Teacher Readiness for AI Education: A TPACK-Based Study in Basic Schools

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ABSTRACT

This study investigated teacher readiness for integrating artificial intelligence in basic education by applying the TPACK (Technological Pedagogical and Content Knowledge) framework. The research addressed the problem of uneven teacher preparedness in adopting artificial intelligence for instructional and professional practices across primary and secondary schools. A qualitative exploratory design was employed using open-ended survey questions to investigate how teachers demonstrated their content, pedagogical, and technological knowledge, how the intersections of these domains emerged in their classroom planning, and what opportunities and challenges influenced their capacity to achieve integrated readiness. Data were collected from eight teachers across three schooling levels, primary, lower secondary, and upper secondary. The findings showed that teachers generally understood the basic functions of artificial intelligence and used it primarily for lesson exploration and administrative preparation, yet they struggled to connect technological tools with pedagogical design and subject representation. Instances of meaningful integration occurred but remained limited, particularly in schools with constrained infrastructure. The study also revealed that teachers perceived artificial intelligence as beneficial for differentiation, efficiency, and reflective practice, although concerns related to ethical use, accuracy, and student dependency persisted. Overall, the results indicated that teacher readiness was developing but had not reached a fully integrated form. The study concluded that sustained professional development focused on technological, pedagogical, and content integration, along with institutional support, was necessary to foster equitable and meaningful use of artificial intelligence in basic education.

Keywords: *artificial intelligence, basic education, education, teacher readiness, TPACK*

1. INTRODUCTION

The swift momentum of digital transformation has fundamentally altered education systems worldwide, establishing Artificial Intelligence (AI) as a key engine of pedagogical advancement in the 21st century. Rather than functioning solely as a technical instrument, AI has evolved into a transformative force that shapes curriculum development, instructional approaches, assessment methods, and the shifting professional responsibilities of teachers (Meylani, 2024). Within primary and secondary schooling, AI tools, including adaptive learning applications, automated evaluation systems, and personalized content platforms, have shown considerable potential to improve learning equity, instructional efficiency, and student achievement (Zhang & Zhang, 2024). However, international studies indicate ongoing disparities in school infrastructure, teacher digital competence, and ethical preparedness, contributing to inconsistent levels of AI adoption across educational contexts (Estaiteyeh & McQuirter,

2024). Given that teachers act as the primary link between AI innovations and classroom implementation, understanding their readiness is crucial to ensuring that AI's educational benefits are realized in fair, responsible, and pedagogically effective ways within basic education (Ahumada, 2024).

The adoption of AI in basic education offers considerable promise while simultaneously introducing notable challenges. On the positive side, AI has the capacity to facilitate personalized learning trajectories, reduce teachers' administrative burdens, and provide immediate feedback that enhances instructional decision-making (Liu et al., 2024). These technologies can increase teacher productivity and enable more focused attention on student engagement and the development of higher-order cognitive skills (Baule & O'Connell, 2025). Conversely, the effective use of AI is frequently hindered by inadequate digital infrastructure, limited teacher understanding of AI concepts, issues related to data privacy and algorithmic fairness, and pronounced disparities between well-equipped and under-resourced schools (Jantanukul, 2024). Such obstacles are especially evident in contexts with constrained resources, where access to professional development is inconsistent and digital innovation remains fragmented (Wangdi, 2024). As primary and secondary schools play a critical role in fostering students' digital competencies and ethical sensitivity, teachers' readiness to integrate AI becomes a key determinant in ensuring that its educational advantages are realized while mitigating associated risks (Yadav, 2025).

Teacher readiness for AI integration involves more than technical proficiency; it includes teachers' motivation, confidence, and autonomy in using and experimenting with AI tools in varied classroom contexts (Tarisayi, 2024). Studies indicate that intrinsically motivated and self-efficacious teachers tend to adopt AI more effectively, even when institutional support is limited (Shafik, 2024). However, many still rely on informal learning, such as peer collaboration and online communities, due to insufficient formal training and institutional guidance (Ahumada, 2024; Minnillo et al., 2024). This situation often results in uneven and fragmented implementation, underscoring the need for systematic examination of how teachers engage with AI across different support conditions (Kaiser & Kaiser, 2025). In basic education, such readiness is crucial, as teachers serve as digital and ethical role models and ensure that AI is integrated responsibly and equitably (Zhang & Zhang, 2024).

To analyze teacher readiness for AI in a comprehensive manner, this study employs the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). TPACK explains effective technology integration through the interaction of Content, Pedagogical, and Technological Knowledge, along with their subdomains (TCK, TPK, and PCK) which together illustrate the complex relationship among content, pedagogy, and technology (Harris & Hofer, 2011; Koehler et al., 2013). Recent scholarship suggests that AI integration necessitates extending this framework

to include AI-specific competencies such as AI-TK, AI-TPK, and AI-TCK, reflecting AI's unique capabilities, constraints, and ethical dimensions (Bautista et al., 2024). Models like Intelligent-TPACK further highlight the importance of ethical and reflective practice (Selik, 2023). Consequently, TPACK and its AI-oriented adaptations provide a strong theoretical foundation for evaluating teacher readiness in the rapidly evolving era of AI in education.

