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# The Human-Centered AI Pedagogical Engagement (HCAI-PE) Framework: A Foundational Paradigm Shift in AI Pedagogy

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## Abstract:

The rapid adoption of artificial intelligence (AI) in education, driven by the need for efficiency and personalization, risks leading to "learnification"—the reduction of education to a technical process disconnected from ethical and relational goals. This paper introduces the Human-Centered AI Pedagogical Engagement (HCAI-PE) Framework as a theoretical approach to this problem, viewing AI not as a replacement for human educators or learners, but as a mediator for cognitive, emotional, and ethical involvement.

HCAI-PE is based on a synthesis of three core theories: Self-Determination Theory (SDT), which ensures AI supports psychological needs for autonomy, competence, and relatedness; Heutagogy, positioning AI as a partner in metacognition to promote a self- and non-neutral mediational tool that scaffolds learning within the Zone of Proximal Development (ZPD).

The framework functions within a dynamic triadic ecosystem composed of a teacher, learner, and AI, defining AI's role across three mediation areas: Cognitive (enhancing thinking and creativity), Emotional (offering emotional support and motivation), and Ethical (prompting reflection on bias and fairness). The model fundamentally redefines the teacher's role as the

"ethical interpreter" and guide. Ultimately, HCAI-PE offers a blueprint for balanced engagement, ensuring AI systems are designed to support, not replace, human agency, reflection, and the core ethical values of teaching and learning.

**Key Words:** AI in Education, Human-Centered AI, Pedagogical Engagement, Self-Determination Theory (SDT), Heutagogy, Ethical Mediation, Learner Agency

## Introduction

### The Importance of a Human-Centered Pedagogical Framework in the Age of AI

The educational landscape of the twenty-first century is undergoing significant changes driven by rapid advances in artificial intelligence (AI). Technologies such as large language models, adaptive learning systems, and conversational agents are increasingly integrated into teaching and learning across various subjects and educational levels. While these innovations provide personalization, efficiency, and broader accessibility, they also raise ethical and pedagogical concerns. The quick automation of cognitive and emotional tasks once thought to be uniquely human raises important questions about the purpose of education, the role of teachers, and the essence of learning itself. In this context, there is an urgent need for a theoretical framework that places AI within a human-centered, relational, and ethically mindful approach to pedagogy.

The Human-Centered AI Pedagogical Engagement Theory (HCAI-PE) was developed to address this need. It views AI not as a substitute for human teachers or students but as a cognitive and emotional connection. This approach enhances human participation, encourages reflective thinking, and boosts ethical awareness. The framework is built on the idea that effective learning results from a combination of thinking, feelings, motivation, and social involvement. Therefore, any educational use of AI should aim to strengthen these aspects rather than weaken them.

Contemporary educational debates often emphasize AI-driven personalization and data analytics as signs of progress. However, these technological perspectives tend to prioritize efficiency and optimization at the expense of depth, empathy, and moral reasoning. This simplified view risks leading to what Biesta (2021) calls “learnification”—the transformation of education into a technical process disconnected from its ethical and relational aims. The

HCAI-PE framework challenges this trend by positioning AI within a human-centered paradigm that sees learning as a deeply relational and meaning-making process.

From this perspective, pedagogy is not just about transferring knowledge but involves a dynamic process of co-creation among teachers, learners, and now, AI as a third participant. The integration of AI into this three-way relationship prompts a reevaluation of how we approach teaching: How can AI facilitate understanding without taking over? How can it foster curiosity, empathy, and critical thinking rather than encouraging passive learning? Addressing these questions draws on cognitive science, educational psychology, and human-computer interaction to develop a cohesive pedagogical framework.

## Conceptual Foundations: From Human-Centered AI to Pedagogical Engagement

The idea of Human-Centered AI (HCAI) comes from research in design and ethics, focusing on systems that improve human control, dignity, and creativity (Shneiderman, 2020; Bryson, 2022). Unlike purely utilitarian automation models, HCAI encourages cooperation between humans and machines, where technology helps rather than replaces human decision-making. In education, this means AI should enhance learners' cognitive and emotional skills. It should promote critical thinking, curiosity, and empathy, aligning technological tools with educational principles.

Pedagogical engagement, traditionally defined as the active, emotional, and cognitive participation of learners in the learning process (Fredricks et al., 2019), provides a complementary perspective for understanding AI's role in education. Engagement is not a fixed trait but a dynamic state that develops through relationships—between learners and content, learners and teachers, and increasingly, between learners and intelligent technologies. Therefore, pedagogical engagement in the era of AI should be redefined as human–AI co-engagement, where learning occurs through interactions with both human and artificial partners.

This redefinition has significant implications. It prompts educators to see AI not merely as an external tool but as a mediating presence capable of influencing thought, emotion, and ethics. Drawing on Vygotsky's principles, we recognize AI as a new kind of cultural tool—one that mediates not only symbolic meaning but also emotional and ethical reflection. When AI offers feedback, asks questions, or demonstrates empathy, it engages in a dialogic process that extends the learner's zone of proximal development into the digital realm.

