Article 2

TRACK as a Transformative Model for Preparing 21st Century Teachers:

Relevance and Implications for the Ethiopian Landscape

Ashenafi Tsegaye Tegegn

Abstract

This review and reflection explores the Technological Pedagogical Content Knowledge (TPACK) framework as a transformative model for preparing 21st-century teachers, with a specific focus on its relevance and implications for the Ethiopian education system. As digital technologies redefine pedagogical landscapes globally, there is an urgent need for teacher education systems—especially in developing contexts like Ethiopia—to adopt integrated approaches that foster technological fluency alongside sound pedagogical and content knowledge. The TPACK framework, which emphasizes the interplay between technology, pedagogy, and subject content, offers a comprehensive paradigm for teacher preparation in digital age classrooms. This paper critically reviews the theoretical underpinnings of TPACK, international and African implementation experiences, and the critical gaps in Ethiopia's teacher training institutions. It further discusses implementation challenges, presents practical strategies for TPACK integration, and outlines implications for curriculum developers, policymakers, and teacher educators. The review concludes with a roadmap for embedding TPACK in Ethiopian teacher education institutions, supporting lifelong learning and technology-enabled instruction aligned with Sustainable Development Goal 4.

Key Words: Digital Age Classrooms, Lifelong Learning, Sustainable Development Goal 4, Teacher Education, TPACK, 21st-Century Teachers.

Introduction and Background

In the 21st century knowledge society, the role of teachers has expanded significantly—from being conduits of information to becoming designers of learning environments, facilitators of inquiry, and mediators of technology-enhanced pedagogy. The increasing integration of digital technologies into all aspects of life and work necessitates that schools not only teach technological skills but also use technology to deepen learning, personalize instruction, and prepare students for complex problem-solving and collaboration in digitally connected contexts (Voogt, Fisser, Good, Mishra, & Yadav, 2015). As such, effective teaching in the digital age requires more than technical proficiency; it calls for a nuanced pedagogical vision that leverages technology to foster engagement, creativity, differentiation, and student agency.

To support this shift, the Technological Pedagogical Content Knowledge (TPACK) framework, introduced by Mishra and Koehler (2006), has emerged as a widely accepted theoretical model guiding the integration of technology in teacher education. Building upon Shulman's (1986) notion of Pedagogical Content Knowledge (PCK), TPACK identifies the complex interplay between three core knowledge domains—content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK)—that teachers must draw upon to deliver effective, digitally mediated instruction. The framework emphasizes that technology integration is

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not a one-size-fits-all process; rather, it is deeply contextual, learner-centered, and pedagogically driven (Koehler, Mishra, & Cain, 2013).

Globally, teacher education institutions are increasingly incorporating TPACK into both pre-service training and in-service professional development. Countries such as the United States, Singapore, and Finland have embedded TPACK-based competencies into national standards, curriculum frameworks, and teacher accreditation systems, with positive outcomes for digital pedagogy and student engagement (Chai, Koh, & Tsai, 2013; Rosenberg & Koehler, 2022). These experiences underscore the importance of grounding technology integration not merely in tool acquisition, but in pedagogical intentionality and subject-specific instructional design.

Nonetheless, in the context of Ethiopia, teacher education programs have been slow to adapt to the demands of the digital era. While significant progress has been made in expanding access to teacher education and emphasizing pedagogical theory and subject mastery, the integration of educational technologies into teaching practice remains minimal (Semela, 2014; MoE, 2020). Many pre-service teachers graduate with limited exposure to digital tools, and in-service teachers often lack the professional development support needed to implement technology effectively in their classrooms (Haile & Asrat, 2021). The recent push for ICT in education under Ethiopia's **Education and Training Roadmap (2018–2030)** highlights a policy-level recognition of this gap, but implementation has been inconsistent and hampered by infrastructure limitations, inadequate training, and insufficient alignment with curriculum reforms (MoE, 2018; Gebremedhin & Fenta, 2015).

