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Complement, Not Substitute: An Integrative Review of Teacher's Pedagogical Roles in AI-Mediated Learning Environments

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Abstract

Artificial intelligence (AI) is shifting from peripheral tools to core learning infrastructure. With the increasing use of artificial intelligence (AI) technology in educational settings, there is a growing need to explore how teachers can enhance their pedagogical roles and skills in AI-mediated learning environments. This study provides insights into in what way teachers can adapt and innovate their pedagogical roles to effectively prepare students for the digital age. This study employed a qualitative research approach through an integrative review research design, literature from 2016-2025, issues related to human and AI co-design and classroom orchestration. It is found that AI supported formative assessment and feedback, teacher AI/data literacy with ethical governance, and simulation based professional learning through conceptual, empirical, and policy publications on the changing pedagogical functions of teachers in AI-mediated learning settings. Artificial intelligence makes the most significant contributions to education when it supports, rather than replacing, the fundamental human effort of teaching. When analytics are used as indicators, feedback tools are used as instruments of learning, and simulations are used as a space to safely practice, artificial intelligence becomes a complement to human judgment, rather than a substitute.

Keywords: AI-mediated learning environments, Teacher agency, Human–AI complementarity, Formative assessment, Learning analytics.

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Introduction

Artificial intelligence (AI) is reshaping classroom practice and teacher decision making into the educational system. The use of AI constantly changing educational system and emerging as new paradigm. This evolution goes beyond the utilization of technology, requiring teachers to acquire new skills in artificial intelligence and improve their methods of teaching in order to efficiently utilize intelligent technology as a partner in the learning process. The teacher-centered model, in which teachers are the primary source of knowledge, is rapidly becoming obsolete, requiring teachers to utilize new AI technology in order to remain relevant in the face of the increasing number of AI-trained teachers (Memon & Kwan, 2025).

The application of AI technology in the education system has generated much discourse regarding the possibility of replacing human teachers with AI technology (Chan & Tsi, 2024). The development of AI technology has provided various benefits, such as customized learning, timely feedback, and round-the-clock accessibility, which has led to the question of what value human teachers add to the learning process.

Education systems are entering a pivotal moment as artificial intelligence (AI) is shifting from peripheral tools to core infrastructure that influences how learning is designed, delivered, and assessed. International guidance stresses both opportunity and caution i.e., AI can expand adaptivity, accelerate feedback loops, and improve accessibility, but effectiveness and equity hinge on how teachers orchestrate these technologies in everyday practice (OECD, 2023; U.S. Department of Education [USDOE], 2023). AI-assisted education includes intelligent tutoring systems, adaptive learning systems, and advanced linguistic systems like ChatGPT, which collectively redefine the education landscape in a more personalized and technology-facilitated manner (Karataş et al., 2024).

Within AI-mediated learning environments, such as intelligent tutoring systems, learning analytics dashboards, and generative AI tools algorithms personalize pacing, scaffold learning processes, and surface fine-grained indicators of progress. Many authors highlight AI's capacity to support differentiated instruction and to inform real-time pedagogical decisions, while meta-analytic work on feedback confirms its centrality to learning and the promise of AI-supported feedback to scale timely guidance (Mariyono & Nur Alif Hd, 2025; Wisniewski et al. 2020).

Importance of teacher's role is increasing rather than diminishing along with using AI-technology. Conceptual scholarship positions AI as a relational and pedagogical shift that reconfigures teacher roles from primary knowledge sources to designers, facilitators, and critical interpreters of AI-generated insights roles that

preserve human judgment, socio-emotional support, and ethical stewardship (Creely & Carabott, 2025; Luckin et al., 2016).

Empirical classroom research echoes this reframing. K–12 teachers report productivity gains and new potentials for differentiation and administrative efficiency, alongside concerns about over-reliance on automation, erosion of critical thinking, and uneven ethical literacy. These findings underscore the need to center teacher agency and to develop robust AI literacy for educators and students alike (Tripathi et al., 2025; USDOE, 2023). At the level of day-to-day practice, human-centered designs that keep teachers in the loop appear decisive. Studies on classroom orchestration demonstrate that co-designed analytics and real-time teacher aids such as wearable dashboards and alerting mechanisms that can direct teachers' limited time to learners who most need help and amplify formative assessment, provided that tools align with teachers' situated needs (Holstein et al., 2019; Holstein et al., 2018).

