



## TPACK for Teachers in 21st Century Education

Kaushik Sarkar<sup>1</sup> & Dr. Aabriti Sharma<sup>2</sup>

1. Ph.D. Research Scholar, Department of Education, Sikkim University, Gangtok, Sikkim  
Email: [kaushiksarkar018@gmail.com](mailto:kaushiksarkar018@gmail.com)
2. Assistant Professor, Department of Education, Sikkim University, Gangtok, Sikkim  
Email: [asharma@cus.ac.in](mailto:asharma@cus.ac.in)

### Abstract:

*The growing integration of digital technologies in education has reshaped instructional practices and heightened the need for teachers to develop integrated forms of professional knowledge. This paper revisits the Technological Pedagogical Content Knowledge (TPACK) framework as a comprehensive lens for understanding effective technology integration in 21st-century classrooms. It critically examines the core components of TPACK, technological, pedagogical, and content knowledge and their dynamic intersections, highlighting their relevance for teacher education, curriculum design, instructional practice, and assessment. The study further explores practical applications of the framework across professional development, curriculum planning, classroom instruction, and performance-based evaluation of technology integration. In addition, it addresses key global constraints affecting TPACK implementation, including inequitable access to resources, cultural variability, and methodological challenges in assessment. Drawing on recent research, the paper outlines future directions for advancing TPACK through personalised and adaptive learning technologies, culturally responsive adaptations, systemic professional support, and the integration of emerging technologies. The study concludes that sustaining and refining the TPACK framework through context-sensitive, practice-oriented, and performance-based approaches is essential for empowering teachers to design meaningful, technology-enhanced learning experiences across diverse educational settings.*

**Keywords:** *Technological Pedagogical Content Knowledge, Teacher Education, Technology Integration, 21st-Century Learning.*

### 1.0 Introduction:

The rapid integration of digital technologies in education has fundamentally transformed teaching and learning practices, requiring teachers to develop a multifaceted set of knowledge and skills. Technological Pedagogical Content Knowledge (TPACK) provides a comprehensive framework for understanding how educators can effectively integrate technology, pedagogy, and subject matter knowledge in instructional design (Mishra & Koehler, 2006; Koehler & Mishra, 2009). TPACK extends beyond individual domains of knowledge, Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK), to emphasise the complex intersections where these domains interact: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and the

overarching TPACK itself. By highlighting these interconnections, the framework offers a practice-oriented lens for examining how teachers adapt instruction to the evolving digital and contextual demands of 21st-century classrooms (Harris & Hofer, 2011). This paper revisits the TPACK framework, exploring its core components, intersections, and relevance for teacher education, curriculum design, and instructional practice, while also addressing contextual challenges, global constraints, and implications for future technology integration in education. Figure 1 represents the TPACK framework and its components.

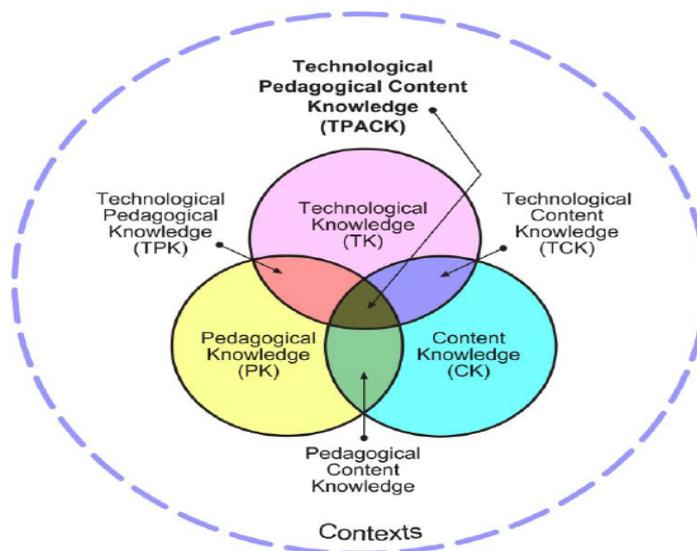


Figure 1. The TPACK framework and its knowledge components (Koehler and Mishra, 2009, p. 63).