This review argues that systematically embedding the TPACK framework within Ethiopia's teacher education curricula can serve as a transformative strategy to enhance the digital readiness, instructional quality, and professional confidence of both pre-service and in-service teachers. By grounding technology integration in sound pedagogy and subject matter expertise, TPACK offers a coherent, context-sensitive model that aligns with Ethiopia's broader goals of educational equity, quality, and 21st century relevance. The ensuing sections explore global best practices, regional trends, and contextual challenges, and propose a set of actionable recommendations for implementing TPACK in the Ethiopian teacher education system.

Conceptual and Theoretical Foundations of TPACK

The TPACK framework is grounded in the foundational work of Shulman (1986), who introduced the concept of *Pedagogical Content Knowledge (PCK)* to emphasize the importance of teachers possessing not only deep subject matter knowledge but also the ability to translate that knowledge into effective instructional practices. Shulman's work highlighted the need for a nuanced understanding of how specific content could be taught in ways that are comprehensible and engaging to learners.

Building on this premise, Mishra and Koehler (2006) proposed the TPACK framework, which introduced *Technological Knowledge (TK)* as an essential third domain alongside content and pedagogy. They argued that in the 21st century educational landscape, effective teaching requires an integrated understanding of content knowledge, pedagogical strategies, and the dynamic capabilities of technology. This extension of Shulman's model responds to the growing demand for digital competence in teaching, where educators are expected to meaningfully incorporate technology into curriculum and instruction (Mishra, Koehler, & Cain, 2013).

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The TPACK framework comprises seven interrelated knowledge domains:

- ***Content Knowledge (CK):*** Mastery of the subject matter, including key concepts, theories, and evidence-based practices.
- ***Pedagogical Knowledge (PK):*** Knowledge of teaching strategies, learning theories, classroom management, and student assessment.
- ***Technological Knowledge (TK):*** Familiarity with various digital tools, platforms, and their affordances for enhancing teaching and learning.
- ***Pedagogical Content Knowledge (PCK):*** *T*he intersection of pedagogy and content, focusing on how to teach specific subject matter effectively.
- ***Technological Content Knowledge (TCK):*** Understanding how technology can support and transform content representation and learning.
- ***Technological Pedagogical Knowledge (TPK):*** Insight into how technological tools can support specific pedagogical approaches.
- ***Technological Pedagogical Content Knowledge (TPACK):*** The integrated knowledge domain where content, pedagogy, and technology converge to enable innovative, effective, and context-responsive teaching.

The strength of the TPACK model lies in its recognition that effective technology integration is not merely about the use of digital tools in isolation. Instead, it involves strategic and thoughtful selection, adaptation, and application of technology to support pedagogical goals and enhance content delivery in ways that align with students' learning needs and contexts (Koehler, Mishra, & Cain, 2013; Voogt et al., 2013). As such, TPACK serves as a conceptual lens for teacher educators, curriculum designers, and teachers to critically reflect on and refine their practices in a digitally-mediated educational environment.

Recent studies further validate TPACK as a vital framework for teacher professional development, especially in the context of remote learning, blended instruction, and emerging technologies such as artificial intelligence and virtual reality (Chai et al., 2020; Rosenberg & Koehler, 2022). It underscores the dynamic, situated, and evolving nature of teacher knowledge as educators continuously adapt to technological advancements and changing learner expectations.

Global Practices in Implementing TPACK

Across the globe, many countries have recognized the transformative potential of the TPACK framework in preparing educators for the demands of 21st century teaching and learning. By embedding TPACK principles into national teacher education policies, professional standards, and institutional curricula, these nations have made significant strides in enhancing teacher digital literacy, instructional innovation, and learner engagement.

To begin with, in the United States, TPACK is widely integrated into teacher licensure requirements and accreditation standards. Many pre-service teacher education programs include structured coursework, practicum experiences, and reflective teaching assignments that promote the use of digital tools in

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pedagogically sound ways (Harris, Mishra, & Koehler, 2009). As to these authors, institutions such as Michigan State University and the University of Central Florida have developed models where teacher candidates engage in designing technology-rich lessons aligned with content standards and student learning goals.

