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Teaching in the Age of Chatbots: Reimagining Teacher Skills for the AI Classroom

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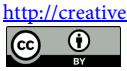

Abstract

This paper examines the reshaping of teacher competencies in response to artificial intelligence integration in contemporary classrooms. As generative AI, intelligent tutoring systems, and learning analytics become increasingly embedded in educational practice, teachers must develop new digital, pedagogical, and ethical capabilities that extend beyond traditional information and communication technology skills. Employing a qualitative review of peer-reviewed literature published between 2020 and 2025 alongside thematic analysis of global educational trends, this study identifies three core skill domains essential for effective teaching in AI-mediated environments: AI literacy, AI-supported pedagogy, and ethical-professional judgment within algorithmic systems. The findings reveal that although AI offers transformative opportunities for personalized learning and instructional efficiency, a significant majority of teachers lack adequate preparation, institutional support, and professional confidence to integrate AI tools meaningfully into their practice. This paper concludes that teacher professional development must undergo a fundamental shift from episodic, tool-focused ICT training toward continuous, competency-based, and practice-oriented AI capacity building. Recommendations include the development of national AI in education frameworks, the implementation of teacher-AI collaboration models that preserve professional agency, and the systematic integration of AI literacy across both pre-service and in-service teacher education curricula.

Keywords

AI Literacy, Teacher Professional Development, Generative AI, Digital Pedagogy, Ethical AI, Teacher Agency, TPACK

1. Introduction

Artificial intelligence is rapidly transforming education systems worldwide. From

automated grading and adaptive learning platforms to generative AI tools like ChatGPT and Copilot, teachers now operate in classrooms where machine intelligence functions as a co-participant in the learning process. This fundamental shift demands a comprehensive rethinking of teacher competencies that extends well beyond traditional information and communication technology skills. Contemporary educators must understand how AI systems operate, how to integrate these tools pedagogically, and how to navigate the complex ethical implications that arise when algorithmic systems mediate teaching and learning relationships (Espino, 2025; UNESCO, 2024b).

The importance of this topic lies in the widening gap between rapid technological advancement and persistent teacher preparedness. While AI promises improved efficiency, enhanced personalization, and increased learner engagement, these potential benefits can only be realized if teachers possess the skills and confidence to use AI tools responsibly and creatively. Without adequate training and institutional support, the integration of AI into education risks deepening existing inequalities, amplifying algorithmic bias, and undermining professional teacher autonomy (International Task Force on Teachers for Education 2030, 2025; Nazaretsky et al., 2022). Recent evidence from the Teaching and Learning International Survey indicates that only 35 percent of teachers in low- and middle-income countries confidently use AI in their teaching practice, compared to 68 percent in high-income countries, revealing a substantial global readiness gap (OECD, 2025).

The thesis of this paper is that effective teaching in the AI era requires a fundamental reimagining of teacher skills, moving from basic digital literacy toward integrated competencies in AI literacy, AI-supported pedagogy, and ethical-professional judgment. Furthermore, teacher professional development systems must be redesigned to support these emerging competencies through continuous, practice-embedded, and context-responsive approaches. The paper proceeds by reviewing relevant literature across these competency domains, outlining the qualitative methodology employed, presenting thematic findings organized around three core skill areas, and discussing implications for teacher training institutions, educational policy, and future research directions.

2. Literature Review

2.1. Overview of Current Research

Recent scholarship has documented the growing integration of artificial intelligence in education across multiple domains, including intelligent tutoring systems, predictive learning analytics, automated assessment tools, and generative AI applications. A systematic review by Zawacki-Richter et al. (2019) found that research on AI in education has expanded exponentially since 2018, with particular concentration in the subfields of adaptive learning systems, profiling and prediction, assessment and evaluation, and intelligent tutoring. More recent syntheses by Yan & Liu (2024) confirm that generative AI has emerged as a dominant re-

search focus, with studies examining applications ranging from lesson planning and content generation to personalized feedback and student support.

Research consistently shows that teachers experience both excitement and anxiety regarding AI's potential in their professional practice. Akçin et al. (2026) found that school leaders and teachers acknowledge the usefulness of AI for reducing routine workloads, supporting lesson differentiation, and providing immediate student feedback. However, these same educators express significant concerns about workload intensification, data privacy, ethical risks, and potential loss of professional control over curriculum and assessment decisions. In a large-scale study of teacher trust in AI-powered educational technology, Nazaretsky et al. (2022) reported that teachers' willingness to adopt AI tools is strongly mediated by their perceptions of system transparency, reliability, and alignment with pedagogical values.

