

Evaluating Technological Pedagogical Content Knowledge among Second-Year Student Teachers: Insights from Learning Management Course

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Abstract

This study examined Technological Pedagogical Content Knowledge (TPACK) among second-year student teachers. The study aimed to assess their proficiency in integrating content knowledge, pedagogy, and technology to create effective learning experiences. Data were collected through a comprehensive evaluation of seven key components of TPACK: Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK). The sample comprised 92 second-year student teachers who enrolled in a Learning Management course at a university in Surin Province during the second semester of 2022. A mixed-methods approach was utilized, combining qualitative and quantitative data from lesson plan analyses, field notes of observations, semi-structured interviews, document reviews, and questionnaires. The findings revealed that student teachers possessed a strong foundation in TPACK, with an overall high level of proficiency ($\bar{x} = 4.19$, S.D. = 0.67). Technological Knowledge (TK) emerged as the strongest area, indicating confidence in using technology in educational settings. However, the study also identified a relative weakness in Technological Content Knowledge (TCK), suggesting the need for further development in aligning technology with specific content areas. The results highlighted the importance of targeted training and continuous professional development to enhance TPACK, ensuring that future educators are fully equipped to integrate technology into their teaching practices effectively.

Keywords: Technological Pedagogical Content Knowledge, Teacher Education, Learning Management Course

Introduction

In the 21st century, the role of educators has undergone a significant transformation, driven by the pervasive integration of technology into every aspect of daily life. As digital tools become increasingly central to both personal and professional spheres, the education sector faces the challenge of preparing students to navigate a world where technological proficiency is essential. Consequently, the role of teachers has expanded beyond traditional instructional duties to include the effective integration of technology into their teaching practices. This shift necessitates a comprehensive understanding of how to blend content knowledge, pedagogical strategies, and technological tools-

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a concept encapsulated in the framework of Technological Pedagogical Content Knowledge (TPACK). TPACK, as conceptualized by Mishra & Koehler (2008), extends Shulman's (1987) foundational idea of Pedagogical Content Knowledge (PCK), which highlights the importance of teachers' ability to convey subject matter in a manner that is pedagogically sound and accessible to students. The TPACK framework adds a crucial layer to this model by integrating technological knowledge, emphasizing that effective teaching in the digital age requires more than just an understanding of content and pedagogy—it demands the ability to seamlessly incorporate technology into the learning process.

As the importance of TPACK in modern education becomes increasingly clear, the challenge lies in ensuring that student teachers are adequately prepared to develop and apply this integrated knowledge in their future classrooms. Research indicates that while many student teachers possess a basic level of technological knowledge, they often face difficulties when it comes to integrating this technology with content and pedagogy effectively (Angeli & Valanides, 2009; Tondeur et al., 2012). These challenges can be attributed to a variety of factors, including limited practical experience with technology in instructional settings, insufficient training in the pedagogical use of digital tools, and a lack of confidence in their ability to align technology with learning objectives (Mouza et al., 2014). In response to these challenges, teacher education programs are increasingly focusing on the development of TPACK as a core competency for future educators. However, the extent to which these programs succeed in fostering TPACK among student teachers varies, and there is a need for ongoing evaluation and refinement of these educational approaches. Understanding TPACK among student teachers is critical for identifying gaps in their preparation and for developing targeted interventions that can enhance their ability to integrate technology into their teaching practices effectively. Recent updates to the TPACK model argue for contextualized knowledge as an additional and distinct component, emphasizing that teachers' knowledge is shaped by external constraints and affordances (Willermark, 2018; Brianza, Schmid, Tondeur, & Petko, 2022). Several systematic and empirical reviews have documented key trends in TPACK development — for example, the use of Lesson Study and other collaborative, practice-based approaches as effective scaffolds for developing integrative teacher knowledge (Soto Gómez, Serván Núñez, & Pérez Gómez, 2015; Vermunt, Vrikk, van Halem, Warwick, & Mercer, 2019). Likewise, syntheses of preservice teacher research indicate evolving patterns in how technological, pedagogical, and content knowledge interact — including differences in which knowledge domains develop first and how contextual factors mediate TPACK development (Wang, Schmidt-Crawford, & Jin, 2018).