Parallel innovations are reshaping teacher education and professional development. Systematic reviews and mixed-methods studies report that immersive simulations now increasingly powered by generative AI agents can enable pre-service and in-service teachers to rehearse instructional moves, manage classroom discourse, and receive targeted feedback in low-risk environments. Such simulations can strengthen instructional decision-making and communication, while raising design and ethics considerations that must be addressed in preparation programs (Han, Luo, et al., 2025; Hong et al., 2025; Létourneau et al., 2025).

Despite this momentum, important knowledge gaps remain. First, there is conceptual ambiguity around what precisely constitutes the "teacher's role" in AI-mediated classrooms. Although the literature affirms the centrality of the teacher, it rarely unpacks the concrete competencies, routines, and decision practices that define effective human–AI pedagogy (Krushinskaia, et al., 2023; OECD, 2023). Second, there is a capacity pathway gap: schools and systems lack actionable models that integrate human–AI complementarity, formative analytics, and simulation-based practice within governance frameworks that center equity, privacy, and transparency. Surveys of current practice show uneven capacity and trust, suggesting the need for sustained professional learning in data literacy, ethics, and change leadership (Virtual, 2025; USDOE, 2023).

Guiding this investigation is a set of interrelated analytical concerns. One line of inquiry examines how pedagogical planning, instructional design, and assessment practices might be reconfigured to draw upon AI capabilities while sustaining the centrality of teacher expertise and protecting student agency. A second line of inquiry considers the integration of AI-supported feedback and learning analytics into formative

assessment routines, attending to both the pedagogical benefits and the risks of exacerbating inequities if such systems are uncritically deployed. A third direction explores the forms of professional learning particularly those incorporating simulation-based practice that are most likely to build the competencies teachers need to navigate AI-mediated learning environments with confidence and ethical awareness. Together, these strands reflect the emerging consensus in the literature that the effectiveness of AI in education ultimately depends on models that uphold human–AI complementarity and retain teacher-centered design as a core pedagogical anchor (Creely & Carabott, 2025; Holstein et al., 2019).

There are two main aspects as it gives teachers a "how-to" guide that goes from a general advocacy stance to a more specific description of design interventions and decision heuristics. As well as it talks about ways to build capacity that use analytics, feedback, and simulation in ways that are based on reliable artificial intelligence. The article presents a literature-informed framework for human-AI pedagogy and integrates research concerning the interconnected topics of real-time instructional management, feedback, and analytics. It also looks critically at new ways of teaching teachers, like using AI in immersive and generative simulations. (Létourneau et al., 2025; OECD, 2023).

The purpose of this study is to make a clearer understanding of what pedagogical roles within AI-mediated learning environments can be played by teachers and how they can use AI for teaching learning? In doing so, the study synthesizes the growing body of literature that examines the integration of AI technologies in classroom practice, with particular attention to the pedagogical, ethical, and organizational demands this integration places on educators. Central to this undertaking is the identification of strategies that enable teachers to design learning experiences in which AI serves as a complement to, rather than a substitute for, professional judgment. These strategies encompass the development of human–AI learning tasks that safeguard teacher autonomy, the use of AI-supported feedback systems and analytics to reinforce formative assessment cycles, the cultivation of teacher-level AI and data literacies grounded in principles of equity and ethical responsibility, and the incorporation of simulation-enhanced professional learning models that support iterative practice and performance refinement. Such clarification is especially urgent given that contemporary policy frameworks increasingly endorse “humans-in-the-loop” approaches, while practitioners continue to report the need for concrete, classroom-level guidance on how to enact these principles (OECD, 2023; USDOE, 2023).

Methods and Materials

This study used a qualitative integrative review design to synthesize contemporary literatures on the evolving pedagogical roles of teachers in AI-mediated learning environments. For the comprehensive examination of complex and rapidly developing field integrative design was selected to cover conceptual, empirical, and policy-oriented publications. Key words as AI in education, Pedagogy and AI, teachers' role and AI, human machine collaboration were used to search for finding article in Different data bases like research4life, EBSCOhost, ERIC, OECD iLibrary etc. were used to find peer-reviewed journal articles, systematic reviews, meta-analyses, and policy reports published between 2016 and 2025, a period during which AI adoption in education expanded significantly. The data collection procedure involved a systematic identification and compilation of literature addressing teacher–AI interaction, AI-supported assessment, learning analytics, teacher agency, and simulation-based professional development. Only studies demonstrating methodological rigor, theoretical grounding, or policy authority were included.

