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ARTICLE

DEVELOPING AN INTEGRATED AI PEDAGOGICAL FRAMEWORK FOR PRE-SERVICE TEACHERS

Desenvolvimento de um Framework Pedagógico Integrado de Inteligência Artificial para a Formação Inicial de Professores

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ABSTRACT | Purpose: This study aims to develop an Integrated AI Pedagogical Framework (IAPF) for pre-service teacher education, addressing the need to prepare future teachers to integrate artificial intelligence in technically informed, pedagogically sound, ethically responsible, and culturally responsive ways. **Method:** The study adopts a conceptual research approach grounded in a constructivist-interpretivist paradigm. It uses conceptual framework analysis based on the systematic synthesis of literature, theoretical perspectives, and international and national policy documents related to artificial intelligence, education, and teacher preparation. **Findings:** The proposed framework integrates four interrelated competency domains: technical, pedagogical, ethical, and cultural. These domains are guided by six core principles: human-centred pedagogy, dynamic adaptability, equity and inclusion, ethical responsibility, cultural responsiveness, and policy alignment. The model offers a multidimensional approach to overcoming the fragmentation of existing frameworks and supporting teacher preparation for AI-mediated educational environments. **Contributions:** The study contributes to the literature by proposing an integrated conceptual model for pre-service teacher education, articulating competencies, principles, and guidelines for the responsible use of AI in education. The framework provides support for curriculum design, teacher preparation, competency assessment, and future empirical research. **Originality:** The originality of the study lies in its integrated model, which positions ethical and cultural dimensions as central rather than peripheral components of teacher preparation for artificial intelligence use in diverse educational contexts.

Keywords | Artificial Intelligence in Education; Pre-service Teacher Education; Teacher Competencies; Ethical AI; Cultural Responsiveness.

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RESUMO | Objetivo: Este estudo tem como objetivo desenvolver um Framework Pedagógico Integrado de Inteligência Artificial para a formação inicial de professores, considerando a necessidade de preparar futuros docentes para integrar a IA de forma técnica, pedagógica, ética e culturalmente responsável. **Metodologia:** A pesquisa adota uma abordagem conceitual, fundamentada no paradigma construtivista-interpretativista. O estudo utiliza análise de framework conceitual, com base na síntese sistemática da literatura, de perspectivas teóricas e de documentos de políticas internacionais e nacionais sobre inteligência artificial, educação e formação docente. **Resultados:** O framework proposto integra quatro domínios de competência inter-relacionados: técnico, pedagógico, ético e cultural. Esses domínios são orientados por seis princípios fundamentais: pedagogia centrada no ser humano, adaptabilidade dinâmica, equidade e inclusão, responsabilidade ética, responsividade cultural e alinhamento com políticas educacionais. O modelo apresenta uma abordagem multidimensional para superar a fragmentação dos frameworks existentes e apoiar a preparação de professores para ambientes educacionais mediados por IA. **Contribuições:** O estudo contribui para a literatura ao propor um modelo conceitual integrado, aplicável à formação inicial de professores, que articula competências, princípios e diretrizes para o uso responsável da IA na educação. O framework oferece subsídios para currículo, formação docente, avaliação de competências e futuras pesquisas empíricas. **Originalidade:** A originalidade do estudo está na proposição de um modelo integrado que posiciona as dimensões ética e cultural como componentes centrais, e não periféricos, da formação docente para o uso da inteligência artificial em contextos educacionais diversos.

Palavras-chave | Inteligência Artificial na Educação; Formação Inicial de Professores; Competências Docentes; Ética em IA; Responsividade Cultural.

INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) has brought about a profound transformation across multiple domains, with education experiencing particularly significant disruption. From adaptive learning platforms and intelligent tutoring systems to automated assessment tools and personalised content delivery, AI is fundamentally reshaping how knowledge is created, accessed, and disseminated (Hwang et al., 2020; Zawacki-Richter et al., 2019). These technologies represent more than supplementary tools, they constitute a paradigmatic shift in the teaching-learning process that demands systematic integration into teacher preparation programmes.

Contemporary teacher education programmes face an unprecedented challenge that extends beyond traditional technology integration. While conventional frameworks like Technological Pedagogical Content Knowledge (TPACK) have successfully guided the incorporation of static technologies, they prove inadequate for addressing the unique characteristics of AI systems. Unlike traditional educational technologies, AI systems are adaptive, autonomous, and continuously evolving, possessing capabilities to generate content, personalise learning pathways, analyse complex datasets, and simulate human-like interactions (Holmes et al., 2019; Luckin et al., 2022). Recent empirical investigations reveal concerning disparities in pre-service teacher preparedness for AI-integrated environments. While some teacher education institutions experiment with AI-based pedagogies, others lack structured approaches, creating uneven competency distributions among future educators (Hastomo et al., 2024; Aktulun et al., 2024). Comparative international studies indicate similar patterns across developed and developing educational systems, with significant variations in institutional capacity and pedagogical integration strategies (Akgun & Greenhow, 2022; Celik, 2023).

Current AI integration frameworks in teacher education exhibit several critical limitations that demand systematic attention. Framework fragmentation represents a primary concern, as existing approaches often focus on isolated competencies rather than comprehensive integration. Recent reviews of AI literacy frameworks reveal a predominant emphasis on technical skills while neglecting pedagogical reasoning and ethical considerations specific to educational contexts (Ng et al., 2021a; Long & Magerko, 2020). Additionally, international frameworks, particularly those developed in Western contexts, often demonstrate cultural and contextual blindness, failing to address diversity in educational practices. Studies from African and Global South contexts highlight the urgent need for culturally responsive AI integration approaches that respect indigenous pedagogical traditions (Quarshie et al., 2025; Akgun & Greenhow, 2022).

Most existing frameworks suffer from static conceptualisation, treating AI as a fixed technology rather than recognising its dynamic, evolving nature. This approach inadequately prepares teachers for the continuous adaptation required in AI-mediated learning environments (Zawacki-Richter et al., 2019). Furthermore, while technical competencies receive considerable attention across various frameworks, ethical reasoning and critical evaluation of AI systems remain peripheral in most teacher preparation models. Recent incidents of AI bias in educational settings underscore the urgency of embedding ethical reasoning as a core competency rather than an optional consideration (Baker & Hawn, 2022). The integration of AI in teacher education aligns with multiple theoretical and policy frameworks that demand more systematic approaches. The United Nations' Sustainable Development Goal (SDG 4) emphasises preparing teachers who can use technology responsibly to expand access and improve learning outcomes, while the UNESCO AI and Education framework (2021) specifically calls for teacher preparation programmes that develop both technical competencies and critical evaluation skills. In the Indian context, the National Education Policy (NEP) 2020 positions digital integration and ethical technology use as fundamental to educational transformation, yet implementation guidance for teacher education institutions remains limited (Government of India, 2020).

The integration of AI in education must be fundamentally grounded in human-centred pedagogical principles that preserve the essential elements of effective teaching. While AI offers unprecedented opportunities for personalisation and efficiency, it cannot replace the relational, emotional, and cultural dimensions of teaching that form the foundation of meaningful educational experiences (Holmes et al., 2019). Teacher education programmes must prepare future educators to strategically leverage AI's affordances while steadfastly safeguarding principles of equity, empathy, critical thinking, and cultural responsiveness.

This study addresses the identified gaps through the development of an Integrated AI Pedagogical Framework (IAPF) specifically designed for pre-service teacher education. Unlike existing approaches that retrofit AI competencies onto traditional frameworks, the IAPF represents a comprehensive reconceptualisation that integrates technical, pedagogical, ethical, and cultural competencies within a unified framework. Through systematic literature synthesis, conceptual framework analysis, and multi-layered conceptual validation, this research contributes to the growing body of knowledge on AI integration in teacher education while providing practical, evidence-based guidance for implementation across varied institutional contexts. This study

employs a conceptual research methodology grounded in a constructivist–interpretivist paradigm, drawing exclusively on secondary literature and policy documents to develop and validate the IAPF.

