Pedagogical Alignment and Teaching Innovation in the Age of Artificial Intelligence: A Literature Review and Conceptual Framework

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ABSTRACT

The integration of artificial intelligence (AI), particularly generative AI, into education is accelerating, reshaping instructional delivery, assessment, and feedback mechanisms. However, research indicates that AI adoption frequently lacks pedagogical alignment, potentially undermining learning outcomes. This paper argues that sustainable teaching innovation in the AI era must be grounded in pedagogical alignment, ensuring AI use supports learning objectives rather than automating instructional tasks. Using a systematic narrative literature review, the study synthesizes scholarship on AI-enhanced pedagogy, teacher AI literacy, instructional design, assessment, and ethical considerations. A comparative synthesis of major pedagogical learning approaches is provided, highlighting alignment opportunities and risks in AI-mediated learning environments. Building on this synthesis, an AI-Aligned Pedagogical Innovation Framework is proposed, integrating learning outcomes, instructional design, assessment, teacher competencies, and ethical-contextual considerations. The framework positions pedagogical alignment as the central mediator between AI capabilities and effective teaching, offering practical guidance for educators and institutions. This study contributes a theoretically grounded roadmap for AI-enhanced teaching innovation that preserves human-centered educational values.

Keywords: pedagogical alignment; teaching innovation; artificial intelligence in education; AI literacy; learning theories

INTRODUCTION

Artificial intelligence (AI) has emerged as one of the most influential forces reshaping contemporary education, with applications ranging from adaptive learning systems and learning analytics to generative AI tools capable of producing text, feedback, and problem-solving guidance (Holmes et al., 2019). These technologies promise increased personalization, scalability, and responsiveness in teaching and learning. As a result, educational institutions worldwide are accelerating AI adoption across formal education systems, particularly in higher education and teacher preparation programs.

Despite this rapid diffusion, growing evidence suggests that AI integration in education frequently lacks pedagogical alignment (Favero et al., 2026). Many implementations are driven by technological availability or institutional efficiency goals rather than by clearly articulated learning objectives or instructional theories (Jesus & Cauermann, 2026)). This disconnect has raised concerns regarding superficial learning, diminished learner agency, and the erosion of critical thinking and reflective practice (Favero et al., 2026). Consequently, scholars increasingly argue that AI-enhanced teaching innovation must be evaluated not by technological sophistication, but by its alignment with pedagogical principles and educational values (Favero et al., 2026).

Pedagogical alignment—defined as the coherence among learning outcomes, instructional activities, and assessment practices—has long been recognized as essential to effective teaching (Biggs & Tang, 1999). In AI-mediated environments, alignment extends beyond traditional instructional design to include the capabilities and limitations of AI systems, teacher AI literacy, ethical considerations, and contextual constraints. Without such alignment, AI risks functioning as an automation mechanism rather than as a pedagogical support tool.

While existing reviews have examined specific AI applications or ethical implications in education, there remains a lack of integrative frameworks that systematically connect AI capabilities with pedagogical learning theories, instructional design, assessment, and teacher competencies. Addressing this gap, the present study adopts a systematic narrative literature review approach, suitable for theory development in rapidly evolving research domains (Grant & Booth, 2009). The study synthesizes interdisciplinary scholarship to examine how pedagogical alignment can mediate between AI innovation and effective teaching practice.

Accordingly, this study pursues two objectives:

- To systematically synthesize literature on pedagogical learning approaches, AI-enhanced teaching practices, and alignment challenges.
- To propose an AI-Aligned Pedagogical Innovation Framework that guides coherent, ethical, and learner-centered AI integration.

By foregrounding pedagogical alignment, this review positions AI as a catalyst for teaching innovation that preserves human-centered educational values rather than replacing instructional judgment.

METHODOLOGY

Review Design

This study adopts a **systematic narrative literature review** methodology, which is particularly suited to emerging and rapidly evolving research fields where empirical findings are heterogeneous and theoretical integration is required (Grant & Booth, 2009). Unlike meta-analytical or PRISMA-driven systematic reviews that prioritize effect size aggregation, systematic narrative reviews emphasize **conceptual synthesis, critical comparison, and theory development**. This approach is widely used in educational technology research to construct integrative frameworks and identify patterns across diverse study designs.

Search Strategy

The research employed a structured and iterative search strategy to identify relevant literature. The authors searched four major academic databases recognized for educational and interdisciplinary research coverage:

- Scopus
- Web of Science (Core Collection)
- ERIC
- ScienceDirect

The search process was conducted between January and March 2026. Boolean search strings combined AI-related terms with pedagogical and instructional constructs. Examples of search strings included:

- “artificial intelligence” AND “pedagogical alignment”
- “generative AI” AND “teaching innovation”
- “AI in education” AND “learning theories”
- “AI literacy” AND “teacher competency”
- “AI-enhanced assessment” AND “instructional design”

Reference lists of key review articles were also manually screened to identify additional seminal or highly cited studies not captured through database searches, supporting citation chaining and theoretical completeness.

Inclusion and Exclusion Criteria

To ensure relevance and quality, explicit inclusion and exclusion criteria were applied.