The review was conducted following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and rigor in the selection of studies . We initially searched the database and found 156 articles, of which we removed 32 duplicates, leaving 124 records to screen. 71 articles were excluded in the title and abstract screening phase due to lack of relevance to the study focus. The other 53 full text articles were assessed for eligibility with the following inclusion criteria a) the degree of explicitness in discussing the integration of artificial intelligence in pedagogical practices, (b) its contribution to clarifying the roles and competencies of teachers in AI-supported environments, and (c) the clarity and applicability of the conceptual and empirical findings. Following full-text assessment, 34 articles were excluded due to limited relevance, methodological limitations or non-applicability to research objectives. Thus, 19 studies were included in the final review and are the basis for the analysis presented in this article.

The analysis procedure followed a structured, multi-stage thematic synthesis. First, all included publications were subjected to open coding to extract recurring concepts related to teacher judgment, assessment practices, human–AI complementarity, data literacy, and professional learning. These initial codes were then refined into higher-order analytical categories that captured the central domains of pedagogical change necessitated by AI. Finally, a cross-study interpretive synthesis was conducted to integrate these thematic strands into a coherent analytical framework that illuminates the pedagogical, ethical, and professional implications of AI-mediated teaching. Throughout the process, conceptual claims were triangulated across empirical

findings, policy recommendations, and theoretical analyses to ensure trustworthiness and interpretive rigor. This review analyzed only publicly available documents and did not involve human participants, no ethics review was considered.

Results and Discussions

Findings from sources published between 2016 and 2025 to explain how teachers can enhance their pedagogical roles in AI-mediated learning environments while sustaining the human core of teaching. Four interlocking domains emerge as the most credible pathways: (i) human–AI pedagogical co-design and classroom orchestration, (ii) AI-supported formative assessment and feedback, (iii) teacher AI/data literacy with ethical governance, and (iv) simulation-based professional learning. These domains converge on a simple proposition with significant practical consequences: Artificial intelligence has its maximum potential in education when it is used to support teachers, rather than replace them, in line with international best practice that supports humans-in-the-loop approaches.

A human-centered reading of the findings

A humanized reading foregrounds the everyday experiences of learners and teachers. In teachers' accounts, AI does not exist as abstract code, it appears as timely hints that support a reluctant student to attempt a solution, as analytics that surface a need for extension for an advanced learner, or as formative traces that make multilingual students' progress visible. Empirical studies of school practice consistently report time-savings and new tensions around authority, assessment, and the cultivation of critical thinking-tensions that require teacher agency, not automation (Tripathi et al., 2025). Conceptual scholarship similarly reframes the role of teachers from knowledge transmitters to designers, facilitators, and interpreters of AI-generated insights, thereby preserving relational, ethical, and contextual elements of pedagogy (Creely & Carabott, 2025; Luckin et al., 2016).

Human–AI pedagogical co-design and classroom orchestration

Across classroom studies, teacher facing analytics (dashboards, subtle alerts, “glanceable” indicators) enhance situational awareness when they are co-designed with educators and aligned to authentic routines. Such designs help teachers triage attention, target explanations, and decide when to withhold intervention so that productive struggle can occur (Holstein et al., 2019; Holstein et al., 2018). The human center of orchestration is thus a division of labor: the system surfaces potentially actionable signals; the teacher discusses meaning and chooses a response that fits a learner and a moment.

The same evidence cautions against designs that over-prescribe. Analytics that attempt to dictate rather than inform can rigidly scale suboptimal practices or misread student intent especially where dialect, disability, or cultural context diverges from training data (Holstein et al., 2019; OECD, 2023). Policy guidance is unambiguous that analytics should augment rather than displace teacher discretion, and that their use must sit within privacy-aware, bias-sensitive, and transparent governance (OECD, 2023; USDOE, 2023). The practical implication is not that teachers become data scientists, but that systems must "speak teacher": translating signals into pedagogically meaningful cues (for example, "now might be a good time for a worked example") is more usable and safer than rank-ordering students by risk (Holstein et al., 2019; USDOE, 2023).