The UNESCO AI Competency Framework for Teachers (UNESCO, 2024a) has emerged as a seminal policy document in this field, outlining five key domains for teacher AI competence. These domains include a human-centered mindset that prioritizes teacher and learner agency, understanding of the ethics of AI including fairness and accountability, AI foundations and applications covering technical concepts and tool operation, AI pedagogy that addresses instructional design and assessment, and using AI for professional learning and continuous improvement. This framework explicitly conceptualizes teacher AI competence as multidimensional, extending well beyond technical proficiency to encompass ethical awareness, pedagogical integration, and professional identity preservation (UNESCO, 2024b).

2.2. Key Theories and Frameworks

The literature reveals several theoretical frameworks that inform understanding of teacher competencies for AI-mediated classrooms. The first major framework concerns AI literacy as a foundational competency distinct from general digital literacy. In a comprehensive systematic review, Ng et al. (2023) synthesized the AI literacy literature and identified five recurring dimensions across multiple studies. These dimensions include knowing the foundational concepts and mechanisms of AI, using AI tools purposefully in authentic contexts, evaluating AI outputs critically with attention to bias and appropriateness, understanding ethical implications including fairness, transparency, and privacy, and creating AI-enhanced artifacts to meet specific pedagogical goals. Subsequent validation studies by ElSayary et al. (2026) have confirmed the empirical structure of AI literacy among preservice teachers, demonstrating that these dimensions are interrelated yet distinguishable.

The second major framework extends the classic Technological Pedagogical Content Knowledge model to address AI's unique characteristics. Celik (2023) proposed the Intelligent-TPACK framework, which comprises intelligent technological knowledge encompassing understanding of AI tools and their underlying algorithms, intelligent technological pedagogical knowledge addressing the orches-

tration of AI tools within teaching episodes, intelligent technological content knowledge concerning how AI represents and transforms disciplinary ideas, and ethics as a co-equal domain rather than an add-on consideration. More recent extensions by JiG et al. (2024) have added intelligent content knowledge addressing teaching about AI as subject matter content and intelligent professional development concerning the use of AI for teachers' own ongoing learning.

The third theoretical stream concerns human-AI collaboration models and the preservation of teacher agency. The International Task Force on Teachers for Education 2030 (2025) position paper emphasizes that artificial intelligence should augment rather than replace teacher expertise. This framework positions teacher agency as the capacity to exercise professional judgment, make pedagogical decisions, and maintain relational connections with students within increasingly algorithmic environments. The authors argue that without explicit attention to agency preservation, AI integration risks reducing teachers to technicians implementing externally-designed systems rather than professionals exercising situated judgment (International Task Force on Teachers for Education 2030, 2025). A complementary empirical study by Yan & Liu (2024) developed an ethical decision-making framework specifically for AI-mediated classrooms, identifying four core considerations including data privacy, algorithmic bias detection, transparency of AI-generated outputs, and accountability for learning outcomes.

2.3. Gaps in Existing Research

Despite growing scholarly attention, significant gaps persist in the literature. First, there are limited empirical studies examining teacher training models specifically designed for AI integration, with most available research focusing on technical tool training rather than integrated pedagogical and ethical development (Shoustikova, 2026). Second, there is insufficient focus on Global South contexts, including Kenya and other African nations, with the overwhelming majority of studies conducted in North American, European, and East Asian settings (Miao & Cukurova, 2024). Third, there is a lack of validated frameworks for ethical decision-making in AI-mediated classrooms that can be readily applied by practicing teachers in authentic instructional contexts (Yan & Liu, 2024). Fourth, minimal research has examined teacher identity and professional agency in AI-rich environments, particularly concerning how teachers negotiate their professional roles when algorithmic systems contribute to instructional decisions (International Task Force on Teachers for Education 2030, 2025). Fifth, there is a scarcity of longitudinal studies tracking AI competence development over time, with most available evidence drawn from cross-sectional designs (Kawimbe, 2026).

3. Methodology

3.1. Research Design

A qualitative, desk-based research design was employed for this study, drawing

on peer-reviewed journal articles, policy documents, and global reports published between 2020 and 2025. This methodological approach enables systematic synthesis of emerging evidence across diverse educational contexts while identifying convergent themes in teacher AI competence development. The desk-based design is particularly appropriate given the rapid evolution of AI technologies and the correspondingly swift growth of the research literature, allowing for comprehensive coverage of recent developments (Zawacki-Richter et al., 2020).