Inclusion Criteria

- Peer-reviewed journal articles, scholarly books, and authoritative institutional reports
- Publications between **2011 and 2026**, reflect contemporary AI developments in addition to elder publications to cover the original pedagogical theories in education.
- Explicit focus on **formal education contexts** (primary, secondary, or higher education)
- Engagement with **pedagogical, instructional, assessment, or ethical dimensions** of AI use
- Studies building on or explicitly referencing **learning theories or instructional frameworks**

Exclusion Criteria

- Non-peer-reviewed sources (e.g., blogs, opinion pieces, promotional materials)
- Studies focused exclusively on **technical AI development** without pedagogical application
- Research conducted outside formal educational settings (e.g., corporate training only)
- Articles addressing digital technologies broadly without specific reference to AI

Screening and Selection Process

- The initial search yielded **312 records**. After removing duplicates, titles and abstracts were screened for relevance to the study objectives. This stage resulted in the exclusion of studies that did not explicitly address pedagogy, instruction, or assessment.
- Full-text screening was subsequently conducted for the remaining articles, applying the inclusion and exclusion criteria in greater depth. This process resulted in a final corpus of **112 studies**, which formed the basis of the review.
- Although the review does not follow a PRISMA flow diagram, the selection process was systematic, transparent, and replicable, consistent with established guidelines for narrative reviews in educational research.

Data Extraction and Analytical Framework

A structured data extraction protocol was used to ensure consistency across studies. Extracted data included:

- Educational context and level
- AI application type (e.g., adaptive systems, generative AI, learning analytics)
- Pedagogical learning theory or instructional framework referenced
- Reported pedagogical benefits and challenges
- Alignment or misalignment between learning outcomes, instruction, and assessment
- Ethical, equity, or contextual considerations

The review analyzed the extracted data using **thematic synthesis**, enabling identification of recurring patterns, tensions, and conceptual relationships across studies. This process involved iterative coding and category refinement, moving from descriptive coding to higher-order analytical themes.

Quality Assessment of Included Studies

To strengthen the rigor of this review, each included study was evaluated using a set of predefined quality criteria adapted from established guidance for narrative and systematic reviews. Specifically, the studies were assessed based on:

- the clarity of their research objectives
- the suitability of their research design
- the transparency of their methodology
- their relevance to AI-enhanced pedagogy
- the credibility of their findings and conclusions.

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The quality assessment emphasized methodological transparency, theoretical value, and alignment with the aims of the review. Studies that provided insufficient methodological information or offered only limited relevance to the pedagogical focus of the review were excluded during the full-text screening stage**.**

Thematic Synthesis and Trustworthiness

Through iterative analysis, four overarching themes emerged:

- Pedagogical alignment in AI-enhanced teaching
- Learning theories and instructional approaches
- Teacher AI literacy and pedagogical competency
- Ethical, equity, and contextual considerations

To enhance analytical rigor, themes were cross-validated against multiple theoretical perspectives and educational contexts. Contradictory findings were explicitly examined rather than excluded, allowing for a balanced and critical synthesis.

Role of AI Tools in the Review Process

The authors used AI-based tools selectively to support literature organization, keyword clustering, and language refinement. Consistent with MDPI ethical guidelines, all AI-assisted outputs were critically reviewed and verified by the authors. AI tools were not used to generate analytical interpretations, theoretical arguments, or the proposed conceptual framework. All synthesis and conclusions reflect the authors' independent scholarly judgment.

Table 1 summarizes selected included studies based on design, context, AI focus and main findings.

Table 1. Comparison of Selected Studies on Artificial Intelligence and Education

Author	**Study Design**	**Educational Context**	**AI Focus**	**Main Finding**
Holmes et al. (2019)	Conceptual book	K–12 and higher education	AI in education	AI is expected to change what students should learn and how education is organized; the framework emphasizes foundational knowledge, competencies, transfer, and using AI without losing the underlying purposes of human learning
Schmidt et al. (2025)	Qualitative	Higher education	Faculty and student perceptions and AI literacy	Faculty and students recognized AI's potential, but both raised concerns about critical thinking, reliability, accuracy, and academic integrity
Jesus & Cauermann (2026)	Qualitative	Higher education	Human-centered AI	Importance of pedagogy and ethics
Dawson et al. (2019)	Empirical	Higher education	Not an AI study; it examines assessment feedback	Staff and students generally saw feedback as serving improvement, but staff emphasized design features such as timing, modality, and connected tasks
Favero et al. (2026)	Review	Higher education	Generative AI	Cognition, agency, emotion, ethics

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Pedagogical Alignment and Teaching Innovation

Pedagogical alignment ensures instructional coherence by linking learning objectives, teaching activities, and assessment (Biggs & Tang, 2011). In AI-enhanced teaching, alignment extends to how AI supports cognitive, collaborative, and ethical learning outcomes. Teaching innovation should not be equated with AI adoption; rather, it involves reconfiguring instructional design to leverage AI capabilities while maintaining learner-centered pedagogy (Goodyear, 2015).

AI applications—such as adaptive learning platforms, automated feedback, or generative AI tools—can enhance learning if carefully integrated with pedagogical intent (Holmes et al., 2019). Misalignment risks include over-reliance on AI, reduced critical thinking, and inequities in learning opportunities. Pedagogical alignment, therefore, is the mediating principle that ensures AI enhances, rather than undermines, teaching innovation.

Constructive Alignment as a Foundation for AI-Enhanced Teaching

Constructive alignment has long been recognized as a cornerstone of effective teaching, emphasizing coherence among learning outcomes, instructional activities, and assessment practices (Biggs & Tang, 2011). In digitally mediated learning environments, alignment has been shown to significantly influence learner engagement, depth of learning, and transfer of knowledge (Mayer, 2020; Zimmerman, 2002). The introduction of AI into educational settings intensifies the importance of alignment, as AI systems actively shape instructional pacing, feedback mechanisms, and learner decision-making processes (Mishra & Koehler, 2006)

Recent studies indicate that AI-enhanced learning environments frequently prioritize technological affordances over pedagogical intent, resulting in what several scholars describe as "technology-led pedagogy" (Holmes et al., 2019; Jesus & Cauermann, 2026)). In such cases, AI tools are deployed for efficiency—automated grading, content generation, or tutoring—without sufficient consideration of whether these functions support intended learning outcomes (Cuban, 2001; Perrotta & Selwyn, 2017). This misalignment can lead to surface learning, diminished metacognitive engagement, and reduced learner autonomy.

