Extending AI-TPACK: Reframing Teacher Readiness for the Generative-AI Era

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Abstract: The increasing presence of artificial intelligence (AI) in education presents both opportunities and challenges for K–12 teacher education. As educators prepare students for an AI-driven world, their readiness to integrate generative AI (GenAI) tools into classrooms becomes crucial. Building on the emerging AI-TPACK framework, this paper extends its theoretical scope to the generative era by introducing three novel dimensions including prompt literacy, ethical AI engagement, and teacher-AI-student partnerships, and examining their implications for teacher readiness and professional learning. Guided by three questions on readiness, competency development, and institutional response, the paper synthesizes current research on GenAI integration and proposes a Strategic Roadmap that operationalizes this extended AI-TPACK model through curriculum design, faculty development, and ethically grounded, equity-focused preparation. Together, the extended AI-TPACK model and the Strategic Roadmap position teacher readiness for GenAI as a paradigm shift in educational thought and practice.

Résumé: La présence croissante de l'intelligence artificielle (IA) dans l'éducation présente à la fois des opportunités et des défis pour la formation des enseignants du primaire et du secondaire. Alors que les enseignants préparent les élèves à un monde dominé par l'IA, leur préparation à l'intégration des outils d'IA générative (GenAI) en classe devient cruciale. S'appuyant sur le cadre émergent AI-TPACK, cet article étend sa portée théorique à l'ère générative en introduisant trois nouvelles dimensions, dont l'alphabétisation rapide, l'engagement éthique envers l'IA et les partenariats enseignant-IA-élèves, et en examinant

leurs implications pour la préparation des enseignants et l'apprentissage professionnel. Guidé par trois questions sur la préparation, le développement des compétences et la réponse institutionnelle, l'article synthétise les recherches actuelles sur l'intégration de GenAI et propose une feuille de route stratégique qui opérationnalise ce modèle AI-TPACK étendu par la conception des programmes d'études, le développement du corps professoral et une préparation fondée sur l'éthique et axée sur l'équité. Ensemble, le modèle AI-TPACK étendu et la feuille de route stratégique positionnent la préparation des enseignants à GenAI comme un changement de paradigme dans la pensée et la pratique éducatives.

Extending AI-TPACK: Reframing Teacher Readiness for the Generative-AI Era

The integration of artificial intelligence (AI) in education is rapidly advancing, presenting both opportunities and challenges that are transforming teaching and learning and prompting educators to rethink their pedagogical strategies (Perkins et al., 2024). In K-12 contexts, AI tools are increasingly used to personalize instruction, enhance student engagement, and streamline administrative tasks. Their capacity to analyze data and adapt to students' unique needs positions AI as a powerful force for innovation, particularly in classrooms with diverse learning styles and paces (Du et al., 2024). As schools prepare students for an AI-driven world, the role of educators in integrating these technologies effectively is paramount (Jeon & Lee, 2023).

Within this landscape, generative AI (GenAI) has emerged as especially relevant for K-12 education. GenAI can create interactive tutoring systems and study aids that provide real-time feedback, supporting deeper understanding and retention (Pelaez et al., 2022). Yet meaningful implementation depends not only on technological availability but also on teacher readiness—a multifaceted construct encompassing pedagogical, professional, social, and personal competencies (Susanto et al., 2022).

Research consistently highlights that teachers' confidence and attitudes toward GenAI are central to readiness, yet many educators feel underprepared (Alshorman, 2024). For instance, Chen (2022) found that although new teachers recognize GenAI's

potential to transform instruction, they often lack the training to use such tools effectively. Consequently, teacher-education programs must embed GenAI-focused preparation to equip educators for an AI-mediated learning environment (Blonder et al., 2024).

This paper explores teacher readiness through the Technological Pedagogical Content Knowledge (TPACK) framework, which provides a holistic view of how technology, pedagogy, and content interact in professional practice. Applying TPACK to GenAI integration enables identification of the knowledge areas teachers must develop to ensure effective and ethical use of these tools. The following questions guide this analysis:

1. How can the TPACK framework help conceptualize teacher readiness for GenAI integration?
2. What knowledge, skills, and attitudes do teachers need to navigate GenAI in practice?
3. What challenges hinder the development of these competencies, and how can teacher-education programs address them?