Furthermore, pedagogical engagement within the HCAI-PE framework includes three interconnected dimensions:

1. Cognitive engagement refers to how AI supports reasoning, creativity, and metacognition.
2. Emotional engagement, showing how AI connects with motivation, empathy, and a sense of belonging.
3. Ethical engagement, showing how interactions with AI promote moral reasoning and awareness of values.

These dimensions are interconnected and support each other. For example, emotionally engaging AI feedback can enhance cognitive involvement, while ethical reflection on AI's limitations can strengthen autonomy and critical thinking. In this way, the HCAI-PE model offers a comprehensive view of engagement where technology functions as a partner in meaning-making rather than just a mechanical tutor.

The core principle of HCAI-PE is that education is an ethical practice. Building on Noddings (2013) and Biesta (2021), pedagogy includes care, trust, and responsibility— qualities that should be upheld and even strengthened in technologically mediated learning environments. Therefore, the ethical aspect of HCAI-PE is not secondary but vital. It involves designing AI systems that are transparent, empathetic, and capable of engaging in meaningful dialogue, fostering reflection on fairness, bias, and human dignity.

In summary, the Human-Centered AI Pedagogical Engagement Theory introduces a paradigm shift: from viewing AI solely as a knowledge source to seeing it as a co-agent in cognitive and emotional development. By integrating human-centered design principles with pedagogical engagement theories, HCAI-PE aims to create learning environments that are not only intelligent but also reflective, empathetic, and ethically grounded.

## Theoretical Foundations and Integration with HCAI-PE

### Self-Determination Theory (SDT): Supporting Motivation and Engagement in AI-Mediated Learning

Self-Determination Theory (SDT), developed by Deci and Ryan (1985, 2000), provides a well-established framework for understanding human motivation in educational settings. SDT states that autonomy, competence, and relatedness are essential psychological needs for

intrinsic motivation, engagement, and well-being. When these needs are fulfilled, learners are more likely to engage consistently, self-directively, and meaningfully with learning tasks. Conversely, environments that block these needs can lead to disengagement or superficial compliance.

In AI-supported learning, SDT can guide the design and use of technology to make sure it boosts, rather than diminishes, human motivation. Specifically:

1. Autonomy relates to learners' sense of control and power over their learning. AI systems can enhance autonomy by offering personalized routes, flexible support, and choices for exploration. For example, a generative AI tool can enable learners to select topics for inquiry, develop multiple solution paths, or co-create content. Human-centered AI ensures that learners remain decision-makers instead of passive followers of algorithms.

2. Competence involves believing that one can complete tasks and master skills. AI provides timely, targeted feedback that boosts learners' confidence. Intelligent tutoring systems and adaptive platforms can identify misconceptions, emphasize strengths, and suggest strategies tailored to each learner. In HCAI- PE, AI supports competence without replacing human judgment; learners are encouraged to critically evaluate AI recommendations, fostering metacognitive reflection alongside skill development.

3. Relatedness involves experiencing a sense of belonging and forming meaningful connections with others. While AI is not human, it can support collaborative learning, discussions, and peer interactions. For example, AI can assist with collaborative writing, offer prompts for peer feedback, or facilitate multilingual communication in diverse classrooms. Importantly, HCAI-PE highlights that AI should enhance human-to-human connections, not imitate or replace teacher– learner interactions.

SDT thus offers a psychological basis for HCAI-PE by emphasizing that engagement occurs when AI interactions fulfill human needs for autonomy, competence, and relatedness. AI acts as a motivator, providing adaptive, ethical, and relational support instead of just automating instructions.

### Heutagogy: Promoting Self-Determined and Reflective Learning

Heutagogy, or self-determined learning (Hase & Kenyon, 2000; Blaschke, 2012), builds on the principles of adult learning and pedagogy by emphasizing learner agency, capability, and

reflective practice. Heutagogy suggests that learners are not only responsible for following instructions but also for setting their own goals, choosing strategies, and reflecting on their outcomes. This approach aligns well with the opportunities provided by AI: technology can offer tools, feedback, and scaffolding that support self-directed learning, helping learners navigate complex knowledge areas.

In AI-supported environments, heutagogy manifests in several ways:

1. Agency in Learning: Learners can choose the order of activities, the type of AI-generated resources they use, and how they incorporate feedback. This promotes autonomy and boosts intrinsic motivation.

2. Capability Development: Heutagogy emphasizes using knowledge creatively in new situations. AI systems can simulate complex scenarios, model reasoning strategies, and prompt learners to critically evaluate multiple solutions.

3. Reflective Practice: AI tools can offer feedback and suggest different perspectives, encouraging learners to reflect on their own thinking, strategies, and assumptions. For example, AI-assisted writing platforms can identify stylistic patterns or recommend alternative arguments, prompting learners to consider why one approach may be more effective than another.