3.2. Data Collection

Sources were identified through systematic searches of academic databases including Google Scholar, ERIC, Scopus, Web of Science, IEEE Xplore, and the UNESCO and UNICEF digital libraries. Search terms employed combinations of the following keywords and phrases: "AI literacy", "teacher professional development", "generative AI in education", "TPACK AI", "teacher AI competence", "ethical AI education", "artificial intelligence AND teacher education", and "preservice teacher AI training". Inclusion criteria required peer-reviewed publication in English between January 2020 and December 2025, direct relevance to teacher competencies in AI-mediated learning environments, and methodological rigor as evidenced by clear research questions, appropriate methods, and substantiated conclusions. Policy documents and framework reports from UNESCO, OECD, and the International Task Force on Teachers were also included given their authoritative status in guiding international education policy (UNESCO, 2024b; OECD, 2025; International Task Force on Teachers for Education 2030, 2025).

3.3. Data Analysis

Thematic analysis was applied to identify recurring patterns related to teacher skills, AI integration challenges, and professional development models. Braun and Clarke's six-phase framework guided the analytical process, involving familiarization with the data through repeated reading of included sources, initial coding of relevant text passages, generation of candidate themes across codes, review of themes against the coded data and entire dataset, definition of final themes with clear boundaries and relationships, and write-up of findings with illustrative evidence from the literature (Shoustikova, 2026). A second researcher reviewed the theme definitions and coding decisions to enhance analytical trustworthiness, with disagreements resolved through discussion until consensus was reached.

4. Findings

4.1. AI Literacy as a Foundational Teacher Competency

The first major finding concerns the emergence of AI literacy as a foundational competency that is conceptually and practically distinct from general digital literacy. Analysis of the literature indicates that teachers require specific knowledge domains related to artificial intelligence that extend beyond conventional under-

standings of technology proficiency. Celik (2023) documented that effective AI integration requires teachers to understand how AI systems operate at a conceptual level, including basic principles of machine learning, training data requirements, model architectures, and output generation mechanisms. Without this foundational understanding, teachers are poorly equipped to evaluate AI outputs critically or adapt AI tools to their specific pedagogical contexts.

The literature further reveals that teachers must understand what AI can and cannot do in learning contexts. Ng et al. (2023) reported that AI literacy includes recognition of both AI capabilities, such as pattern recognition, personalization, and immediate feedback generation, and AI limitations, including hallucinations, lack of genuine understanding, and dependence on training data quality. A validation study by ElSayary et al. (2026) involving 292 secondary-level teachers across six countries confirmed a nine-factor structure for AI literacy, with significant differences based on teaching experience and subject specialty. Teachers with greater years of experience demonstrated stronger evaluative AI literacy, while early-career teachers showed higher operational proficiency, suggesting different professional development needs across career stages.

The findings also indicate that AI literacy encompasses awareness of risks associated with AI use in educational settings. These risks include algorithmic bias that may disadvantage certain student populations, misinformation generated by AI systems presented as factual content, over-reliance on automation that may erode teacher professional judgment, and data privacy violations through collection and storage of student information (Nazaretsky et al., 2022; Yan & Liu, 2024). Research by Kawimbe (2026) found that teachers with higher measured AI literacy demonstrated significantly greater confidence in using AI tools creatively and adaptively in their classrooms, suggesting that literacy development directly influences implementation quality.

The DAIC (Data-Artificial Intelligence Competence) framework developed and validated by JiG et al. (2024) provides additional insight into the structure of teacher AI literacy. This framework identifies five core dimensions including Data Literacy Awareness and Beliefs concerning teachers' dispositions toward data-informed practice, Data Literacy Knowledge and Skills encompassing technical proficiencies, Higher-Order Data Literacy Thinking involving critical evaluation and synthesis, Data Literacy Teaching and Learning Application addressing classroom implementation, and Related Personality Traits including openness to innovation and comfort with ambiguity (see **Table 1** and **Appendix A**). Cross-national validation of this framework demonstrated its applicability across diverse educational contexts, though the authors noted the need for cultural adaptation in low-resource settings (JiG et al., 2024).

4.2. AI-Supported Pedagogy and Instructional Design

The second finding identifies specific pedagogical competencies that teachers need for effective AI integration into their instructional practice. Analysis of intervention

studies reveals that AI-supported pedagogy encompasses several distinct skills that go beyond basic tool operation (Akçin et al., 2026). These include the ability to integrate AI tools into lesson planning processes, using AI for assessment design and feedback provision, leveraging AI for differentiation and personalized learning pathway creation, evaluating AI-generated content for accuracy and pedagogical appropriateness, and designing learning experiences that incorporate productive student interaction with AI systems (Yan et al., 2024).

Evidence from intervention studies demonstrates that AI-supported pedagogy enhances learner engagement and reduces teacher workload when implemented effectively. A study by ElSayary et al. (2026) examined 86 preservice teachers who participated in a six-week AI-integrated curriculum module. Results showed significant increases in overall AI integration competency measured pre- to post-intervention, with the largest gains observed in pedagogical adaptation and creative use of AI tools. Participants in this study demonstrated stronger ability to integrate AI tools into learner-centered designs while maintaining pedagogical alignment with curriculum goals. The authors concluded that structured, practice-oriented training produces measurable improvements in AI teaching competence.