From an innovation perspective, teaching innovation is not only the adoption of novel technologies but the **reconfiguration of pedagogical relationships**—between learners, content, instructors, and assessment (Hakkarainen et al., 2013). AI, therefore, must build on a pedagogical logic that prioritizes meaning-making, critical inquiry, and reflective learning. Pedagogical alignment serves as the mechanism through which AI capabilities are translated into educational value rather than instructional automation. Constructive alignment provides the theoretical foundation for integrating AI into teaching. Because learning outcomes differ across pedagogical traditions, AI-supported instructional design must also vary according to the assumptions of different learning theories.

Teaching Innovation Beyond Automation

A growing body of literature cautions against equating AI adoption with pedagogical innovation. While AI can enhance personalization and scalability, excessive automation risks marginalizing human judgment and pedagogical intentionality (Balaji & Ghosh, 2025). Studies in higher education contexts demonstrate that students exposed to AI-generated explanations without guided reflection often demonstrate weaker conceptual understanding compared to those engaged in instructor-facilitated inquiry (Mayer, 2008; Jesus & Cauermann, 2026)).

Teaching innovation in the AI era thus requires a **shift from task automation to cognitive augmentation**. AI tools should support higher-order learning processes—analysis, synthesis, evaluation rather than replacing them. Alignment ensures that AI interventions are pedagogically purposeful, reinforcing deep learning rather than efficiency-driven instructional shortcuts.

Behaviorist Foundations and AI-Driven Automation

Behaviorist learning theory conceptualizes learning as a change in observable behavior shaped by reinforcement and repetition (Skinner, 1953). AI-driven adaptive learning systems align closely with behaviorist principles, particularly through automated drills, immediate feedback, and mastery-based progression. Empirical studies demonstrate that such systems can improve procedural fluency and short-term performance, especially in foundational skills and test preparation contexts (Holmes et al., 2019).

However, literature consistently highlights limitations of behaviorist-aligned AI applications. Overemphasis on reinforcement and correctness can restrict learning to lower-order cognitive outcomes, reducing opportunities for conceptual understanding and transfer (Mayer, 2008). From an alignment perspective, behaviorist AI tools are most effective when learning outcomes explicitly prioritize skill acquisition rather than critical reasoning or creativity. Misalignment occurs when such tools are applied indiscriminately across complex learning tasks, leading to pedagogical reductionism.

Cognitivist Perspectives: Cognitive Load and Personalization

Cognitivist theories emphasize mental processes such as information encoding, schema construction, and cognitive load management (Mayer, 2020). AI systems that personalize content sequencing, adapt instructional pacing, or generate explanatory feedback can support cognitivist learning goals. Research indicates that adaptive explanations and worked examples generated by AI may reduce extraneous cognitive load when carefully designed.

Nonetheless, recent studies caution that generative AI may inadvertently increase cognitive overload by providing excessive, poorly structured, or redundant information (Jesus & Cauermann, 2026)). Pedagogical alignment requires instructors to regulate AI-generated content, ensuring coherence with instructional objectives and learners' cognitive readiness. Without such mediation, personalization risks becoming cognitive fragmentation.

Constructivist Approaches and Epistemic Agency

Constructivist learning theory posits that learners actively construct knowledge through inquiry, reflection, and meaning-making (Piaget, 1972). AI tools can support constructivist pedagogy by offering scaffolding, simulations, and exploratory environments that encourage hypothesis testing and conceptual exploration.

However, a recurring concern in the literature is the erosion of epistemic agencies when generative AI provides ready-made answers. Jesus and Cauermann (2026) describe this phenomenon as epistemic outsourcing, whereby learners rely on AI-generated explanations rather than engaging in cognitive struggle. Effective alignment requires positioning AI as a cognitive scaffold that prompts inquiry rather than replaces it, preserving learners' responsibility for knowledge construction.

Sociocultural Theory and AI-Mediated Interaction

From a sociocultural perspective, learning is socially situated and mediated by tools, language, and interaction (Vygotsky, 1978). AI-supported collaborative platforms, peer-feedback systems, and conversational agents can enhance dialogue and shared meaning-making when aligned with collaborative learning goals (Kővári, 2025).

Nevertheless, empirical findings suggest that poorly designed AI mediation may reduce authentic peer interaction, substituting algorithmic responses for human dialogue (Hakkarainen et al., 2013). Alignment thus requires ensuring that AI amplifies, rather than replaces, social learning processes

Experiential and Inquiry-Based Learning in AI Contexts

Experiential learning emphasizes learning through authentic experience, reflection, and iterative cycles of action (Kolb, 1984). AI-powered simulations and virtual environments offer significant potential for experiential learning by providing immersive, real-time feedback. However, Balaji and Ghosh (2025) warn that automation may short-circuit reflection, a core component of experiential learning.

Inquiry-based learning similarly benefits from AI-supported data analysis and exploration tools. Yet, when AI generates conclusions rather than supporting evidence evaluation, inquiry degenerates into answer consumption. Alignment requires deliberate instructional design that foregrounds questioning, interpretation, and reflection

Self-regulated learning and Connectivism

Self-regulated learning emphasizes learners' ability to plan, monitor, and evaluate their own learning processes, fostering learner autonomy, metacognitive awareness, and strategic control (Zimmerman, 2002). AI-supported learning analytics dashboards and adaptive feedback systems can enhance self-regulation by visualizing progress, providing timely feedback, and prompting reflection on learning strategies. However, empirical studies caution that excessive AI guidance may undermine learners' capacity for independent self-monitoring and decision-making, creating dependency rather than promoting autonomy (Holmes et al., 2019). From a pedagogical alignment perspective, AI should function as a metacognitive scaffold that supports learners' regulation of their own learning rather than replacing it.

