

The Transformative Role of Artificial Intelligence in Teacher Education: Implications for a New Paradigm of Teacher Preparation—A Critical Literature Review

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ARTICLE INFORMATION	ABSTRACT
<p>Article history: Published: October 2026</p> <p>Keywords: Artificial Intelligence Teacher Education Teacher Preparation AI literacy Digital Pedagogy Educational Technology Teacher Professional Development human-AI collaboration Critical Digital Competence Ethics of AI in Education New Paradigm</p>	<p>Artificial intelligence (AI) is rapidly transforming educational systems and challenging conventional approaches to teacher preparation. This critical literature review examines the transformative role of AI in teacher education and explores its implications for developing a new paradigm of teacher preparation. Drawing on a critical synthesis of contemporary literature on AI, teacher education, digital pedagogy, and educational transformation, the review analyzes how emerging AI technologies are reshaping teachers' professional knowledge, pedagogical practices, assessment capabilities, and professional identities. The findings indicate that AI has considerable potential to enhance teacher preparation through personalized learning, intelligent tutoring, automated and formative feedback, data-informed decision-making, simulation-based practice, and expanded opportunities for reflective and collaborative learning. However, the review also identifies significant challenges, including ethical and privacy concerns, algorithmic bias, unequal access to AI technologies, inadequate digital and AI competencies among teacher educators and student teachers, concerns about academic integrity, and the risk of overreliance on automated systems. The analysis further suggests that the integration of AI requires a shift from technology-centered models of teacher preparation toward a human-centered, critically informed, and ethically grounded approach in which teachers are prepared not merely to use AI tools but to evaluate, question, and pedagogically integrate them. The review therefore argues for a new paradigm of teacher education characterized by AI literacy, critical digital competence, ethical reasoning, pedagogical adaptability, continuous professional learning, and human-AI collaboration. Such a paradigm is essential for preparing teachers who can effectively navigate AI-mediated educational environments while preserving the relational, ethical, and human dimensions of teaching and learning.</p>

1. Introduction

1.1 Background to the Study

Artificial Intelligence (AI) has emerged as a major force shaping contemporary education, with applications increasingly extending beyond conventional digital technologies to include generative AI, intelligent tutoring systems, adaptive learning, automated feedback, learning analytics, and AI-supported content creation. The growing capabilities of AI are changing how knowledge is produced, accessed, assessed, and communicated within educational environments. In particular, generative AI has expanded the capacity of educational stakeholders to produce and interact with text, images, feedback, lesson materials, and other forms of content. Consequently, AI is increasingly influencing the relationship between teachers, learners, and technology, creating what UNESCO describes as a teacher-AI-student dynamic and requiring education systems to reconsider the roles and competencies of teachers (Miao & Cukurova, 2024).

The transformation brought about by AI has important implications for teacher education because teachers require more than technical knowledge to use AI effectively in educational contexts. They need to understand the capabilities and limitations of AI systems, critically evaluate AI-generated information, integrate AI appropriately into pedagogical practice, and address issues relating to ethics, privacy, bias, accountability, and human agency. UNESCO's AI Competency Framework for Teachers identifies 15 competencies across five dimensions: a human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning (Miao & Cukurova, 2024). The framework reflects a growing recognition that preparing teachers for AI requires a combination of technological, pedagogical, ethical, and professional competencies rather than simple familiarity with digital tools.

The emergence of AI also raises fundamental questions about the adequacy of existing models of teacher preparation. Traditional teacher education has generally emphasised subject knowledge, pedagogical knowledge, classroom management, assessment, professional practice, and reflective competence. However, teachers now increasingly operate in environments where AI can support lesson planning, resource development, assessment, feedback, personalised learning, and professional learning. The OECD (2024) observes that education systems are increasingly considering how teachers can integrate digital technologies, including AI, into teaching, learning, and assessment. At the same time, the OECD (2025) argues that the continuing development of AI requires education systems to reconsider the competencies, knowledge, skills, attitudes, and learning experiences that will be needed in the future. These developments suggest that teacher preparation may need to move beyond conventional digital competence towards a broader conception of AI-related professional competence.

Despite these opportunities, the integration of AI into teacher education presents significant pedagogical, ethical, institutional, and professional challenges. Concerns include inaccurate or fabricated AI-generated information, algorithmic bias, privacy and data protection, academic integrity, intellectual property, unequal access to technology, and potential overdependence on automated systems. These challenges reinforce the importance of maintaining human agency and professional judgement in AI-supported education. UNESCO (2024) therefore emphasises a human-centred approach in which teachers are equipped to use AI safely, ethically, and effectively while retaining responsibility for educational decisions. Recent analysis of teacher AI competency frameworks also indicates that attention is increasingly shifting from merely understanding AI to developing pedagogically grounded competencies, implementation strategies, and methods for evaluating teachers' AI competence (UNESCO IITE, 2026).

Against this background, the increasing influence of AI presents teacher education with an opportunity to reconsider the nature and purpose of teacher preparation. The issue is no longer simply whether prospective teachers should learn to operate AI tools, but how teacher education programmes can prepare teachers to work critically, ethically, creatively, and professionally in AI-mediated educational environments. A new paradigm of teacher preparation may therefore require the integration of AI literacy, AI-enhanced pedagogy, ethical reasoning, critical evaluation of AI outputs, professional agency, and human-centred educational practice. This critical literature review is consequently concerned with examining how AI is transforming teacher education, identifying the emerging competencies and professional roles associated with this transformation, and analysing the implications for the development of a new paradigm of teacher preparation. Such an approach is consistent with the growing international emphasis on preparing teachers not merely to use AI, but to exercise informed professional judgement and ensure that AI contributes to inclusive, ethical, and meaningful educational practice (Miao & Cukurova, 2024; OECD, 2025).

1.2 Statement of the Problem

The rapid development of Artificial Intelligence (AI), particularly generative AI, is transforming teaching, learning, assessment, lesson planning, feedback, and professional development. These changes are creating new expectations for teachers, who increasingly need AI literacy, critical evaluation skills, ethical awareness, data literacy, and the ability to integrate AI into pedagogically appropriate practices. However, existing teacher education programmes have traditionally focused on subject knowledge, pedagogical knowledge, classroom management, assessment, and general digital competence, with comparatively less emphasis on the specialised competencies required for AI-enabled educational environments. UNESCO's AI Competency Framework for Teachers highlights the need for competencies related to human-centred approaches, AI ethics, AI foundations and applications, AI pedagogy, and professional learning (Miao & Cukurova, 2024). This suggests that the rapid development of AI is creating demands that many conventional approaches to teacher preparation may not yet adequately address.

The problem is further complicated by the pedagogical, ethical, and professional challenges associated with AI, including inaccurate information, algorithmic bias, privacy concerns, academic integrity, unequal access, and potential overdependence on automated systems. Although research on AI in education is expanding rapidly, there remains limited consensus regarding the competencies AI-ready teachers require, how these competencies should be incorporated into teacher education curricula, and how teacher preparation should evolve in response to changing human-AI relationships. Recent international work on teacher AI competency frameworks demonstrates increasing attention to this issue but also points to continuing questions concerning implementation and assessment (UNESCO IITE, 2026). The central problem, therefore, is the apparent mismatch between the rapid transformation of education through AI and the capacity of existing teacher preparation models to respond effectively. This critical literature review addresses this gap by synthesising existing evidence on the transformative role of AI in teacher education and examining its implications for developing a new paradigm of teacher preparation that combines technological competence, pedagogical knowledge, ethical responsibility, critical judgement, and human professional agency.

1.3 Purpose of the Review

This review critically examines the existing literature on the transformative role of artificial intelligence (AI) in teacher education. It synthesizes and evaluates current research on how AI is reshaping teacher preparation, including the development of pre-service teachers' knowledge, skills, pedagogical practices, and professional competencies. The review also considers the opportunities and challenges associated with integrating AI into teacher education and examines the implications of these developments for the future design, structure, and delivery of teacher preparation programmes. Ultimately, the review seeks to identify emerging trends, gaps, and areas requiring further research to inform the development of teacher education that is responsive to the evolving demands of AI-enabled educational environments.

1.4 Objectives of the Review

The review aims to:

- Examine how Artificial Intelligence (AI) is being integrated into teacher education and how it is transforming teacher preparation.
- Identify the AI-related knowledge, skills, and competencies required of prospective and practising teachers.
- Analyse the pedagogical, professional, ethical, and institutional implications, as well as the challenges, of integrating AI into teacher education.
- Synthesise the existing literature to identify research gaps and develop a conceptual basis for a new paradigm of teacher preparation in the AI era.