HCAI-PE incorporates heutagogy by viewing AI as a reflective partner. AI does not prescribe solutions but prompts learners to think critically and ethically. This method helps develop both skills and moral reasoning, ensuring learners not only gain knowledge but also grasp the implications of their decisions, especially in environments influenced by intelligent systems.

**Sociocultural Learning Theory: AI as a Mediational Tool**

Sociocultural learning theory (Vygotsky, 1978) views learning as a socially mediated process that highlights interaction, collaboration, and the use of cultural tools. The key concept is the Zone of Proximal Development (ZPD)—the space between what learners can do on their own and what they can achieve with guidance or mediation.

Within HCAI-PE, AI serves as a mediational tool in the ZPD, boosting learners' capabilities by providing scaffolds that encourage higher-order thinking. Examples include:

1. Adaptive Tutoring and Guidance: AI can customize hints, prompts, or resources to match a learner's current level, enabling progress beyond what they could accomplish alone.

2. Simulation and Modeling: AI-driven simulations enable learners to explore complex systems (e.g., ecological models, language practice, ethical dilemmas) in a safe and organized manner.

3. Dialogic Interaction: AI can promote discussion by suggesting questions, identifying reasoning gaps, or illustrating argumentation techniques.

Importantly, sociocultural theory also emphasizes the cultural and ethical context of tools. AI is not neutral; it reflects the assumptions, values, and biases present in its design. HCAI-PE highlights that teachers serve as ethical interpreters, helping learners understand and critically evaluate AI's guidance. This ensures that AI-assisted learning remains socially relevant and ethically reflective, fostering both cognitive and moral development.

**Integrating the Theories: A Unified Framework**

HCAI-PE synthesizes insights from **SDT, heutagogy, and sociocultural theory** into a cohesive conceptual framework for AI-mediated learning:

1. SDT offers a motivational perspective, ensuring that engagement promotes autonomy, competence, and relatedness. AI must align with these human needs to foster lasting, meaningful engagement.

2. Heutagogy provides a self-directed, reflective approach that sees learners as active creators of knowledge, with AI acting as a reflective partner that aids in metacognition and skill development.

3. Sociocultural theory presents a relational view, seeing AI as a mediational tool in social, cultural, and ethical contexts that encourage dialogue, teamwork, and moral reasoning.

Through this integration, AI becomes more than just a tool for efficiency; it turns into a cognitive, emotional, and ethical mediator. Its aim is to support balanced engagement, where learning is simultaneously reflective, relational, and self- directed.

**Operationalizing HCAI-PE: Mechanisms of Engagement**

The HCAI-PE framework defines AI-mediated engagement through three connected dimensions:

**1. Cognitive Mediation**

a. AI supports problem-solving, reasoning, and creativity.

b. Encourages meta-cognition by prompting learners to think about their strategies and assumptions.

c. Offers adaptive feedback while maintaining human agency.

**2. Emotional Mediation**

a. AI monitors affective states (e.g., frustration, confidence) and offers supportive prompts.

b. Enhances motivation and belonging when combined with teacher-led guidance.

c. Encourages reflection on emotional responses to learning challenges.

**3. Ethical Mediation**

a. AI prompts learners to think about biases, fairness, and implications of algorithmic outputs.

b. Promotes moral reflection and ethical decision-making in AI-driven tasks.

c. Teachers guide critical evaluation of AI suggestions to foster responsible AI literacy.

These dimensions function within a triadic ecosystem: teacher, learner, and AI. Each participant plays a complementary role.

**Teacher**: ethical interpreter, creator of learning experiences, facilitator of reflection**. Learner**: active co-constructor, critical thinker, reflective agent.

**AI**: adaptive scaffold, reflective partner, ethical prompt.

Reciprocal interaction among these actors ensures that AI boosts human engagement without replacing it, preserving the human-centered ethos of education.

**The Role of Parents as External Mediators:**

The Human-Centered AI Pedagogical Engagement (HCAI-PE) Framework centers on a triadic ecosystem composed of the teacher, the learner, and the AI system, as these are the

three primary components of direct pedagogical practice. Although not explicitly stated, environments are recognized as vital external mediators and crucial sociocultural context factors that strongly influence the entire ecosystem's functioning. Drawing on Sociocultural Learning Theory (Vygotsky, 1978), parents serve as primary cultural agents who shape the learner's ultimate relationship with the AI tool, especially regarding ethical standards, data privacy perceptions, and access to technological resources necessary for equitable participation. Furthermore, parental involvement plays a significant role in fulfilling the learner's psychological needs—specifically Relatedness and Autonomy—as outlined by Self-Determination Theory (Deci & Ryan, 2000). The teacher, in their role as the "Ethical Interpreter," must actively mediate the boundaries between the core triadic engagement and this influential external layer, often by communicating ethical reasoning and adjusting pedagogical expectations to accommodate the family's unique sociocultural and economic circumstances. Therefore, parents are not part of the AI mediation mechanism but are an essential component of the environment that influences the system's overall success and humanistic outcomes.