NEED AND SIGNIFICANCE OF THE STUDY

The rapid proliferation of artificial intelligence in educational contexts has created an unprecedented gap between technological advancement and teacher preparation. Despite the growing integration of AI tools, including intelligent tutoring systems, generative AI platforms, automated assessment technologies, and adaptive learning environments, teacher education programmes have been slow to develop systematic and coherent responses to these developments (Zawacki-Richter et al., 2019; Sperling et al., 2024). This disparity leaves pre-service teachers inadequately prepared for classrooms that are increasingly mediated by intelligent technologies, raising serious concerns about the readiness of the next generation of educators to engage with AI in ways that are technically informed, pedagogically sound, ethically responsible, and culturally sensitive.

Current teacher preparation approaches to AI integration remain largely fragmented and institution-dependent. Empirical evidence demonstrates significant disparities in AI readiness among pre-service teachers, with non-STEM educators reporting substantially higher levels of anxiety and lower confidence in AI integration compared to their STEM counterparts (Aktulun et al., 2024). These disciplinary differences are compounded by the inadequacy of existing frameworks to guide AI integration comprehensively. Frameworks such as TPACK, while foundational for technology integration, prove insufficient for addressing AI's unique characteristics of adaptability, autonomy, and continuous evolution (Holmes et al., 2019; Celik, 2023). The absence of a unified, comprehensive model means that pre-service teachers receive inconsistent and often superficial exposure to AI competencies, with technical training frequently prioritised over the pedagogical, ethical, and cultural dimensions that are equally essential for effective AI-mediated teaching (Ng et al., 2021a; Long & Magerko, 2020).

The urgency of this need is further amplified by rapid developments in educational AI policy at both international and national levels. UNESCO's AI and Education guidelines (2021) explicitly call for systematic teacher preparation that encompasses technical competencies alongside critical evaluation skills, ethical reasoning, and cultural responsiveness. At the national level, India's National Education Policy (NEP) 2020 mandates the integration of digital technologies into education and emphasises the importance of teacher capacity building, yet stops short of providing detailed implementation frameworks for teacher education institutions (Government of India, 2020). This policy-practice gap threatens to perpetuate and deepen educational inequities, as institutions with greater financial and technological resources advance AI integration while others, particularly in under-resourced and Global South contexts, continue to lag behind (Quarshie et al., 2025; Akgun & Greenhow, 2022).

Taken together, these converging challenges, fragmented frameworks, unequal teacher preparedness, and insufficient policy guidance, underscore the critical need for a structured, evidence-based model that prepares pre-service teachers holistically for AI-enhanced educational environments. The Integrated AI Pedagogical Framework (IAPF) proposed in this study directly

responds to this need by offering a coherent, multidimensional, and contextually responsive approach to AI integration in teacher education.

RESEARCH QUESTIONS

- RQ1. How is the Integrated AI Pedagogical Framework (IAPF) for pre-service teacher education developed through systematic literature synthesis and conceptual framework analysis?
- RQ2. What AI-related competencies, domains, and guiding principles constitute the Integrated AI Pedagogical Framework (IAPF) as informed by existing research and theoretical perspectives?
- RQ3. How coherent, relevant, and applicable is the IAPF when evaluated against existing AI education frameworks and international and national policy directives?

REVIEW OF RELATED LITERATURE

The integration of Artificial Intelligence (AI) into teacher education has generated a growing body of research, yet much of this work remains fragmented across disciplinary boundaries, with studies tending to address isolated dimensions of AI integration rather than synthesising them into a coherent model for pre-service teacher preparation. To establish the conceptual foundation for the Integrated AI Pedagogical Framework (IAPF), the literature is organised thematically into four interrelated areas: (1) AI in education: scope and evolution; (2) competency models and framework approaches; (3) ethical and cultural dimensions; and (4) implementation challenges and policy gaps. This synthesis moves beyond descriptive summaries to identify theoretical tensions and conceptual gaps that directly justify the development of the IAPF.

Theme 1: AI in Education: Scope and Evolution

The application of AI in educational settings has expanded rapidly, encompassing intelligent tutoring systems, adaptive learning platforms, automated assessment tools, and generative AI technologies. Zawacki-Richter et al. (2019) conducted a systematic review of AI in higher education and found that while AI tools hold significant promise for personalising learning and supporting student engagement, the pedagogical and human dimensions of AI adoption remain critically underexplored, and educators themselves are among the least represented groups in AI-in-education research. Holmes et al. (2019) similarly argue that teacher education programmes must simultaneously equip teachers to use AI pedagogically and to teach about AI critically and ethically, a dual mandate that existing frameworks have not adequately addressed.

The emergence of generative AI has added particular urgency to this challenge. Wei et al. (2025) demonstrated that generative AI can meaningfully enhance pre-service teachers' reflective thinking when integrated through structured pedagogical frameworks, while Sun and Huang (2025) found that such tools support more sophisticated collaborative lesson planning among pre-service

teachers. These findings confirm both the educational value and the pedagogical complexity of generative AI, reinforcing the need for principled frameworks to guide its integration into teacher preparation programmes.

Theme 2: Competency Models and Framework Approaches

The question of what competencies teachers need to integrate AI effectively has been central to the research literature. The TPACK framework (Mishra & Koehler, 2006; Koehler & Mishra, 2009), which conceptualises effective technology integration as residing at the intersection of technological, pedagogical, and content knowledge, remains widely adopted but has significant limitations in the AI context. As Holmes et al. (2019) and Celik (2023) demonstrate, AI systems are adaptive, autonomous, and continuously evolving, characteristics that demand qualitatively different forms of teacher knowledge and judgment than the relatively stable technologies for which TPACK was designed.

Several scholars have attempted to address this limitation through AI-specific frameworks. Long and Magerko (2020) proposed an AI literacy framework centred on human-AI interaction, while Ng et al. (2021a) developed a more integrative model incorporating technical understanding, critical evaluation, and ethical reasoning. Sperling et al. (2024) conducted a scoping review of AI literacy in teacher education and found that despite growing scholarly interest, AI literacy remains largely absent from teacher education programmes as a formalised and systematically integrated component, a research-to-practice gap of considerable significance. Empirical studies further reveal that pre-service teacher AI competencies are uneven and context-dependent: Hastomo et al. (2024) found that Indonesian pre-service teachers demonstrated greater confidence in using AI for content generation than for pedagogical design or ethical evaluation, while Aktulun et al. (2024) documented significant disparities between STEM and non-STEM pre-service teachers in AI attitudes and anxiety. Younis (2024) provided evidence that structured, framework-driven AI literacy programmes produce measurable improvements in pre-service teacher competency, reinforcing the value of principled, systematic approaches to AI integration in teacher preparation.

Theme 3: Ethical and Cultural Dimensions

Among the most significant and consistently underaddressed dimensions of AI in teacher education are its ethical and cultural implications. Baker and Hawn (2022) document how AI systems trained on historically unequal data reproduce and amplify existing educational inequalities, disproportionately disadvantaging students from minority and lower socioeconomic communities. Birhane (2021) extends this analysis by arguing that AI systems cannot capture the full complexity of human social life, and that uncritical reliance on AI outputs in educational decision-making carries significant risks of misrepresentation and harm. The broader societal context of technology and racial inequality, documented by Benjamin (2019), provides important background to understanding why algorithmic systems so frequently disadvantage marginalised communities in educational settings. Akgun and Greenhow (2022) identify a range of ethical challenges in K-12 AI integration,

including student data privacy, transparency, and the risk of over-reliance on automated systems, and argue for teachers who can evaluate these implications critically and advocate for their students in AI-mediated environments.

The cultural dimensions of AI integration are equally significant but receive comparatively less attention in the literature. Quarshie et al. (2025) demonstrate that globally developed AI tools frequently fail to accommodate the linguistic diversity, indigenous knowledge systems, and resource constraints of African educational settings, risking the reinforcement of existing patterns of educational inequality. Despite widespread scholarly acknowledgment of these ethical and cultural concerns, most AI education frameworks continue to treat them as peripheral rather than central considerations, a tendency that the IAPF explicitly seeks to reverse.

Theme 4: Implementation Challenges and Policy Gaps

Significant barriers to effective AI integration in teacher education persist at institutional and policy levels. Celik (2023) demonstrated that even when teachers possess relevant technological knowledge, translating this into meaningful pedagogical practice remains challenging without sustained professional development and institutional support. Ertmer and Ottenbreit-Leftwich (2010) identified teacher beliefs, confidence, and institutional culture as critical determinants of technology integration success, factors equally relevant to AI adoption. Quarshie et al. (2025) documented infrastructural and policy barriers across African higher education institutions, while Choudhury et al. (2024) highlighted the absence of validated, contextually appropriate assessment instruments as a persistent gap in the Indian context.

