutors negotiate learning by time and geography. An educational symbiosis is possible—the intelligent learning coaches that grow up together with learners, responding to cognitive development, shifts in affect, and development of moral character. Entangled humanism not only readies us to address these futures, but it encourages us to design them with philosophic understanding and social responsibility.

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BJ: Conceptualization, Project administration, Writing – original draft, Writing – review & editing. AV: Writing – original draft, Writing – review & editing. SV: Writing – original draft, Writing – review & editing. SM: Writing – original draft, Writing – review & editing. JC: Writing – original draft, Writing – review & editing.

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