The final implications for practice derived from the Human-Centered AI Pedagogical Engagement (HCAI-PE) Framework call for crucial shifts in system design, professional development, and educational governance, aiming to improve human agency, ethical thinking, and continuous engagement. These key implications require a multilayered commitment: AI system design must clearly emphasize transparency, flexibility, and include ethical prompts; AI functions should be limited to offering feedback and support rather than making decisions, which helps maintain learner autonomy and prevents cognitive offloading. At the same time, teacher professional development must be thoroughly updated to prepare educators with advanced AI literacy, ethical reasoning skills, and knowledge of reflective teaching strategies, enabling them to serve as ethical mediators within the learning environment. For learner growth, the framework encourages coaching students to work with AI, critically evaluate its outputs, and reflect ethically on the technology itself, fostering core capabilities of Heutagogy. Lastly, assessment and inclusion practices need to evolve by using AI-mediated assessments to measure process-oriented engagement (not just final products) and by employing adaptive features to serve diverse learner needs and promote fair access. By aligning motivational, reflective, and social elements across these practical areas, HCAI-PE offers a balanced, principled approach to integrating AI in education.

## Model Dynamics, Pedagogical Strategies, and Implications Dynamics of HCAI-PE: Triadic Interaction

The HCAI-PE framework positions AI as an active mediator of cognitive, emotional, and ethical engagement, functioning within a three-part system consisting of the teacher, learner, and AI system. This three-way interaction is active and reciprocal: each participant constantly influences and responds to the others.

1. Teacher Role: In HCAI-PE, teachers are not replaced by AI but act as facilitators, ethical interpreters, and reflective guides. They coordinate the learning environment by choosing AI tools that match educational goals, observing their impact, and supporting critical assessment of AI-generated suggestions. Teachers make sure that student engagement stays authentic, ethical, and socially mediated.

2. Learner Role: Learners actively participate in building knowledge, capable of independent inquiry and critical thinking. When interacting with AI, they engage in metacognitive activities—reviewing reasoning methods, evaluating the accuracy of AI-generated content, and making ethical decisions about AI suggestions. The learner's autonomy is essential, supported by AI scaffolds but never replaced.

3. AI Role: AI functions as a cognitive, emotional, and ethical mediator, capable of providing adaptive feedback, modeling reasoning strategies, and prompting reflection on values and fairness. It may suggest alternative approaches, identify misunderstandings, or offer emotional support by recognizing learner frustration or confusion. Its design is human-focused, emphasizing transparency, ethical awareness, and relationship building.

The dynamic interaction among these actors ensures that AI complements rather than controls the learning process, supporting the broader goals of education—knowledge building, ethical thinking, and relationship development.

## Operationalizing the Cognitive Dimension

Cognitive mediation within HCAI-PE focuses on improving learners' higher-order thinking, problem-solving, and creativity. AI provides adaptive scaffolds customized to each individual's skill level, enabling learners to go beyond what they could accomplish on their own. Practical mechanisms include:

Intelligent Tutoring Systems (ITS): AI identifies knowledge gaps and provides hints, explanations, or example problems without giving direct answers, encouraging learners to think critically and self-correct.

Generative AI for Knowledge Construction: AI can generate different solutions, prompts, or research ideas that help enhance the learner's understanding. For example, a generative AI writing assistant might propose various thesis structures, encouraging learners to analyze and choose the best approach.

Meta-Cognitive Support: AI systems can offer reflective prompts that encourage learners to evaluate their reasoning, monitor progress, and plan future actions. This aligns with heutagogical principles, promoting self-directed learning and reflective practice.

Cognitive mediation enhances when combined with teacher guidance. Educators can frame AI feedback within context, motivate learners to critically evaluate suggestions, and create activities that involve reasoning and synthesis.

The Emotional Mediation aspect of the Human-Centered AI Pedagogical Engagement (HCAI-PE) Framework plays a key role in maintaining the psychological conditions needed for deep learning, mainly by applying the principles of Self-Determination Theory (SDT) during AI-learner interactions. This aspect is essential for keeping motivation high, promoting persistence, and enhancing learning outcomes by making sure the learning experience is inherently supportive.

This process is operationalized through integrated mechanisms. Affective Computing (AC) systems (D'Mello & Graesser, 2024; Vistorte et al., 2024) are strategically used to detect non-cognitive states (e.g., frustration, boredom) through multimodal input such as keystrokes or interaction patterns. By identifying these states, the AI offers timely, non-judgmental interventions—like adjusting task difficulty or suggesting new strategies—thus managing productive struggle and supporting the SDT needs for Competence and Autonomy. Additionally, Motivational Feedback is personalized to recognize progress and emphasize mastery, fulfilling the SDT need for Competence by framing performance around growth rather than evaluation. Finally, social connection is promoted when AI systems support collaborative learning environments by proposing strategic peer pairings or generating discussion prompts, strengthening learners' sense of Relatedness and reducing feelings of isolation.