Connectivism conceptualizes knowledge as distributed across networks of people, technologies, and information sources (Siemens, 2005). AI-powered search, synthesis, and recommendation tools naturally support connectivist learning by facilitating access to diverse information and enabling learners to navigate complex knowledge networks. Nevertheless, these affordances also introduce challenges related to epistemic trust, algorithmic bias, and the uncritical acceptance of AI-generated information (Schmidt et al., 2025). Effective pedagogical alignment therefore requires educators to cultivate critical evaluation, information literacy, and epistemic vigilance, ensuring that learners engage critically with AI-generated content rather than treating it as inherently authoritative.

Table 2. Comparative Overview of Pedagogical Learning Approaches in AI-Enhanced Teaching

Pedagogical Learning Approach	**Core Learning Assumption**	**Instructional Emphasis**	**Aligned AI Role**	**Risks of Pedagogical Misalignment**	**Key Sources**
Behaviorism	Learning as observable behavioral change	Reinforcement, repetition, mastery learning	Automated feedback, adaptive drills, intelligent tutoring systems	Overemphasis on lower-order skills; limited conceptual understanding	Skinner (1953); Holmes et al. (2019)
Cognitivism	Learning as information processing and schema construction	Scaffolding, sequencing, cognitive load management	Personalized explanations, adaptive content sequencing	Cognitive overload; fragmented knowledge structures	Mayer (2008); Mayer (2020)
Constructivism	Knowledge actively constructed through inquiry and reflection	Exploration, problem-solving, reflective learning	Cognitive scaffolding, simulations, exploratory environments	Epistemic outsourcing; reduced learner sense-making	Piaget (1972); Jesus & Cauermann (2026)
Sociocultural Theory	Learning mediated through social interaction and cultural tools	Dialogue, collaboration, guided participation	AI-supported collaborative platforms, peer-feedback tools	Reduced authentic social interaction; algorithmic mediation replacing dialogue	Vygotsky (1978); Hakkarainen et al., 2013

Experiential Learning	Learning through experience and reflection	Authentic tasks, experiential cycles, reflection	Simulations, virtual environments, real-time feedback	Short-circuiting reflection; automation of experiential processes	Kolb (1984);
Inquiry-Based Learning	Learning driven by questioning and evidence evaluation	Problem formulation, investigation, interpretation	AI-supported data analysis, information exploration	AI-generated answers replacing inquiry and reasoning	Holmes et al. (2019)
Self-Regulated Learning	Learners actively plan, monitor, and evaluate learning	Metacognitive monitoring, goal setting	Learning analytics dashboards, adaptive feedback	Overreliance on AI guidance; reduced learner autonomy	Zimmerman (2002); Holmes et al. (2019)
Connectivism	Knowledge distributed across networks and digital systems	Navigation, synthesis, evaluation of networked knowledge	AI-powered search, synthesis, and recommendation systems	Uncritical reliance on AI-generated knowledge; epistemic trust issues	Siemens (2005); Schmidt et al., 2025

The table synthesizes dominant pedagogical learning approaches and illustrates how AI tools may support or undermine learning depending on alignment with instructional intent and assessment practices.

AI Literacy and Teacher Competency

Teacher AI literacy is critical for effective AI integration. Educators with higher AI literacy can integrate AI tools in ways that promote learner-centered, reflective, and ethically responsible practice (Bai & Talin, 2025; Hakkarainen et al., 2013). AI literacy encompasses technical knowledge, pedagogical judgment, and ethical reasoning, emphasizing the importance of professional development aligned with both technological and pedagogical competencies.

Teacher AI literacy has emerged as a critical determinant of effective AI integration. Beyond technical proficiency, AI literacy encompasses pedagogical decision-making, ethical reasoning, and reflective practice (Schmidt et al., 2025). Studies consistently show that educators with higher AI literacy are more likely to design learning activities that leverage AI for inquiry, feedback, and collaboration rather than content substitution.

Professional development programs focused solely on tool training are insufficient. Effective programs integrate pedagogical theory, case-based learning, and ethical reflection, enabling teachers to critically evaluate when and how AI should be used (Hakkarainen et al., 2013). Without such competencies, AI adoption risks reinforcing existing pedagogical weaknesses rather than fostering innovation.

Artificial intelligence has significantly expanded the range of assessment and feedback practices available in formal education. AI-supported assessment includes automated grading, formative feedback generation, learning analytics, and adaptive testing systems. These applications promise efficiency, immediacy, and scalability; however, their pedagogical value depends heavily on alignment with learning outcomes and instructional design (Boud & Falchikov, 2007).

Research indicates that AI-based assessment is most effective when used formatively, supporting learning processes rather than merely evaluating final products. Automated feedback systems can provide timely guidance that supports self-regulated learning and metacognitive development, particularly when feedback is explanatory rather than corrective (Dawson et al., 2019). However, studies caution that feedback generated by AI may prioritize surface features such as correctness or linguistic form over conceptual understanding, particularly in generative AI contexts.

Pedagogical misalignment occurs when AI assessment tools are deployed primarily for efficiency or surveillance rather than learning support. Automated grading systems may inadvertently reinforce behaviorist learning patterns even when course outcomes emphasize critical thinking or creativity (Zhao & Dang, 2026). Moreover, generative AI complicates traditional assessment models by enabling students to outsource cognitive labor, challenging assumptions about authorship, originality, and learning evidence (Ahangama, 2026)

Aligned AI-enhanced assessment requires a shift toward authentic, process-oriented, and reflective assessment designs. Examples include iterative drafts with AI-supported feedback, learning portfolios, and assessment tasks that emphasize justification, reflection, and decision-making rather than final answers. In such models, AI functions as a formative scaffold rather than an evaluative authority (Liu et al., 2026).