Singapore has also shown strong policy-level commitment through the implementation of successive national *Information and Communication Technology (ICT) Master Plans*, which explicitly embed TPACK-based competencies into both pre-service and in-service teacher professional development programs. The Ministry of Education, in collaboration with teacher education institutions, has emphasized the cultivation of digitally confident teachers who can meaningfully integrate technology into their pedagogical repertoires (Lim & Chai, 2008; Chai, Koh, & Tsai, 2013). Teachers are also supported through *Professional Learning Communities (PLCs)* that foster peer collaboration and continuous digital innovation.

In Finland, teacher education is strongly research-based, and TPACK is reflected in the pedagogical approaches of universities of education, where the development of teacher-researchers is a central goal. Finnish teacher candidates are encouraged to apply *design thinking and reflective inquiry* as they integrate digital technologies with curriculum content in iterative and learner-centered ways (Ilomäki & Lakkala, 2011). The emphasis on autonomy and creativity allows Finnish educators to experiment with emerging tools and adapt their practices to diverse classroom contexts.

Australia has institutionalized TPACK within the *Australian Professional Standards for Teachers*, recognizing it as a core competency necessary for delivering effective instruction in digitally- mediated learning environments. National teacher education programs have adopted technology integration frameworks aligned with TPACK to guide pre-service training and support in-service teachers in using digital tools to meet diverse student needs (Australian Institute for Teaching and School Leadership [AITSL], 2020).

Importantly, India has also begun integrating TPACK principles within its evolving teacher education landscape. *The National Education Policy (NEP) 2020* emphasizes the importance of digital literacy, blended learning, and technology-supported pedagogy. Initiatives such as *DIKSHA* (Digital Infrastructure for Knowledge Sharing) and *NISHTHA* (National Initiative for School Heads' and Teachers' Holistic Advancement) have been offering structured digital curricula that reflect TPACK-oriented design, equipping teachers with competencies to effectively blend content, pedagogy, and technology in diverse classroom settings (Ministry of Education, 2020). Indian teacher education institutions, including Regional Institutes of Education and Central Universities, are increasingly incorporating TPACK-based frameworks into pre-service curricula and promoting action research on technology integration (Mishra, 2021).

Collectively, these international experiences highlight that aligning teacher education policies, institutional curricula, and professional standards with TPACK not only fosters digital competence among educators but also significantly enhances student engagement, differentiated instruction, and lifelong learning. They demonstrate the importance of sustained policy support, professional development infrastructure, and a reflective teaching culture in realizing the full potential of TPACK.

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Table 1 Comparative Overview of TPACK Implementation in Selected Countries

Country	Policy Integration	Pre-Service Teacher Education	In-Service Teacher Development	Institutional Practices	Notable Initiatives / Programs
United States	Integrated into teacher licensure and accreditation standards (e.g., CAEP)	Emphasizes coursework and practicum with digital tool integration	Focused PD sessions, workshops, and blended learning models	University-based models (e.g., MSU's TPACK labs)	Learning Activity Types framework; ISTE Standards
Singapore	Embedded in national ICT Master Plans I–IV	TPACK competencies embedded in curriculum design	Continuous PD through Professional Learning Communities (PLCs)	Collaborative lesson planning and technology-rich microteaching	Future-Schools@ Singapor, eduLab, iTEACH framework
Finland	Reflected in national teacher education policies	Strong research-based teacher training using TPACK and design thinking	Less centralized; strong emphasis on teacher autonomy and reflection	Universities promote iterative, inquiry-based integration	OPEKA (Teacher Digital Competence Tool), eNorssi network
Australia	Recognized in Australian Professional Standards for Teachers (AITSL)	TPACK principles guide curriculum in teacher education programs	PD aligned with national teaching standards; focus on digital pedagogy	Use of digital platforms for reflective practice and mentoring	Digital Technologies Hub; National Digital Learning Resources Network
India	Highlighted in NEP 2020; supports digital pedagogy integration	Some integration in pre-service programs via NCTE and central universities	Large-scale national PD through MOOCs and platforms like DIKSHA	Action research, pilot programs in RIEs and TEIs	NISHTHA, DIKSHA, PM eVidya, NCERT e-Content