1.5 Research Questions

The review is guided by the following questions:

- How is Artificial Intelligence being integrated into teacher education, and in what ways is it transforming teacher preparation?
- What AI-related knowledge, skills, and competencies are emerging as essential for prospective and practising teachers?

- What are the pedagogical, professional, ethical, and institutional implications and challenges of integrating AI into teacher education?
- What gaps in the existing literature inform the development of a new paradigm of teacher preparation for an AI-enabled educational environment?

1.6 Significance of the Review

This review is significant because it examines the relevance of artificial intelligence (AI) to teacher education and professional practice. For teacher educators and student teachers, it provides insights into how AI can support teaching, learning, assessment, lesson planning, and the development of digital competencies. For educational institutions, the review can inform decisions about AI integration, infrastructure, policies, and ethical practices. It also provides policymakers and curriculum developers with evidence that can guide the development of appropriate policies, standards, and teacher-education curricula that prepare teachers to use AI responsibly and effectively.

The review is also valuable to researchers and professional development providers. Researchers can use the identified findings, trends, gaps, and methodological issues to guide future studies on AI and teacher education. Professional development providers can draw on the evidence to design training programmes that strengthen teachers' AI literacy, pedagogical skills, ethical awareness, and ability to evaluate AI-generated content. Overall, the review contributes to a clearer understanding of the opportunities and challenges associated with preparing teachers for an increasingly AI-supported educational environment.

1.7 Scope and Delimitations

This review focuses on artificial intelligence as applied to education and teacher education, including relevant technologies such as generative AI, intelligent tutoring systems, adaptive learning technologies, automated assessment, and AI-supported teaching and learning tools. It covers both pre-service teacher education and, where relevant, in-service teacher education and professional development. The review considers evidence from relevant geographical and educational contexts, with attention to studies addressing teacher preparation, classroom practice, teacher competencies, AI literacy, ethics, and institutional implementation. The publication period should be specified according to the review design (for example, studies published between [2022] and [2026]). The review includes relevant peer-reviewed journal articles, conference papers, books or book chapters, systematic and literature reviews, and credible institutional or policy reports, where appropriate. Literature is selected based on its direct relevance to AI and teacher education, while studies focused exclusively on AI applications outside education or unrelated professional fields are excluded. These delimitations help maintain a manageable and coherent body of evidence while ensuring that the review remains focused on the preparation, development, and professional practice of teachers in relation to AI.

2. Review of Related Literature

2.1 Artificial Intelligence and the Transformation of Teacher Education

The emergence of generative Artificial Intelligence (GenAI) is increasingly challenging conventional approaches to teacher preparation. Whereas earlier educational technologies were primarily conceived as tools used by teachers to support established pedagogical practices, contemporary AI systems can generate instructional content, provide feedback, support assessment, facilitate lesson planning and participate directly in learning interactions. Consequently, the literature increasingly conceptualizes AI as a force capable of reshaping the professional knowledge and practices of teachers.

UNESCO (2024) argues that AI has introduced a new teacher–AI–student dynamic, requiring a reconsideration of teachers' roles and competencies. Its AI Competency Framework for Teachers identifies 15 competencies across five dimensions: human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning.

More recent evidence strengthens this argument. Panday-Shukla (2025), examining 52 pre-service teachers and 21 teacher educators, found that participants recognized the potential of GenAI but that AI literacy remained low, despite moderate levels of general digital literacy. The study concluded that many pre-service teachers were not adequately prepared to teach in an environment in which GenAI becomes increasingly prevalent.

Similarly, a 2025 study of 15 pre-service teachers found that future educators recognized AI's potential for personalized learning and classroom efficiency but expressed concerns about over-reliance on AI, loss of the human element, privacy and algorithmic bias. Participants also identified insufficient institutional training and support as major barriers to developing AI literacy.

Critical discussion. These findings suggest that the problem is not simply a lack of access to AI technologies. Rather, there is a preparation gap between the growing presence of AI in education and the capacity of teacher education programmes to prepare future teachers for its pedagogical and ethical implications. The literature therefore increasingly supports a shift from viewing AI as an additional technological competency toward viewing it as a component of professional teacher competence.

2.2 AI Literacy as an Emerging Dimension of Teacher Competence

AI literacy has become one of the most important concepts in contemporary discussions of teacher preparation. However, recent research indicates that the construct remains conceptually and empirically fragmented.

Sperling et al. (2024), through a scoping review, found that AI literacy was an emerging but underdeveloped area within teacher education. Their analysis particularly highlighted insufficient attention to teachers' practical knowledge and professional judgement, suggesting that AI literacy should extend beyond technical understanding.

More recent evidence provides further support for this criticism. Shi (2025) developed and validated the Teachers' Generative AI Competencies (T-GAIC) instrument using data from 478 pre-service and in-service teachers. The resulting framework identified five dimensions: technological proficiency, pedagogical compatibility, preparing students for GenAI use, professional development and communication, and risk and ethical awareness.

This is significant because it demonstrates empirically that teacher GenAI competence is multidimensional. A teacher who knows how to operate ChatGPT or another GenAI system cannot automatically be considered professionally competent in its educational use. Even more recently, a 2026 systematic review of 33 empirical studies examining teacher AI-literacy measurement tools found that most instruments rely on self-reported confidence rather than demonstrated competence. The review also identified a mismatch between existing assessment instruments and the growing importance of GenAI, with many instruments still concentrating on general AI concepts.

Critical discussion. This creates an important methodological problem in teacher education. If AI competence is measured primarily by teachers' perceptions of their own confidence, teacher education institutions may overestimate actual competence. Future preparation therefore needs assessment methods that evaluate what teachers can actually do, including their ability to evaluate AI outputs, recognize bias, make ethical decisions and integrate GenAI pedagogically.

Thus, the literature supports conceptualizing AI literacy as:

Technical knowledge + critical evaluation + pedagogical application + ethical reasoning + professional judgement.

2.3 Generative AI and Pre-Service Teacher Preparation

The literature published in 2025 provides particularly useful evidence concerning pre-service teachers.

Huang, Wu and Wu (2025) conducted a 12-week intervention involving 90 pre-service English-language teachers. The experimental group demonstrated significant improvements in overall GenAI literacy and across five dimensions: technical proficiency, critical evaluation, communication, creative application and ethical competence.

This finding is particularly important for your study because it provides evidence that AI competence can be developed through structured teacher education, rather than assuming that future teachers will acquire it independently.

Similarly, a 2025 study of 200 pre-service teachers found significant gaps in their understanding of AI mechanisms. It also found positive relationships between AI understanding, engagement with AI, perceptions of AI applications and ethical considerations. The authors emphasized the importance of practical training and collaborative learning.

Critical discussion. These studies challenge the assumption that younger or digitally experienced student teachers will automatically possess AI competence. Digital familiarity does not necessarily equal AI literacy.

This distinction is particularly relevant to teacher education. A student teacher may be highly competent in using social media, digital platforms or conventional educational technologies while lacking the ability to interrogate AI-generated information or understand algorithmic limitations.

The evidence therefore supports intentional AI preparation, rather than assuming that student teachers will develop competence through informal exposure.

2.4 Teacher Educators and the Transformation of Teacher Education

An important but sometimes neglected dimension is the role of teacher educators themselves.

Teacher educators influence the curriculum, pedagogical models and professional norms through which pre-service teachers encounter AI. Consequently, teacher educators' own AI competence can have a multiplier effect on future generations of teachers.

A 2025 mixed-methods study involving 91 Danish teacher educators found diverse perceptions of GenAI, ranging from enthusiasm about innovative teaching to concerns regarding ethics, assessment and the preservation of foundational skills. The study identified three major areas of AI literacy relevant to teacher education: AI literacy, AI didactics and AI assessment. It also argued for a broader conception of AI literacy that includes ethical, cultural and democratic dimensions.

Critical discussion. This finding is important because curriculum reform cannot succeed if teacher educators themselves lack sufficient AI competence. The transformation of teacher preparation therefore operates at two levels:

Teacher educator competence → Pre-service teacher competence → Future classroom practice

Teacher education reform must consequently address not only student teachers but also the professional development of teacher educators.

2.5 AI Pedagogy and the Changing Role of the Teacher

Recent literature increasingly distinguishes between using AI and using AI pedagogically.

Shi (2025) places pedagogical compatibility at the centre of GenAI competence, indicating that teachers need to determine whether AI applications are compatible with particular teaching purposes rather than simply knowing how to operate them.

Panday-Shukla (2025) similarly reports that teacher educators and pre-service teachers recognize potential benefits of GenAI while simultaneously expressing concerns about excessive dependence and the loss of human elements in education.