The HCAI-PE framework holds that this emotional mediation is effective only when combined with human oversight, which is designed to prevent the ethical issues of the Simulation Paradox (Noddings, 2013). This boundary is maintained by designating the teacher as the Human Anchor: interpreting the AI's emotional signals as instructional data rather than definitive diagnoses. The teacher provides necessary relational care and uses the AI's feedback to help learners develop emotional self-regulation strategies. This human-guided, metacognitive step ensures that the technology enhances the learner's Autonomy and emotional intelligence, thereby preserving the authentic, empathetic core of the educational relationship.

The Ethical Mediation dimension and the subsequent Pedagogical Implementation Strategies are core features of the Human-Centered AI Pedagogical Engagement (HCAI-PE) Framework. They distinguish it from models focused only on cognitive or affective efficiency and ensure that AI integration actively promotes critical awareness and reflection on human values, elevating learning to a practice of critical mindfulness.

Ethical mediation involves making the AI system itself a subject of critical inquiry, encouraging reflection on fairness and social responsibility: Bias Awareness and Critical Reflection are achieved when AI is intentionally used to identify patterns in data and reveal potential biases in its algorithmic outputs. This approach requires learners to actively assess issues of fairness and equity (Woolf et al., 2022), thereby developing advanced AI literacy as a form of critical engagement with technology. Ethical Dilemmas and Scenario Analysis occur when AI simulations are designed to present complex ethical challenges in real-world contexts (such as simulated resource allocation or socio-scientific decision-making), prompting learners to apply moral reasoning and consider the outcomes of their decisions. Transparency and Explainability (FATE) are fulfilled when AI systems must provide insights into their processes, explaining the rationale behind recommendations or outputs. This fosters trust, enables critical evaluation of algorithmic logic, and promotes the ethical understanding needed for responsible human-AI cooperation (Shneiderman, 2020). The teacher remains an essential ethical mediator, ensuring that AI-generated prompts lead to meaningful, nuanced discussions and the genuine internalization of ethical principles, moving beyond superficial compliance. Implementing HCAI-PE requires intentionally aligning AI capabilities with human-centered pedagogical goals within the triadic ecosystem (Teacher, Learner, AI) through key strategies: Curricular Integration ensures AI tools are embedded directly into established learning objectives instead of being treated as isolated add-ons; Scaffolded Interaction

involves carefully sequencing AI interventions to progressively increase learner responsibility, fostering autonomy (Heutagogy) while providing support within the Zone of Proximal Development (Vygotsky, 1978), and adjusting dynamically to prevent cognitive offloading; Teacher Professional Development (PD) must be targeted and robust, equipping educators with expertise in AI literacy, ethical facilitation, and reflective teaching to prepare them for their complex mediating role; Learner Orientation provides students with explicit instruction on the AI's role, capabilities, and limitations, building essential AI literacy; and finally, Monitoring and Assessment require ongoing observation and evaluation of AI-mediated interactions by teachers, who must continuously adapt instructional strategies to maintain a healthy balance between technological support and human guidance. Through these combined efforts, HCAI-PE guarantees that AI supports active, reflective, and ethically conscious learning—rather than replacing the human effort vital for deep engagement and personal growth.

**Future Directions and Research Opportunities**

HCAI-PE opens several avenues for research:

1. Empirical Validation: Research can explore how AI-driven cognitive, emotional, and ethical engagement affects learning outcomes across various disciplines and age groups.
2. Tool Design: Research can analyze the best AI interface designs, feedback methods, and integration approaches to improve human-centered engagement.
3. Ethical Reflection and AI Literacy: Long-term studies can analyze how ethical

   AI prompts impact learners' moral reasoning and critical thinking.
4. Inclusive Education: Research can explore how HCAI-PE helps diverse learners, including those with learning differences or limited previous experience with technology.

By integrating theoretical foundations with practical application, HCAI-PE offers a comprehensive framework for 21st-century education, balancing innovation with human-centered principles.

The HCAI-PE framework redefines AI in education as a partner in learning, mediating cognitive, emotional, and ethical engagement. By integrating Self-Determination Theory, Heutagogy, and Sociocultural Learning Theory, it provides a comprehensive view of AI's role

in teaching.

AI is not a replacement for teachers or learners but a tool that improves human abilities while promoting autonomy, competence, relatedness, reflection, and ethical thinking. Implementing HCAI-PE requires careful integration, ongoing professional development, and continuous ethical evaluation.

This approach transforms AI into a tool for empowerment, enabling learners to engage critically, reflectively, and ethically in creating knowledge, while also ensuring that educational technology remains aligned with fundamental human values of teaching and learning.