At the policy level, while UNESCO's AI and Education guidelines (2021) call for teacher preparation programmes that develop both technical competencies and critical evaluation skills, and India's National Education Policy 2020 (Government of India, 2020) mandates digital integration and teacher capacity building, the translation of these aspirations into actionable implementation frameworks remains limited. This policy-practice gap underscores the need for evidence-based frameworks capable of guiding systematic AI integration in teacher education at both institutional and curricular levels.

Synthesis: The Case for the IAPF

Across the four thematic areas reviewed above, a consistent pattern emerges: existing approaches to AI in teacher education address individual dimensions of the challenge without integrating these into a unified, principled, and contextually adaptable model. Theoretical frameworks such as TPACK and AI literacy models provide valuable but incomplete foundations, tending to prioritise cognitive or technical dimensions while underrepresenting the ethical, cultural, and implementation dimensions equally essential to effective AI integration. The absence of a comprehensive, integrative framework specifically designed for pre-service teacher education represents the central conceptual gap that the IAPF addresses.

RESEARCH METHODOLOGY

Research Paradigm

This study is grounded in a constructivist–interpretivist paradigm, which holds that knowledge and theoretical frameworks are socially constructed through the systematic interpretation of prior scholarship, theoretical perspectives, and conceptual reasoning rather than through objective measurement or empirical testing (Jabareen, 2009; Snyder, 2019). Such a paradigm is particularly appropriate for conceptual research, where the aim is not to generate or test empirical hypotheses but to synthesise existing scholarly knowledge into a coherent, theoretically grounded model. The present study adopts this stance in developing the IAPF: a domain where empirical investigation is still nascent and conceptual clarity is a necessary prerequisite for rigorous future inquiry.

Research Approach

A conceptual research methodology was employed, drawing upon Jabareen's (2009) conceptual framework analysis as the primary methodological anchor. Conceptual framework analysis is specifically designed for studies that seek to develop new theoretical frameworks by systematically mapping, synthesising, and integrating concepts drawn from existing scholarly literature and theoretical traditions. It is well established in educational research as a rigorous approach to framework development in fields where theoretical synthesis is both necessary and intellectually productive (Jabareen, 2009; Torraco, 2016). The approach was further informed by Snyder's (2019) framework for literature review as a research methodology. Importantly, this methodology does not involve the collection, generation, or analysis of primary empirical data of any kind. All knowledge claims in this study are derived from the systematic synthesis and theoretical integration of existing peer-reviewed literature and policy documents.

Sources of Evidence

Consistent with the conceptual and non-empirical nature of this study, the research relied exclusively on secondary sources throughout all phases of framework development. Sources published between 2018 and 2025 and addressing themes of AI integration in education, teacher competencies, AI literacy, ethical dimensions of AI, culturally responsive pedagogy, and pre-service teacher preparation were included. Databases searched included ERIC, Scopus, Web of Science, IEEE Xplore, ACM Digital Library, and Education Source. International policy frameworks including UNESCO's AI in Education guidelines (2021), India's National Education Policy 2020 (Government of India, 2020), and the United Nations' Sustainable Development Goal 4 (United Nations, 2015) were also included. Foundational theoretical works published prior to 2018, such as TPACK (Mishra & Koehler, 2006) and constructivist theory (Vygotsky, 1978; Piaget, 1972), were retained where necessary. Generative AI competency frameworks informed by emerging tools are addressed in studies such as Zhang and Villanueva (2023), whose work on digital teacher training contributed to the technical domain conceptualisation. Literature not available in the English language, grey literature, and non-peer-reviewed commentary were excluded.

Phases of Framework Development

The development of the IAPF followed a structured, sequential, and transparent six-phase process grounded in Jabareen's (2009) conceptual framework analysis methodology. Figure 1 presents a visual overview of this six-phase process.

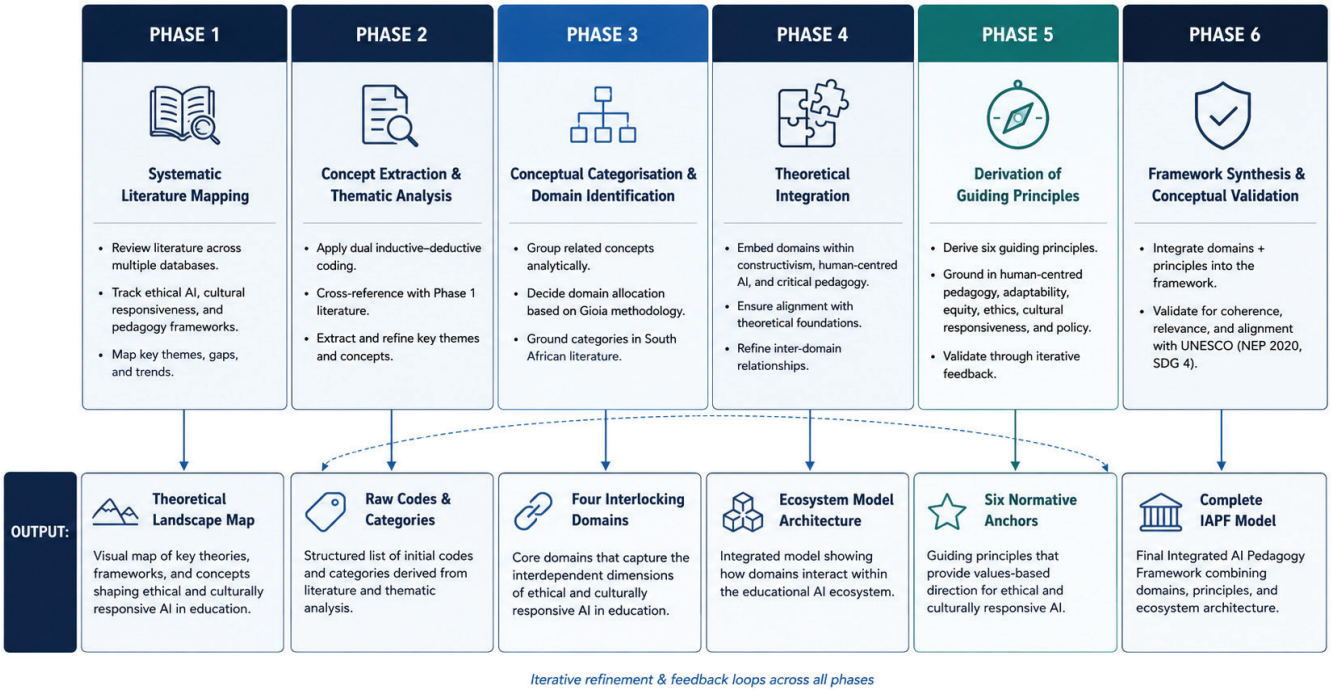

Figure 1. Six-Phase IAPF Development Process (based on Jabareen, 2009)

Table 1. Six-Phase Framework Development Process (IAPF)

Phase	Stage	Activities	Output
1	Systematic Literature Mapping	Review of AI literacy, TPACK, ethical AI, culturally responsive pedagogy, and policy frameworks across ERIC, Scopus, WoS, IEEE, ACM (2018-2025)	Theoretical landscape map
2	Concept Extraction & Thematic Analysis	Dual inductive-deductive coding using Braun & Clarke (2006); cross-referencing against TPACK, AI literacy, UNESCO frameworks	Raw codes and categories
3	Conceptual Categorisation & Domain Identification	Analytical grouping; decision to add cultural as fourth domain based on Global South literature (Quarshie et al., 2025; Akgun & Greenhow, 2022)	Four interlocking domains
4	Theoretical Integration	Domains embedded in constructivism (Vygotsky, 1978; Piaget, 1972), human-centred AI (Holmes et al., 2019), and critical pedagogy (Baker & Hawn, 2022)	Ecosystem model architecture
5	Derivation of Guiding Principles	Six principles distilled from recurring scholarly consensus: human-centred pedagogy, adaptability, equity, ethics, cultural responsiveness, policy alignment	Six normative anchors
6	Framework Synthesis & Conceptual Validation	Integration of domains + principles into complete IAPF; literature triangulation; policy alignment analysis against UNESCO (2021), NEP 2020, SDG 4	Complete IAPF model