Critical discussion. The emerging evidence therefore challenges a technology-centred model of teacher preparation. The relevant question is no longer:

Can the teacher use AI?

but:

Can the teacher exercise sound pedagogical judgement about when, why and how AI should be used?

This represents an important shift from technology competence to pedagogical AI competence.

The teacher consequently remains central, but the nature of professional expertise changes. Teachers increasingly become:

- designers of AI-supported learning;
- evaluators of AI-generated information;
- facilitators of critical thinking;
- ethical decision-makers;
- mediators between learners and AI;
- designers of authentic assessment.

2.6 AI, Assessment and Teacher Preparation

Assessment is emerging as one of the most difficult areas of AI integration.

Generative AI can produce essays, explanations, lesson plans, questions and other outputs traditionally used to assess student learning. This creates concerns about the validity of conventional assessment practices.

The recent literature on teacher educators identifies AI assessment as a distinct area requiring professional knowledge. A 2025 study of Danish teacher educators found that assessment was one of the central concerns surrounding GenAI integration into teacher education. The T-GAIC framework developed by Shi (2025) similarly includes competencies relating to preparing students for effective GenAI practices, demonstrating that teachers need to understand not only their own use of AI but also how learners should use it responsibly. Critical discussion. This suggests that teacher preparation should not merely teach future teachers how to detect AI-generated student work. It should prepare them to redesign assessment around reasoning, application, reflection, authentic performance and the learning process. Thus, AI potentially changes not only how teachers teach but also how teachers determine whether learning has occurred.

2.7 Ethical Competence and Human Agency

Ethical competence has become increasingly prominent in recent research:

- The 2025 study by Huang et al. demonstrated significant improvements in ethical competence following structured GenAI preparation among pre-service teachers.
 - Shi's (2025) validated competency framework similarly identifies risk and ethical awareness as one of five dimensions of teachers' GenAI competence.
 - UNESCO (2024) places ethics and a human-centred mindset at the core of its international teacher competency framework.
- Critical discussion. The convergence of these sources is significant. It indicates that ethics is moving from the margins of AI discussions toward the centre of teacher competence.

Nevertheless, ethical competence should not be reduced to knowledge of ethical principles. Teachers must be capable of applying those principles to actual situations involving:

- Biased AI outputs;
- student privacy;
- inaccurate information;
- unequal access;
- academic integrity;
- inappropriate automation;
- overdependence on AI.

Therefore, teacher preparation should develop ethical judgement in practice, rather than simply teaching a list of ethical rules.

2.8 Institutional Support and Professional Development

Recent research also emphasizes that individual teacher competence is insufficient without institutional support.

The 2025 qualitative study of pre-service teachers identified insufficient training and lack of institutional support as major barriers to AI literacy development.

The 2025 study of teacher educators similarly emphasized the need for both formal professional development and informal collaborative learning opportunities.

Most importantly, the new 2026 systematic review of 43 empirical studies on in-service teacher AI literacy concluded that teacher AI literacy is shaped by three interacting levels:

- individual competence;
- psychological factors such as confidence and attitudes;
- institutional context.

It further found that sustained, practice-oriented professional development tends to be more effective than simple awareness-raising activities. Critical discussion. These findings challenge approaches that place responsibility for AI integration entirely on individual teachers. Teacher competence develops within institutional environments. Without leadership, policy, infrastructure, time and professional learning opportunities, even highly motivated teachers may struggle to integrate AI effectively.

Thus, the transformation of teacher preparation should be understood as both an individual and institutional transformation.

2.9 Emerging Evidence for a New Paradigm of Teacher Preparation

The most recent literature increasingly supports a shift away from a narrow technology-adoption paradigm.

The emerging evidence can be synthesized as follows:

Traditional orientation	Emerging AI-oriented paradigm
Teacher as knowledge transmitter	Teacher as learning designer and mediator
Individual training	General digital competence
Fixed professional knowledge	Specialized AI/GenAI competence
Conventional assessment	AI-aware authentic assessment
Adoption of tools	Professional judgement about AI

This transformation is supported by UNESCO's competency framework, the 2025 empirical studies of pre-service teachers and teacher educators, the validated GenAI competency instrument, and the 2026 systematic review of teacher AI literacy.

2.10 Stronger Critical Synthesis for Your Research

The recent literature allows a much sharper argument for your research.

What is already known? Recent studies demonstrate that AI has considerable potential to support teaching, learning, personalization, assessment and professional work.

What is increasingly recognized? Researchers increasingly recognize that teachers require specialized AI and GenAI competencies encompassing technical, pedagogical, ethical and professional dimensions.

What remains problematic? Teacher education programmes are still struggling to systematically develop these competencies, while AI-literacy measurement itself remains inconsistent and often relies on self-reported confidence rather than demonstrated competence.

What is the deeper gap? The literature has increasingly examined AI integration into teaching, but there is still a need to conceptualize how AI should transform the philosophy, curriculum, pedagogy, assessment and professional development structures of teacher preparation itself.

What does your study therefore contribute? Your study can move the discussion from:

“How can teachers use AI?” toward:

“How should teacher education be reconceptualized when AI becomes an integral component of educational practice?”

That is a much stronger positioning for your research topic.

2.11 Updated Research Gap

A particularly strong research-gap statement for your thesis would be:

Despite the rapid expansion of research on Artificial Intelligence in education, the literature remains fragmented regarding the implications of AI for the fundamental design of teacher preparation. Recent studies have demonstrated gaps in pre-service teachers' AI literacy, limited institutional support, insufficient pedagogical preparation and continuing uncertainty concerning ethical and assessment practices (Panday-Shukla, 2025; Huang et al., 2025; Shi, 2025). Furthermore, recent systematic evidence indicates that teacher AI literacy is conceptually fragmented and frequently assessed through self-reported confidence rather than demonstrated professional competence (Kokoç et al., 2026). Although international frameworks such as UNESCO's AI Competency Framework for Teachers provide important guidance, a continuing gap remains between competency frameworks and the broader reconceptualization of teacher education curricula, pedagogy, practicum, assessment and professional learning (UNESCO, 2024). The critical issue, therefore, is not merely how AI can be incorporated into existing teacher education programmes, but how the emergence of AI necessitates a new paradigm of teacher preparation grounded in AI literacy, pedagogical competence, ethical reasoning, professional judgement and human agency.

3. Methodology

3.1 Research Design

This study adopted a critical literature review design to examine the transformative role of Artificial Intelligence (AI) in teacher education and its implications for a new paradigm of teacher preparation. Rather than treating AI as simply another educational technology, the review critically examined how its emergence may reshape teacher competencies, pedagogical practices, professional identities, curricula, institutional arrangements, and ethical responsibilities.

The review was informed by a critical interpretivist orientation, recognising that the educational significance of AI is socially and institutionally mediated. Accordingly, the analysis considered not only reported benefits of AI but also competing perspectives, limitations, ethical concerns, contextual inequalities, and assumptions underlying claims of technological transformation.

3.2 Literature Search and Selection

Relevant literature was identified through structured searches of major academic databases and scholarly search platforms covering education, social sciences, technology, and interdisciplinary research. Search terms combined concepts relating to artificial intelligence, generative AI, large language models, teacher education, teacher preparation, teacher competence, AI literacy, professional development, pedagogy, and educational transformation. Boolean operators were used to combine and refine search terms.

The review prioritised peer-reviewed journal articles, scholarly books and chapters, systematic and scoping reviews, empirical and conceptual studies, and authoritative policy and institutional publications. Recent literature on generative AI received particular attention because of the rapid development of technologies such as large language models. Earlier foundational literature was retained where it provided important theoretical perspectives on teacher knowledge, digital competence, educational technology, or professional learning.

Studies were included when they directly addressed AI and teacher education or provided significant conceptual, pedagogical, professional, ethical, or policy implications for teacher preparation. Sources were excluded when they focused exclusively on technical AI development, lacked meaningful relevance to teaching or teacher education, were primarily promotional, or lacked sufficient scholarly or methodological credibility.

3.3 Critical Appraisal and Analysis

The selected literature was critically appraised according to conceptual clarity, methodological rigour, evidential strength, contextual relevance, theoretical contribution, recognition of limitations, and potential sources of bias. Particular attention was given to distinguishing empirical evidence from theoretical claims and technological speculation.

Data from the selected literature were organised according to key analytical dimensions, including AI applications in teaching, emerging teacher competencies, professional identity, pedagogy, assessment, ethical and governance challenges, equity, and institutional transformation.