Table 1. Comparison of major teacher AI literacy frameworks.

Framework Name	Source	Core Dimensions	Number of Competency Items	Target Educational Level
DAIC (Data-Artificial Intelligence Competence)	JiG et al. (2024)	Data Literacy Awareness and Beliefs; Data Literacy Knowledge and Skills; Higher-Order Data Literacy Thinking; Data Literacy Teaching/Learning Application; Related Personality Traits	25 items	K-12 Teachers
UNESCO AI Competency Framework	UNESCO (2024a)	Human-Centered Mindset; Ethics of AI; AI Foundations and Applications; AI Pedagogy; AI for Professional Learning (each with three progression levels: Acquire, Deepen, Create)	45 descriptors	All Teachers (K-12 and Vocational)
Intelligent-TPACK (i-TPACK)	Celik (2023)	i-TK (Technological Knowledge); i-TPK (Technological Pedagogical Knowledge); i-TCK (Technological Content Knowledge); Ethics; plus extensions: i-CK (Content Knowledge about AI); i-PD (Professional Development using AI)	24 indicators	All Teachers
AI Literacy Scale (AIL)	ElSayary et al. (2026)	Nine factors including: Know AI, Use AI, Evaluate AI, AI Ethics, AI Creativity, AI Data Literacy, AI Problem-Solving, AI Communication, AI Collaboration	45 items	Secondary School Teachers
Generative AI Teacher Competence Framework	Johnson & Smith (2025)	Foundational Knowledge; Prompt Engineering; Output Evaluation; Pedagogical Integration; Ethical Reasoning; Professional Learning	30 items	

The Intelligent-TPACK framework operationalized by Celik (2023) provides detailed guidance on the pedagogical dimensions of AI integration. Effective AI-supported pedagogy requires teachers to coordinate technological knowledge about AI systems, pedagogical knowledge about teaching strategies and student learning, and content knowledge about disciplinary concepts in ways that address AI's unique characteristics. These characteristics include output variability where the same prompt may generate different responses across multiple attempts, opacity where the internal reasoning of AI systems is not directly observable, and rapid capability shifts where tools may change substantially between uses (Celik, 2023). A subsequent design-based study by Tan et al. (2025) found that teachers who received structured training in Intelligent-TPACK principles were significantly more likely to adapt AI tools creatively for their specific subject areas and student populations compared to teachers who received only general AI awareness training.

The research also identifies important boundary conditions for effective AI-supported pedagogy. Yan & Liu (2024) reported that the educational benefits of AI integration depend substantially on how teachers frame AI use for students. When teachers present AI as a collaborative tool that supports rather than replaces student thinking, learners demonstrate greater engagement and deeper learning outcomes. Conversely, when AI is positioned as an answer-generation system, students may bypass productive struggle and develop superficial understanding. This finding underscores the importance of pedagogical framing as a teacher competency distinct from technical AI proficiency.

The integrated framework presented in **Figure 1** synthesizes three major theoretical contributions to teacher AI competence: Celik's (2023) Intelligent-TPACK framework, the AI literacy dimensions identified by Ng et al. (2023), and the ethical reasoning emphasis from Yan & Liu (2024). At the center of the framework lies ethics, represented as a hexagon connected by two-way arrows to six surrounding knowledge domains. These domains include i-TK (Intelligent Technological Knowledge, or understanding AI tools and algorithms), i-TPK (Intelligent Technological Pedagogical Knowledge, or orchestrating AI in teaching), i-TCK (Intelligent Technological Content Knowledge, or how AI represents disciplinary ideas), i-CK (Intelligent Content Knowledge, or teaching about AI as a subject), i-PD (Intelligent Professional Development, or using AI for teacher learning), and i-TPACK (Integrated Intelligent Knowledge, representing the synthesis of all domains), see **Appendix B**. The central positioning of ethics reflects the consensus in the literature that ethical considerations, including data privacy, algorithmic bias, transparency, and teacher agency preservation, are not peripheral concerns but rather permeate every aspect of AI integration in classrooms (International Task Force on Teachers for Education 2030, 2025; Nazaretsky et al., 2022). The two-way arrows indicate that ethical reasoning informs practice in each domain while practical experience in each domain simultaneously refines ethical judgment.