## 1.1 Core component of TPACK

### Technological Knowledge (TK):

Technological Knowledge (TK) refers to an educator’s understanding of technology tools and their potential to enhance teaching and learning. Technological Knowledge refers to knowledge of how to operate computers and relevant software (Gur & Karamete, 2015).

### Pedagogical Knowledge (PK)

According to Morine-Dersheimer and Kent (1999) pedagogical knowledge is a combination of many components, including classroom management and organisation, instructional models and strategies, and classroom communication and discourse. Those researchers also contend that personal beliefs, practical experience, and reflection also play a large role in shaping pedagogical knowledge.

### Content Knowledge (CK)

Content knowledge is knowledge about the actual subject matter that is to be learned or taught. As Shulman (1986) noted, this knowledge would include knowledge of concepts, theories, ideas, organisational frameworks, knowledge of evidence and proof, as well as established practices and approaches toward developing such knowledge.

## 1.2 Intersections Within the TPACK Framework

### Pedagogical Content Knowledge (PCK)

Pedagogical Content Knowledge (PCK), the overlap proposed by Shulman, refers to the idea that pedagogy and content are interwoven. Shulman defines it as “subject matter knowledge for teaching” (Shulman, 1986).

## **Technological Content Knowledge (TCK)**

Technology Content Knowledge (TCK) refers to an understanding of which technologies are appropriate to use in various disciplines, whether in the classroom or on the job. Inherent here, too, is the understanding that technology may require a compromise of content or may enhance representation of content (Harris et al., 2009; Mishra & Koehler, 2008).

## **Technological Pedagogical Knowledge (TPK)**

Technological Pedagogical Knowledge refers to the comprehension of how teaching and learning processes are influenced when specific technologies are applied in certain ways. It involves understanding the instructional opportunities and limitations offered by various technological tools, as well as how these tools can be effectively aligned with discipline-specific and developmentally suitable teaching strategies and designs (Koehler & Mishra, 2009).

## **Technological Pedagogical Content Knowledge (TPCK/TPACK)**

Technological Pedagogical Content Knowledge (TPACK) refers to the complex interrelationship between a teacher's technology use, instructional methods, and understanding of the subject matter (Mishra & Koehler, 2006).

### **2.0 Significance of the Study:**

This study underscores the relevance of the TPACK framework for effective digital pedagogy in 21st-century classrooms. By examining the intersections of content, pedagogical, and technological knowledge, the study highlights how TPACK provides a structured lens for understanding and enhancing teachers' capacity for meaningful technology integration. The findings are significant for teacher education and professional development, offering insights into designing training programmes that cultivate adaptive, context-sensitive, and practice-oriented technological competencies. Furthermore, the study informs curriculum design and instructional planning by demonstrating how TPACK can guide the purposeful use of digital tools to enrich student learning experiences. Addressing challenges such as cultural variability, resource inequities, and assessment complexities, the study emphasises the need for flexible, inclusive, and sustainable approaches to TPACK development. Ultimately, it advances theory and practice in educational technology, supporting teachers in translating integrated knowledge into effective classroom practices that meet evolving pedagogical and learner needs.

### **3.0 Applications of the TPACK Framework:**

#### **3.1 Teacher Education and Professional Development:**

Professional development programmes frequently adopt the TPACK framework to design training that supports in-service teachers in building the knowledge and skills required for the effective integration of technology into classroom teaching (Getete, 2025).

#### **3.2 Curriculum Design:**

Instructional designers utilise the TPACK framework to integrate technology seamlessly into lesson planning, treating it as a core element rather than an optional add-on, which helps build coherent learning experiences that enhance student understanding and participation (Vijayatheepan, 2024).

#### **3.3 Curriculum Instruction:**

Teachers can effectively blend content knowledge, pedagogical strategies, and technological skills by

intentionally using the TPACK framework to design lessons that integrate technology in ways that strengthen subject-specific learning. For instance, they can use interactive geometry software to let students explore and visualise geometric concepts (Li et al., 2025).

### **3.4 Assessment of Technological Integration:**

Through structured evaluations of teachers' TPACK skills using performance-oriented tasks and instructional design activities, schools and researchers can pinpoint precise areas where knowledge is lacking and professional growth is needed, enabling the implementation of targeted development programs that enhance educators' ability to integrate technology effectively into teaching and learning (Angeli & Valanides, 2009).