Source: Developed by the author based on Jabareen (2009)

- **Phase 1:** Systematic Literature Mapping. The first phase involved a comprehensive and structured review of existing literature across five thematic areas: AI literacy models; TPACK and technology integration frameworks; ethical AI in education research; culturally responsive pedagogy; and international policy frameworks. The purpose of this phase was to map the existing theoretical landscape, identify recurring constructs, and locate the conceptual gaps and tensions that would justify the development of a new, integrated model.
- **Phase 2:** Concept Extraction and Thematic Analysis. In the second phase, concepts, themes, and theoretical propositions were systematically extracted from the reviewed literature using both inductive and deductive orientations, consistent with Braun and Clarke's (2006) thematic analysis approach as adapted for conceptual rather than empirical inquiry.
- **Phase 3:** Conceptual Categorisation and Domain Identification. The extracted concepts were systematically organised into higher-order conceptual categories. A significant analytical decision emerged at this stage: an initial three-domain model was found to be theoretically insufficient. Scholarly literature from Global South educational contexts provided compelling evidence that cultural responsiveness constitutes a qualitatively distinct dimension (Quarshie et al., 2025; Akgun & Greenhow, 2022), justifying the identification of cultural competence as a fourth, independent domain.
- **Phase 4:** Theoretical Integration. The four core domains were integrated within three complementary theoretical traditions: constructivist learning theory (Vygotsky, 1978; Piaget, 1972); human-centred AI principles (Holmes et al., 2019; Luckin et al., 2022); and critical perspectives on technology and power (Baker & Hawn, 2022; Birhane, 2021). This integration led to the conceptualisation of the IAPF as an ecosystem model: dynamic, non-hierarchical, iterative, and mutually reinforcing.
- **Phase 5:** Derivation of Guiding Principles. Six guiding principles were distilled from recurring theoretical emphases identified across the literature: human-centred pedagogy; dynamic adaptability; equity and inclusion; ethical responsibility; cultural responsiveness; and policy alignment. These principles serve as normative anchors ensuring the framework retains its human-centred, ethical, and contextually responsive character across varied implementation contexts.
- **Phase 6:** Framework Synthesis and Conceptual Validation. The four competency domains, six guiding principles, and their interrelationships were synthesised into the complete IAPF structure. Conceptual validation was undertaken through literature triangulation and systematic alignment analysis with existing theoretical frameworks and international and national policy directives.

Ensuring Rigour in Conceptual Research

Rigour in conceptual research is established through means appropriate to its non-empirical nature. In the present study, rigour was addressed through three strategies. Transparency was maintained through systematic and explicit documentation of all methodological decisions. Consistency was ensured by applying the same conceptual categorisation logic and decision rules

throughout all phases. Theoretical grounding was established by anchoring every component of the IAPF in multiple independent scholarly sources and aligning the framework with established theoretical traditions and policy frameworks.

Methodological Limitations

As a conceptual study grounded exclusively in secondary literature, the present research carries several inherent limitations. The exclusive reliance on English-language sources may exclude relevant scholarship published in other languages. The rapidly evolving nature of AI technologies means that specific competency frameworks referenced in the reviewed literature may require updating. Most significantly, the framework has been subjected to conceptual validation only, its effectiveness in practice remains to be established through future empirical investigation.

FINDINGS AND CONCEPTUAL ANALYSIS

Research Question 1: How is the IAPF developed through systematic literature synthesis and conceptual framework analysis?

The six-phase development process documented in the Methodology section produced several analytically significant outcomes that warrant direct attention in this findings section. Rather than reiterating the procedural sequence, this section focuses on the key conceptual decisions, theoretical tensions, and analytical trade-offs that emerged during the development of the IAPF, as these constitute the substantive findings of the conceptual inquiry.

The most consequential analytical decision in the development process was the expansion from an initial three-domain model to a four-domain architecture. Early phases of concept extraction and categorisation produced a provisional framework comprising technical, pedagogical, and ethical competencies. However, sustained engagement with Global South educational literature (Quarshie et al., 2025; Akgun & Greenhow, 2022) revealed that cultural responsiveness could not be adequately subsumed within either the ethical or pedagogical domain without losing its analytical specificity. The decision to elevate cultural competence to an independent, co-equal domain represented a significant theoretical commitment: that the geographic and linguistic situatedness of AI systems constitutes a distinct category of teacher knowledge, not a subcategory of ethical awareness. A second significant tension emerged during theoretical integration. Three theoretical traditions, constructivism, human-centred AI, and critical pedagogy, were considered as foundations. Constructivism alone would have prioritised cognitive growth and scaffolding without adequately addressing the power dynamics embedded in AI systems. Critical pedagogy alone would have foregrounded structural critique without providing a positive account of learning and development. The integration of all three traditions was therefore a deliberate response to the limitations of any single theoretical framework, producing an architecture that simultaneously affirms the importance of learning, the centrality of the human teacher, and the necessity of critical engagement with AI as a socially situated technology. A third analytical outcome was the distinction between competency

domains and guiding principles as architecturally separate but mutually constitutive elements of the IAPF. Domains define what teachers need to know and be able to do; principles define how the framework should operate across contexts. This two-tier architecture ensures that the IAPF is not merely a competency checklist but a normatively governed model capable of maintaining coherence across diverse institutional and cultural contexts.

Research Question 2: What AI-related competencies, domains, and guiding principles constitute the IAPF?

Through systematic literature synthesis and conceptual analysis, the present study identifies four interrelated competency domains and six guiding principles that together constitute the structural and normative architecture of the IAPF. These components did not emerge arbitrarily but were derived from recurring patterns, theoretical tensions, and documented gaps in the existing body of research. Figure 2 presents a visual representation of the four co-equal, non-hierarchical, and mutually reinforcing competency domains of the IAPF, while Table 2 details their key competencies and pedagogical needs.