While previous studies have examined teachers' technological or attitudinal readiness (e.g., Shrestha & Yi, 2025), few have conceptualized the unique forms of professional knowledge that GenAI requires. To address this gap, this paper extends the emerging AI-TPACK framework presented by Ning et al. (2024) by theorizing how generative AI redefines teacher readiness. Earlier formulations of AI-TPACK retained the original seven-component structure of TPACK and primarily examined how teachers' technological, pedagogical, and content knowledge applied to AI tools. This paper expands that foundation by introducing three new dimensions: prompt literacy, ethical AI engagement, and teacher-AI-student partnerships, which reposition AI-TPACK for the generative-AI era.

Literature Review

Teacher readiness is a multifaceted construct that encompasses pedagogical, professional, social, and personal competencies, along with psychological attributes such as self-efficacy (Prihantini, 2024; Darling Hammond et al., 2002). Pedagogical competence, the ability to manage the learning process through clear explanation, diverse

teaching methods, and dialogic engagement, remains central (Susanto et al., 2022). Professional competence involves the capacity to integrate evolving knowledge and ethical practice within institutional and policy frameworks, ensuring accountability and continual growth (Kunter et al., 2013). Social competence reflects teachers' ability to collaborate, communicate, and build inclusive relationships with students and colleagues (Male & Palaiologou, 2015), while personal competence encompasses adaptability, reflection, and the disposition to learn from experience (Tynjälä & Gijbels, 2012). Psychological readiness, especially high self-efficacy, supports resilience, motivation, and innovation in practice (Alfredo & Prijanto, 2022). These foundations remain crucial, yet the emergence of GenAI introduces new complexities that extend beyond earlier formulations of teacher readiness.

A consistent finding across studies is that confidence and attitudes are pivotal to technology integration. Moorhouse (2024) observes that novice teachers often admire GenAI's potential but feel unprepared due to lack of exposure in training programs, a gap made sharper for teachers who are not digital natives. Castéra et al. (2020) found that younger teacher educators tend to have stronger technological knowledge, while older educators tend to have stronger pedagogical and content knowledge. Age thus plays a clear, inverse role in shaping technological versus pedagogical-content components of TPACK. Technology readiness theory highlights optimism, innovativeness, discomfort, and insecurity as key dispositions shaping adoption (Parasuraman, 2000). These dimensions map closely onto GenAI integration, where enthusiasm must be balanced against fears of obsolescence or complexity. Related research reinforces this multidimensionality: positive attitudes and confidence predict deeper and more sustainable integration (Lichtenthaler, 2020), while negative perceptions create barriers that require professional development, peer support, and awareness efforts to overcome (Su et al., 2022; Ottenbreit-Leftwich et al., 2022; Scott et al., 2021). Such findings show that readiness is not only about acquiring skills, but also about cultivating a reflective and ethical stance toward innovation.

Teacher attitudes and adoption behaviors have also been studied through the Technology Acceptance Model (TAM). Perceived usefulness and ease of use shape intentions to integrate AI, while GenAI anxiety, enjoyment, and even gender differences emerge as meaningful predictors of uptake (Zhang et al., 2023; Karina & Kastuhandani, 2024). These findings indicate that

adoption hinges as much on affective and contextual factors as on technical ability. Yet GenAI also introduces competencies, such as prompt literacy, which TAM and traditional TPACK did not anticipate, highlighting the need for a new conceptual lens.