Key: CAEP: Council for the Accreditation of Educator Preparation (U.S.); **ISTE**: International Society for Technology in Education; **PLCs**: Professional Learning Communities; **NCTE**: National Council for Teacher Education (India); **RIEs**: Regional Institutes of Education; **TEIs**: Teacher Education Institutions

TPACK in Sub-Saharan Africa: *Emerging Trends and Lessons*

The integration of the TPACK framework in Sub-Saharan Africa is still in its formative stages but shows promising signs of growth and contextual adaptation. As many African countries strive to reform their education systems to meet the demands of the digital age, TPACK is gradually being recognized as a valuable framework for guiding technology integration in teacher education and professional development.

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In South Africa, the Department of Basic Education (DBE) has increasingly embedded digital literacy and pedagogical use of technology into its *Continuing Professional Teacher Development (CPTD)* initiatives. Professional development programs for in-service teachers now incorporate elements of TPACK to support teachers in integrating ICT tools in ways that align with curriculum content and pedagogical goals (Jita, 2016). Moreover, teacher education institutions are being encouraged to redesign curricula that foster the development of digital pedagogical competencies.

Kenya has also taken significant strides through its *Digital Literacy Program (DLP)*, a national initiative launched in 2016 that aims to equip teachers and learners with digital devices and skills. Teacher training under the DLP is informed by TPACK principles, ensuring that technology use in classrooms is not merely technical but meaningfully integrated into curriculum delivery (Makokha & Waweru, 2017). Pre-service teachers undergo modules on ICT pedagogy, and schools are gradually adopting lesson planning practices that reflect TPACK-informed design.

In Nigeria and Ghana, the adoption of TPACK has gained strong hold within selected teacher education institutions. For instance, universities such as the University of Ibadan in Nigeria and the University of Cape Coast in Ghana had already begun embedding TPACK concepts into pre-service teacher education curricula. These efforts are often supported by collaborative research projects and the development of *Professional Learning Communities (PLCs)* that focus on reflective practice and peer mentoring in digital pedagogy (Agyei & Voogt, 2012; Adovonou, 2022). Despite infrastructural challenges, educators are increasingly experimenting with blended learning environments that require an understanding of the intersections between content, pedagogy, and technology.

Emerging evidences across the region highlight several key lessons. First, successful TPACK integration necessitates the development of localized digital content that aligns with national curricula and cultural contexts. Imported educational technologies and resources must be adapted to meet local linguistic, pedagogical, and socio-economic realities (Oluoch & Gachago, 2023). Second, infrastructure readiness, including access to reliable internet, electricity, and digital devices, remains a significant barrier to scaling TPACK-aligned practices, particularly in rural and underserved areas. Finally, ongoing faculty development is crucial. Teacher educators themselves must be equipped with TPACK competencies to effectively model and scaffold technology integration for pre-service teachers (Boateng & Tindi, 2020).

In a nutshell, while TPACK implementation in Sub-Saharan Africa remains at an early stage, it is increasingly viewed as a viable and contextually adaptable framework for promoting digital transformation in teacher education. Continued investment in infrastructure, capacity building, and curriculum reform will be essential to unlocking the full potential of TPACK in advancing equitable, technology-enabled learning across the region.

Ethiopia's Teacher Education Reforms and Digital Readiness

Ethiopia's Education and Development Road-Map (2018–2030), the National Teacher Education Policy Framework (2018b), Education Sector Development Program-VI (2020–2025), the Higher Education Reform Agenda (2021–2030), and more recently, the Teacher Competency Framework (2023) all give due emphasis to and call for teachers' pedagogical excellence and professional standards. Programs such as the *Higher Diploma Program (HDP)* in the higher education institutions, and *Continuous Professional*

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Development (CPD) in the primary and secondary schools have enhanced pedagogical skill-building. However, integration of technology remains minimal. Many teachers lack confidence in selecting and using educational technologies (Habtamu & Alemayehu, 2020).