A thematic synthesis and critical interpretive analysis was then undertaken. Initial findings were coded and grouped into broader themes, after which relationships, contradictions, gaps, and emerging patterns were examined across the literature. The analysis was guided by three questions: (1) What does the existing literature consistently demonstrate? (2) Where does evidence remain contested or insufficient? and (3) What implications do these findings have for the future design of teacher preparation?

3.4 Trustworthiness and Ethical Considerations

The credibility of the review was strengthened through the use of explicit search and selection criteria, comparison of evidence across multiple sources, inclusion of contrasting perspectives, and critical examination of methodological limitations. The review avoided treating claims about AI's benefits as inherently equivalent to empirical evidence of educational improvement.

Although the study did not involve human participants, ethical principles concerning accurate representation of scholarship, appropriate attribution, intellectual integrity, and responsible interpretation were observed. Particular attention was given to ethical issues associated with AI, including privacy, algorithmic bias, data governance, academic integrity, transparency, accountability, and human agency.

3.5 Methodological Limitations

The review recognises several limitations. The rapidly evolving nature of AI means that the evidence base remains dynamic, particularly in relation to generative AI. Existing research is also unevenly distributed geographically and methodologically, with considerable variation in definitions of AI, AI literacy, digital competence, and educational transformation. Publication and technological novelty biases may further influence the available evidence. In addition, the interpretive nature of a critical review means that the synthesis necessarily involves researcher judgement.

Despite these limitations, the methodology provides a rigorous basis for examining whether AI represents merely an additional technological resource for teachers or signals a more fundamental transformation of teacher education. The analysis therefore focuses on the extent to which AI requires teacher preparation programmes to reconsider the knowledge, competencies, professional identities, pedagogies, ethical frameworks, and institutional conditions required for effective teaching in AI-mediated educational environments.

4. Findings and Discussion

4.1 AI as a Catalyst for Reconfiguring Teacher Education

The critical synthesis indicates that Artificial Intelligence (AI) is emerging as more than an additional digital resource within teacher education. Its growing capacity to generate, organise, analyse, and personalise educational content is challenging established assumptions concerning the nature of teaching, professional knowledge, pedagogical practice, assessment, and teacher preparation. The literature nevertheless suggests that AI does not produce transformation automatically. Its educational value is mediated by teacher competence, institutional capacity, ethical governance, infrastructure, and the contexts in which it is implemented.

A central finding of the review is therefore the distinction between technology adoption and paradigm transformation. Technology adoption involves incorporating AI into existing educational practices, whereas paradigm transformation involves reconsidering the purposes, competencies, structures, and professional assumptions underlying teacher education. The latter is more consequential because it addresses how the emergence of AI changes what teachers need to know and what teacher education institutions need to prepare them to do.

The literature points particularly toward a transition from a model in which teachers are primarily prepared as transmitters and mediators of established knowledge towards one in which they are prepared as critical designers, evaluators, facilitators, ethical decision-makers, and orchestrators of human-AI learning environments.

4.2 Transformation of Pedagogical Practice

One of the most consistently identified implications of AI concerns the transformation of pedagogical practice. AI systems can support lesson planning, instructional-material development, differentiation, feedback, assessment design, content generation, and professional learning. Generative AI has accelerated these possibilities by allowing teachers to interact with sophisticated computational systems through natural-language prompts.

However, the critical literature cautions against equating increased technological capability with improved pedagogy. The ability of an AI system to generate a lesson plan or assessment item does not establish that the resulting material is pedagogically appropriate, factually reliable, culturally responsive, or suitable for a particular group of learners. AI-generated outputs remain dependent on the quality of the prompts, underlying models, available information, and professional judgement applied to their use.

The emerging implication is therefore not the replacement of teacher expertise but its reconfiguration. Teachers may increasingly delegate routine or preparatory tasks to AI while concentrating professional effort on contextual interpretation, learner relationships, pedagogical decision-making, creativity, ethical judgement, and the design of meaningful learning experiences.

This suggests a shift from AI-assisted efficiency towards AI-enhanced professional practice. The distinction is important because efficiency alone does not constitute educational transformation. Transformation occurs when AI enables teachers to undertake educational work differently while preserving human responsibility for pedagogical decisions.

4.3 From Digital Competence to Critical AI Competence

The review identifies a significant expansion of the competencies required of teachers. Traditional digital literacy, although still important, is increasingly insufficient in environments where AI can generate content, make recommendations, analyse data, and participate directly in educational processes.

Future teachers require a broader form of critical AI competence encompassing technical understanding, pedagogical application, critical evaluation, ethical reasoning, and professional judgement.

This competence includes the ability to:

- understand the basic principles and limitations of AI;
- evaluate the accuracy and relevance of AI-generated outputs;
- recognise bias and potentially discriminatory outputs;
- protect personal and educational data;
- use AI to support rather than undermine pedagogy;
- design appropriate interactions with generative AI;

- critically interpret AI-generated recommendations;
- reconsider assessment practices in AI-mediated environments; and
- make professionally and ethically defensible decisions about when AI should or should not be used.

The significance of this finding extends beyond the addition of an “AI skills” module to existing teacher-education programmes. AI competence needs to become embedded across the curriculum. It should inform pedagogical studies, curriculum design, assessment, educational psychology, practicum experiences, professional ethics, and continuing professional development.

Thus, the relevant question is no longer simply whether teachers are digitally competent, but whether they are capable of exercising critical professional agency in relation to AI.

4.4 Reconstructing Teacher Professional Identity

The growing capacity of AI to generate educational content also challenges traditional conceptions of teacher expertise. When AI systems can produce explanations, examples, lesson materials, questions, summaries, and feedback, teachers can no longer be conceptualised primarily as the exclusive providers of information.

This does not diminish the professional importance of teachers. Rather, it changes the basis upon which professional expertise is exercised. The emerging teacher role increasingly involves curating, contextualising, evaluating, designing, facilitating, mentoring, and making ethical decisions. Teachers must determine which information is trustworthy, which AI-generated outputs are pedagogically useful, and how technological resources should be adapted to the cultural, linguistic, developmental, and social circumstances of learners. This transformation reinforces rather than eliminates the human dimensions of teaching. Empathy, communication, motivation, relational trust, cultural responsiveness, ethical judgement, and understanding of individual learners remain central to effective teaching. The critical implication is that teacher education should not prepare teachers merely to operate AI systems. It should prepare them to govern the educational use of AI.

This represents an important shift from a technology-centred conception of teacher competence towards a human-centred model of professional AI competence.

4.5 Human Agency versus Technological Substitution

The literature reveals a persistent tension between two interpretations of AI: augmentation and substitution.

The augmentation perspective views AI as a resource that extends teachers' capabilities, reduces routine workload, supports professional learning, and facilitates more responsive teaching. The substitution perspective assumes that increasingly sophisticated AI systems may perform tasks historically associated with teachers and potentially reduce the need for human intervention.

The critical synthesis provides stronger support for an augmentation-oriented approach than for a simple substitution narrative. Teaching is not reducible to information transmission or computational processing. It is an inherently social and relational practice involving interpretation, judgement, values, motivation, classroom relationships, and responsibility.

Consequently, AI should be positioned within teacher education as a collaborative technology rather than an autonomous pedagogical authority. Teachers should be prepared to interrogate AI recommendations, identify limitations, override inappropriate outputs, and remain accountable for educational decisions.

Teacher agency is therefore a foundational condition of responsible AI integration. The central concern should not be whether AI can perform a task, but whether delegating that task to AI enhances or diminishes meaningful educational practice.

4.6 Ethical and Epistemic Challenges

The transformative potential of AI is accompanied by significant ethical and epistemic concerns. The literature identifies challenges involving privacy, data governance, algorithmic bias, misinformation, intellectual property, academic integrity, transparency, accountability, and surveillance.

The problem of epistemic reliability is particularly significant. Generative AI systems can produce plausible and authoritative-sounding responses that may nevertheless contain inaccuracies or distortions. Teacher preparation must therefore cultivate the ability to verify and triangulate AI-generated information rather than treating technological fluency as sufficient.

Similarly, algorithmic bias raises questions about whose knowledge and perspectives are represented in AI systems. Teachers need the critical capacity to recognise when AI-generated content may reproduce cultural, linguistic, social, or ideological biases.

Privacy and data governance create an additional layer of professional responsibility. As educational institutions increasingly incorporate AI systems into learning and assessment, teachers may encounter technologies capable of processing substantial amounts of learner data. Responsible AI use therefore requires understanding not only technological functionality but also data protection, consent, accountability, and appropriate boundaries of use.

These challenges indicate that ethical competence must be integrated into AI teacher preparation rather than treated as a separate or optional consideration.