Persistent challenges further complicate teacher readiness. Limited professional development opportunities reduce confidence and slow adoption (Fundi et al., 2024; Su et al., 2022). Lack of technical and pedagogical support creates gaps between perceived readiness and classroom realities (Ottenbreit-Leftwich et al., 2022). Equity concerns, including gender divides in digital competence, remain unresolved (Paliwal & Singh, 2021; Campos & Scherer, 2024). Digital leadership and policy support are critical to overcoming these barriers (Cheng & Wang, 2023; Nazaretsky et al., 2022). Importantly, new teachers' struggles to integrate GenAI, despite their students' digital fluency, reveal a widening preparedness gap (Moorhouse, 2024). Recent studies emphasize the need to measure and strengthen GenAI-related TPACK competencies, linking digital proficiency to teachers' ability to integrate AI effectively (Hava & Babayiğit, 2024).

Across these strands, the literature highlights that readiness for GenAI depends not only on pedagogical skill and confidence but also on professional development, equity of access, and ethical awareness. While TPACK remains a useful baseline for framing these competencies, GenAI exposes its limitations. Teachers must now develop prompt literacy-the ability to design and interpret AI prompts pedagogically (Nyaaba & Zhai 2024), alongside ethical and critical engagement with issues of bias, transparency, and responsible use (Cabellos et al. 2024; Su et al. 2022), and the capacity to mediate teacher-AI-student partnerships that sustain human judgment and agency in AI-supported classrooms (Jeon & Lee 2023; Çelik et al. 2023; Ottenbreit-Leftwich et al. 2023). These dimensions mark not an incremental evolution, but a paradigm shift in how teacher knowledge itself must be understood. They motivate the conceptual extension proposed in this paper; one that is an expanded AI-TPACK framework that reconceptualizes teacher readiness for an AI-saturated educational landscape. Recent studies have used the term *AI-TPACK* to describe relationships among traditional TPACK elements in AI contexts (e.g., Ning et al., 2024). However, these formulations largely retained the original seven-component TPACK structure, focusing on how teachers' existing technological, pedagogical, and content knowledge applied to AI tools. The present paper extends this foundation by theorizing the

new epistemic, ethical, and relational competencies that generative AI demands. This extension situates AI-TPACK within the generative-AI era, offering a deeper account of the professional knowledge teachers require to navigate and shape AI-enhanced learning environments.

Building on this identified gap, the AI-TPACK framework reconceptualizes teacher readiness by expanding the original TPACK model to include new professional competencies required in generative-AI contexts. Integrating GenAI into education demands a robust theoretical foundation to guide its pedagogically sound and ethically responsible use. The Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006) provides that foundation, illuminating how technology, pedagogy, and content interact in teacher practice. However, the accelerating integration of GenAI highlights the limitations of this traditional structure, revealing the need for an evolved model that captures emerging epistemic, ethical, and relational dimensions of teacher knowledge.

While TPACK has long provided a valuable lens for understanding how teachers combine technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK), its original articulation was not designed for the complex affordances and challenges of GenAI. Recent studies that employ the term *AI-TPACK* (e.g., Ning et al., 2024) have begun mapping these intersections, yet most retain TPACK's seven-component structure and focus primarily on how teachers' existing TK, PK, and CK apply to AI tools. This paper extends that foundation, theorizing the additional competencies that GenAI integration requires. These three dimensions deepen the AI-TPACK model by foregrounding epistemic, ethical, and relational capacities that redefine what it means to be ready to teach and learn in the generative-AI era.

Redefining Core Domains

The extended AI-TPACK framework reconceptualizes teacher readiness for the generative-AI era by introducing three distinctive dimensions including prompt literacy, ethical AI engagement, and teacher-AI-student partnerships. Together, these dimensions represent a paradigm shift in professional knowledge, requiring teachers to cultivate epistemic, ethical, and relational capacities that redefine how teaching and learning occur in AI-mediated environments.

Prompt literacy refers to teachers' ability to craft, decompose, and critically evaluate generative queries and responses so that AI outputs support disciplinary reasoning and learning goals rather than supplant them. It entails the capacity to design scaffolded prompts that elicit reasoning steps and metacognitive reflection, anticipate and diagnose failure modes, and embed attribution and traceability within classroom prompts. Through these practices, teachers transform prompts from technical commands into pedagogical scaffolds that guide both content understanding and critical AI literacy (Nyaaba & Zhai, 2024).