Despite these advances, relatively few empirical studies examine how second-year student teachers in Thailand, particularly those enrolled in interdisciplinary programs, develop TPACK. This gap motivates the present study. While prior studies have concentrated on pre-service teachers in general, few have examined how early-stage teacher education students develop TPACK within interdisciplinary programs. This focus is both timely and necessary, as it provides insights into how teacher preparation can be strengthened at a crucial formative stage. Specifically, there is a lack of localized data on the TPACK profile of second-year student teachers from various subject areas enrolled in

a Learning Management Course, in a specific regional context of Surin Province. This study aims to fill that gap by providing a detailed TAPCK evaluation to inform targeted curricular refinement.

Objectives

The purpose of this study was to evaluate Technological Pedagogical Content Knowledge (TPACK) among second-year student teachers who enrolled in a Learning Management course at a university in Surin Province during the second semester of 2022. By explicitly linking to the identified research gap, the study sought to determine how second-year students develop TPACK across seven key components—Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK)—and to highlight the specific strengths and weaknesses that inform teacher education practices.

Literature Review

Technological Pedagogical Content Knowledge (TPACK) framework, proposed by Koehler & Mishra (2008), is an extension of Shulman's idea of Pedagogical Content Knowledge (PCK). TPACK emphasizes the integration of technology in teaching, recognizing that effective teaching lies at the intersection of technology, pedagogy, and content knowledge. The framework helps educators understand how these components interact to create an effective teaching and learning environment. The TPACK framework drawn upon this study is shown in Figure 1.

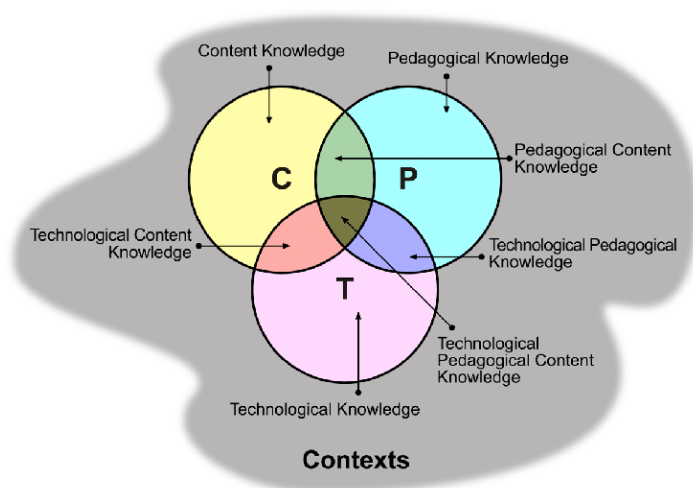


Figure 1 Technological Pedagogical Content Knowledge framework and its knowledge components (Koehler & Mishra, 2008)

Research Methodology

This study employed mixed-methods research (Creswell & Plano Clark, 2011).

1. Population and Sample

The population consisted of 25 classes, totaling 649 Thai second-year student teachers, who enrolled in a Learning Management Course during the second semester of 2022 at a university in Surin Province. The sample consisted of 4 classes, totaling 92 Thai second-year student teachers, who enrolled in a Learning Management Course during the second semester of 2022 at a university in Surin Province. The author supervised the practice across all 4 classes of the course. These student teachers were majoring in various interdisciplinary subjects, including programs in Mathematics, Biology, Classical Dance, Physical Education, Thai, Social Studies, Agricultural, Digital Technology for Education, Elementary Education, and Early Childhood Education.

The sample was chosen due to the author's direct instructional responsibility for these specific second-year classes in a Learning Management Course, ensuring reliable access and in-depth data collection through observation and interview over the semester.