Teacher AI literacy is critical in mediating assessment alignment. Educators must understand both the affordances and limitations of AI feedback systems, including issues of bias, transparency, and reliability. Without pedagogical oversight, AI-based assessment risks narrowing learning outcomes and undermining learner agency. Alignment-driven assessment design ensures that AI enhances feedback quality while preserving the integrity of learning evaluation (Vinci et al., 2026)

Student Agency, Academic Integrity, and Generative AI

The rise of generative AI has intensified debates surrounding student agency, academic integrity, and the nature of learning evidence. While generative AI can support idea generation, drafting, and feedback, it also raises concerns about plagiarism, authorship, and the erosion of cognitive engagement (Bretag, 2016; Sutherland-Smith, 2008). These concerns are fundamentally pedagogical rather than technological. A growing body of research emphasizes the advantages of AI tools for education. AI enables customized training and adaptive feedback based on student needs (Zeki et al., 2025).

From a pedagogical alignment perspective, academic integrity challenges emerge when assessment designs fail to account for AI capabilities. Tasks that emphasize recall or generic responses are particularly vulnerable to AI substitutions. Conversely, assessments that foreground contextualized reasoning, reflection, and iterative learning processes are more resistant to misuse and more aligned with meaningful learning outcomes (Dahal, 2026)

Student agency is a critical mediating construct in AI-enhanced learning environments. When students perceive AI as an authoritative source rather than a cognitive tool, agency may be diminished. Research suggests that transparent AI use policies and explicit instruction on responsible AI use can enhance learner agency by framing AI as a support for thinking rather than a replacement for it (Qin et al., 2025). Additionally, an over-reliance on automated methods can hinder students' ability to think critically and discourage creativity. Student perspectives provide important insights into how AI is experienced in educational settings. Cheng et al. (2023) developed the Student Conceptions of AI in Education Scale (SCAIES) was developed based on eight factors . According to Sullivan et al. (2023), student voice is virtually absent in this discussion over the use of AI in education. According to one study, even though AI is thought to have the ability to foster users' creativity, students have preconceived notions about it because they believe it lacks originality (Marrone et al., 2022). Idroes et al. (2023) found that undergraduate students generally held positive perceptions of AI use in education, recognizing its potential to enhance learning and teaching. Students identified virtual tutoring, universal access to learning resources, and continuous feedback as the most significant benefits of AI-supported education. At the same time, they expressed concerns about the potential erosion of teacher–student relationships, highlighting the importance of preserving meaningful human interaction alongside AI integration. Sangapu (2018) used online surveys to investigate how teachers and students perceived the usage of AI in the classroom. Half of the respondents thought artificial intelligence was beneficial for students, while the least number said it was detrimental. Nearly 80% of the students responded negatively to the idea of instructors being entirely replaced by robots, but roughly two-thirds of the students thought favorably of the teaching approach in which a teacher employs AI as a support.

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Educators play a central role in fostering ethical AI engagement by embedding academic integrity within instructional design rather than relying solely on detection technologies. Aligned pedagogical strategies include AI-assisted drafting with mandatory reflection, process documentation, and peer discussion of AI-generated outputs. These approaches reposition integrity as a learning outcome rather than a compliance issue.

AI-Aligned Pedagogical Innovation Framework

The AI-Aligned Pedagogical Innovation Framework draws on three complementary bodies of scholarship: **constructive alignment theory**, **learning theory–informed instructional design**, and **human-centered AI in education**. Constructive alignment theory provides foundational logic, emphasizing coherence among learning outcomes, teaching activities, and assessment practices (Biggs & Tang, 2011). This principle is extended in the present framework to account for the mediating role of AI technologies in shaping instructional interactions.

Learning theories—including behaviorism, cognitivism, constructivism, sociocultural theory, experiential learning, and self-regulated learning—inform how AI tools can support or undermine learning processes depending on alignment conditions. Rather than privileging a single pedagogical paradigm, the framework adopts a **theory-responsive approach**, recognizing that pedagogical intent determines appropriate AI use.

Human-centered AI perspectives further inform the framework by emphasizing transparency, agency, and ethical responsibility (Jesus & Cauermann, 2026). These perspectives challenge techno-deterministic models of educational innovation and reinforce the necessity of pedagogical mediation in AI-enhanced teaching.

Framework Structure and Core Dimensions

The framework positions **pedagogical alignment** as the central mediating construct between AI capabilities and effective teaching innovation. Surrounding this core are five interdependent dimensions:

(1) **Learning Outcome Alignment**
Learning outcomes extend beyond disciplinary knowledge to include AI literacy, critical thinking, metacognitive skills, and ethical reasoning. Alignment at this level ensures that AI use supports intended cognitive and dispositional outcomes rather than efficiency-driven objectives.

(2) **Instructional Design Alignment**
Instructional activities must be intentionally designed to leverage AI affordances in ways that promote inquiry, collaboration, and reflection. This dimension emphasizes that AI should scaffold learning processes rather than substitute for pedagogical interaction.