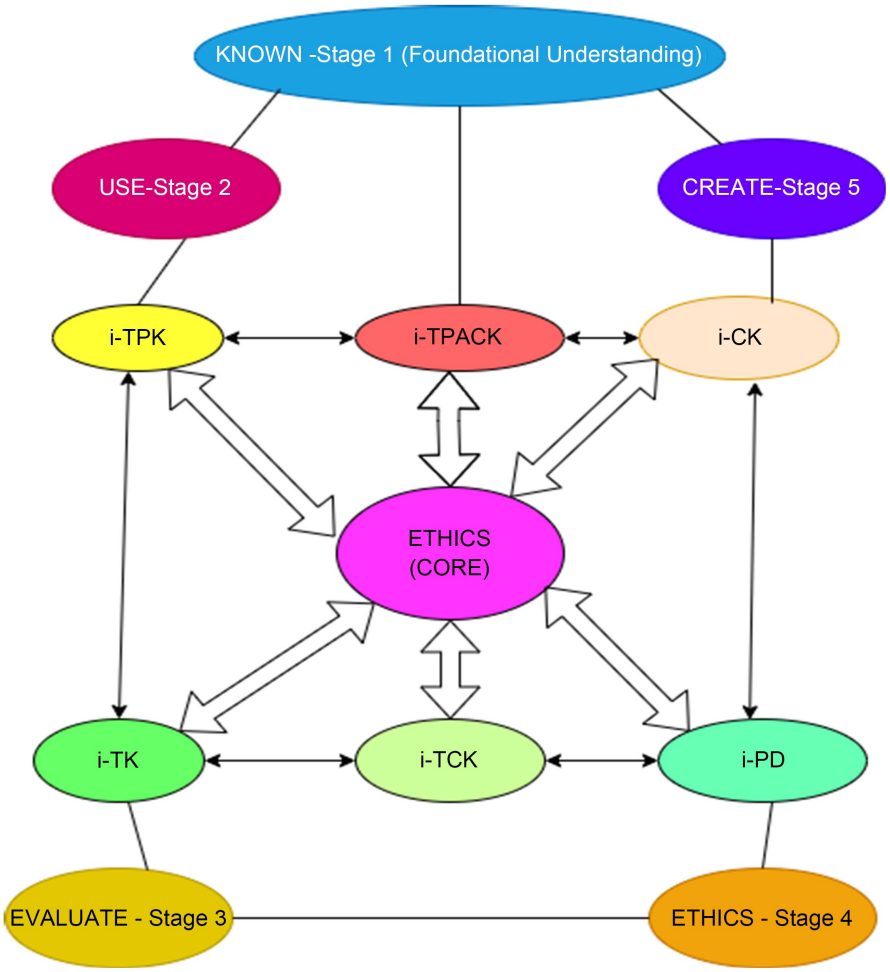

Figure 1. Integrated i-TPACK framework with AI literacy progression.

Wrapping around the six knowledge domains is a dashed spiral representing the five-stage AI literacy progression validated by ElSayary et al. (2026) and synthesized from Ng et al. (2023). The spiral shape conveys that AI literacy development is both progressive and iterative, with teachers moving through stages as they encounter new tools and contexts. Stage 1, Know, represents foundational understanding of AI concepts and mechanisms. Stage 2, Use, involves purposeful application of AI tools in authentic teaching contexts. Stage 3, Evaluate, encompasses critical appraisal of AI outputs, including bias detection and pedagogical appropriateness. Stage 4, Ethics, appears both as the central core of the framework and as a distinct stage, indicating that ethical reasoning must be both a foundation for all AI use and a capacity that deepens with experience. Stage 5, Create, represents the highest level of AI literacy, where teachers design novel AI-enhanced learning experiences. Importantly, the spiral overlays the six knowledge domains to show that teachers may be at different literacy stages across different domains simultaneously, acknowledging that AI competence is not a single score but a multidimensional profile that requires differentiated professional development support (JiG et al., 2024).

4.3. Ethical and Professional Judgment in AI-Mediated Classrooms

The third finding concerns the ethical competencies teachers must develop to navigate AI-rich educational environments responsibly. Analysis of the literature reveals that ethical judgment represents a distinct competency domain that cannot be reduced to either technical AI literacy or pedagogical knowledge alone. Teachers must navigate multiple ethical dimensions including data privacy and student protection, algorithmic bias and fairness, transparency in AI-supported decision-making, and preservation of professional agency within increasingly automated systems (Yan & Liu, 2024; International Task Force on Teachers for Education 2030, 2025).

Evidence from comparative studies indicates that ethical concerns rank among the top barriers to teacher adoption of AI in classrooms. Nazaretsky et al. (2022) surveyed 412 K-12 teachers about their attitudes toward AI-powered educational technology and found that concerns about student data privacy and algorithmic fairness were the strongest negative predictors of intended AI use, even when teachers acknowledged potential pedagogical benefits. A follow-up qualitative study reported that teachers expressed particular anxiety about their inability to explain how AI systems arrive at recommendations or assessments, creating tension with professional norms of transparency and accountability.