2. Research instruments

2.1 Evaluation Form of Student Teachers' Lesson Plans

2.2 Field Notes of Observation for Student Teachers' Micro-Teaching

2.3 Evaluation Form for Student Teachers' Micro-Teaching

2.4 Evaluation Form for Student Teachers' Teaching Behavior

2.5 Evaluation Form for Student Learning Behaviors

2.6 Semi-Structured Interview on Student Teachers' TPACK

2.7 Questionnaire on Student Teachers' TPACK Post-Instruction in the Learning Management Course

3. Data Collection

To evaluate TPACK, the second-year student teachers were asked to design and write their lesson plans in groups of 2-3 people. After the author revised their lesson plans, the students were asked to prepare their teaching using Micro-Teaching based on the revised plans. Multiple data sources were used in this study: classroom lessons were observed and video recorded. Each group's observed lesson lasted about 40 minutes. The student teachers were also asked to reflect on their teaching practices after each class. All interviews were conducted in a semi-structured manner, allowing the sample to discuss their successes and progress. Additionally, the author interviewed them about their teaching after the lessons. All interviews were recorded and transcribed verbatim. Documents such as lesson plans, worksheets, learning materials, assignments, and reflective journals were reviewed as additional data. After completing the Micro-Teaching, the student teachers were asked to complete questionnaires on TPACK development, using a 5-point Likert scale format.

4. Data Analysis

The data were analyzed using mean and standard deviation. Moreover, methodological triangulation was achieved through multiple data sources, including lesson plans, interview transcriptions, field notes, and document reviews. This process allowed the same data to be viewed from various perspectives, clarifying the meaning of the data in a larger context. The data from the questionnaires were analyzed using descriptive statistics, specifically the mean and standard deviation. The interpretation of the mean scores reflects the TPACK of second-year student teachers as follows:

4.50 – 5.00: TPACK is at the highest level.

3.50 – 4.49: TPACK is at a high level.

2.50 – 3.49: TPACK is at a moderate level.

1.50 – 2.49: TPACK is at a low level.

Results

The results, focus on the seven key components of TPACK—Content Knowledge (CK), Pedagogical Knowledge (PK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK)—are presented in Table 1.

Table 1 Evaluation of TPACK and its components among second-year student teachers

TPACK and its components	Evaluation of TPACK and its components among second-year student teachers			
	$\bar{x}$	S.D.	Meaning	rank
1. Content Knowledge (CK)	4.18	0.63	high	4
2. Pedagogical Knowledge (PK)	4.17	0.69	high	6
3. Technological Knowledge (TK)	4.30	0.71	high	1
4. Pedagogical Content Knowledge (PCK)	4.22	0.66	high	2
5. Technological Content Knowledge (TCK)	4.16	0.67	high	7
6. Technological Pedagogical Knowledge (TPK)	4.18	0.68	high	5
7. Technological Pedagogical Content Knowledge (TPACK)	4.21	0.68	high	3
total	4.19	0.67	high	

As can be seen in Table 1, the results revealed the ranking of the seven TPACK components: Technological Knowledge (TK) ranked highest ($\bar{x} = 4.30$, $SD = 0.71$), followed by Pedagogical Content Knowledge (PCK) ($\bar{x} = 4.22$, $SD = 0.66$), Technological Pedagogical Content Knowledge (TPACK) ($\bar{x} = 4.21$, $SD = 0.68$), Content Knowledge (CK) ($\bar{x} = 4.18$, $SD = 0.63$), Technological Pedagogical Knowledge (TPK) ($\bar{x} = 4.18$, $SD = 0.68$), Pedagogical Knowledge (PK) ($\bar{x} = 4.17$, $SD = 0.69$), and Technological Content Knowledge (TCK) ranking lowest ($\bar{x} = 4.16$, $SD = 0.67$).

The results, organized according to the seven key components of TPACK, were as follows:

1. Content Knowledge (CK)

The results indicated that second-year student teachers have a strong command of Content Knowledge (CK), as reflected in their high average score of 4.18 (S.D. = 0.63). This solid understanding of their subject matter is evident in both their lesson planning and teaching practices. Key findings were as follows:

1.1 Comprehensive Lesson Planning: Student teachers consistently developed detailed lesson plans that included essential components like objectives, content, and assessments. Their plans were well-aligned with educational goals, showcasing their ability to translate content knowledge into structured lessons.