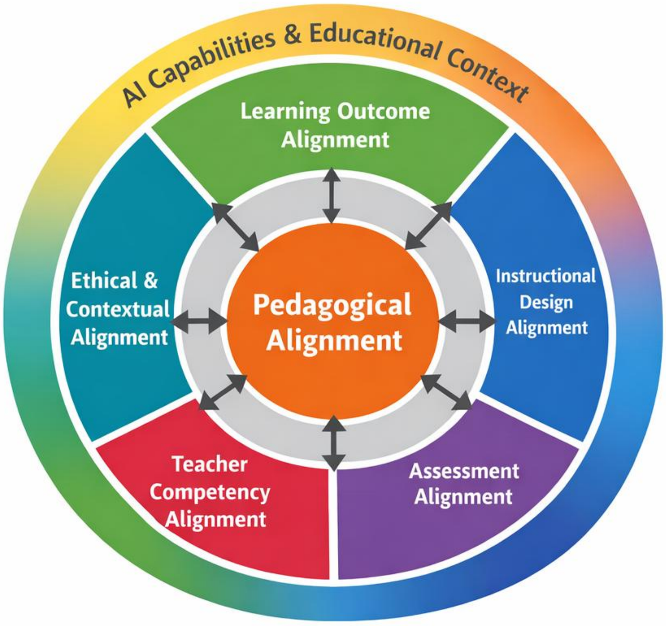
(3) **Assessment Alignment**
Assessment practices should reflect learning goals and instructional design, incorporating formative, authentic, and process-oriented approaches. AI-enabled assessment must be aligned to evaluate learning processes, not merely outputs, to avoid reinforcing surface learning.

(4) **Teacher Competency Alignment**
Teacher AI literacy operates as an enabling condition across all dimensions. Educators require not only technical knowledge but also pedagogical judgment and ethical reasoning to align AI use with educational intent (Schmidt et al., 2025).

(5) **Ethical and Contextual Alignment**
Ethical principles—equity, transparency, data privacy, and learner agency—must be embedded within pedagogical decision-making. Institutional context, disciplinary norms, and cultural values further shape alignment conditions.

Figure 1 conceptualizes these dimensions as dynamically interconnected rather than hierarchically ordered, emphasizing that misalignment in any dimension can compromise overall teaching effectiveness.

Figure 1. AI-aligned Pedagogical Innovation Framework



Comparison with Existing AI-in-Education Models

Existing frameworks in AI in education tend to emphasize technological functionality, system architecture, or ethical guidelines in isolation. For example, technology-centric models focus on AI affordances such as adaptivity or automation, often under-specifying pedagogical intent. Ethical AI frameworks, while critical, frequently operate as external compliance mechanisms rather than integrated instructional principles.

In contrast, the AI-Aligned Pedagogical Innovation Framework is distinguished by:

- Positioning **pedagogical alignment as the primary organizing principle**
- Integrating **learning theory explicitly**, rather than implicitly
- Treating **teacher competency as a central design variable**, not a peripheral condition
- Embedding **ethical considerations within instructional design**, not as post-hoc constraints

This integrative positioning addresses a critical gap in the literature, where AI adoption is often discussed independently of pedagogical alignment.

Dynamic Nature of Alignment in AI-Enhanced Teaching

A key contribution of the framework is its recognition of pedagogical alignment as a **dynamic and iterative process**. AI systems evolve, institutional policies change, and learner needs shift over time. Consequently, alignment must be continuously re-evaluated through reflective practice and evidence-informed decision-making.

This dynamic perspective aligns with contemporary views of teaching innovation as an adaptive process rather than a fixed intervention. It underscores the role of educators as reflective designers who actively shape how AI mediates learning experiences.

Ethical Dimensions of AI Integration: Equity, Access, and the Digital Divide

Ethical considerations are central to pedagogical alignment in AI-enhanced education. Issues of data privacy, algorithmic bias, transparency, and accessibility directly influence learning equity and trust. Scholars argue that ethical AI use must be embedded within instructional design rather than treated as an external compliance concern (Schmidt et al., 2025). Incorporating AI into educational environments also presents difficulties for students' socio-emotional learning, which is essential for their overall development (Holmes, 2023; UNESCO, 2023). In fact, the objective of inclusive education is to improve every student's well-being, especially in the area of socio-emotional learning, while attending to all students' needs beyond academic performance and attendance (OECD, 2023). By unintentionally decreasing the need for human interaction, some AI-driven tools may hinder students' sociability, feeling of trust, and empathy for others, increasing their reliance on digital interfaces (Pons, 2023; UNESCO, 2023).

Due to differing levels of access to the technology, the growing integration of AI-powered educational systems may pose problems for inclusion and fairness in education. Technical, socio-technical, and sociological issues may arise from this so-called "digital divide" (Carter, Liu, and Cantrell, 2020). The efficient application of AI technologies depends on technical aspects including computational data, broadband speed, and technological availability. Because the internet allows AI systems to access databases, online resources, and real-time data necessary for current information, these technologies frequently require internet access for maximum performance. However, schools with a high proportion of children from socioeconomically disadvantaged backgrounds already report a greater deficiency and poor quality of digital resources.

Social aspects include user demographics and socioeconomic features (e.g., gender, age, income, family size, and educational level) that can influence who has access to AI technologies (Carter, Liu, and Cantrell, 2020]). These also include other societal elements that affect access to AI tools, such as culture, laws, and policies. These social factors can decide who has access to and can benefit from AI technology in learning contexts, making them particularly relevant to educational disparities. For example, underprivileged pupils might not have as much access to AI-enhanced learning resources. The way AI is incorporated into educational systems is also influenced by cultural norms and restrictions, which may lead to differences in the caliber of education obtained. These socioeconomic and cultural differences can exacerbate already-existing disparities by causing a growing disparity in educational performance (OECD, 2024). Comparisons between urban and rural areas regularly show that rural areas have worse access to AI-related learning, lower adoption, and less engagement. Lack of ICT infrastructure, insufficient resources, erratic internet, a small number of devices, and inadequate AI literacy or training among teachers are the primary causes (Jeon, 2025).

AI-powered simulations have the potential to improve cultural diversity and customize learning environments. These technologies, for example, can encourage respect for Indigenous and minority cultures (Reihana et al., 2023). However, cultural variations in the uptake of AI technologies are another aspect of access discrepancies. Students from culture with lower levels of trust might not have access to AI resources that promote things like health and wellbeing. These abilities and attitudes can shape disparities in access to AI technologies by influencing how users engage with and view AI advancements.