Although research on digital transformation in education is expanding, notable gaps persist. Much of the literature still concentrates on general ICT integration rather than treating AI as a distinct domain with specific pedagogical and ethical implications. Existing studies also focus largely on higher education, leaving primary and secondary teachers underexplored despite their key role in building early AI literacy (Holmes & Tuomi, 2022). Moreover, prior work often emphasizes infrastructure over teachers' agency, motivation, and autonomy, especially in contexts with limited institutional support (Alshammary & Alhalafawy, 2023). Empirical studies from resource-constrained basic schools remain particularly limited, even though these settings face unique challenges in capacity, training, and ethical preparedness (Scherer et al., 2023; Zawacki-Richter et al., 2019). These gaps highlight the need to examine how teachers in basic education engage with AI through the TPACK lens and how their readiness is shaped by both enabling factors and systemic barriers.

In response to these gaps, the present study aims to examine teacher readiness for AI education in basic schools by applying the TPACK framework. Specifically, the study seeks to: (1) analyze how teachers demonstrate their Content, Pedagogical, and Technological Knowledge in integrating AI into teaching and professional practice across primary and secondary levels; (2) identify the extent to which the intersections of TPACK (TCK, TPK, and PCK) emerge in teachers' use of AI for lesson design, instructional strategies, and student engagement; and (3) investigate the opportunities and challenges that influence teachers' capacity to achieve integrated TPACK readiness for AI adoption, particularly in resource-constrained school contexts. Through these objectives, the study intends to provide empirical insights that support more coherent, equitable, and sustainable AI integration in basic education.

2. METHODOLOGY

2.1. Research Design

This study employed a qualitative exploratory research design to investigate teacher readiness for AI integration in basic education. An exploratory approach was selected because the use of AI in primary and secondary schools remains an emerging area, requiring flexible inquiry to capture teachers' evolving practices, perceptions, and contextual realities. Positioned within an interpretivist paradigm (Saunders et al., 2016), the study emphasizes understanding subjective meanings constructed by teachers

regarding AI use. This design aligns with Creswell (2014) view that qualitative exploratory studies are appropriate for examining complex and underexplored educational phenomena.

2.2. Participants of the Study

Participants consisted of eight teachers selected through purposive sampling to ensure representation across various levels of basic education. The sample comprised three primary school teachers (SD), two lower secondary teachers (SMP), and three upper secondary teachers (SMA). Purposive sampling was employed to include teachers with direct experience in using AI tools for instruction, consistent with qualitative research that prioritizes depth of insight over sample size breadth (Creswell & Clark, 2018). All participants had a minimum of one year of teaching experience and prior engagement with at least one AI-based educational tool.

2.3. Instruments

Data were collected using an open-ended survey instrument designed to elicit detailed accounts of teachers' experiences with AI in classroom and professional settings. The instrument consisted of three sets of questions aligned with the research objectives: (1) teachers' demonstrations of Content, Pedagogical, and Technological Knowledge in AI integration; (2) manifestations of TCK, TPK, and PCK in instructional design and learning engagement; and (3) perceived opportunities and challenges shaping their readiness for holistic TPACK.

To ensure validity, the survey items were reviewed by two experts in educational technology and qualitative research for clarity, relevance, and alignment with the TPACK framework. Reliability was enhanced through a pilot test with two teachers, leading to minor revisions for wording clarity and conceptual coherence.

2.4. Data Analysis Techniques

Data were analyzed using thematic analysis following Braun & Clarke (2006) six-step framework: familiarization, coding, theme generation, theme review, theme definition, and reporting. This method was selected for its flexibility in identifying patterns across qualitative responses. Coding was conducted manually to maintain close engagement with the data. The emerging themes were organized according to the TPACK framework to ensure that the interpretation accurately reflected teachers' knowledge domains and the intersections relevant to AI integration. Triangulation was conducted through peer debriefing with an educational technology expert to enhance the trustworthiness of the analysis.

3. RESULT AND DISCUSSION

The findings indicate that teacher readiness for integrating AI in basic education varies widely across school levels, particularly in their understanding of Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). While most teachers demonstrate basic awareness of what AI can do, they still struggle to connect AI meaningfully with the content they teach. This mirrors Scherer et al. (2023) and Meylani (2024), who highlight that readiness for emerging technologies is strongly shaped by teachers' digital competence and professional experience. As one public elementary school teacher explained, *"I know AI can help create questions or summarize material, but when it comes to explaining a science concept in depth with AI, I honestly don't know where to start."* This sentiment illustrates that AI-related CK remains underdeveloped, especially when teachers attempt to use AI to generate richer representations of disciplinary content.