Ethical AI engagement represents teachers' integrated competence to identify, articulate, and act on the normative issues that arise in GenAI use, including bias, privacy, transparency, and equity. This involves developing bias-detection and mitigation strategies, cultivating data-privacy literacy relevant to classroom contexts, and designing equitable AI-supported learning tasks. Ethical engagement thus extends both content and pedagogical knowledge into new moral and social terrains, ensuring that AI integration aligns with principles of justice, inclusion, and professional responsibility (Mateus et al. 2024; Su et al. 2022).

Teacher-AI-student partnerships reimagine classroom dynamics as triadic interactions among humans and intelligent systems. In this configuration, teachers orchestrate AI affordances, students engage critically with AI-generated artifacts, and AI functions as a mediated co-agent in knowledge construction. Such partnerships require teachers to design clear role distributions by deciding who does what and why, while scaffolding student critique of AI outputs and constructing collaborative tasks that foreground human judgment. These relationships transform pedagogy from a unidirectional process into a participatory, co-creative practice that situates AI as a catalyst for inquiry rather than a substitute for thought (Çelik et al. 2023).

Together, these dimensions extend the AI-TPACK framework beyond its original seven-component structure, formalizing a theoretical evolution that recognizes the epistemic, ethical, and relational complexities of teaching in an AI-saturated educational landscape.

The Intersections as Sites of Innovation

While GenAI reshapes the individual domains of TK, PK, and CK, its most significant impact emerges at their intersections. It is here

that teachers confront the deepest tensions and the greatest opportunities, negotiating how technological capacity interacts with pedagogy and disciplinary content.

The power of TPACK lies in its intersections, and GenAI magnifies both their promise and their tensions. Within Technological Pedagogical Knowledge (TPK), teachers must adapt instructional strategies to leverage GenAI for inquiry and differentiation while ensuring that the technology supports rather than dominates learning (Wu et al., 2022). Technological Content Knowledge (TCK) requires teachers to act as content curators, discerning when AI-generated knowledge enriches subject learning and when it risks distortion (Kimmons, 2020; Park et al., 2023). Pedagogical Content Knowledge (PCK) demands nuanced methods that integrate disciplinary depth with innovative pedagogy; for example, using AI simulations in science while scaffolding interpretation (Park et al., 2023). At the most integrated level, AI-TPACK emphasizes orchestration of GenAI in ways that preserve human agency, equity, and ethical awareness, requiring teachers to cultivate critical AI literacy; including bias awareness, data ethics, and socio-technical implications (Woodruff et al., 2023; Cabellos et al., 2024).

These transformations reveal that AI-TPACK does not simply add another layer to TPACK; it redefines the very structure of professional knowledge. This redefinition unfolds through three interrelated shifts. First, an epistemic reorientation occurs as teachers become mediators of AI-generated knowledge rather than mere supervisors of technological tools, assuming new responsibility for evaluating the validity and pedagogical use of machine outputs. Second, a competence elevation positions prompt literacy as a first-order professional skill, distinct from earlier forms of technological knowledge, because it mediates how AI is woven into pedagogical routines and content practices. Third, a normative embedding integrates ethical and critical AI engagement within pedagogical and content knowledge, treating ethical discernment not as an optional add-on but as a constitutive dimension of teacher expertise. Together, these shifts signal that AI-TPACK represents a paradigm change in how teacher knowledge, agency, and responsibility are conceptualized.

Novel Contribution of AI-TPACK

We extend the emerging AI-TPACK framework (Ning et al., 2024), proposing an enhanced conceptualization that reconceptualizes

teacher readiness for the GenAI era (Figure 1). Unlike traditional TPACK, which focused on the synergy of technology, pedagogy, and content, this extended AI-TPACK introduces three distinctive dimensions: prompt literacy, ethical and critical AI engagement, dynamic teacher-AI-student partnerships.