Contextual factors, including institutional policies, disciplinary norms, and cultural expectations also shape AI effectiveness. What constitutes pedagogically aligned AI use in one educational context may be inappropriate in another. Therefore, alignment must be understood as **context-sensitive**, requiring continuous reflection and adaptation. Across classroom and policy studies, teachers are the mechanism that turns AI from a potentially exclusionary automation system into a more inclusive pedagogical support (Xia & Guo, 2025)

Cultural responsiveness in relation to AI alignment

Culturally responsive education integrates multiple cultural values, experiences, and views into teaching methods and curricula to promote inclusive and equitable learning (Chen et al., 2022; Muñiz, 2019). Ladson-Billings' (1994) Culturally Relevant Pedagogy promotes student involvement, cultural integrity, and empowerment, emphasizing the significance of developing AI tools that respect students' identities and lived experiences (Kashyap et al., 2024). This method improves student engagement and learning outcomes by recognizing cultural advantages, but it confronts major implementation obstacles, especially in situations with systematic inequities and limited resources. Teachers in underserved areas frequently lack access to necessary training and culturally diverse materials, particularly in developing countries where a reliance on Western curricula and English-medium instruction undermines local languages and knowledge systems (Nyaaba et al., 2024; UNESCO, 2020). AI technologies present promising opportunities to address these barriers by enabling culturally responsive education on a large scale, potentially assisting teachers in creating localized resources, developing culturally relevant lesson plans, and providing multilingual support to diverse communities (Liu et al., 2023).

The role of AI in sustaining pedagogy

In education, sustainability is defined as the long-term improvement of learning outcomes, access, and efficiency, as well as education systems' resilience to retain fairness, professional agency, critical thinking, and moral accountability (Olsson et al., 2022). In teacher education, sustainability is defined as the preparedness of teachers to adapt to AI-mediated environments while maintaining pedagogical judgment, inclusive practice, and human-centered professional ideals. According to research, AI could help to create more sustainable education systems by providing scalable answers to long-standing issues. Sustainable instructors in AI-mediated situations are pedagogically flexible, ethically accountable, and professionally robust. From this perspective, it is not only about being operationally efficient, but also about how one affects the environment and if one uses technology ethically. As the use of AI-based educational applications grows in the education and training sectors, it has been suggested that educators must understand the impact these applications have on energy and material use, as well as maintain a balanced view between educational innovation and environmental conservation (Abu Kharma, 2026). In the context of teacher education, this means that rather than unthinking adoption, curricular and institutional decisions should be influenced by responsible choices and pedagogical arguments for the use of AI tools. Sustainable access to AI technologies may enhance both educators' and learners' lifetime learning, allowing them to make better decisions about their evolution and providing them with tools for continual professional growth (Zhang et al., 2023). Similarly, when used properly, AI allows teachers to enhance their teaching and evaluation approaches, resulting in increased self-regulation and metacognitive knowledge of the profession. As a result, high-quality teaching practice can be improved and sustained throughout time (Ramnarain et al., 2024).

DISCUSSION

Key Implications of the proposed framework

The findings reinforce that AI alone does not constitute teaching innovation; effectiveness depends on alignment with learning goals, instructional strategies, assessment, and ethical considerations. Key implications include:

- Alignment-driven AI integration: AI should scaffold rather than replace cognitive, collaborative, or reflective processes.
- Teacher competency: Educators require AI literacy and pedagogical judgment to integrate tools meaningfully.
- Ethical oversight: AI use should promote equity, transparency, and learner agency.
- Learning theory relevance: Different pedagogical approaches dictate distinct AI uses, as summarized in Table 1.

By centering pedagogical alignment, the framework addresses risks of over-automation, superficial learning, and ethical missteps. It provides a practical guide for designing AI-enhanced curricula, teacher training programs, and institutional policies.

The proposed framework synthesizes principles from constructive alignment theory, human-centered AI, and contemporary learning theories. Unlike technology-centric models, it positions pedagogical alignment as the mediating mechanism that translates AI affordances into meaningful learning outcomes. The proposed framework complements broader educational technology models while addressing a distinct gap. Unlike TPACK, which emphasizes the integration of technological, pedagogical, and content knowledge, the proposed framework focuses on aligning AI capabilities with learning outcomes, instructional strategies, assessment, teacher competency, and ethical-contextual considerations. Similarly, whereas models such as SAMR primarily classify levels of technology integration, the proposed framework provides guidance on when and why AI should be used to support pedagogical objectives. In this way, the framework extends established educational

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technology models by placing pedagogical alignment at the center of AI-enhanced teaching rather than treating AI as simply another instructional technology.

The framework offers practical guidance for multiple stakeholders:

- **Educators** can use it to evaluate whether AI tools meaningfully support learning objectives and instructional strategies.
- **Teacher education programs** can integrate the framework into AI literacy and professional development curricula.
- **Institutions and policymakers** can apply it to guide AI adoption strategies, quality assurance, and ethical governance.

By linking theory, practice, and ethics, the framework functions as both an analytical lens and a design tool for AI-enhanced teaching innovation.

Disciplinary Applications of the AI-Aligned Pedagogical Innovation Framework

While the AI-Aligned Pedagogical Innovation Framework is theoretically generalizable, its application varies across disciplinary contexts. Disciplinary epistemologies shape learning outcomes, assessment norms, and acceptable forms of AI mediation.

In STEM education, AI assists in automated problem-solving, simulations, and adaptive practice. Alignment challenges arise when AI systems provide solutions without supporting conceptual understanding. Research highlights the importance of inquiry-based and model-based learning designs in which AI supports experimentation and visualization rather than answer generation.