## Discussion:

The rapid adoption of Artificial Intelligence (AI) in education has primarily been driven by a focus on technological efficiency, automated grading, and data-driven personalization. While these uses offer practical benefits, they often prioritize optimization over humanistic and relational teaching goals, which can lead to a risk of "learnification"—the process of reducing education to a purely technical, measurable activity. The Human-Centered AI Pedagogical Engagement (HCAI-PE) framework is an essential theoretical approach, repositioning AI not as a managerial tool or replacement for human agency, but as a cognitive, emotional, and ethical mediator that promotes human growth. HCAI-PE offers a comprehensive, integrated model for managing the complexities of AI-influenced learning, ensuring that technology supports core values like autonomy, reflection, and ethical participation.

### The Tripartite Theoretical Grounding: Ensuring Humanistic Alignment

The framework's conceptual rigor comes from combining three well-known educational theories, which together ground AI functionality in human psychological needs, reflective practice, and sociocultural context.

### Motivational Alignment: Self-Determination Theory (SDT)

SDT asserts that meaningful engagement is maintained through the satisfaction of three innate psychological needs: autonomy, competence, and relatedness (Deci & Ryan, 2000; Ryan &

Deci, 2000). HCAI-PE requires that AI systems be designed to support, and never undermine, these needs, providing a key contrast to control-focused educational software.

Autonomy: AI promotes independence by providing personalized options for learning paths, resource choices, and pacing. This shifts AI from being just prescriptive tutoring to enabling learners to act as self-directed decision-makers.

Competence: AI systems offer timely, detailed, and focused feedback—a crucial tool for building a sense of competence—without the evaluative anxiety sometimes linked to human assessment. This targeted feedback should be presented to promote reflection and growth, aligning with self-efficacy principles.

Relatedness: While AI cannot replace genuine human connection, it can support relatedness by enabling collaborative peer interactions, overseeing group **dynamics, and providing scaffolding in communication tasks, thus aiding the social aspect of learning.**

This grounding ensures that engagement is **intrinsic** and meaningful, serving the learner's developmental goals rather than mere compliance with algorithmic prescriptions.

**Reflective Practice: Heutagogy and Capability**

HCAI-PE incorporates Heutagogy—the study of self-determined learning—to ensure AI supports the development of **capability** and true learner agency (Blaschke, 2012; Hase & Kenyon, 2000).

- AI as a Partner in Metacognition: The framework considers AI a vital tool for double-loop learning. Unlike traditional technology that mainly aims to improve task efficiency (single-loop), AI in HCAI-PE should assist learners in questioning the assumptions and strategies behind their learning process. For example, generative AI can simulate different reasoning approaches or critique a student's initial problem-solving method, encouraging a reflective reevaluation of the entire approach.
- **Fostering Self-Directedness:** By encouraging self-reflection and enabling the learner to set their own goals and assess their own progress, HCAI-PE elevates the learner from a recipient of instruction to an active co-constructor, integrating the AI into the process of self-determination.

### 3. Contextual and Relational Learning: Sociocultural Theory

Drawing on the work of Vygotsky (1978), HCAI-PE views AI as a novel **cultural tool** that mediates learning within social and cultural contexts. The primary function of AI, like any Vygotskian tool, is to extend the learner's capabilities by providing adaptive **scaffolding** within the Zone of Proximal Development (ZPD).

- **Mediation of Dialogue:** AI is a tool for dialogue, providing hints, questions, and resources that help the learner transition from what they can do with assistance to what they can do independently.
- **The Non-Neutral Tool:** The sociocultural perspective emphasizes that cultural tools are not neutral; they are embedded with assumptions, values, and biases. This realization is crucial for HCAI-PE, demanding that the teacher act as an **ethical interpreter**—mediating the learner's critical relationship with the tool itself to avoid internalizing its implicit biases.

## The HCAI-PE Operational Model: Mechanisms and Tensions

HCAI-PE operates within a **dynamic triadic ecosystem** of the Teacher, Learner, and AI. The effectiveness of the framework is tested by its ability to manage the conceptual tensions inherent in its three dimensions of mediation.

### Cognitive Mediation: Scaffolding and the Risk of Offloading

Cognitive mediation involves AI systems—such as Intelligent Tutoring Systems (ITS) and advanced generative AI—that scaffold complex cognitive tasks, model sophisticated thinking, and provide deep content analysis (Holmes et al., 2019). The benefit is clear: AI can support students in tackling problems far beyond their current capacity, accelerating skill acquisition.

The Tension: Cognitive Offloading: The primary risk here is cognitive offloading, which conflicts with Heutagogy. If AI becomes too efficient at giving correct answers or overly detailed solutions, students might rely on the machine to handle reasoning, synthesis, and problem-solving, hindering the development of strong internal cognitive structures. HCAI-PE requires AI to be intentionally designed with friction—providing prompts or critiques instead of final solutions—to encourage learners to complete the cognitive process on their own.