Together, these dimensions distinguish AI-TPACK as a paradigm shift in how teacher knowledge is conceptualized, laying the foundation for the Strategic Roadmap that follows. At the same time, they reconfigure the traditional intersections of TPACK itself, demonstrating how GenAI reshapes the relationships among technology, pedagogy, and content. Prompt literacy mediates the link between technology and pedagogy: when teachers design lesson sequences, prompt templates become instructional scaffolds that embed AI interaction into pedagogy. Ethical engagement reshapes the connection between technology and content, requiring teachers to judge when AI-generated material preserves disciplinary integrity and when it risks epistemic distortion. Teacher-AI-student partnerships transform pedagogical content knowledge by embedding AI-mediated generative work within disciplinary teaching while maintaining practices that elicit reasoning and authentic student voice.

The framework represents an epistemic reorientation, shifting the locus of authority by making teachers mediators of AI-generated knowledge rather than passive supervisors of technological tools. It marks a competence elevation, positioning prompt literacy as a first-order professional capability distinct from traditional technological knowledge. Finally, it enacts a normative embedding, integrating ethical discernment as a constitutive dimension of pedagogical and content knowledge rather than an optional extension. Through these interdependent shifts, AI-TPACK aligns epistemic, pedagogical, and ethical capacities, extending TPACK into a new paradigm that defines readiness for the GenAI era.
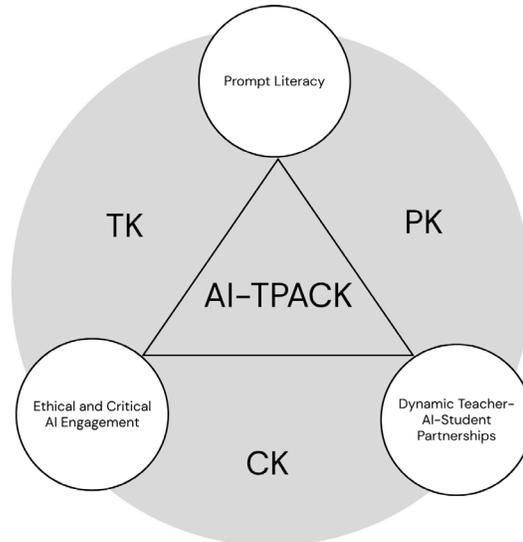
Figure 1: AI-TPACK: conceptual overlay showing three novel dimensions and their effects on TPACK intersections.

Discussion

This discussion is structured around the three guiding questions that framed the analysis. Rather than restating the literature, each question is now addressed through the lens of the AI-TPACK model and the Strategic Roadmap, highlighting their conceptual and practical contributions.

Guiding Question 1
How can the TPACK framework help understand teacher readiness for integrating GenAI in the classroom?

While TPACK provides a valuable baseline for exploring teacher readiness, the AI-TPACK model extends it by showing that GenAI requires new dimensions of knowledge, including prompt literacy, ethical engagement, and teacher-AI-student partnerships. The traditional framework highlights the interplay of technology, pedagogy, and content knowledge, but its value lies not only in evaluating proficiency in each domain but in diagnosing how these domains interact in practice. Teachers must be able to adapt pedagogical strategies to leverage GenAI capabilities in content delivery and student engagement, aligning technology with subject-specific goals (Sarumaha, 2020).

Research confirms that this blending is central to readiness. Ning et al. (2024) emphasize that pedagogical content knowledge (PCK) remains pivotal for meaningful AI integration, while Rafiq et al. (2022) show that confidence in technological knowledge (TK) increases the likelihood of adopting innovative tools. Similarly, Wang and Zhao (2021) argue that hands-on design activities enhance teachers' TPACK, strengthening both confidence and competence. Reflection further supports readiness: Valtonen et al. (2020) found that pre-service teachers' self-appraisal of their TPACK revealed both strengths and areas for growth, guiding targeted professional development.