### **4.0 Global Constraints on TPACK Integration:**

#### **4.1 Inequitable Access to Resources in TPACK Implementation:**

One of the primary challenges in implementing TPACK globally lies in unequal access to technological infrastructure, digital resources, and professional training, as teachers in under-resourced and rural contexts demonstrate significantly lower TPACK development compared to their urban counterparts (Li, 2025).

#### **4.2 Cultural Challenges in TPACK:**

Although the TPACK framework offers a comprehensive model for technology integration, it insufficiently addresses cultural dimensions of teaching and learning, as empirical evidence shows that technology use often conflicts with deeply rooted traditional practices, requiring educators to adapt TPACK in culturally responsive ways (Haga, 2025).

#### **4.3 Assessment Complexity in TPACK Evaluation:**

Another challenge is the assessment of TPACK in practice. Evaluating teachers' integration of technology, subject matter expertise, and instructional methods presents significant methodological challenges due to the varied nature of educational contexts and the multifaceted competencies involved (Li, 2025).

### **5.0 Future Direction:**

#### **5.1 Technology Integration in the Learning Process Based on the TPACK Framework:**

Within the TPACK framework, technology integration in teaching can be understood in relation to instructional goals and the nature of classroom learning activities. Teachers who possess adequate TPACK competence are better equipped to select and apply appropriate technological tools that align with students' learning needs and pedagogical requirements (Setyowati & Rachmajanti, 2023, as cited in Latip et al., 2023).

#### **5.2 Personalised and Adaptive Learning Technologies:**

Advances in technology have increased the focus on personalised and adaptive learning, where data are used to align instruction with learners' needs, interests, and learning speeds. Future TPACK research should therefore examine how teachers can develop the necessary knowledge and skills to support such practices. The effective use of adaptive learning technologies requires teachers to align technological tools with appropriate pedagogical strategies and content goals to enhance student learning, a principle strongly emphasised in research on instructional technology integration (McKnight et al., 2016).

#### **5.3 Adapting TPACK for Diverse Cultural Settings:**

Haga (2025) demonstrates that cultural variables significantly shape how technology, pedagogy, and content

are operationalised in teaching, highlighting the limitations of traditional TPACK models in intercultural settings and the need for more inclusive, context-sensitive frameworks.

#### **5.4 Sustaining and Scaling TPACK Through Systemic Support:**

Kong et al. (2023) show that TPACK-based initiatives can be sustained and expanded when professional development is designed as a flexible, course-based programme supported by continuous mentoring, school-level communities of practice, and institutional resources that enable teachers to translate TPACK knowledge into long-term classroom practice.

#### **5.5 Integration of Emerging Technologies:**

As emerging technologies such as AI, VR, AR, and IoT continue to evolve rapidly, the TPACK framework must be continually refined to incorporate new forms of technological knowledge and their pedagogical implications, thereby remaining relevant and effective in contemporary teaching contexts (Alkubaisi, 2025).

#### **5.6 Performance-Based Assessment of TPACK:**

Performance-based assessment of TPACK, through the systematic analysis of teachers' lesson plans and instructional artefacts, offers a more valid and practice-oriented evaluation of teachers' technology integration skills than reliance on self-reported measures alone (Akyuz, 2018).

#### **5.7 Evolving TPACK-Oriented Professional Development:**

From a TPACK perspective, teacher professional development must evolve into an ongoing, adaptive learning process that integrates technological change with pedagogical reflection and subject-specific practice over the course of teachers' careers (Meletiou-Mavrotheris and Papanastasiou, 2024).

#### **Conclusion:**

This study reaffirms that the TPACK framework remains a vital lens for understanding and enhancing teachers' capacity to integrate technology, pedagogy, and content knowledge in 21st-century classrooms. By emphasising the interconnectedness of these knowledge domains, TPACK provides a structured approach for designing effective instruction, guiding curriculum planning, and informing professional development. However, its practical implementation is constrained by inequities in resources, cultural considerations, and challenges in assessing complex teacher competencies. Future directions must focus on adaptive, context-sensitive, and performance-oriented strategies that align emerging technologies with pedagogical and content goals. Sustained professional support, systemic backing, and continual refinement of the framework are essential to ensure that TPACK not only remains relevant but also effectively empowers teachers to foster meaningful, technology-enhanced learning experiences across diverse educational settings.

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