From the perspective of TK, several teachers reported using generative AI to accelerate routine tasks such as lesson planning, material development, and drafting assessments. These practices resonate with Baule & O'Connell (2025) and Minnillo et al. (2024), who argue that AI has the potential to enhance teachers' productivity through automation and personalization. However, teachers' confidence in aligning AI-generated suggestions with their pedagogical approach remains uncertain. As expressed by a private lower secondary school teacher, *"AI is fast, but I'm never fully sure whether the output fits how I usually teach my students."* This concern aligns with Jantanukul (2024) and Shafik (2024), who emphasize that many educators still treat AI as a technical tool rather than a pedagogical catalyst.

In practice, the intersections of TPK, TCK, and PCK within the TPACK framework were not yet fully evident. Although some teachers experimented with chatbots or AI-based activity generators to diversify instructional methods, deeper pedagogical planning was not consistently visible. This reinforces findings by Harris & Hofer (2011) and Koehler et al. (2013), who argue that effective technology integration requires simultaneous understanding of pedagogy, content, and technology. As noted by a public upper secondary school teacher, *"Sometimes I use AI to look for activity ideas, but the suggestions aren't always realistic for my classroom, where students' abilities vary widely."* The inability to contextualize AI recommendations suggests that both TPK and TCK remain fragile, echoing insights from Bautista et al. (2024) and Liu et al. (2024) on the importance of designing AI-enhanced instruction that is pedagogically and contextually grounded.

Even so, the study identified positive examples of AI-supported instructional innovation. A private primary school teacher shared, *"I created an AI-assisted adaptive quiz, and the students became more engaged because the questions adjusted to their level."* This aligns with Alshammary & Alhalafawy (2023), who assert that digital

platforms can improve learning outcomes when appropriately designed and implemented. Nonetheless, such practices were still relatively rare, suggesting that AI-driven TPACK integration remains uneven across schools.

Teachers across levels also recognized significant opportunities offered by AI, including supporting differentiated instruction, increasing efficiency, and promoting more inclusive learning experiences. These affordances are consistent with Holmes & Tuomi (2022), Zhang & Zhang (2024), and Yadav (2025), who highlight AI's potential to provide adaptive support and personalized learning pathways. Some teachers also used AI to support reflective practice. A upper secondary school vocational teacher remarked, *"Sometimes I ask AI whether my teaching method fits my objectives, and it helps me consider other options I might not have thought of."* This practice reflects Ahumada's (2024) emphasis on reflective digital-era pedagogy.

Despite these opportunities, structural challenges strongly affect teachers' readiness. Limited device availability, weak internet connectivity, and inconsistent platform access hinder AI integration, especially in resource-constrained schools. These findings reaffirm Tarisayi (2024) and Wangdi (2024), who point out persistent digital divides in basic education. Another major barrier is the lack of systematic training that integrates both technical and pedagogical dimensions. This aligns with Bautista et al. (2024) and Kaiser & Kaiser (2025), who note that many AI training programs focus on operational skills rather than pedagogical application. Ethical concerns, such as accuracy, student data privacy, and the risk of plagiarism, are also prominent, as noted in Holmes & Tuomi (2022) and Selik (2023). A public lower secondary school teacher expressed, *"I'm worried that if students rely too much on AI, they won't truly learn, or they'll just copy whatever the system generates."*

Overall, the findings suggest that while teachers exhibit emerging readiness in CK, PK, and TK, the integration of these domains into a cohesive TPACK framework remains limited. The interplay of opportunities and constraints underscores the need for systemic interventions (policy support, sustained professional development, and institutional guidance) echoing recommendations by Zawacki-Richter et al. (2019) and Holmes & Tuomi (2022). Strengthening TPACK competence is therefore essential for ensuring equitable and sustainable AI adoption, particularly in schools with limited resources.

4. CONCLUSION

Based on the study's findings, teacher readiness for integrating AI in primary and secondary schools remains layered and has not yet achieved a fully integrated TPACK form, even though teachers have demonstrated relevant foundational CK, PK, and TK. The answers to the research questions reveal that teachers are able to utilize AI primarily for content exploration and lesson preparation; however, their understanding

of how TPK, TCK, and PCK intersect is still limited, particularly when designing learning experiences that pedagogically leverage AI's capabilities. Challenges related to infrastructure, technological literacy, and ethical considerations further hinder the development of integrated TPACK in resource-constrained school environments. Therefore, this study recommends that policymakers and education authorities provide sustained professional development explicitly oriented toward TPACK-AI rather than general technical training. Schools are also encouraged to establish teacher learning communities that support contextual and ethical AI practices, while teachers themselves are advised to continue strengthening pedagogical reflection so that AI use not only increases efficiency but also enriches students' learning experiences. Through these efforts, AI integration in basic education can progress in a more equitable, meaningful, and sustainable manner.

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