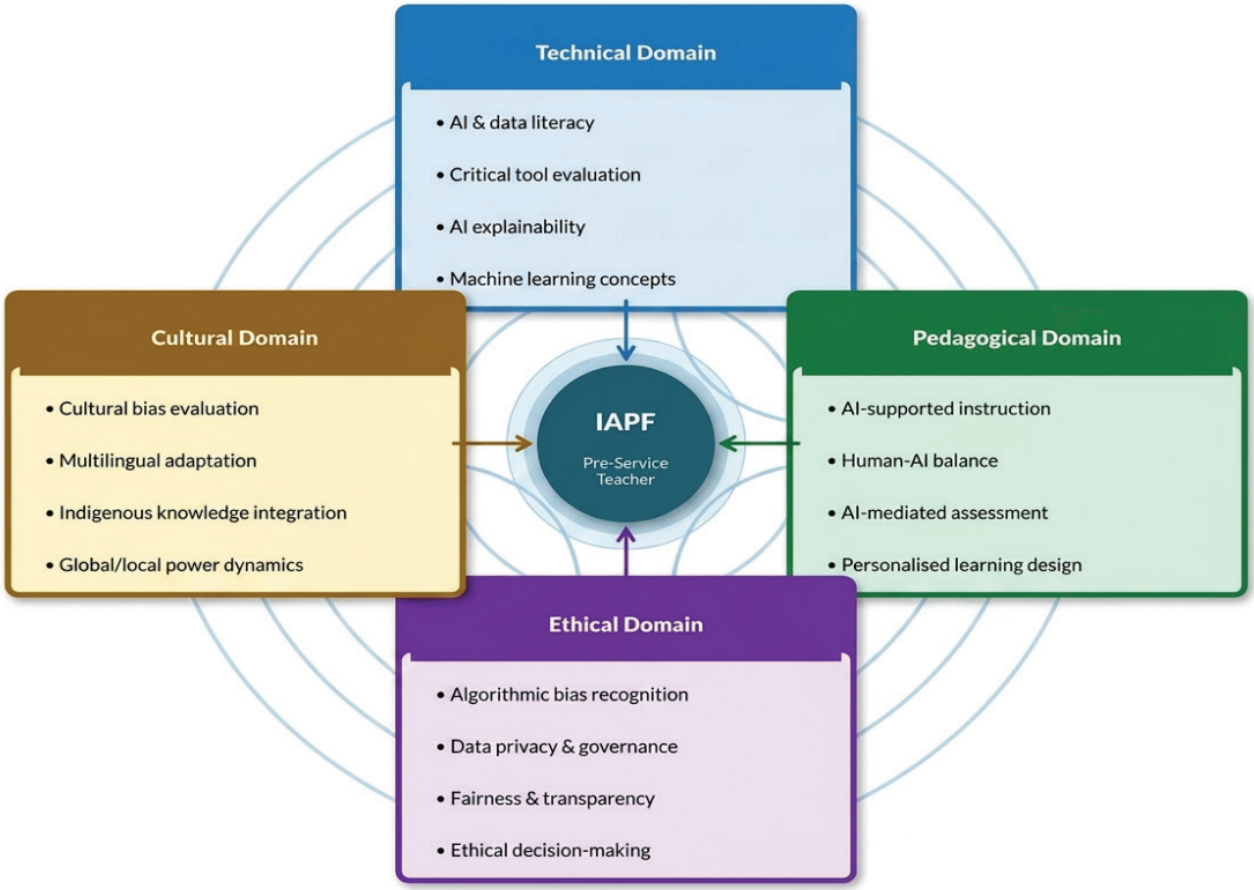

Figure 2. The Four Competency Domains of the IAPF as co-equal, non-hierarchical and mutually reinforcing components

Table 2. The Four Competency Domains of the IAPF

Domain	Key Competencies	Pedagogical Needs
Technical	AI literacy; data literacy; critical tool evaluation; AI explainability	Hands-on AI tool engagement; critical digital literacy development
Pedagogical	AI-supported instructional design; human-AI balance; AI-mediated assessment	AI-enhanced lesson planning; integrating personalisation with collaborative learning
Ethical	Algorithmic bias recognition; fairness; data privacy; transparency	Ethical decision-making training; digital rights awareness; critical reflection
Cultural	Cultural bias evaluation; multilingual adaptation; indigenous knowledge integration	Culturally responsive AI pedagogy; critical examination of global AI tools in local contexts

Source: Developed by the author based on systematic literature synthesis

1. Technical Competencies

Technical competencies constitute the foundational layer of the IAPF, providing pre-service teachers with the knowledge and skills necessary to understand, navigate, and critically engage with AI systems in educational settings. Research on AI literacy frameworks consistently demonstrates that teachers must possess more than surface-level familiarity with AI tools, they require a conceptual understanding of how AI systems function, including the principles underlying machine learning, generative AI, and intelligent tutoring systems (Ng et al., 2021a; Long & Magerko, 2020). A particularly important dimension is data literacy, the ability to interpret, evaluate, and responsibly manage educational data (Ng et al., 2021b). Closely related is AI explainability, which enables teachers to interpret AI-generated outputs and communicate them transparently to learners and colleagues (Celik, 2023).

2. Pedagogical Competencies

Pedagogical competencies address the capacity of pre-service teachers to integrate AI tools meaningfully into instructional design, classroom practice, and assessment. The existing literature consistently emphasises that AI should function as a support to, rather than a substitute for, human pedagogical decision-making (Holmes et al., 2019; Luckin et al., 2022). A central pedagogical competency is the ability to design AI-supported learning environments that enhance student engagement, foster personalisation, and maintain instructional coherence (Wei et al., 2025; Sun & Huang, 2025). This includes competence in AI-mediated assessment design, encompassing the use of automated feedback systems that complement rather than replace teacher-led evaluation (Younis, 2024).

3. Ethical Competencies

Ethical competencies represent a central and non-negotiable dimension of the IAPF. Research on algorithmic bias documents how AI systems can reproduce, amplify, and institutionalise existing

social inequalities, disproportionately disadvantaging students from marginalised communities (Baker & Hawn, 2022; Birhane, 2021). The key ethical competencies include the ability to recognise algorithmic bias and discrimination, to ensure fairness and equity in AI-mediated instruction, to protect student data privacy, and to promote transparency and accountability in AI-assisted decision-making (Baker & Hawn, 2022; Akgun & Greenhow, 2022). Embedding ethical competencies as a core dimension of teacher preparation ensures that AI is used in ways that are responsible, just, and aligned with the fundamental values of education as a humanising practice.

4. Cultural Competencies

Cultural competencies constitute the fourth domain of the IAPF and address one of the most significant and frequently overlooked dimensions of AI integration in education, the tendency of AI systems to reflect the cultural assumptions, linguistic norms, and societal biases of the predominantly Western, high-income contexts in which they are developed (Quarshie et al., 2025; Akgun & Greenhow, 2022). The key cultural competencies include the ability to evaluate cultural bias in AI systems, to adapt AI tools for use in multilingual and multicultural classrooms, to integrate local and indigenous knowledge systems within AI-supported learning environments, and to recognise power dynamics embedded within globally produced technological systems (Quarshie et al., 2025). Cultural competencies ensure that the IAPF is not a universalising model but one that is genuinely responsive to the diversity of educational realities across national and regional contexts.

The Six Guiding Principles of the IAPF

Preliminary Assessment Indicators for IAPF Competency Domains

To strengthen the practical utility of the IAPF for teacher education institutions seeking to operationalise the framework, Table 5 proposes preliminary assessment indicators for each competency domain. These indicators are intended as observable descriptors that can guide the development of future assessment instruments, portfolio tasks, practicum evaluation rubrics, and competency-based course assessments. They are grounded in the theoretical foundations and pedagogical literature informing each domain and are offered as a starting point for institutional adoption rather than as a finalised assessment system.

Table 5. Preliminary Assessment Indicators for Each IAPF Competency Domain

Domain	Indicator 1	Indicator 2	Indicator 3
Technical	Can accurately explain how at least two AI systems (e.g., adaptive learning platform, generative AI tool) function, including their data inputs, outputs, and limitations	Critically evaluates an AI-generated educational output (e.g., automated feedback, assessment result) by identifying at least two reliability concerns or potential biases	Demonstrates data literacy by correctly interpreting a learning analytics dashboard and communicating findings to a non-specialist audience
Pedagogical	Designs a lesson plan that integrates an AI tool purposefully, with explicit justification for why AI-mediated instruction enhances rather than replaces human-led components	Demonstrates the ability to balance AI-driven personalisation with collaborative, inquiry-based classroom activities in a practicum or simulated teaching context	Critically reflects on an AI-assisted assessment experience, identifying at least one instance where teacher judgment should override or supplement AI-generated evaluation
Ethical	Identifies and articulates a specific instance of algorithmic bias in an educational AI tool, explaining its potential impact on a defined student population and proposing a pedagogical mitigation strategy	Demonstrates knowledge of student data privacy obligations by correctly applying relevant institutional or national data protection guidelines to a classroom AI scenario	Constructs a transparent communication to students and/or parents explaining how an AI tool is being used in the classroom, what data it collects, and how results will be used
Cultural	Evaluates a globally developed AI educational tool for cultural appropriateness in their specific classroom context, identifying at least two instances of cultural bias or contextual mismatch and proposing adaptations	Designs an AI-supported learning activity that explicitly incorporates students' linguistic and cultural backgrounds, demonstrating how local knowledge systems can coexist with AI-generated content	Critically reflects on the power dynamics embedded in a specific AI tool, identifying whose knowledge and values are centred and whose are marginalised, and articulating implications for equitable pedagogy

Source: Developed by the authors; indicators grounded in Ng et al. (2021a), Baker & Hawn (2022), Quarshie et al. (2025), and Choudhury et al. (2024)

The four competency domains of the IAPF are not only empirically grounded but also theoretically anchored in constructivist learning theory. Vygotsky's (1978) concept of the Zone of Proximal Development directly informs the pedagogical competency domain, particularly in its emphasis on AI-mediated scaffolding that supports learners at the boundary of their independent capability. Piaget's (1972) principles of assimilation and accommodation are reflected in the dynamic adaptability principle, which recognises that teachers must continuously integrate new AI affordances into existing pedagogical schemas while revising frameworks that no longer accommodate the realities of AI-mediated teaching. Vygotsky's social constructivism also underpins the cultural competency domain, affirming that knowledge, including knowledge about and through AI, is always socially situated and culturally mediated. These theoretical mappings ensure that the IAPF is not merely a competency checklist but a framework whose architecture reflects established principles of how human learning and professional knowledge develop. In addition to the four competency domains, the IAPF is governed by six guiding principles that serve as the normative and directional foundation of the framework. Figure 3 presents a visual representation of these six guiding principles as normative anchors, while Table 3 details their descriptions and supporting literature.