4.7 Assessment in an AI-Mediated Educational Environment

Assessment represents one of the areas most directly disrupted by generative AI. The ability of AI systems to generate essays, explanations, answers, lesson plans, and other forms of academic output challenges conventional assumptions about authorship, originality, and individual performance.

The appropriate response is unlikely to be the simple prohibition of AI. Instead, teacher education needs to prepare future teachers to redesign assessment around forms of learning that emphasise reasoning, application, reflection, creativity, communication, problem-solving, and demonstrated understanding.

AI therefore creates an opportunity to move away from assessment practices that focus predominantly on the reproduction of information towards more authentic and process-oriented assessment.

Future teachers should be prepared to distinguish between productive AI use and forms of use that undermine learning. They should also understand how assessment can incorporate transparent and ethically responsible AI use while maintaining academic standards. This requires the development of AI-aware assessment literacy as a core dimension of teacher competence.

4.8 Equity, Access, and Context

The literature also demonstrates that AI's benefits cannot be assumed to be universally accessible. Differences in connectivity, infrastructure, institutional resources, teacher expertise, language availability, and access to advanced AI systems may significantly influence educational outcomes.

This issue is particularly important in contexts where teacher education institutions face resource constraints. If AI integration proceeds without addressing these structural inequalities, it may deepen rather than reduce existing educational disparities.

The transformative potential of AI must therefore be evaluated through an equity lens. Teacher preparation should enable future teachers to ask not only whether AI is effective but also:

- Who has access to the technology?
- Who benefits from its use?
- Who may be excluded?
- Whose knowledge and language are represented?
- What forms of inequality might AI reproduce?
- What institutional support is required for meaningful participation?

This perspective is essential for ensuring that AI transformation remains educationally and socially responsible.

4.9 Institutional Transformation and the Role of Teacher Educators

The findings further demonstrate that AI integration cannot be achieved through individual teacher competence alone. Teacher education institutions themselves must develop the capacity to support responsible AI adoption.

This includes curriculum reform, staff development, infrastructure, assessment policies, data-governance mechanisms, academic-integrity frameworks, and institutional guidance concerning appropriate AI use.

Teacher educators are particularly important in this transformation. They influence the professional knowledge and practices that student teachers acquire. If teacher educators themselves lack critical AI competence, teacher preparation programmes may continue to reproduce conventional models of teaching while attempting to incorporate fundamentally new technologies.

Consequently, professional development for teacher educators should be treated as a strategic institutional priority.

The transformation of teacher education therefore operates at three interconnected levels:

- Individual level: teacher knowledge, competence, identity, and professional agency;
- Programme level: curriculum, pedagogy, assessment, and practicum;
- Institutional level: policy, infrastructure, governance, leadership, and professional development.
- Meaningful transformation requires alignment across all three.

4.10 Toward a New Paradigm of Teacher Preparation

The most significant contribution of the critical synthesis is the proposition that AI requires a shift from technology integration to paradigm transformation.

The traditional model of teacher preparation has often emphasised disciplinary knowledge, pedagogical knowledge, classroom management, assessment, and increasingly digital competence. These remain essential. However, the emergence of AI requires these domains to be reconsidered in relation to new forms of human-AI interaction.

The review therefore proposes six interrelated dimensions of an AI-responsive teacher-preparation paradigm:

Dimension	Central Focus
AI literacy	Understanding AI capabilities, limitations, and applications
AI-pedagogical competence	Integrating AI into teaching on pedagogically defensible grounds
Critical and ethical reasoning	Evaluating accuracy, bias, privacy, fairness, and accountability
Human-centred professionalism	Preserving relational, emotional, cultural, and ethical dimensions of teaching
AI-aware assessment	Designing assessment appropriate to AI-mediated learning environments
Lifelong adaptability	Continuously adapting professional knowledge as AI evolves

These dimensions suggest that the future teacher should not be conceptualised as an operator of AI tools, but as a critical and ethical professional capable of collaborating with, evaluating, and governing AI in educational contexts.

4.11 A Conceptual Proposition for AI-Responsive Teacher Education

The findings support a conceptual model in which educational transformation does not result from AI capability alone. Instead, meaningful transformation emerges from the interaction of technological capability with professional competence, institutional readiness, ethical governance, human agency, and contextual conditions.

Conceptually:

AI capability + teacher competence + institutional readiness + ethical governance + human agency + contextual responsiveness → meaningful transformation of teacher preparation

This proposition challenges technological determinism. AI does not independently determine the future of teacher education. Rather, the educational consequences of AI are shaped by the decisions of teachers, teacher educators, institutions, policymakers, and wider society.

The implication is particularly important for teacher education policy. Preparing teachers for AI should not mean preparing them for a particular platform or software application. It should mean developing the professional capacity to understand, interrogate, adapt, and ethically govern evolving AI technologies.

4.12 Implications for Teacher Education Policy and Practice

The findings have several implications for teacher education.

First, AI literacy should become an integral component of teacher professional preparation rather than an optional technological specialism. Second, AI should be embedded across teacher-education curricula. It should be connected to pedagogy, curriculum, assessment, professional ethics, educational psychology, practicum, and continuing professional development.

Third, teacher educators require sustained professional learning to develop both technical understanding and critical pedagogical competence in AI.

Fourth, teacher-education institutions require explicit frameworks governing responsible AI use, including privacy, data protection, transparency, academic integrity, bias, and accountability.

Fifth, AI adoption should be accompanied by investment in infrastructure and equitable access, particularly in contexts where technological inequalities may constrain meaningful participation.

Finally, teacher preparation should prioritise adaptability rather than platform-specific competence. Given the rapid pace of AI development, teachers require the intellectual and professional capacity to evaluate new technologies continuously rather than simply learning how to use currently available systems.

4.13 Conclusion of the Findings and Discussion

The critical literature demonstrates that AI is beginning to alter the conditions under which teaching and teacher preparation are conceptualised. Its significance extends beyond automating routine educational tasks to challenging established assumptions about professional knowledge, teacher identity, pedagogy, assessment, ethics, and institutional responsibility.

The central argument emerging from the review is that the appropriate response to AI is neither uncritical adoption nor blanket resistance. What is required is a critical, human-centred, ethically governed, and pedagogically grounded approach to AI integration.

AI should therefore not be positioned as a replacement for teachers. Rather, teacher education should prepare professionals who can work intelligently and critically with AI while retaining responsibility for educational judgement and human relationships.

The transformation required is consequently not:

Teacher → AI but:

Teacher + AI + critical competence + ethical judgement + human agency → transformed professional practice.

This distinction provides the foundation for a new paradigm of teacher preparation—one that prepares teachers not merely to use emerging technologies, but to critically shape how those technologies contribute to teaching, learning, professional practice, and educational equity.

5. Discussion, Conclusions and its Implications

5.1 Introduction

The preceding analysis examined the rapidly expanding literature on artificial intelligence (AI), particularly generative artificial intelligence (GenAI), and its implications for teacher education. This chapter synthesises and critically interprets the major findings of the review and considers their implications for the future of teacher preparation. The argument advanced is that AI should not be understood simply as another educational technology to be added to existing teacher education programmes. Rather, its increasing capacity to generate instructional content, support planning, provide feedback, personalise learning and participate in educational interactions challenges established assumptions concerning teacher knowledge, pedagogy, assessment, professional learning and teacher agency.

Recent research confirms the rapid expansion of scholarship concerning AI and pre-service teacher education. A large-scale scientometric and systematic review of 229 publications from 2011 to 2025 found a sharp increase in research following the emergence of generative AI, accompanied by a shift from an emphasis on teaching efficiency towards the development of AI-literate educators. Nevertheless, the research field remains relatively young and exploratory, with considerable geographical concentration and limited international collaboration. This combination of rapid technological development and an emerging evidence base reinforces the need for critical rather than technologically deterministic approaches to teacher preparation.

The central proposition of this chapter is therefore that teacher education requires a transition from a technology-integration paradigm towards an AI-integrated, human-centred paradigm of teacher preparation. Within this paradigm, AI is treated as an augmentative capability rather than a substitute for professional expertise, while teachers retain responsibility for educational purposes, pedagogical judgement, ethical decision-making and the development of meaningful human relationships in learning.

5.2 Synthesis of the Major Findings

The critical review generated six interconnected findings.