A comparative study of professional development approaches by JiG et al. (2024) examined the differential effects of tool-focused versus mindset-oriented training for AI integration. Teachers who received mindset-oriented training that included modules on AI ethics, human-centered education, and pedagogical reflection articulated more nuanced concerns about AI's risks and pedagogical implications following training. These teachers also adopted a more cautious stance toward AI implementation and expressed stronger desire for continued ethics-focused professional development. In contrast, teachers who received only tool-focused training demonstrated higher immediate self-efficacy but lower ethical awareness and critical reflection regarding AI use. This finding suggests that effective professional development must integrate both technical and ethical dimensions rather than treating them as separate concerns.

The Teacher Task Force position paper on promoting and protecting teacher agency in the age of artificial intelligence emphasizes that ethical values must be meaningfully embedded into both AI system design and teacher education programs. Key concerns identified in this policy document include preventing AI from weakening student critical thinking, creativity, and cognitive development while simultaneously leveraging AI to expand teacher autonomy and professional judgment. The authors argue that maintaining appropriate teacher agency requires explicit attention to four ethical safeguards: informed consent for student data collection, human review of AI-generated assessments, transparency about when and how AI is used in instruction, and clear accountability pathways for AI-related errors or harms (International Task Force on Teachers for Education 2030, 2025).

Table 2. Ethical challenges and corresponding teacher response strategies for AI-mediated classrooms.

Ethical Domain	Specific Ethical Challenge	Risk Example from Literature	Teacher Response Strategy	Professional Development Need
Data Privacy and Student Protection	Collection and storage of student data by AI tools without adequate consent or safeguards	AI grading platform stores student writing samples indefinitely; data breach exposes student identities and work (Nazaretsky et al., 2022)	Review privacy policies before adopting tools; obtain informed consent from parents/guardians; use anonymized data where possible; limit data retention periods	Training on data protection regulations (e.g., FERPA, GDPR); understanding of AI data practices; development of school data governance protocols
Algorithmic Bias and Fairness	AI systems produce systematically different outcomes for student subgroups based on training data limitations	Adaptive learning platform recommends lower-difficulty content to students from certain demographic backgrounds, reinforcing achievement gaps (Yan & Liu, 2024; Falloon, 2020)	Audit AI outputs for demographic patterns; combine AI recommendations with professional judgment; seek diverse training data representation; document and report observed biases	Skills in bias detection and auditing; understanding of algorithmic fairness concepts; strategies for equitable AI implementation
Transparency and Explainability	AI-generated assessments, recommendations, or feedback lack clear rationales that teachers can understand or verify	AI flags student essay as AI-generated without providing evidence; teacher cannot explain basis for accusation to student or parent (International Task Force on Teachers for Education 2030, 2025)	Use AI systems with explainable features; conduct human review of AI outputs before action; maintain documentation of AI use decisions; develop classroom AI use policies	Knowledge of explainable AI (XAI) concepts; procedures for AI output verification; communication strategies for explaining AI use to stakeholders
Professional Agency Preservation	AI systems make instructional or assessment decisions that override teacher professional judgment	District mandates use of AI-generated lesson plans; teacher feels obligated to follow AI recommendations even when pedagogically inappropriate (Çelik & Akgün, 2025)	Maintain professional override authority; use AI as advisory rather than prescriptive; participate in school-level AI governance decisions; develop personal AI use philosophy	Frameworks for human-AI collaboration; strategies for maintaining professional boundary-setting; advocacy skills for teacher voice in AI adoption
Accountability and Liability	Responsibility for AI-caused errors or harms is unclear, placing teachers at risk	AI tutoring system provides incorrect scientific information; student learns misinformation; teacher held responsible despite using approved tool (Celik, 2023)	Document AI tool limitations for students and families; verify critical AI outputs; maintain professional liability awareness; report system errors to administrators	Understanding of professional liability in AI context; documentation practices; incident reporting procedures

Note. **Table 2** synthesizes ethical challenges identified across multiple peer-reviewed sources (2022-2025). Teacher response strategies are derived from case studies and professional development evaluations cited in the literature.

5. Discussion

5.1. Interpretation of Findings

The findings of this review suggest that teacher competence in the AI era extends significantly beyond technical skills to encompass integrated capabilities combining AI literacy, pedagogical innovation, and ethical reasoning. This integration is not merely additive but transformative, requiring teachers to develop fundamentally new ways of thinking about their professional roles, their relationships with students, and the nature of the learning process itself. The emergence of multiple frameworks including DAIC (JiG et al., 2024), i-TPACK (Çelik & Akgün, 2025), and the UNESCO AI Competency Framework (UNESCO, 2024a) reflects growing international consensus on the multidimensional nature of teacher AI competence. However, the translation of these frameworks into classroom practice remains uneven, with significant implementation gaps between high-income and low- and middle-income countries (Miao & Cukurova, 2024).