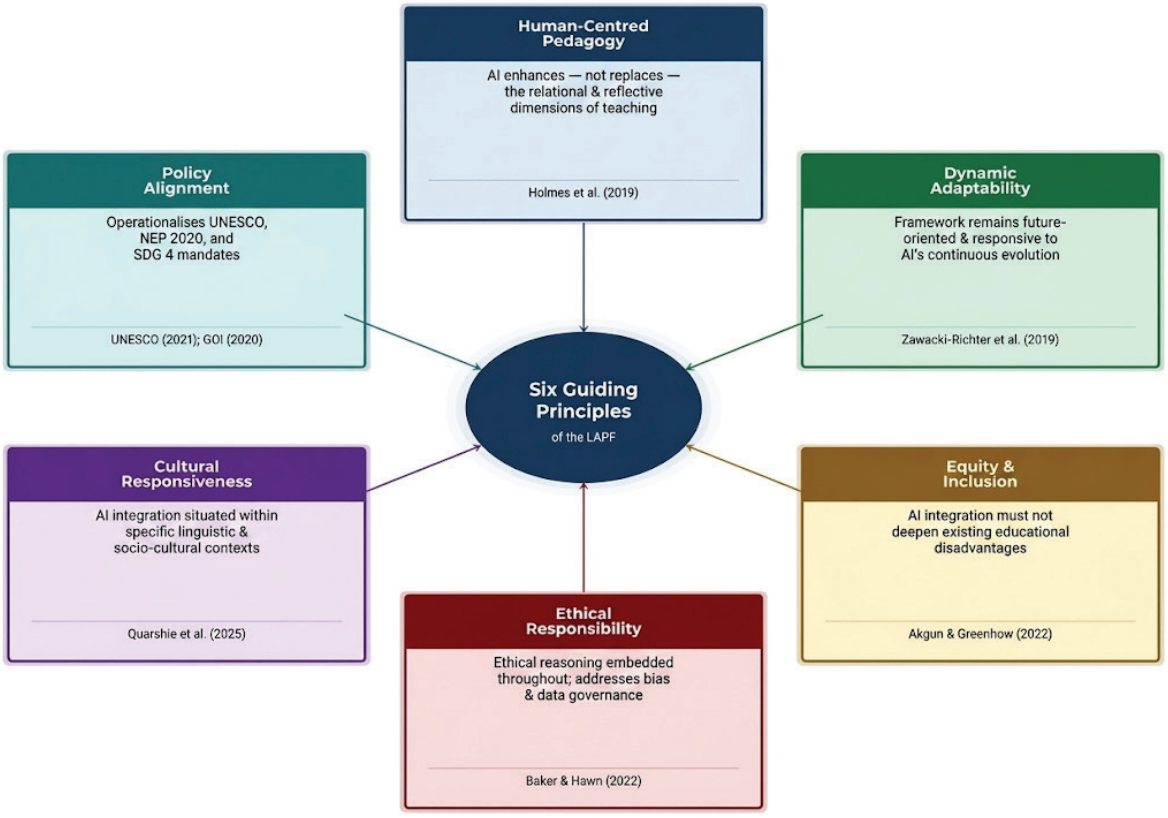

Figure 3. The Six Guiding Principles of the IAPF as normative anchors governing the framework

Table 3. The Six Guiding Principles of the IAPF

Guiding Principle	Description	Supporting Literature
Human-Centred Pedagogy	AI must enhance, not replace, the relational and reflective dimensions of teaching	Holmes et al. (2019); Luckin et al. (2022)
Dynamic Adaptability	Framework remains future-oriented and responsive to AI's continuous evolution	Zawacki-Richter et al. (2019); Celik (2023)
Equity and Inclusion	AI integration must not deepen existing educational disadvantages	Akgun & Greenhow (2022); Quarshie et al. (2025)
Ethical Responsibility	Ethical reasoning embedded throughout; addresses algorithmic bias and data governance	Baker & Hawn (2022); Birhane (2021)
Cultural Responsiveness	AI integration situated within specific linguistic and socio-cultural contexts	Quarshie et al. (2025); Akgun & Greenhow (2022)
Policy Alignment	Framework operationalises UNESCO AI guidelines, NEP 2020, and SDG 4	UNESCO (2021); Government of India (2020); United Nations (2015)

Source: Developed by the author based on systematic literature synthesis

Taken together, the four competency domains and six guiding principles constitute a comprehensive, theoretically grounded, and practically oriented architecture for the IAPF. Their integration within a unified ecosystem model, in which domains and principles interact dynamically rather than functioning in isolation, ensures that the framework addresses the full complexity of AI integration in pre-service teacher education.

Research Question 3: How coherent, relevant, and applicable is the IAPF when evaluated against existing AI education frameworks and international and national policy directives?

The coherence, relevance, and applicability of the IAPF were examined through a multi-layered process of conceptual validation appropriate to the non-empirical, interpretivist nature of the present study. This process involved literature triangulation, systematic comparison with existing AI education frameworks, theoretical consistency analysis, and alignment with international and national educational policy directives. Since the study adopts a conceptual research design grounded in Jabareen's (2009) methodology, the evaluation focuses on theoretical robustness, scholarly grounding, and practical relevance rather than empirical testing.

1. Coherence of the Framework

The IAPF demonstrates strong internal coherence by integrating four interrelated competency domains: technical, pedagogical, ethical, and cultural, within a unified and theoretically grounded conceptual structure. Unlike many existing frameworks that address these dimensions in isolation, the IAPF conceptualises all four as mutually constitutive elements that collectively define what it means to be an AI-ready pre-service teacher. Technical competencies provide the foundational knowledge necessary to engage meaningfully with AI systems. Ethical competencies guide the responsible use of AI tools (Baker & Hawn, 2022; Birhane, 2021). Cultural competencies ensure AI applications are evaluated in relation to diverse learner contexts (Quarshie et al., 2025; Akgun & Greenhow, 2022). The coherence of the IAPF is further strengthened by its six guiding principles, which function as normative anchors connecting the domains into a conceptually unified system, confirmed through systematic alignment with existing literature (Ng et al., 2021a; Holmes et al., 2019; Celik, 2023).

2. Relevance of the Framework

The relevance of the IAPF is demonstrated through its direct response to the contemporary challenges facing teacher education. Existing research consistently documents a significant gap between the pace of AI adoption and the preparedness of teachers to engage critically, ethically, and pedagogically with these technologies (Zawacki-Richter et al., 2019; Sperling et al., 2024). The IAPF addresses this limitation by reconceptualising teacher AI competence as a multidimensional construct. At the global level, the IAPF directly operationalises the principles articulated in UNESCO's AI and Education guidelines (2021). At the national level, it aligns with India's National Education Policy 2020 (Government of India, 2020) and the United Nations' Sustainable Development Goal 4 (United Nations, 2015). By embedding these policy directives into its structural architecture, the IAPF ensures that teacher preparation remains forward-looking, globally informed, and nationally relevant.

3. Applicability of the Framework

Beyond its theoretical coherence and policy relevance, the IAPF demonstrates strong practical applicability. For teacher education institutions, the IAPF offers concrete guidance for curriculum

design, enabling the development of courses in AI literacy, data ethics, AI-supported pedagogy, and culturally responsive AI integration. It also functions as a diagnostic instrument, enabling teacher educators to assess student teachers' competency profiles across all four domains (Choudhury et al., 2024). For policymakers, the IAPF offers an evidence-based model for translating broad policy mandates into specific, implementable frameworks, particularly in multilingual and resource-constrained settings (Quarshie et al., 2025). For researchers, the IAPF provides a theoretically grounded foundation for future empirical investigation. It is important to acknowledge that the applicability of the IAPF at this stage is conceptually rather than empirically demonstrated.