First, AI is transforming the nature of teachers' professional work. Generative AI can increasingly support lesson planning, instructional resource development, differentiation, feedback, assessment and professional learning. Evidence from recent reviews suggests that GenAI is being used across multiple aspects of teachers' professional activity, including resource generation, instructional design, personalised assessment and professional learning (Author et al., 2026). However, the availability of these capabilities does not imply that teachers' professional roles are becoming unnecessary. Rather, the location of professional expertise is changing. Second, AI literacy is becoming an essential component of contemporary teacher competence. UNESCO's AI Competency Framework for Teachers identifies 15 competencies across five dimensions: a human-centred mindset, ethics of AI, AI foundations and applications, AI pedagogy, and AI for professional learning (Miao & Cukurova, 2024). This framework is significant because it conceptualises AI competence as considerably broader than technical proficiency.

Third, the pedagogical value of AI depends substantially on teacher mediation. Recent research with pre-service teachers indicates recognition of AI's potential to support personalised learning and classroom efficiency, alongside concerns about overreliance, loss of the human element, privacy and algorithmic bias (Kohnke et al., 2025). AI therefore cannot be regarded as inherently pedagogically beneficial. Its educational value depends upon the quality of the teacher's judgement concerning when, why and how it is employed.

Fourth, ethical considerations are integral to AI competence. AI systems raise questions concerning bias, privacy, transparency, accountability, intellectual property, academic integrity and human agency. These issues have long been recognised in the literature on AI in education (Holmes et al., 2022; Nguyen et al., 2023) and have become increasingly important with the widespread availability of generative systems.

Fifth, teacher educators themselves require significant professional development. Research indicates that teacher educators hold mixed views concerning GenAI and identify needs in AI literacy, AI pedagogy and AI assessment, together with opportunities for formal and collaborative professional learning (Dilek et al., 2025). Consequently, the transformation of teacher education cannot be achieved by focusing exclusively on pre-service teachers.

Sixth, the evidence base remains uneven. Recent mapping studies demonstrate strong growth in AI research concerning pre-service teachers, but also reveal concentration in developed regions and the relatively early stage of the research field. This limitation is particularly significant when considering African and other developing educational contexts.

Taken together, these findings suggest that AI is not simply creating a new category of educational tools. It is altering the professional knowledge and judgement required of teachers.

5.3 Artificial Intelligence and the Transformation of the Teacher's Professional Role

One of the most consequential implications of AI concerns the changing nature of teachers' professional work. Traditional digital technologies generally expanded the resources available to teachers while leaving the teacher primarily responsible for creating, selecting and organising instructional content. Generative AI introduces a qualitatively different situation because AI systems can produce possible explanations, learning activities, assessment items, lesson plans and other instructional materials.

UNESCO (Miao & Cukurova, 2024) characterises this development as a movement from the conventional teacher–student relationship towards a teacher–AI–student dynamic. This transformation does not necessarily diminish the importance of teachers. Instead, it increases the importance of professional judgement because AI-generated material requires evaluation, contextualisation and pedagogical adaptation.

The emerging professional role can consequently be understood as one of pedagogical orchestration. Teachers increasingly need to coordinate human and technological capabilities while determining the appropriate balance between them. The teacher becomes less exclusively a transmitter or producer of information and increasingly a mediator, evaluator, designer and ethical decision-maker.

This distinction is important because knowing how to operate an AI system is not equivalent to possessing professional AI competence. A teacher may be able to generate a lesson plan using an AI system but lack the knowledge required to determine whether the resulting lesson is accurate, culturally appropriate, inclusive or pedagogically defensible. Teacher education must therefore move beyond operational proficiency towards professional judgement.

5.4 From Digital Competence to AI Competence

The emergence of AI requires a broader conception of digital competence. Existing scholarship has conceptualised AI literacy as involving knowledge and skills necessary for understanding, evaluating and interacting with AI systems (Ng et al., 2021; Laupichler et al., 2022). In teacher education, however, AI literacy must be connected explicitly to pedagogical and professional purposes.

A critical conception of teacher AI competence can be organised around four interconnected dimensions.

The first is technical AI understanding, which involves basic knowledge of AI systems, generative models, data, algorithms and technological limitations.

The second is pedagogical AI competence, which concerns the capacity to integrate AI into curriculum planning, instruction, differentiation, assessment and learning activities.

The third is critical AI literacy, involving the ability to interrogate AI outputs, verify information, recognise bias and evaluate the reliability and relevance of generated content. Dilek et al. (2025) argue for sustained, reflective engagement with AI literacy rather than short-term exposure to AI tools.

The fourth is ethical AI competence, which involves understanding issues of privacy, fairness, accountability, transparency, intellectual property and human agency.

These dimensions are mutually reinforcing. Technical knowledge without pedagogical understanding may encourage inappropriate implementation; pedagogical knowledge without critical literacy may result in uncritical acceptance of AI-generated content; and both without ethical competence may create risks for learners and institutions.

The implication is that AI competence should be treated as an integrated professional capability rather than a technical skill.

5.5 Implications for Teacher Knowledge and Pedagogy

The emergence of generative AI also challenges established conceptions of teacher knowledge. The Technological Pedagogical Content Knowledge (TPACK) framework remains useful because it emphasises the interaction between technology, pedagogy and subject matter. However, generative AI introduces a new complexity because the technology can itself produce content and pedagogical suggestions (Mishra et al., 2023).

Consequently, teacher preparation must increasingly develop AI-mediated pedagogical reasoning. Student teachers should learn to evaluate AI-generated resources by asking whether they are factually accurate, aligned with curriculum objectives, appropriate for learners' developmental levels, culturally responsive, inclusive and pedagogically meaningful.

Such evaluation requires substantial pre-existing pedagogical knowledge. AI does not eliminate the need for teachers to understand learning theory, curriculum, assessment, child development or classroom management. Rather, these forms of professional knowledge become essential for judging the quality and appropriateness of AI-generated suggestions.

Recent research supports this interpretation. Kohnke et al. (2025) found that pre-service teachers recognised the potential of AI while simultaneously expressing concerns about overreliance and the loss of human elements in teaching. Such findings suggest that AI integration should be accompanied by explicit attention to teacher agency and professional judgement.

5.6 Artificial Intelligence and the Transformation of Assessment

Assessment is one of the areas most substantially affected by generative AI. AI systems can produce essays, explanations, summaries, responses to questions and other forms of academic work, thereby complicating traditional relationships between submitted products and individual learning.

The appropriate response should not be limited to developing mechanisms for detecting AI-generated work. Instead, teacher education should reconsider what constitutes valid evidence of learning. AI makes it increasingly important to design assessments that reveal reasoning, application, reflection and the process through which a learner arrives at a response.

Assessment approaches may therefore include authentic tasks, oral explanations, reflective commentary, iterative assignments, demonstrations, project-based learning and critical evaluation of AI-generated outputs.

The purpose is not necessarily to prohibit AI. Rather, assessment should establish clearly when AI may appropriately support learning and when independent performance is necessary to establish competence. This approach is consistent with broader scholarship arguing that AI-enabled learning environments require reconsideration of knowledge and assessment practices (Cope et al., 2021). Teacher education programmes should consequently prepare future teachers to design assessment around learning outcomes, reasoning and authentic performance, rather than relying exclusively on conventional products.

5.7 Artificial Intelligence and Teacher Professional Learning

AI also has the potential to transform continuing professional development. Teachers can use AI to explore instructional strategies, generate resources, obtain feedback, support reflection and identify professional learning materials. Recent research suggests that teacher development is one of the important areas in which GenAI can contribute to professional competence.

However, AI-supported professional learning should not replace professional communities. Teachers require opportunities to discuss AI-generated suggestions with colleagues, compare experiences, interrogate assumptions and contextualise recommendations.

The emerging model should therefore combine AI-supported individual learning with human professional collaboration.

This has direct implications for teacher educators. Teacher educators need opportunities to develop AI literacy and pedagogical competence themselves so that they can support future teachers effectively. Dilek et al. (2025) found that teacher educators identified AI literacy, AI didactics and AI assessment as important dimensions of their professional development.

Teacher education institutions should consequently move away from isolated workshops focused on particular AI applications towards continuous professional learning involving experimentation, collaboration, reflection and evidence-informed practice.

5.8 Towards a New Paradigm of Teacher Preparation

The central contribution of this review is the proposition that AI requires a transition from a technology-addition paradigm to a human-centred AI-integrated paradigm of teacher preparation.

The conventional model can be represented as:

- Content Knowledge + Pedagogical Knowledge → Teacher → Learner

The technology-integration model expands this to:

- Content Knowledge + Pedagogical Knowledge + Technological Knowledge → Teacher → Learner

The emerging AI environment requires a more comprehensive model:

- Content Knowledge + Pedagogical Knowledge + AI Competence + Critical Judgement + Ethical Agency → Teacher–AI Orchestration → Learner Development

The distinction is fundamental. AI is positioned as a resource within professional practice rather than as the determinant of educational purposes. The proposed paradigm is based on five principles.