A particularly important insight concerns the relationship between teacher mindset and competence development. The comparative evidence from professional development studies indicates that tool-focused training alone may increase immediate self-efficacy but does not necessarily cultivate ethical awareness or critical reflection (Çelik & Akgün, 2025). Conversely, mindset-oriented training that emphasizes ethics and human-centered pedagogy fosters deeper reflective capacities but may not fully address technical confidence gaps (Nazaretsky et al., 2022). This finding suggests that effective professional development cannot adopt either approach in isolation but must integrate both technical and ethical dimensions in a balanced, sequential, or spiral manner. The Hong Kong SAR Education Bureau's layered approach, which sequences AI Literacy and Skills before moving to AI + Subjects and then AI Leadership, provides one model for such integration (Education Bureau, Hong Kong SAR, 2025).

The findings also reveal the persistent challenge of preserving teacher agency within increasingly algorithmic environments. As documented by the International Task Force on Teachers for Education 2030 (2025), teachers' risk being positioned as technicians implementing externally-designed AI systems rather than professionals exercising situated judgment about their students' needs. Maintaining appropriate agency requires not only individual teacher capabilities but also supportive institutional policies, transparent AI system design, and professional cultures that value teacher input into AI integration decisions. Without such systemic support, even highly AI-literate teachers may find their professional autonomy constrained by the technologies they are expected to use.

5.2. Implications

Several significant implications emerge from this analysis for different stakeholder groups. For teacher training institutions, pre-service teacher education curricula must be redesigned to include AI literacy as a core competency rather than an elective supplement. This redesign should encompass foundational AI concepts,

pedagogical integration strategies, ethical frameworks for responsible AI use, and extended opportunities for practice-based learning with AI tools in authentic classroom settings (Shoustikova et al., 2026). Institutions should consider mapping AI competencies across their existing program structures rather than adding standalone courses, integrating AI content into methods courses, assessment courses, and field experiences.

For ministries of education, national AI in education guidelines should be developed drawing on international frameworks while addressing local contexts, resource constraints, and cultural values. The contextualization work by Srisawasdi & Chaipidech (2025) for the Thai education system provides a model for how global frameworks can be adapted to national circumstances, including considerations of infrastructure availability, language support, and alignment with existing curriculum standards. Ministries should also invest in infrastructure, ongoing technical support, and recognition of teacher AI competence through certification or career pathway incentives.

For schools and districts, continuous professional development models are needed that move beyond one-off workshops to sustained, practice-embedded learning communities. The Hong Kong SAR Education Bureau's Digital Education AI in Education Series provides an example of systematic professional development structuring, with programs organized into AI Literacy and Skills, AI + Subjects, and AI Leadership categories (Education Bureau, Hong Kong SAR, 2025). Schools should also establish ethical oversight mechanisms, such as AI use review committees, that include teacher voices in decisions about which AI tools to adopt and how to govern their use.

For policymakers more broadly, investment in AI education infrastructure must be accompanied by attention to equity considerations. The current gap between high-income and low- and middle-income countries in teacher AI readiness documented by OECD (2025) threatens to exacerbate rather than reduce global educational inequalities. Policy responses should include targeted support for under-resourced schools, development of low-bandwidth AI tools appropriate for limited connectivity environments, and international knowledge-sharing mechanisms that enable Global South countries to learn from diverse implementation experiences.

5.3. Limitations

This study has several limitations that should be acknowledged. First, the desk-based research design limits empirical generalizability; findings are based on synthesis of existing literature rather than primary data collection from teachers or classrooms. While this approach enables broad coverage of a rapidly developing field, it cannot provide the contextual depth or causal evidence that would emerge from longitudinal or experimental studies. Second, the rapid pace of technological change in AI means that current literature may be outpaced by new developments before this paper is published. Generative AI capabilities are evolving particularly

quickly, and findings about specific tools may have limited shelf life.

Third, the predominance of studies from high-income contexts in the available literature limits insights into Global South realities, including the Kenyan context specifically mentioned in this paper's authorship. While efforts were made to include diverse sources, the research base remains heavily skewed toward North American, European, and East Asian settings (Miao & Cukurova, 2024). Fourth, most available studies are cross-sectional rather than longitudinal, limiting understanding of how AI competence develops over time across teacher careers. Finally, the literature on teacher AI competence remains heavily focused on K-12 general education, with limited attention to early childhood education, vocational education, or adult learning contexts.