AI-supported formative assessment and feedback

AI tools can support on the centrality of timely, high-quality feedback for learning and indicates that AI's distinctive contribution is speed at scale. Automated routines can provide immediate process-level hints on routine tasks and reveal performance patterns that might otherwise be invisible until grading is complete (Mariyono & Nur Alif Hd, 2025). In the context of certain conditions, AI-generated feedback can approximate human feedback on performance outcomes; however, the same synthesis underscores the need for teacher oversight to preserve nuance, address affect, and ensure equity (Kaliisa et al., 2025; Wisniewski et al., 2020).

Hybrid operational model is defensible. Routine correctness checking and surface-level suggestions can be delegated to automation, whereas teachers remain responsible for decisions about which feedback to emphasize, how to phrase it for a particular learner, and when to convert feedback into a full re-teaching episode, especially where cultural or linguistic context shapes learning (USDOE, 2023; Wisniewski et al., 2020). Policy guidance adds that formative data should support learners rather than surveil or rank them (OECD, 2023; USDOE, 2023). Consider a teacher reviewing an analytics panel at day's end: the system flags a cluster of similar errors in proportional reasoning; the teacher discerns that language, not mathematics, is the source of difficulty and designs a visual re-teaching sequence. Here, AI's speed meets professional noticing, and learning benefits because each agent does its part (Holstein et al., 2019; Mariyono & Alif Hd, 2025).

Teacher AI/data literacy and ethical governance

Surveys and field snapshots depict enthusiasm tempered by uncertainty: educators want practical guidance, protected time, and clear rules of engagement (Virtual, 2025). International policy frameworks converge on the view that trustworthy AI in education depends on explicit guardrails—privacy protections, bias mitigation,

transparency, and documentation—paired with realistic expectations about model capabilities and failure modes (OECD, 2023; USDOE, 2023). In this light, professional development priorities cohere around three strands: (a) AI literacy (what systems can and cannot do, and typical error modes), (b) data literacy (responsible interpretation of model outputs, uncertainty, and representativeness), and (c) ethics and equity (bias checks, consent, data minimization, accessibility). Conceptual work on AI-oriented pedagogy supports reframing teacher identity toward "professional interpreter" of AI signals, preserving relational and ethical dimensions that technology cannot replicate (Creely & Carabott, 2025; Luckin et al., 2016).

Simulation-based professional learning

Simulation offers a low-risk arena to practice high-leverage instructional moves. A meta-analysis of VR-based teacher education reports moderate positive effects on teacher learning, with variation by immersion level and alignment to pedagogical objectives (Han, et al. 2025). Early mixed-methods studies of generative-AI-enhanced simulations indicate that AI agents can sustain dynamic, responsive role-play that strengthens decision-making and communication, while design must manage cognitive load and interface constraints (Hong et al, 2025). Findings from systematic reviews of AI-driven tutoring systems complement this picture: when teachers orchestrate these systems with explicit learning goals, student engagement and performance tend to improve suggesting that teachers trained to integrate these systems have more options for targeted practice and feedback (Létourneau et al., 2025).

For humanized professional learning, two features stand out. First, scenarios should mirror the moral texture of classroom life like balancing encouragement with academic integrity in AI-assisted writing. Second, simulations should include debrief protocols that connect decisions to evidence and ethics: Which signals were weighed? Which bias checks were applied? What would change next time? Such protocols operationalize policy calls for humans-in-the-loop by making loop-keeping a practiced habit (OECD, 2023; USDOE, 2023).