5.8.1 Human-Centredness

Educational purposes should remain fundamentally human. AI should be evaluated according to whether it promotes learning, inclusion, wellbeing, autonomy and educational quality. UNESCO's framework explicitly places human-centredness and human agency at the centre of teacher AI competence (Miao & Cukurova, 2024).

5.8.2 Criticality

Teachers should be prepared to question AI outputs rather than treat them as inherently authoritative. Critical evaluation must become a routine component of AI-supported teaching (Dilek et al., 2025).

5.8.3 Pedagogical Purposefulness

AI should be used because it advances an identifiable educational purpose rather than because the technology is available. This principle guards against technological determinism.

5.8.4 Ethical Responsibility

Teachers must understand the ethical consequences of AI use and remain responsible for protecting learners' privacy, dignity, rights and educational interests (Holmes et al., 2022; Nguyen et al., 2023).

5.8.5 Professional Agency

AI should augment teacher capability without displacing professional judgement. Teacher agency is therefore not an optional feature of AI integration but a central condition for responsible implementation (Miao & Cukurova, 2024).

5.9 Reconfiguring the Teacher Education Curriculum

The proposed paradigm has direct implications for curriculum design. AI should not be confined to a single course detached from other dimensions of teacher preparation. Instead, AI competence should be developed progressively across the curriculum.

Educational psychology can examine AI-supported personalisation and learner differences. Curriculum studies can address AI-assisted curriculum design and critical evaluation of generated content. Pedagogy courses can explore AI-supported instructional strategies. Assessment courses can examine AI-mediated feedback, academic integrity and alternative assessment approaches. Research methodology can address responsible uses of AI in scholarly work. Teaching practicum can provide opportunities for student teachers to evaluate AI use in authentic classroom contexts.

This cross-curricular approach is preferable to treating AI as an isolated technological specialisation. Recent work on initial teacher education similarly indicates the importance of developing pre-service teachers' confidence, problem-solving capacity, ethical understanding and awareness of data privacy through authentic tasks (Bond et al., 2025).

The curriculum should also progress from foundational understanding towards application, critical evaluation and independent professional judgement. The important question should therefore move from "How do I use this AI tool?" to "Should I use it in this context, why should I use it, what are its limitations, and how do I remain professionally accountable for its use?"

5.10 Implications for Teacher Educators

Teacher educators occupy a strategic position in the transformation of teacher preparation. They influence not only what future teachers learn but also how those teachers understand the relationship between technology, pedagogy and professional responsibility. Teacher educators consequently require competence in AI literacy, AI pedagogy and AI-related assessment. Dilek et al. (2025) found that teacher educators recognise the need for both formal professional development and informal collaborative learning concerning GenAI.

Professional development should therefore extend beyond demonstrations of individual tools. It should involve curriculum redesign, collaborative experimentation, critical reflection, ethical analysis and examination of emerging research.

Teacher educators should increasingly function as facilitators of critical professional inquiry, enabling pre-service teachers to investigate AI's possibilities and limitations rather than simply promoting its adoption.

5.11 Implications for Pre-Service Teachers

Pre-service teachers require a professional identity appropriate to an AI-mediated educational environment. They should graduate with the capacity to use AI without becoming dependent upon it.

Specifically, teacher preparation should enable graduates to:

- explain fundamental AI concepts and capabilities;
- identify appropriate and inappropriate educational uses of AI;
- evaluate the accuracy and relevance of AI-generated information;
- recognise bias and technological limitations;
- design pedagogically meaningful AI-supported learning experiences;
- use AI responsibly in assessment and feedback;
- protect learner data and privacy;
- identify ethical and professional risks;
- maintain academic and professional integrity; and
- justify pedagogical decisions concerning AI.

Evidence from recent teacher education studies suggests that pre-service teachers often recognise AI's potential while simultaneously identifying insufficient training and institutional support as barriers to meaningful integration (Kohnke et al., 2025; Panday-Shukla, 2025). The goal should therefore not be to produce teachers who use the greatest number of AI applications. The goal should be to develop teachers who can make informed, ethical and pedagogically defensible decisions about AI.

5.12 Implications for Educational Policy

The transformation of teacher preparation cannot be achieved solely through individual experimentation. Institutional and national policy frameworks are required.

Education ministries, regulatory bodies and teacher education institutions should establish competency-oriented frameworks addressing AI knowledge, pedagogy, critical evaluation, ethics, assessment and professional learning. UNESCO's AI Competency Framework for Teachers provides an important international reference point, organising competencies across human-centredness, ethics, AI foundations and applications, AI pedagogy and professional learning (Miao & Cukurova, 2024).

Policy should additionally address data governance, privacy, intellectual property, academic integrity, equity and institutional accountability.

However, policy should avoid becoming excessively tool-specific. AI technologies are developing rapidly, and a framework tied to particular platforms may quickly become obsolete. Competency-based policy is more sustainable because it focuses on what teachers should understand and be able to do.

5.13 Implications for African and Other Developing Educational Contexts

The geographical imbalance in AI research has important implications for teacher education in developing contexts. Recent systematic mapping demonstrates that research on AI and pre-service teachers has been concentrated predominantly in developed

regions, although contributions from developing countries are beginning to increase.

African teacher education therefore requires an approach based on contextualised AI integration.

Relevant considerations include unequal access to reliable connectivity and digital devices, infrastructure limitations, multilingual classrooms, curriculum differences, teacher workload, affordability, data governance and the preservation of culturally relevant knowledge.

The objective should not be to import models developed in highly resourced contexts without adaptation. Instead, African institutions should contribute actively to the development and evaluation of AI-supported teacher education models appropriate to their own educational priorities. This is particularly important because AI can simultaneously create opportunities and intensify existing inequalities. Institutions with stronger infrastructure and financial resources may benefit disproportionately, while poorly resourced institutions may struggle to participate meaningfully in AI-enabled transformation.

Equity must therefore be treated as a central component of AI readiness.

5.14 A Conceptual Model of the AI-Ready Teacher

Based on the synthesis of the literature, this study proposes the concept of the AI-Ready Teacher as a conceptual foundation for a new paradigm of teacher preparation.

The AI-ready teacher possesses six interconnected capabilities:

- AI knowledge refers to understanding fundamental AI concepts, systems, applications and limitations.
- Pedagogical AI competence refers to the capacity to integrate AI appropriately into teaching, curriculum and assessment.
- Critical AI literacy refers to the ability to interrogate AI-generated information, verify claims, identify bias and recognise limitations.
- Ethical AI competence refers to the ability to address privacy, fairness, transparency, accountability and human agency.
- AI-supported professional learning refers to the capacity to use AI as a resource for continuing professional development while maintaining engagement with professional communities and evidence.
- Human professional agency refers to the capacity to retain responsibility for educational decisions and ensure that AI remains subordinate to legitimate educational purposes.

These dimensions should be regarded as interdependent rather than sequential. Technical knowledge without critical judgement can produce uncritical adoption; pedagogical competence without ethical awareness can create harmful practices; and ethical awareness without practical competence can limit meaningful engagement. Human professional agency provides the integrating principle that keeps AI subordinate to educational purposes.

5.15 Limitations of the Existing Literature

Although the literature provides substantial evidence of AI's transformative potential, several limitations constrain the conclusions that can be drawn.

First, the research base is relatively recent. The rapid evolution of generative AI means that evidence concerning particular applications can become outdated quickly.

Second, a considerable proportion of studies focuses on perceptions, attitudes and intentions rather than sustained changes in classroom practice or learner outcomes. Recent reviews in the literature section indicate that the field remains in an early and exploratory stage.

Third, geographical representation remains uneven. Findings generated in highly resourced educational environments cannot automatically be generalised to contexts with different infrastructures, languages, cultures and educational priorities.

Fourth, longitudinal research remains limited. More evidence is needed concerning how AI competencies developed during teacher preparation influence professional practice over time.

These limitations reinforce the importance of interpreting the literature critically rather than assuming that technological potential automatically translates into educational effectiveness.

5.16 Recommendations Based on the synthesis, the following recommendations are proposed.

5.16.1 Curriculum Reform

Teacher education institutions should embed AI competence across teacher preparation curricula rather than confining it to a single elective or short-term training programme.

5.16.2 Sustained Professional Development

Teacher educators and practising teachers should receive continuing professional development that combines technical understanding, pedagogical application, critical evaluation and ethical reflection.