As to existing literature and official documents (e.g., MoE, 2022, 2020; Gebremedhin & Fenta, 2015; Tadesse & Gillies, 2015), challenges include the following:

- ***Infrastructure gaps:*** Many Teacher Education Institutions (TEIs) lack reliable internet, functional computer labs, or access to educational software.
- ***Capacity gaps:*** Faculty often lack training in digital pedagogy or TPACK-based instructional design.
- ***Curricular fragmentation:*** Separate treatment of technology, pedagogy, and content undermines the integrated approach promoted by TPACK.
- ***Policy-practice disconnect:*** Despite ICT-for-Education policies, there is limited translation into teacher education practices.

Pathways to TPACK Integration in Ethiopian Teacher Preparation

To institutionalize TPACK, Ethiopia needs a multi-level approach:

- ***Curriculum Redesign:*** Develop modules that explicitly integrate CK, PK, and TK. This could include problem-based learning, co-teaching, and field-based digital projects.
- ***Institutional Development:*** Establish TPACK innovation labs in TEIs to support practice-based learning and instructional design.
- ***Faculty Capacity-Building:*** Offer certification programs and professional learning communities for teacher educators.
- ***ICT Infrastructure Investment:*** Prioritize digital inclusion by equipping TEIs with ICT tools and OER.
- ***Policy Harmonization:*** Align national ICT, teacher development, and curriculum policies under a unified TPACK-aligned implementation strategy.
- ***Monitoring and Research:*** Introduce TPACK competency frameworks in teacher assessment tools and promote design-based research in teacher training programs.

The Role of Digital Pedagogical Leadership

To sustain TPACK integration, Ethiopia must cultivate *digital pedagogical leadership* among teacher educators and policy-makers. These leaders can:

- Champion innovation in TEIs.
- Mentor novice teachers in technology-enhanced lesson planning.
- Influence curriculum review bodies.
- Collaborate with international networks on best practices.

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This leadership is crucial for institutionalizing a culture of digital teaching and lifelong learning.

Conclusion

The TPACK framework offers a robust and integrative model for transforming teacher education in the digital era. By emphasizing the dynamic interplay among content knowledge, pedagogical expertise, and technological fluency, TPACK equips educators with the capacity to design and deliver learning experiences that are both contextually relevant and technologically enriched. For a country like Ethiopia—where efforts to modernize education are central to national development priorities—TPACK presents a timely and strategic opportunity to elevate the quality of teaching and learning across the education system.

The integration of TPACK into Ethiopia's teacher preparation programs can serve as a catalyst for educational innovation. It can help bridge the persistent digital divide by fostering a generation of teachers who are not only content experts and effective pedagogues, but also confident users of digital tools and platforms. This, in turn, can enhance student engagement, support differentiated instruction, and promote 21st century competencies such as creativity, collaboration, critical thinking, and digital literacy.

Notwithstanding, effective implementation of TPACK requires more than conceptual adoption; it calls for systemic and structural reforms. Key prerequisites include the renewal of pre-service teacher education curricula to reflect TPACK-informed competencies, substantial investment in digital infrastructure and connectivity—particularly in rural and underserved areas—and ongoing, context-specific professional development to support teachers' evolving technological and pedagogical needs. Moreover, education leaders and policymakers must foster a culture of innovation and reflective practice, ensuring that the use of technology is purposeful, inclusive, and aligned with national education goals.

By anchoring TPACK in Ethiopia's broader educational reform agenda, the country can move toward a more equitable, future-ready education system that meets the learning needs of all students in a rapidly digitizing global society. In doing so, Ethiopia can not only enhance its teacher quality and learning outcomes but also position itself as a forward-looking nation that leverages technology for inclusive and transformative education.

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