**Emotional Mediation: Affective Computing and the Simulation Paradox**

Emotional mediation utilizes Affective Computing (AC) to detect a learner's non- cognitive states—such as frustration, boredom, or confusion—via analysis of dialogue, response speed, or facial expressions (D'Mello & Graesser, 2024; Vistorte et al., 2024; Yuvaraj, 2025). The goal is to provide timely motivational support or adapt instructional difficulty to maintain optimal engagement (Fredricks et al., 2019).

The Tension: The Simulation Paradox: The core tension is that AI's affective responses are algorithmic simulations, not genuine human empathy. AI can identify a state and trigger a pre-set supportive message, but it cannot truly "care" in the relational sense (Noddings, 2013). Relying too much on simulated emotional support risks undermining the human relational essence of teaching. Therefore, the teacher's role is crucial: they must guide the learner in interpreting the AI's emotional feedback and using it to foster emotional self-regulation, rather than just accepting the machine's attempt at comfort.

**Ethical Mediation: AI as a Catalyst for Moral Reasoning**

This dimension elevates AI literacy and ethical competence from a supplementary topic to a core pedagogical outcome. Ethical mediation uses AI to prompt value-sensitive discussions and critical reasoning (Holmes et al., 2021).

Fostering Ethical Literacy: AI can simulate complex ethical dilemmas or reveal its own algorithmic limitations and biases, making the technology an active part of the curriculum. For example, a generative AI tool could be asked to critique its own historical data set for bias or explain why it generated a specific, potentially unfair, recommendation (Woolf et al., 2022).

The Imperative for FATE: HCAI-PE aligns with principles of FATE (Fairness, Accountability, Transparency, and Explainability) (Woolf et al., 2022). By embedding these principles into instruction, the framework educates learners to be responsible users and creators of AI technologies (Bryson, 2022).

**The Redefined Teacher's Role: The Ethical Interpreter and Guide**

In the HCAI-PE framework, the teacher is fundamentally redefined, moving away from being the primary source of content to becoming the central Ethical Interpreter and Reflective Guide. This role is non-negotiable for the framework's success.

New Competencies and Responsibilities

1. Ethical Mediation and AI Literacy: The teacher's main role is to facilitate the ethical relationship between the student and the machine. This requires strong AI literacy—the ability to understand how AI functions, where its data biases are, and how its outputs can influence learning and society (Holmes et al., 2021). They must guide classroom discussions that critically examine the non- neutrality of AI tools.

2. Preserving Relationality and Care: The teacher makes sure that the human elements of relational learning—care, trust, and empathetic understanding—are not lost amid technological efficiency. While the AI provides algorithmic support, the teacher offers authentic human interpretation and guidance for emotional self-regulation.

3. Facilitation of Metacognition: The teacher designs tasks that require learners to think reflectively with the AI's scaffolding. They make sure students are not just using the tool but questioning it: "Why did the AI suggest this approach?" and "How does this compare to my initial idea?"

## Systemic Challenges for Educators

The shift to the Ethical Interpreter role presents significant systemic challenges. Current teacher professional development (PD) models often lag behind technological change, focusing on technical use rather than **pedagogical integration** and **ethical facilitation** (Porayska-Pomsta, 2024). HCAI-PE necessitates a new model of PD that integrates philosophical inquiry, data literacy, and ethical case studies directly into teacher preparation. Failure to adequately prepare teachers for this complex mediatory role risks collapsing the sophisticated HCAI-PE structure into a simplified, control-based AI implementation.

## Future Implications

The HCAI-PE framework provides a necessary and comprehensive theoretical guide for navigating the complexities of AI in education, ensuring that technology supports human agency and ethical growth. By thoroughly integrating SDT, Heutagogy, and Sociocultural Theory, the framework redefines AI as an ethical and emotional facilitator.

## Conclusion

The rapid and widespread integration of Artificial Intelligence (AI) into educational settings has created an urgent need to go beyond just efficiency and personalization. While AI provides significant technological benefits, focusing too much on data-driven optimization risks reducing the complex, relational nature of education into a purely technical, measurable process—a phenomenon known as "learnification." The Human- Centered AI Pedagogical Engagement (HCAI-PE) Framework has been developed as a key theoretical response, ensuring that technological advancements stay rooted in humanistic pedagogical values.

The HCAI-PE framework fundamentally redefines the AI system's role from simply being a tool for automation or replacement to serving as a cognitive, emotional, and ethical mediator. Its core strength is in combining three key educational theories.

1. Self-Determination Theory (SDT): This integration requires AI design to support the core human needs for autonomy, competence, and relatedness, ensuring that technology enhances intrinsic motivation rather than undermining learner agency.
2. Heutagogy: This perspective positions AI as a partner in reflection, actively prompting learners toward metacognition and double-loop learning to foster self-directedness and capability.
3. Sociocultural Learning Theory: This frames AI as a powerful, yet non-neutral, mediational **tool** within the Zone of Proximal Development (ZPD) .