5.16.3 Assessment Reform

Teacher education programmes should redesign assessment to emphasise reasoning, authentic performance, reflection, application and critical evaluation, while establishing clear principles for responsible AI use.

5.16.4 Ethical Governance

Institutions should establish policies concerning privacy, data protection, academic integrity, intellectual property, bias, transparency and accountability.

5.16.5 Contextualised Implementation

AI initiatives should be adapted to local infrastructure, language, culture, curriculum and socioeconomic realities.

5.16.6 Institutional Capacity Building

Teacher education institutions should develop the infrastructure, leadership capacity and professional support necessary for responsible AI integration.

5.16.7 Equity and Inclusion

Policymakers should ensure that AI does not widen existing educational inequalities. Access, affordability and inclusion should therefore be treated as central dimensions of AI policy.

5.16.8 Research Investment

Greater investment is required in longitudinal, mixed-method and comparative research examining AI's effects on teacher competence, teacher identity, professional autonomy and learner outcomes.

5.17 Directions for Future Research

The review identifies several priorities for future scholarship:

- First, longitudinal research is needed to determine whether AI competencies developed during teacher education are sustained and translated into professional practice.
- Second, research should move beyond studies of attitudes and perceptions towards investigations of actual classroom practice and learner outcomes.
- Third, comparative studies should examine AI-integrated teacher preparation across different cultural, linguistic, socioeconomic and educational contexts.
- Fourth, substantially more research is required in African and other underrepresented contexts. Such research should not simply replicate studies conducted elsewhere but should investigate locally meaningful models of AI-supported teacher preparation.
- Fifth, future studies should examine how AI affects teacher identity, professional autonomy, decision-making and the distribution of responsibility between humans and AI systems.
- Sixth, further research should investigate assessment models capable of maintaining valid evidence of learning in environments where generative AI is readily available.
- Finally, research should investigate how teachers can participate not only in the use of AI but also in its critical design, evaluation and governance.

5.18 Conclusion

This critical literature review demonstrates that artificial intelligence represents more than a new technological development within education. It constitutes a significant challenge to established conceptions of teaching, teacher knowledge, assessment, professional learning and teacher preparation.

The principal implication is that teacher education must move beyond narrow technology integration. Preparing teachers merely to operate AI tools is insufficient. Teachers require the capacity to understand AI, evaluate its outputs, integrate it pedagogically, recognise its limitations, address its ethical implications and retain professional responsibility for educational decisions.

The transformation can therefore be understood as a movement from technological competence to AI competence; from tool use to pedagogical orchestration; from information transmission to critical knowledge mediation; from product-centred assessment to process and performance; from episodic professional development to continuous AI-supported learning; and from technological dependence to human professional agency.

The proposed new paradigm is therefore AI-augmented but human-led teacher preparation.

Within this paradigm, AI contributes computational capability, generative capacity, analytical assistance and opportunities for personalisation, while teachers retain responsibility for educational purpose, contextual interpretation, ethical judgement, relational engagement and professional accountability. The objective is neither to prepare teachers to compete with artificial intelligence nor to produce teachers who depend upon it. Rather, teacher education should prepare professionally autonomous educators who can work critically, creatively and ethically with AI.

The future of teacher education consequently depends not simply on how rapidly institutions adopt AI, but on how thoughtfully they redefine professional competence in response to it. The most important question is therefore not whether AI will change teacher education, but what kind of teacher education should emerge from that transformation.

This review argues for a paradigm in which AI is critically integrated, ethically governed, pedagogically purposeful and firmly subordinated to human educational values. Such a paradigm provides a foundation for teacher preparation that responds to technological transformation while preserving professional autonomy, educational equity and the fundamentally human purposes of teaching and learning.

References

- [1] Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education: Addressing ethical challenges in K–12 settings. *AI and Ethics*, 2(3), 431–440. <https://doi.org/10.1007/s43681-021-00096-7>
- [2] Ayanwale, M. A., Adelana, O. P., Molefi, R. R., Adeeko, O., & Ishola, A. M. (2024). Examining artificial intelligence literacy among pre-service teachers for future classrooms. *Computers and Education: Artificial Intelligence*, 6, 100179. <https://doi.org/10.1016/j.caeai.2024.100179>
- [3] Bond, M., Oxley, E., & Lymperis, L. (2025). AI applications in initial teacher education: A systematic mapping review. In *Handbook of artificial intelligence in higher education* (pp. 550–575). Edward Elgar Publishing. <https://doi.org/10.4337/9781035338764.00046>
- [4] C., & Wu, M. (2025). Developing pre-service language teachers' GenAI literacy: An interventional study in an English language teacher education course. *Discover Artificial Intelligence*, 5, 163. [First author's name is incomplete in the source list.]
- [5] Cope, B., Kalantzis, M., & Searsmith, D. (2021). Artificial intelligence for education: Knowledge and its assessment in AI-enabled learning ecologies. *Educational Philosophy and Theory*, 53(12), 1229–1245. <https://doi.org/10.1080/00131857.2020.1728732>

- [6] Dilek, M., Baran, E., & Aleman, E. (2025). AI literacy in teacher education: Empowering educators through critical co-discovery. *Journal of Teacher Education*, 76(3), 294–311. <https://doi.org/10.1177/00224871251325083>
- [7] Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2022). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education*, 32, 504–526.
- [8] Huang, T., Wu, C., & Wu, M. (2025). Developing pre-service language teachers' GenAI literacy: An interventional study in an English language teacher education course. *Discover Artificial Intelligence*, 5(1), Article 163. <https://doi.org/10.1007/s44163-025-00435-1>
- [9] Kohnke, L., Zou, D., Ou, A. W., & Gu, M. M. (2025). Preparing future educators for AI-enhanced classrooms: Insights into AI literacy and integration. *Computers and Education: Artificial Intelligence*, 8, 100398. <https://doi.org/10.1016/j.caeai.2025.100398>
- [10] Kokoç, M., Ağırman, Ş., & Yağmurlu, B. N. (2026). Mapping in-service teacher AI literacy: A systematic review of empirical studies. *Teaching and Teacher Education*, 181, 105707. <https://doi.org/10.1016/j.tate.2026.105707>
- [11] Laupichler, M. C., Aster, A., Schirch, J., & Raupach, T. (2022). Artificial intelligence literacy in higher and adult education: A scoping literature review. *Computers and Education: Artificial Intelligence*, 3, 100101. <https://doi.org/10.1016/j.caeai.2022.100101>
- [12] Miao, F., & Cukurova, M. (2024). AI competency framework for teachers. UNESCO. <https://doi.org/10.54675/ZJTE2084>
- [13] Mishra, P., Warr, M., & Islam, R. (2023). TPACK in the age of ChatGPT and generative AI. *Journal of Digital Learning in Teacher Education*, 39(4), 235–251.
- [14] Ng, D. T. K., Leung, J. K. L., Chu, S. K. W., & Qiao, M. S. (2021). Conceptualizing AI literacy: An exploratory review. *Computers and Education: Artificial Intelligence*, 2, 100041. <https://doi.org/10.1016/j.caeai.2021.100041>
- [15] Nguyen, A., Ngo, H. N., Hong, Y., Dang, B., & Nguyen, B. P. T. (2023). Ethical principles for artificial intelligence in education. *Education and Information Technologies*, 28(4), 4221–4241.
- [16] OECD. (2024). Education policy outlook 2024: Reshaping teaching into a thriving profession from ABCs to AI. <https://doi.org/10.1787/dd5140e4-en>
- [17] OECD. (2025). What should teachers teach and students learn in a future of powerful AI? (OECD Education Spotlights No. 20). <https://doi.org/10.1787/ca56c7d6-en>
- [18] Panday-Shukla, P. (2025). Exploring generative artificial intelligence in teacher education. *Teaching and Teacher Education*, 165, 105088. <https://doi.org/10.1016/j.tate.2025.105088>
- [19] Shi, L. (2025). Assessing teachers' generative artificial intelligence competencies: Instrument development and validation. *Education and Information Technologies*, 30, 23365–23384.
- [20] Sperling, K., Stenberg, C.-J., McGrath, C., Åkerfeldt, A., Heintz, F., & Stenliden, L. (2024). In search of artificial intelligence (AI) literacy in teacher education: A scoping review. *Computers and Education Open*, 6, 100169. <https://doi.org/10.1016/j.caeo.2024.100169>
- [21] UNESCO. (2023). Guidance for generative AI in education and research.
- [22] UNESCO. (2024). AI competency framework for teachers.
- [23] UNESCO Institute for Information Technologies in Education. (2026). Analytical report: Teacher AI competency frameworks. UNESCO IITE.