4. Comparison with Existing Frameworks

A systematic comparison with existing AI education frameworks further affirms the unique contribution and coherence of the IAPF. Figure 4 presents the complete IAPF ecosystem model, while Tables 4 and 4b provide a structured comparison with existing frameworks.

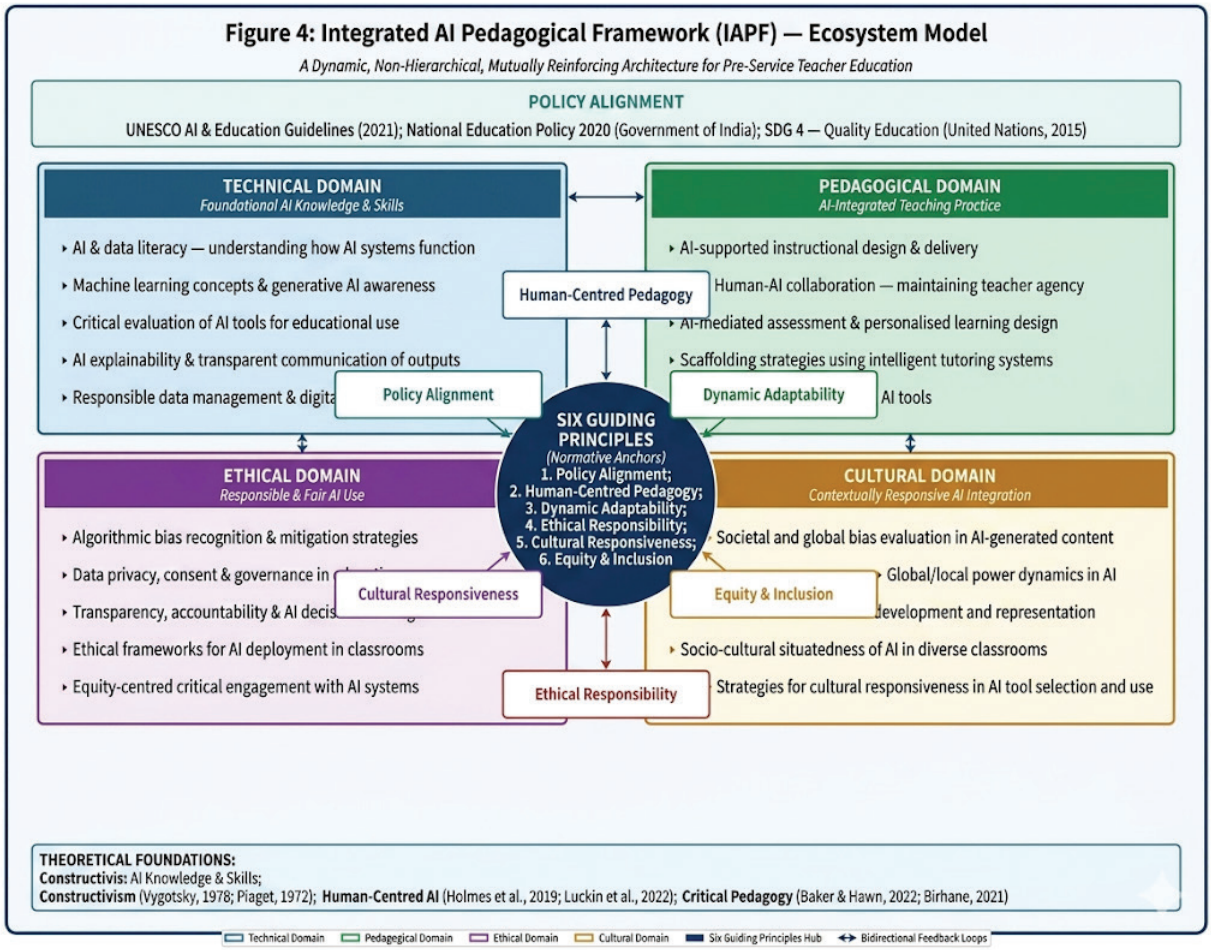

Figure 4. Integrated AI Pedagogical Framework (IAPF) Ecosystem Model showing four domains, six principles, feedback loops and non-hierarchical interconnections

Table 4. Systematic Comparison of IAPF with Existing Frameworks

Framework	Core Focus	Strengths	Gaps	IAPF Contributions
TPACK (Mishra & Koehler, 2006)	Tech-Pedagogy-Content intersection	Widely adopted; clear structure	Not AI-specific; ignores ethics & culture; treats technology as static	Adds ethical + cultural domains; future-proofing for AI
AI Literacy (Ng et al., 2021a)	Technical + evaluation + ethics	Systematic competencies	Weak implementation in teacher education; no cultural dimension	Embedded in pre-service teacher curriculum with cultural domain
AI Literacy (Long & Magerko, 2020)	Human-AI interaction	User-centred approach	Minimal pedagogical integration; no teacher education focus	Links pedagogy + ethics + culture for teachers specifically
Holmes et al. (2019)	Global AI in education synthesis; policy lens	Policy alignment; comprehensive review	Limited competency grounding; no domain structure for teacher prep	Detailed four-domain structure with guiding principles
IAPF (This Study)	Technical, Pedagogical, Ethical, Cultural: Integrative ecosystem model	Integrative + culturally responsive + principle-governed	Foundation established for future empirical validation	Unifies 4 domains + 6 principles into a cohesive pre-service teacher training model

Source: Developed by the author based on systematic literature synthesis

Table 4b. Domain and Principle Coverage Mapping Across Frameworks

Framework	Technical	Pedagogical	Ethical	Cultural	Human-Centred Pedagogy	Dynamic Adaptability	Equity & Inclusion	Policy Alignment
TPACK (Mishra & Koehler, 2006)	Present	Present	Absent	Absent	Partial	Absent	Absent	Absent
AI Literacy (Ng et al., 2021a)	Present	Partial	Present	Absent	Present	Absent	Partial	Absent
AI Literacy (Long & Magerko, 2020)	Present	Partial	Partial	Absent	Present	Absent	Absent	Absent
Holmes et al. (2019)	Partial	Present	Partial	Absent	Present	Partial	Partial	Present
IAPF (This Study)	Present	Present	Present	Present	Present	Present	Present	Present

Present = fully addressed; Partial = partially addressed; Absent = not addressed. Source: Developed by the author based on systematic literature synthesis.

The IAPF addresses the limitations of each existing framework by unifying technical, pedagogical, ethical, and cultural competencies within a single, principle-governed ecosystem model specifically designed for pre-service teacher education. The IAPF contributes to the field by positioning ethics and culture as co-equal domains alongside technical and pedagogical competencies, reflecting the constructivist principle that knowledge is always socially, culturally, and ethically situated (Vygotsky, 1978; Piaget, 1972). In summary, the IAPF demonstrates strong coherence, high relevance, and promising practical applicability. While empirical validation remains a necessary next step, the conceptual foundation established by the IAPF provides a comprehensive and well-grounded basis for future implementation, research, and policy development.

Educational Implications

The findings of this study carry significant and wide-ranging implications for the future of teacher education in an era defined by rapid and ongoing AI advancement. The development of the IAPF, grounded in four competency domains, six guiding principles, and conceptually validated

through literature triangulation and policy alignment, represents a substantive contribution to how teacher education institutions, policymakers, and researchers might approach the challenge of preparing pre-service teachers for AI-enhanced educational environments.

Implications for Teacher Education Institutions

For teacher education institutions, the IAPF offers a structured and evidence-based pathway for curriculum reform that moves beyond the prevailing tendency to treat AI integration as a technical add-on to existing programmes. Teacher education programmes can draw on the IAPF to develop dedicated courses in AI literacy, data ethics, AI-supported instructional design, and culturally responsive AI pedagogy, ensuring that pre-service teachers graduate with a multidimensional rather than narrowly technical understanding of AI in education (Ng et al., 2021a; Sperling et al., 2024). The framework also supports the design of practicum and field experience components, where pre-service teachers can engage with AI tools in real or simulated classroom contexts.