Attitudes also shape GenAI adoption. Positive orientations toward innovation enable experimentation, while negative perceptions, such as fears of obsolescence or complexity, can create barriers (Mateus et al., 2024). Ethical concerns, including data privacy and bias, add another layer of complexity, requiring balanced approaches that foster both trust and responsibility in AI integration (Cabellos et al., 2024).

Taken together, these findings affirm TPACK as a valuable diagnostic lens but also reveal its limits. The rise of GenAI requires teachers to move beyond traditional TK, PK, and CK to engage in new practices such as prompt literacy, critical AI evaluation, and the negotiation of teacher-AI-student partnerships. These are the conceptual innovations articulated in the AI-TPACK model, which reframes and extends readiness for the demands of the GenAI era.

In summary, AI-TPACK refines the TPACK framework by identifying specific competencies that mediate technology-pedagogy-content integration in GenAI contexts. It positions teachers as epistemic stewards who evaluate AI outputs, design prompts, and orchestrate triadic interactions; thus, TPACK remains useful but requires formal extension to capture these new duties.

Guiding Question 2
What knowledge, skills, and attitudes are required by teachers to navigate the GenAI landscape in their teaching practice?

The AI-TPACK model reframes teacher competencies as integrated forms of readiness, emphasizing that effective practice in the GenAI era depends on cultivating prompt literacy, embedding ethical and critical AI engagement, and sustaining teacher-AI-student partnerships. While the traditional TPACK framework highlights

the interplay of technology, pedagogy, and content knowledge, GenAI introduces new demands that extend beyond its original scope.

Technological knowledge (TK) remains foundational but requires expansion. Educators must understand the functionalities, affordances, and limitations of GenAI tools. They need to pivot from adaptive platforms to AI-driven feedback systems. Beyond operational fluency, they must critically evaluate outputs to ensure alignment with educational goals and standards. They must also recognize ethical considerations in data use and bias (Cabellos et al., 2024). Hands-on design activities strengthen this readiness. As Wang and Zhao (2021) show, such experiences build both confidence and proficiency. Teachers additionally need familiarity with AI competencies mapped to learning taxonomies to support higher-order thinking (Ng et al., 2023).

Pedagogical knowledge (PK) calls for adapting methods to leverage GenAI while sustaining core aims of critical thinking, creativity, and problem-solving. Effective pedagogy treats GenAI as a tool to deepen inquiry and collaboration; not to replace human judgment. Designing inquiry-based, collaborative tasks that incorporate GenAI can enhance engagement. However, this requires nuanced integration of pedagogy with disciplinary content (Ning et al., 2024). Embedding active-learning strategies within TPACK further supports this balance (Hidayati et al., 2022).

Attitudinal readiness highlights the dispositions teachers bring to GenAI adoption. A growth mindset, confidence, and openness to experimentation are vital for engaging with these tools productively. Positive orientations support innovation (Mateus et al., 2024). Prompt-crafting skills, now an essential professional competence, enable meaningful AI interaction (Nyaaba & Zhai, 2024). At the same time, ethical responsibility remains central. Teachers must foster trust and accountability in AI use (Cabellos et al., 2024).

By cultivating these knowledge, skills, and attitudes, educators can harness GenAI's potential with agility and purpose. AI-TPACK interprets these domains not as isolated areas but as integrated readiness, where prompt literacy, ethical engagement, and dynamic partnerships represent a paradigm shift in professional knowledge. This reconceptualization ensures that teacher preparation for GenAI is not simply additive but transformative, positioning educators to lead in an AI-saturated landscape.

In essence, the knowledge, skills, and attitudes required for GenAI readiness are embodied in the AI-TPACK dimensions themselves. Teacher preparation must cultivate these through prompt-literacy artifacts, ethics-infused content modules, and practicum experiences that model teacher-AI orchestration, with the Strategic Roadmap providing actionable pathways for implementation.

Guiding Question 3

What challenges hinder competency development, and how can teacher education programs address these gaps?

