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Theoretical And Conceptual Foundations Of The Ai-Tpack Model

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ABSTRACT

This section analyzes the theoretical and conceptual foundations of the AI-TPACK model, which describes the structure of teachers' professional knowledge in digital learning environments. The study explains the conceptual rationale for the transition from the traditional TPACK model to AI-TPACK, examines the content of the AI-TK, AI-PK, and AI-CK knowledge domains, and provides a theoretical basis for their integration into digital learning environments. The methodology combines comparative theoretical analysis, a systems approach, and conceptual synthesis. The analysis shows that AI-TPACK treats technological knowledge in terms of interaction with an intellectual partner rather than the use of a static tool. The relationships among AI-TK, AI-PK, and AI-CK expand the pedagogical possibilities of digital learning environments and place new demands on teachers' professional competence. This section can provide a theoretical foundation for educational research, teacher professional development programs, and education policy documents.

Keywords: AI-TPACK, TPACK, artificial intelligence, digital learning environment, AI-TK, AI-PK, AI-CK, teachers' professional knowledge, technological and pedagogical integration.

INTRODUCTION

The rapid integration of artificial intelligence into education is fundamentally changing the structure of teachers' professional knowledge. The traditional Technological Pedagogical Content Knowledge (TPACK) model treats technology as a tool for achieving pedagogical goals. The adaptive, autonomous, and self-improving features of AI technologies call for a reconsideration of these conceptual boundaries. In response, the AI-TPACK model considers teachers' competence in working with AI in close connection with their pedagogical and content knowledge. This section aims to systematically analyze the theoretical foundations of AI-TPACK, identify how it differs from traditional TPACK, and establish a conceptual basis for integrating it with the digital learning environment. Mishra and Koehler developed TPACK in 2006, drawing on Shulman's concept of Pedagogical Content Knowledge (PCK). The model encompasses three core knowledge domains, Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK), together with the integrated forms of knowledge that arise at their intersections.

In the traditional model, technology is primarily regarded as a tool, understood as a supporting resource for achieving pedagogical goals. The development of AI technologies has highlighted the limitations of this view. According to Celik (2023) and Ning et al. (2024), AI technologies support teaching and can also transform the structure of teachers' cognitive activity and their teaching methods. AI-TPACK therefore conceptualizes technology as a partner, an intelligent agent that interacts with the teacher. The following table summarizes the main differences between the TPACK and AI-TPACK models.

TPACK and AI-TPACK Models in the Digital Learning Environment

Comparison criterion	TPACK model	AI-TPACK model
Conceptual basis	Shulman's concept of PCK	PCK and the cognitive and transformative potential of AI
Role of technology	Tool	Partner and intelligent agent
Knowledge structure	TK, PK, CK, and their intersections	AI-TK, AI-PK, AI-CK, and integrated AI-TPACK
Function of technology	Support and assistance	Transformation and autonomous decision-making
Ethical dimension	Secondary	Core component (AI ethics)
Teacher's role	Selects and uses technology	Collaborates with technology and provides ethical oversight

These differences show that AI-TPACK treats technological knowledge as a component that has equal standing with pedagogical and content knowledge and helps shape both. This broadens the requirements for teachers’ professional preparation to include epistemological and ethical considerations alongside practical skills. The model’s three core knowledge domains, AI-TK, AI-PK, and AI-CK, relate dialectically to one another, and each has a distinct focus and function. AI-TK (AI-related technological knowledge) involves understanding the technical foundations, functional capabilities, and limitations of AI technologies. As defined by Celik (2023), AI-TK includes the ability to work with AI-based systems, use their basic functions, and assess their technical capabilities. This domain requires an understanding of the principles underlying technologies such as machine learning, natural language processing, and neural networks. AI-PK (AI-related pedagogical knowledge) involves understanding the pedagogical capabilities of AI technologies, including their advantages and limitations in education. It includes designing AI-supported pedagogical strategies such as personalized learning, automated feedback, and adaptive learning pathways. AI-PK also includes the ability to assess potential pedagogical risks, such as adverse effects on learners’ independent thinking and excessive reliance on automation. AI-CK (AI-related content knowledge) concerns the relationship between AI technologies and the content of a specific discipline. It involves evaluating how AI changes subject content, which topics can be learned more effectively with AI, and when the reliability of AI should be called into question. In history, for example, the use of AI to classify and analyze sources falls within AI-CK. The following table summarizes the content and functions of these three knowledge domains.

Artificial Intelligence and Pedagogical Knowledge Domains

Knowledge domain	Definition	Key components	Practical applications
AI-TK	Understanding the technical foundations and functional capabilities of AI technologies	Machine learning principles, neural networks, natural language processing (NLP), and technical limitations	Configuring AI tools and assessing their technical capabilities
AI-PK	Understanding the pedagogical possibilities and limitations of AI	Personalized learning, adaptive feedback, and pedagogical risks	Designing AI-supported learning strategies
AI-CK	Understanding how AI interacts with and affects subject content	Transformation of subject content and assessment of reliability and impartiality	Using AI to select, analyze, and evaluate content

Source: Institute of Pedagogical Innovations.

The dialectical relationship among these three domains is central to the integrative nature of AI-TPACK. AI-TK defines the technical possibilities, AI-PK shapes pedagogical strategies, and AI-CK ensures alignment with subject content. Together, they enable teachers to collaborate pedagogically with AI. Contemporary educational research interprets the digital learning environment (DLE) from several perspectives. Broadly defined, it is a pedagogical system built on information and communication technologies to individualize learning, increase interactivity, and improve educational quality. This environment encompasses e-learning platforms (LMSs), digital learning resources, multimedia tools, and communication systems.

Kulboyeva (2026) describes the digital learning environment as a system that is “part of the global information space and is integrated across various fields and areas.” Shilova defines it as “the set of relationships in educational activity mediated by the use of digital technologies and digital educational resources.” The digital learning environment and the AI-TPACK model are integrated in two ways. First, the digital environment provides a setting for applying AI-TK, AI-PK, and AI-CK, since AI technologies perform pedagogical functions within that environment. Second, incorporating AI transforms the digital learning environment itself, giving it the characteristics of a smart learning environment. In this process, AI-TPACK provides a theoretical basis for understanding and evaluating teachers’ professional activity in digital environments. The following table shows the principal components of the digital learning environment and how they integrate with the AI-TPACK knowledge domains.

Integration of Digital Learning Environment Components with AI-TPACK

Digital environment component	Integration with AI-TPACK	Practical applications
E-learning platforms (LMSs)	Synthesis of AI-TK and AI-PK	Automatic creation of adaptive learning pathways
Digital learning resources	Integration of AI-CK and AI-TK	AI-assisted content generation and verification
Interactive communication tools	Centered on AI-PK	Automated feedback and monitoring systems
AI-based assessment systems	AI-TPACK integration	Automation of formative and summative assessment

The AI-TPACK model is a theoretical framework for reconceptualizing the structure of teachers’ professional knowledge as AI technologies are integrated into education. It differs from traditional TPACK primarily in the shift from viewing technology as a tool to viewing it as a partner, and in making ethics a core component of the model. The AI-TK, AI-PK, and AI-CK knowledge domains relate dialectically to one another. Their synthesis constitutes teachers’ competence in

collaborating pedagogically with AI [8]. The digital learning environment provides a setting for applying and testing these knowledge domains. A thorough understanding of the theoretical and conceptual foundations of AI-TPACK has practical importance for teacher preparation, professional development, and education policy.

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