1.2 Effective Content Delivery: In micro-teaching sessions, student teachers clearly and accurately conveyed key concepts, making the material accessible to students. They successfully connected new content with students' existing knowledge, enhancing engagement and comprehension.

1.3 Emphasis on Core Ideas: Student teachers focused on the most important concepts within their subjects, ensuring that these were highlighted throughout their lessons, which helped students grasp the fundamental aspects of the content.

1.4 Challenges in Content Sequencing: Some student teachers struggled with organizing content in a logical sequence. In some cases, they did not adequately review prior knowledge before introducing new material, which could lead to gaps in student understanding.

2. Pedagogical Knowledge (PK)

The results showed that second-year student teachers possessed strong Pedagogical Knowledge (PK), with an average score of 4.17 (S.D. = 0.69). This indicates that they are generally proficient in using various teaching strategies and adapting their methods to suit different classroom contexts. Key findings were as follows:

2.1 Diverse Instructional Techniques: Student teachers effectively employed a wide range of teaching methods, demonstrating flexibility in adapting their approaches to meet the diverse needs of students. This adaptability was particularly evident in their ability to use different techniques depending on the classroom context.

2.2 Student-Centered Teaching: They successfully implemented student-centered approaches, creating engaging learning experiences that catered to individual student needs. This focus on the learner helped foster a more inclusive and participatory classroom environment.

2.3 Classroom Management Challenges: While proficient in teaching strategies, some student teachers struggled with managing classroom dynamics, particularly in organizing and maintaining effective classroom management. This suggests that while they are strong in delivering content, there is room for improvement in managing classroom behavior and maintaining a conducive learning environment.

3. Technological Knowledge (TK)

The results indicated that second-year student teachers have a robust understanding of Technological Knowledge (TK), with an average score of 4.30 (S.D. = 0.71), the highest among all evaluated components. This suggests that they are confident in their ability to utilize technology effectively in their teaching. Key findings were as follows:

3.1 Frequent and Effective Use of Technology: Student teachers consistently integrated technology into their teaching practices, as evidenced by the highest score in the domain, where they frequently used technology in their lessons. This regular use of digital tools reflects their comfort and proficiency with technology in educational settings.

3.2 Staying Updated with Emerging Technologies: They showed an ability to stay current with new and emerging technologies, quickly learning and adapting these tools to enhance their teaching practices. This ability ensures that they are not only proficient with existing technologies but also prepared to incorporate new advancements.

3.3 Challenges in Troubleshooting: While generally confident in using technology, some student teachers faced difficulties in troubleshooting technical issues on their own. This indicates that while they can effectively integrate technology into their teaching, they may need additional support or training in resolving technical problems independently.

4. Pedagogical Content Knowledge (PCK)

The results revealed that second-year student teachers have a strong foundation in Pedagogical Content Knowledge (PCK), with an average score of 4.22 (S.D. = 0.66). This indicates their ability to effectively integrate content knowledge with appropriate teaching strategies to enhance student learning. Key findings were as follows:

4.1 Effective Teaching Methods: Student teachers demonstrated a strong capability to select and apply teaching methods that promote higher-order thinking and deep learning in their students.

4.2 Alignment of Content and Pedagogy: They were generally successful in ensuring that the content was delivered in a manner that was accessible and engaging for students. This alignment between content and pedagogy helped students not only understand the material but also apply it in meaningful ways.

4.3 Challenges with Higher-Order Questioning: While student teachers were proficient in using appropriate teaching methods, there were some challenges in employing higher-order questioning techniques. Some tended to rely on recall-based questions rather than those that encourage critical thinking and deeper engagement with the content. This suggests a need for further development in questioning strategies to fully support student learning.