The operational success of HCAI-PE relies on managing the inherent conceptual tensions across its three mediation dimensions: Cognitive, Emotional, and Ethical. These tensions include the risk of cognitive offloading in scaffolding, the simulation paradox in affective computing, and the need for ongoing oversight to prevent algorithmic bias. Crucially, HCAI-PE redefines the teacher's role, elevating the educator to the position of Ethical Interpreter and Reflective Guide. The teacher’s essential task is to critically evaluate interactions with AI, promote high AI literacy and ethical reasoning among students, and maintain the vital human elements of relationality and care. In conclusion, HCAI-PE offers a necessary theoretical blueprint for responsible, 21st-century pedagogy. By aligning technological progress with core human values of teaching and learning, the framework ensures AI is used as a tool for empowerment— enabling learners to think critically, reflectively, and ethically about knowledge—rather than as an instrument of control or compliance. The next phase of work should include empirical validation of these dimensions and dedicated efforts toward teacher

professional development and equitable, human-centered AI design.

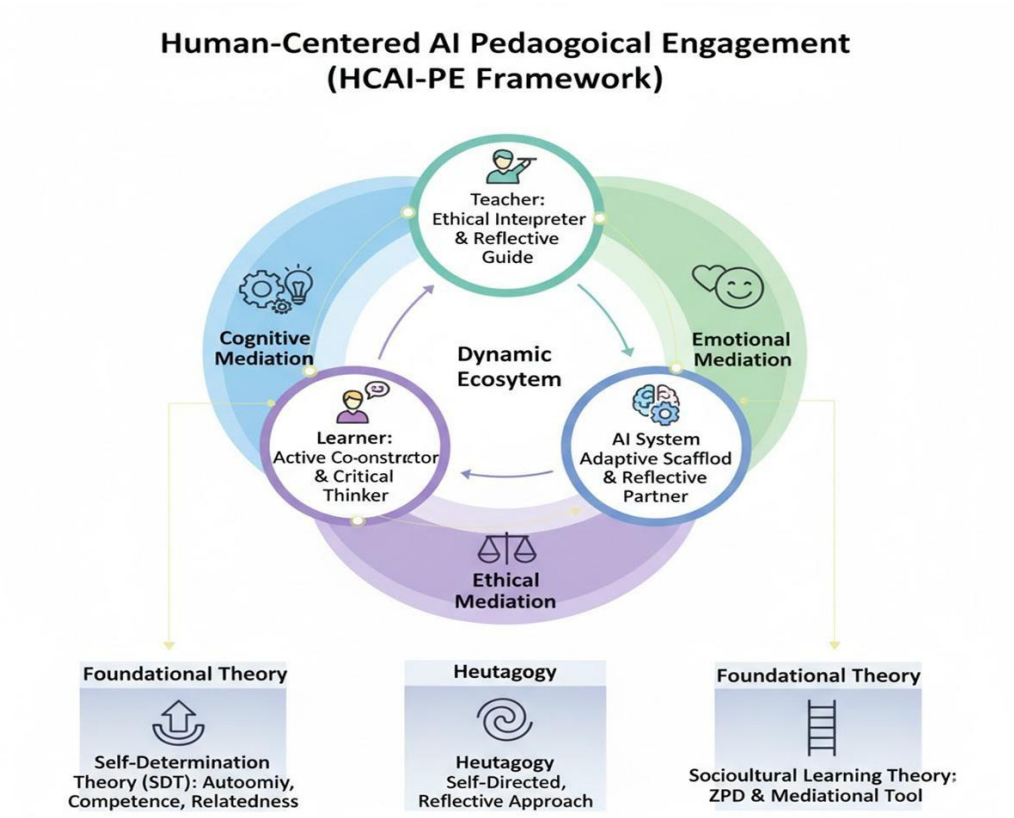
**Research Priorities**

1. **Empirical Validation:** Future research must empirically validate the framework's core hypotheses: specifically, how AI-mediated support for **autonomy** and **reflection** leads to deeper, more sustained engagement (Fredricks et al., 2019).

2. **Equity and Access:** A significant implementation barrier is the disparity in infrastructure and resources. The HCAI-PE framework, to remain human- centered, must address issues of **digital equity**, ensuring that ethical, high- quality AI tools are accessible to all, and that AI does not exacerbate existing achievement gaps.

3. **Policy and Design:** The framework calls for AI developers and policymakers to adopt the principles of **Human-Centered AI** (Shneiderman, 2020), embedding ethical safeguards and transparent design from the initial conceptual stages.

Ultimately, HCAI-PE ensures that AI becomes a **tool for empowerment**, enabling learners to engage critically, reflectively, and ethically in the creation of knowledge, thereby aligning technological advancement with the core human values of teaching and learning.



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