In the humanities and social sciences, generative AI provides writing support, argument development, and content synthesis. Pedagogical alignment in these contexts requires careful attention to epistemic practices such as interpretation, critique, and authorship. AI tools can support drafting and feedback, but learning outcomes must explicitly emphasize reasoning, positionality, and reflective judgment.

Teacher education represents a particularly critical application context. Pre-service teachers must develop both pedagogical expertise and AI literacy. Studies indicate that modeling aligned AI use in teacher education programs influences future classroom practice. When teacher candidates experience AI as a reflective pedagogical tool rather than a shortcut, they are more likely to adopt ethical and learner-centered AI practices.

In health and medical education, AI has the potential to enhance learning through diagnostic simulations, clinical reasoning exercises, and personalized case-based instruction. To achieve meaningful pedagogical alignment, however, AI should serve as a tool that supports clinical reasoning and reflective practice rather than replacing professional judgment. Accordingly, assessment should prioritize students' ability to interpret clinical information, make ethical decisions, and deliver patient-centered care instead of simply reproducing AI-generated responses.

Within business and economics education, AI can assist students with tasks such as data analysis, financial modeling, forecasting, and scenario planning. Its educational value depends on encouraging learners to critically examine AI-generated outputs rather than accepting them uncritically. Students should be expected to justify their decisions using sound economic principles, evaluate alternative solutions, and consider the ethical and societal implications of AI-supported recommendations.

AI offers significant opportunities in engineering education by supporting design optimization, programming, and complex simulation environments. Effective pedagogical alignment requires AI to function as a scaffold that enhances problem-solving and iterative design processes while ensuring that students continue to develop fundamental analytical skills, mathematical competence, and professional engineering judgment. Assessment should therefore focus on the reasoning behind engineering decisions as much as the final solutions.

In legal education, AI can streamline legal research, document review, and case summarization, allowing students to engage more efficiently with legal materials. Nevertheless, pedagogical alignment requires that AI complement, rather than substitute for, legal reasoning. Assessment should emphasize students' ability to interpret legal principles, construct persuasive arguments, exercise ethical judgment, and apply the law to complex cases instead of relying primarily on AI-generated legal analyses.

These disciplinary examples demonstrate that pedagogical alignment is not a one-size-fits-all solution but a context-sensitive design principle. The framework supports adaptive implementation while maintaining coherence across educational settings.

The findings underscore that AI adoption alone does not constitute pedagogical innovation. Effective AI-enhanced teaching requires alignment across learning outcomes, instructional design, assessment, teacher competencies, and ethical considerations. Institutions should therefore shift from technology-driven implementation strategies to alignment-driven pedagogical planning.

At the policy level, accreditation and quality assurance frameworks should explicitly address pedagogical alignment in AI use. Professional development initiatives must integrate AI literacy with pedagogical theory and ethical reasoning. Without such systemic support, AI risks reinforcing inequities and superficial learning practices.

Table 3. Examples of Pedagogical Alignment Across Disciplines

Discipline	**AI Applications**	**Primary Pedagogical Goal**	**Alignment Considerations**
STEM	Simulations, coding assistants	Problem solving	Avoid solution dependency
Humanities	Writing support, text analysis	Critical interpretation	Preserve authorship and reasoning
Social Sciences	Data analysis, policy simulation	Critical inquiry	Evaluate AI bias and evidence
Health Sciences	Diagnostic support, virtual patients	Clinical reasoning	Maintain human judgment and ethics
Business	Forecasting, analytics	Decision-making	Transparency and ethical reasoning
Engineering	Design optimization, simulation	Iterative design	Develop analytical reasoning
Law	Legal research, case summarization	Legal argumentation	Maintain interpretive reasoning
Arts & Design	Image generation, creative ideation	Creativity	Preserve originality and artistic agency

LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

Despite its contributions, this study has several limitations. First, as a systematic narrative review, the analysis prioritizes theoretical synthesis over quantitative aggregation of effect sizes. While appropriate for theory-building, future research may employ meta-analytic approaches as empirical evidence matures. Second, the reviewed literature is predominantly focused on higher education contexts, limiting generalizability to primary and secondary education.

Future research should empirically validate the proposed AI-Aligned Pedagogical Innovation Framework across diverse educational settings and disciplines. Longitudinal studies are needed to examine how pedagogical alignment influences learner outcomes over time, particularly with sustained AI use. Additionally, research should explore culturally responsive AI pedagogy, examining how alignment principles interact with local educational values and practices.

Despite rapid growth in AI in education research, several critical gaps remain. First, there is a lack of longitudinal studies examining how pedagogical alignment influences learning outcomes over sustained AI use. Most existing studies focus on short-term interventions, limiting understanding of cumulative effects on learner agency and epistemic development.

Second, empirical validation of alignment-focused frameworks remains limited. Future research should operationalize pedagogical alignment constructs and examine their mediating role using mixed-methods designs. Such studies would strengthen causal claims regarding AI-enhanced teaching effectiveness.

Third, equity and cultural responsiveness remain underexplored. AI systems are often developed within dominant educational paradigms, raising questions about alignment with diverse cultural values and pedagogical traditions. Research is needed to examine how alignment principles interact with culturally sustaining pedagogies.

Finally, teacher education and professional learning represent a critical research frontier. Longitudinal studies tracking how AI literacy development influences instructional decision-making would provide valuable insights for policy and practice.

CONCLUSION

This study synthesizes contemporary research on AI-enhanced pedagogy and proposes a conceptual framework emphasizing pedagogical alignment. By integrating learning outcomes, instructional design, assessment, teacher competencies, and ethical-contextual considerations, the framework offers a roadmap for coherent, learner-centered AI integration. This approach positions AI as a tool for enhancing pedagogy rather than replacing it, supporting educators and institutions in achieving innovative and responsible teaching practices.

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