From the perspective of AI-TPACK, the central challenge is not simply the lack of training but the absence of structures that cultivate the novel competencies GenAI requires. Teachers face systemic barriers including limited professional development, concerns about data privacy and bias, and inequities in access, that, if unaddressed, risk reducing GenAI integration to superficial use (Saubern et al., 2020; Rahman et al., 2023; Absari et al., 2020). Traditional TPACK highlights the tensions teachers experience in balancing technology, pedagogy, and content, but the GenAI era intensifies these tensions by adding new demands of prompt literacy, ethical AI engagement, and teacher-AI-student partnerships.

To address these challenges, teacher education programs must embed foundational GenAI literacy into curricula, covering not only technical fluency but also critical evaluation of AI outputs and ethical responsibilities (Cabellos et al., 2024). Initiatives such as hands-on training with GenAI tools, inquiry-based projects, and collaborative lesson design can strengthen confidence and competence (Su et al., 2022; Ottenbreit-Leftwich et al., 2022). Programs should also create peer-learning spaces, where preservice teachers experiment with GenAI collectively, supported by immediate feedback from AI-powered tutors, fostering a culture of continuous and reflective professional growth.

Ethical engagement must remain a core priority. Teacher education should directly address responsible data handling, bias mitigation, and equitable access, aligning with global standards such as The United Nations Educational, Scientific and Cultural Organization's (2024) AI competency guidelines. By doing so, programs ensure that readiness is not only technical but also democratic and inclusive.

The Strategic Roadmap advanced in this paper provides a practical framework for translating AI-TPACK into institutional practice. It organizes professional development around cultivating prompt literacy, embedding ethical and critical AI engagement, and designing learning environments that balance human and machine agency. In this way, the roadmap moves beyond generic calls for "more training," offering a structured, systemic response to barriers that have historically constrained technology integration. Together, AI-TPACK and the Strategic Roadmap provide both the conceptual lens and the pragmatic pathway for building GenAI-ready educators.

Ultimately, competency development is hindered less by individual hesitation than by structural constraints like limited professional development, policy fragmentation, and inequities in access. AI-TPACK addresses these by embedding ethical and equitable practice as a core program objective, while the Strategic Roadmap offers phased, measurable steps for scaling readiness across institutions.

Future Directions: Operationalizing AI-TPACK in Teacher Education

Having outlined the AI-TPACK model as a conceptual framework for reinterpreting teacher readiness, the next step is to consider its practical implications. The Strategic Roadmap operationalizes AI-TPACK by translating its three novel dimensions of prompt literacy, ethical AI engagement, and teacher-AI-student partnerships into five actionable pillars for teacher education.

To ensure that future educators are prepared for the increasing presence of GenAI in classrooms, faculties of education must adopt a structured and sustainable approach to professional learning. This roadmap offers a phased model for integrating AI into teacher education, balancing foundational knowledge, hands-on practice, and ongoing development (see Figure 2). By embedding GenAI into teacher preparation programs, this framework ensures that educators gain the confidence, competencies, and ethical awareness needed to navigate the evolving technological landscape.
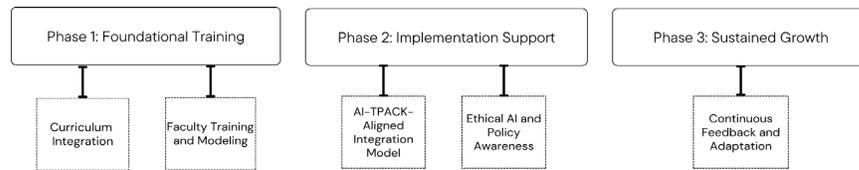
Figure 2: Building Teacher Readiness for GenAI: A Strategic Framework

The model is built around five interrelated pillars, each reflecting one or more dimensions of AI-TPACK. Curriculum integration advances prompt literacy by embedding AI-focused learning into coursework, encouraging candidates to explore how GenAI reshapes pedagogy, assessment, and differentiated instruction. Faculty training and development fosters teacher-AI-student partnerships, equipping educators to model AI-enhanced pedagogy in ways that preserve human judgment and student agency. The AI-TPACK model itself functions as the organizing conceptual lens, extending TPACK to include the GenAI-specific competencies that make readiness both technical and ethical. Ethical AI and policy awareness explicitly connect to the second novel dimension of AI-TPACK, ensuring candidates grapple with bias, data privacy, and equity throughout their training. Finally, continuous feedback and adaptation sustains all three dimensions, creating iterative cycles where educators refine their AI practices in dialogue with peers, researchers, and policymakers.