Beyond curriculum design, the IAPF has direct implications for faculty professional development. Teacher educators themselves must be equipped with the knowledge, skills, and critical dispositions necessary to model effective and ethically grounded AI integration (Celik, 2023; Younis, 2024). Additionally, the IAPF provides a basis for developing competency assessment mechanisms, drawing on instruments such as the AI-TPACK scale validated by Choudhury et al. (2024), that enable institutions to monitor pre-service teacher AI readiness systematically.

Implications for Policymakers

For policymakers at national and institutional levels, the IAPF provides a practically applicable model for translating broad policy aspirations into concrete, actionable frameworks for teacher education. While international and national policy directives, including UNESCO's AI and Education guidelines (2021), India's National Education Policy 2020 (Government of India, 2020), and the United Nations' Sustainable Development Goal 4 (United Nations, 2015), have established a clear mandate for AI-ready teacher preparation, they have not provided detailed implementation guidance. The IAPF addresses this policy-practice gap by offering a structured model that operationalises these policy goals at the level of curriculum design, competency development, and institutional practice. Policymakers can also draw on the IAPF to develop regulatory frameworks and accreditation standards that incorporate AI competencies as a core dimension, ensuring equitable AI integration across diverse national and regional educational systems (Akgun & Greenhow, 2022; Quarshie et al., 2025).

Implications for Researchers

For researchers in educational technology, teacher education, and AI in education, the IAPF establishes a theoretically grounded foundation for a new generation of empirical and conceptual

inquiry. Researchers can use the IAPF to design studies that examine pre-service teacher AI competency development across multiple dimensions simultaneously (Zawacki-Richter et al., 2019; Long & Magerko, 2020). The IAPF also invites cross-cultural and comparative research that examines how the framework's domains and principles manifest differently across national, linguistic, and socio-cultural contexts (Quarshie et al., 2025). Furthermore, researchers can use the IAPF as a basis for developing and validating new assessment instruments that measure pre-service teacher AI competency holistically across all four domains (Choudhury et al., 2024).

Broader Significance

Taken together, the implications of this study affirm that the preparation of AI-ready pre-service teachers is not a narrowly technical challenge but a fundamentally pedagogical, ethical, and cultural one. Teacher education must prepare future educators not only to use AI tools effectively but to engage with them critically, questioning their assumptions, evaluating their outputs, advocating for their students in AI-mediated environments, and adapting global technologies to local educational realities. The IAPF provides a structured, principled, and contextually responsive pathway toward this goal.

LIMITATIONS

While the Integrated AI Pedagogical Framework (IAPF) provides a comprehensive conceptual model for AI integration in teacher education, several limitations must be transparently acknowledged.

First, the exclusive reliance on English-language sources may exclude relevant scholarship published in other languages, potentially limiting the representativeness of the conceptual synthesis with respect to non-English-speaking educational contexts and non-Western theoretical traditions.

Second, the IAPF has undergone conceptual validation only. Its effectiveness and practical applicability in real classroom settings, including its capacity to produce measurable improvements in pre-service teacher AI competency and pedagogical integration, remain to be established through future empirical investigation.

Third, AI technologies evolve rapidly, which may affect the continued relevance of specific tools, applications, and competency requirements outlined in the framework. Periodic review and revision of the IAPF will be necessary as the field develops.

Fourth, although cultural responsiveness is integrated as a core domain, the model was developed primarily from English-language literature and within an Indian educational context. Adaptation may be required for implementation in other socio-cultural environments.

SUGGESTIONS FOR FURTHER STUDIES

To strengthen the evidence base and applicability of the IAPF, future research should focus on the following priority areas.

Empirical Validation Studies. Systematic implementation of the IAPF in teacher education programmes is needed to test the framework's effectiveness in improving AI competency, pedagogical integration, and ethical awareness among pre-service teachers. Pilot studies across multiple institutional contexts would provide the empirical grounding currently absent from the framework's validation.

Cross-Cultural Testing. Adaptation and evaluation of the IAPF across diverse national and cultural contexts is essential to ensure its generalisability and inclusivity. Research that tests, adapts, and extends the IAPF in Global South settings, particularly in multilingual and resource-constrained educational environments, would significantly strengthen its contextual responsiveness (Quarshie et al., 2025).

Longitudinal Impact Studies. Investigating the long-term outcomes of AI-integrated teacher education structured around the IAPF on instructional practices, student learning outcomes, and institutional adoption patterns would provide valuable evidence about the framework's sustained impact.

Assessment Instrument Development. Developing and validating multidimensional assessment instruments that measure pre-service teacher AI competency across all four domains of the IAPF represents a critical priority, addressing the notable gap in the existing literature for validated, holistic AI competency measurement tools (Choudhury et al., 2024).

CONCLUSION

This study was undertaken in response to a clearly documented and pressing gap in the field of teacher education, the absence of a comprehensive, theoretically grounded, and contextually responsive framework for preparing pre-service teachers to engage with Artificial Intelligence in educational settings in ways that are technically informed, pedagogically sound, ethically responsible, and culturally sensitive. Through systematic literature synthesis, conceptual framework analysis, and multi-layered conceptual validation, the study has developed the Integrated AI Pedagogical Framework (IAPF), a unified, principle-governed ecosystem model that represents a substantive contribution to the growing body of scholarship on AI integration in pre-service teacher education.

The study addressed three research questions, each of which made a distinct contribution to the field. In response to RQ1, the study demonstrated that the IAPF can be developed through a rigorous, transparent, and theoretically informed six-phase process of conceptual framework analysis grounded in Jabareen's (2009) methodology. In response to RQ2, the study identified four interrelated competency domains: technical, pedagogical, ethical, and cultural, and six guiding principles, human-centred pedagogy, dynamic adaptability, equity and inclusion, ethical responsibility, cultural responsiveness, and policy alignment, each grounded in and justified by existing scholarly literature. In response to RQ3, the IAPF demonstrated strong conceptual coherence, high contextual relevance, and promising practical applicability when evaluated against existing AI education frameworks and international and national policy directives including UNESCO's AI in Education guidelines (2021), India's National Education Policy 2020 (Government of India, 2020), and SDG 4 (United Nations, 2015).

The IAPF makes several distinct theoretical contributions. The IAPF contributes to the field by positioning technical, pedagogical, ethical, and cultural competencies as co-equal and mutually reinforcing domains within a unified model specifically designed for pre-service teacher education, addressing a persistent fragmentation in existing frameworks (Holmes et al., 2019; Long & Magerko, 2020; Ng et al., 2021a). By grounding the framework within constructivist learning theory (Vygotsky, 1978; Piaget, 1972), human-centred AI principles (Holmes et al., 2019; Luckin et al., 2022), and critical perspectives on technology and power (Baker & Hawn, 2022; Birhane, 2021), the IAPF advances the theoretical conversation toward a more holistic, socially situated, and ethically grounded understanding of teacher AI competence. The explicit inclusion of cultural responsiveness as a core domain represents a particular contribution to a field predominantly shaped by Western, English-language scholarship (Quarshie et al., 2025; Akgun & Greenhow, 2022).

It is important to acknowledge that the present study has inherent limitations. As a conceptual study grounded exclusively in secondary literature, the IAPF has not been subjected to empirical testing. The exclusive reliance on English-language sources and the framework's primary development within the Indian educational context mean that adaptation may be required for other socio-cultural settings. These limitations define the boundaries of the present findings and the directions in which future research must proceed.

Looking ahead, the IAPF is designed not as a fixed or final model but as a living framework intended to evolve through empirical testing, cross-cultural validation, and ongoing scholarly engagement. Ultimately, this study affirms that preparing pre-service teachers for AI-enhanced educational environments is one of the most consequential challenges facing teacher education in the contemporary period. The IAPF offers a principled, comprehensive, and contextually responsive response to this challenge: one that insists on placing human values, ethical responsibility, and cultural relevance at the centre of AI integration in education.

AI Disclosure Statement

The authors confirm that artificial intelligence (AI) tools were not used in any phase of this research, including literature search, data analysis, conceptual framework development, or manuscript preparation. All content, including the synthesis of existing literature, the construction of the Integrated AI Pedagogical Framework, and the writing of this manuscript, was carried out exclusively by the authors. This statement is provided in accordance with the editorial policy of the Review of Artificial Intelligence in Education.

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