5.4. Future Research Directions

Based on the gaps identified in this review, future research should prioritize several complementary directions. Classroom-based studies examining teacher-AI collaboration in authentic instructional settings are urgently needed, employing mixed methods designs that capture both implementation processes and learning outcomes. Such studies should attend to variation across subject areas, grade levels, and student populations to develop differentiated understanding of effective AI integration. Development and validation of AI-specific teacher competency frameworks for diverse cultural contexts represents a second priority, building on the foundational work of JiG et al. (2024) and Ng et al. (2023) while ensuring relevance to low-resource environments.

Research in African and low-resource contexts specifically should be prioritized given the current gaps in the literature. Studies examining how teachers in Kenya, Nigeria, South Africa, and other African nations are responding to AI opportunities and challenges would provide essential evidence for policy development. Such research should attend to infrastructure constraints, cultural factors affecting AI adoption, and locally-developed innovations that might transfer across contexts. Longitudinal studies tracking teacher AI competence development across professional careers would provide needed evidence about learning trajectories and the durability of professional development effects. Such studies might follow cohorts of teachers from pre-service training through their first several years of practice, measuring AI competence at multiple time points.

Design-based research on professional development models that effectively integrate technical, pedagogical, and ethical dimensions would address the current evidence gap regarding what works in teacher AI preparation. Such research should compare different PD formats including online, blended, and face-to-face delivery, different durations from short workshops to semester-long programs, and different content emphases including tool-focused, pedagogy-focused, and ethics-focused approaches. Finally, comparative studies examining how different policy approaches influence teacher AI adoption and competence development would inform national and regional policymaking. Such studies might compare

jurisdictions with centralized AI policies against those with decentralized approaches or examine the effects of certification requirements versus voluntary professional development.

6. Conclusion

This paper has argued that the transition from chalk to chatbots requires a fundamental reimagining of teacher skills and professional development systems. The evidence synthesized in this review demonstrates that AI literacy, AI-supported pedagogy, and ethical judgment form the three core competency domains for effective teaching in AI-mediated classrooms. These domains are not separate additions to existing teacher knowledge but rather represent integrated capabilities that transform how teachers understand their professional roles, relationships with students, and approaches to instructional design.

The current state of teacher preparation for AI integration is inadequate in most educational systems. Many teachers lack the foundational AI literacy needed to evaluate tools critically, the pedagogical knowledge to integrate AI meaningfully into instruction, and the ethical frameworks to navigate privacy, bias, and agency concerns responsibly. Addressing these gaps requires systemic change across multiple levels. Teacher education programs must embed AI literacy across their curricula rather than treating it as an add-on topic. Professional development must shift from episodic, tool-focused workshops to continuous, practice-embedded learning that integrates technical, pedagogical, and ethical dimensions. Policy frameworks must provide guidance while preserving teacher agency, recognizing that teachers are not merely implementers of externally designed systems but professionals whose judgment is essential to appropriate AI integration.

The goal of these efforts is not simply to help teachers use AI tools but to empower them to shape AI's role in education. As the International Task Force on Teachers for Education 2030 (2025) has argued, technology should serve teaching, and teachers must remain the catalysts of transformation who shape, guide, and humanize AI's role in classrooms. The question facing education systems globally is whether AI will be part of future classrooms, as that question has already been answered by technological development and adoption patterns. Rather, the urgent question is how teachers will be supported to shape AI's role in education responsibly, creatively, and equitably. This paper has contributed to answering that question by identifying the competencies teachers need, the preparation systems required to develop those competencies, and the research priorities that should guide further inquiry in this rapidly evolving field.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendices

Appendix A: Summary of Key Frameworks for Teacher AI Competence

Framework Name	Source	Core Dimensions	Competency Items	Target Level
DAIC	JiG et al. (2024)	5 dimensions	25 items	K-12 Teachers
UNESCO AI Competency	UNESCO (2024b)	5 domains × 3 levels	45 descriptors	All Teachers
i-TPACK	Celik (2023)	6 domains + Ethics	24 indicators	All Teachers
AIL Scale	ElSayary et al. (2026)	9 factors	45 items	Secondary Teachers
GenAI Competence	Johnson & Smith (2025)	6 domains	30 items	All Teachers

Appendix B: Professional Development Program Examples

Program	Location	Structure	Duration	Target Audience
Digital Education AI Series	Hong Kong SAR	3 levels: Literacy, Subjects, Leadership	60 hours total	K-12 Teachers
AI Integration Certificate	Thailand	Contextualized framework	45 hours	Secondary Teachers
i-TPACK Training Module	Türkiye	Technical + pedagogical + ethical	36 hours	Pre-service Teachers