Implementation occurs across three progressive phases: foundational training, implementation support, and sustained growth. In the foundational phase, teacher candidates are introduced to AI literacy and ethical considerations, developing a conceptual understanding of GenAI's capabilities and limitations. The implementation phase involves hands-on practice, where candidates apply AI tools in lesson planning, assessment, and classroom management under guided mentorship. Finally, the sustained growth phase focuses on long-term professional development, embedding AI pedagogy within institutional policies, fostering peer collaboration, and supporting research-driven best practices.

By adopting this structured and forward-thinking approach, faculties of education can move beyond surface-level AI adoption toward a robust, equity-centered model of AI integration. This framework not only prepares teachers to leverage AI effectively but

also fosters a critical, reflective mindset that ensures technology serves as a tool for enhancing learning rather than replacing human-centered pedagogy. In doing so, teacher education programs can equip the next generation of educators to navigate and shape an AI-driven educational future with both confidence and responsibility.

To advance this agenda, several testable propositions emerge from the AI-TPACK framework and its Strategic Roadmap.

- First, teachers who receive explicit training in prompt literacy should produce lesson artifacts that display deeper disciplinary reasoning than those whose preparation focuses only on general technological knowledge.
- Second, embedding ethical-AI modules within content courses should strengthen teachers' capacity to detect and mitigate bias in AI outputs.
- Third, classrooms deliberately organized around teacher-AI-student partnerships are expected to show higher levels of student agency and metacognitive engagement.

These propositions establish a research trajectory through which AI-TPACK can be empirically examined, refined, and extended across diverse educational contexts. In doing so, the model bridges theory and implementation, ensuring that its paradigm-level insights into prompt literacy, ethical engagement, and collaborative human-AI partnerships translate into measurable transformation in teacher education and classroom practice.

In this way, AI-TPACK provides the conceptual grammar, while the Strategic Roadmap operationalizes it within teacher-education practice. The model bridges theory and implementation, ensuring that insights related to prompt literacy, ethical engagement, and collaborative human-AI partnerships inform tangible improvements in programs, faculty development, and classroom practice.

Conclusion

This paper examined teacher readiness for GenAI through three guiding questions. The analysis confirmed that the TPACK framework provides a valuable foundation for understanding readiness, offering a holistic view of how technology, pedagogy, and content intersect in practice. However, the synthesis of emerging

research and challenges revealed that TPACK alone is insufficient to address the distinctive demands of GenAI.

While the term *AI-TPACK* has appeared in recent literature (e.g., Ning et al., 2024), this paper extends that framework by embedding epistemic, ethical, and relational competencies at the core of professional knowledge. Through the dimensions of prompt literacy, ethical and critical engagement, and teacher-AI-student partnerships, the extended AI-TPACK framework reframes readiness not as tool proficiency but as the cultivation of new forms of expertise grounded in epistemic awareness, ethical discernment, and relational practice.

The accompanying Strategic Roadmap translates this conceptual extension into actionable guidance for teacher education programs. By embedding GenAI literacy, fostering collaboration, and addressing ethical and equity considerations, the roadmap demonstrates how institutions can transform conceptual innovation into sustainable programmatic practice.

Together, the extended AI-TPACK framework and the Strategic Roadmap offer both theoretical and practical contributions: conceptually, they expand understandings of teacher knowledge in an AI-saturated world; practically, they chart a pathway for comprehensive, ethically grounded preparation. In doing so, this paper positions teacher readiness for GenAI as both a conceptual redefinition and a practical mandate for program design.

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