Integrating the domains: A practical model for teacher-led AI

Synthesizing the four domains yields a practice model centered on teacher judgment, formative evidence, ethical guardrails, and rehearsed decision-making. Several design moves recur across the corpus: Start from pedagogy rather than tools, clarifying intent before selecting AI features (OECD, 2023; USDOE, 2023). Instrument the formative loop so automation accelerates evidence collection while teachers curate the content, tone, and follow-up of feedback (Kaliisa et al., 2025; Wisniewski et al., 2020). Translate analytics into action through "who needs what, when" cues rather than

abstract metrics, a shift associated with improved help-giving in busy classrooms (Holstein et al., 2019; Holstein et al., 2018). Make equity checks explicit by asking whose data are missing or misread (OECD, 2023; USDOE, 2023). Institutionalize rehearsal via simulation so discourse moves, feedback conferences, and data-informed decisions can be practiced and debriefed (Han et al., 2025; Hong et al., 2025). Finally, document teacher overrides of AI suggestions and the rationales behind them to build trust, support reflection, and inform system improvement (OECD, 2023; USDOE, 2023).

Why humanization matters: Identity, emotion, and trust

Teachers are not mere decision engines; they are meaning-makers for communities. AI's entrance can unsettle identities raising concerns about plagiarism, over-reliance, or deskilling but tools become allies when teachers set the terms: personalizing hints, redesigning tasks to foreground process, or using analytics to initiate humane conversations with students about their learning (Tripathi et al., 2025; USDOE, 2023). Policy documents stress trust as the hinge: clear governance, sustained professional learning, and transparent communication with families enable adoption that is both responsible and durable (OECD, 2023; USDOE, 2023). In practice, trust grows from small wins a faster feedback loop here, a well-timed reteach there and from students feeling seen rather than sorted.

Boundary conditions and risks

The synthesis also identifies boundary conditions or limitations. Analytics are only as inclusive as their data, under-representation of dialects, abilities, or contexts can misread intent or inflate error signals (OECD, 2023; USDOE, 2023). Poorly designed feedback can overwhelm or promote shortcutting, automation requires teacher-curated pacing and framing to remain formative (Kaliisa et al., 2025; Wisniewski et al., 2020). Capacity gaps in time, training, and policy clarity can stall adoption even where tools are promising (Michigan Virtual, 2025). These risks are manageable when schools treat AI adoption as instructional improvement rather than procurement: co-design for fit, invest in professional learning so teachers can reason about outputs, and enact governance so communities understand what is used and why (Holstein et al., 2019; OECD, 2023; USDOE, 2023).

Implications for stakeholders

For teachers, begin with a single unit and a single formative loop: use AI to collect evidence, script likely responses, and keep a brief override log that captures moments when professional judgment diverges from the system (USDOE, 2023). For school leaders, create protected collaborative planning time and prioritize tools with

teacher-centered affordances and explicit commitments to privacy and fairness (OECD, 2023; USDOE, 2023). For teacher educators, integrate simulation-based practica in which candidates rehearse giving feedback with and without AI prompts, then debrief the equity and ethics of their choices (Han et al., 2025; Hong et al., 2025). For policymakers, fund human-in-the-loop research and professional learning at parity with technology procurement, and require open documentation of model limitations so schools can make informed choices (OECD, 2023; USDOE, 2023).

Limitations and directions for future research

This review prioritizes breadth over the internal validity of any one trial because it is an integrative synthesis; effect sizes and contextual contingencies differ among studies. Longer interventions, more diverse samples, and more robust reporting on equity impacts are required, even though numerous reviews show that AI-supported tools generally improve engagement and performance when integrated into cogent pedagogy. The priority directions are longitudinal studies of teachers' identity and practices within AI-mediated contexts, design-based research with a focus on analytics for teachers that capture their strategies and feelings of belonging, ethics-in-practice trials with a focus on particular bias tests and transparency mechanisms, and comparative studies of simulation-based professional development that identify which elements most strongly support teachers' practices.

Conclusion

Artificial intelligence achieves educational significance when it honors the human labor inherent in teaching. Analytics are used as clues, feedback tools are used as amplifiers, and simulations are used as rehearsals. Equity is used as a design requirement rather than an afterthought. The path forward is incremental and relational: a teacher consults a limited list of cues, makes a choice about a specific next step, and records a brief rationale, a department runs through a simulation of a family conversation about AI-assisted writing; a teacher works through a simulation of a feedback conference with an avatar created by AI technology, makes mistakes safely, and improves. Such small-scale human actions, augmented by technology that is carefully designed, build upon the most thoughtful of educational technology's implications. In reality the role of the teacher is not being diminished, it is being deepened

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