5. Technological Content Knowledge (TCK)

The results showed that second-year student teachers have a solid understanding of Technological Content Knowledge (TCK), with an average score of 4.16 (S.D. = 0.67). This reflects their ability to integrate technology with content knowledge, though there are some areas where further improvement is needed. Key findings were as follows:

5.1 Effective Use of Technology to Enhance Content Delivery: Student teachers were able to use various technological tools to present content in a way that enhanced student understanding. They effectively selected technologies that aligned with the subject matter, helping to make complex concepts more accessible to students.

5.2 Integration of Technology with Content: The results indicated that student teachers could effectively integrate technology to support and enrich the learning of specific content areas. For example, they utilized digital tools to provide visual aids or interactive activities that reinforced key concepts.

5.3 Challenges with Complex or Abstract Content: Some student teachers struggled with using technology to teach more complex or abstract content. In particular, they found it difficult to select and use appropriate technologies for content that required a higher level of cognitive engagement. This suggests that while they are generally proficient with technology, they need more training or experience in applying it effectively in more challenging content areas.

6. Technological Pedagogical Knowledge (TPK)

The results indicated that second-year student teachers possessed strong Technological Pedagogical Knowledge (TPK), with an average score of 4.18 (S.D. = 0.68). This suggests that they are generally proficient in selecting and applying technologies that effectively support and enhance their pedagogical practices. Key findings were as follows:

6.1 Strategic Selection of Technology: Student teachers demonstrated a good ability to choose appropriate technologies that align with their teaching methods. They effectively used technology to support various pedagogical strategies, ensuring that the tools they selected enhanced student engagement and learning outcomes.

6.2 Enhancement of Pedagogical Practices: The use of technology by student teachers was not just for the sake of inclusion but was thoughtfully integrated to improve the overall teaching and learning process.

For example, they used interactive tools and digital platforms to facilitate group discussions, assessments, and differentiated instruction, which supported diverse learning styles and needs.

6.3 Challenges in Consistent Integration: Although the overall TPK scores were high, some student teachers faced difficulties in consistently integrating technology with pedagogy, particularly in ensuring that the chosen technologies were the best fit for the specific teaching methods or content being delivered. This inconsistency suggests a need for more experience or training in making optimal technology-pedagogy connections.

7. Technological Pedagogical Content Knowledge (TPACK)

The results revealed that second-year student teachers have developed a solid foundation in Technological Pedagogical Content Knowledge (TPACK), with an average score of 4.21 (S.D. = 0.68). This indicates their overall proficiency in integrating content, pedagogy, and technology to create effective and engaging learning experiences. Key findings were as follows:

7.1 Holistic Integration of TPACK: Student teachers demonstrated the ability to seamlessly combine content knowledge, pedagogical strategies, and technological tools in their teaching. This holistic approach enabled them to deliver lessons that were both educationally sound and engaging for students. For instance, they effectively used digital tools to enhance the delivery of complex content while employing pedagogical techniques that catered to different learning styles.

7.2 Effective Content Delivery with Technology: The highest scores were observed in the student teachers' ability to teach content by integrating technology in a way that aligns with students' abilities and interests. This suggests that they are capable of using technology not just as an add-on, but as an integral part of the teaching process that supports and enhances learning.

7.3 Challenges in Lesson Planning Integration: Despite their strong overall performance, some student teachers struggled with lesson planning integration, specifically in planning and implementing strategies that integrate content, technology, and pedagogy effectively before the lesson. This indicates a need for further practice in the planning stages to ensure that all elements are cohesively integrated before teaching begins.

Discussion

The findings offered valuable insights into second-year student teachers' preparedness to integrate content, pedagogy, and technology into their teaching practices. The discussion connects these findings with the broader body of literature and emphasizes their implications for teacher education. The high scores in TK and TPACK confirm the pivotal role of technological fluency in effective teaching (Koehler & Mishra, 2009), while challenges in sequencing content and questioning strategies reflect gaps also observed in earlier studies (Ball, Thames, & Phelps, 2008). By situating the results within both theoretical and practical contexts, the study

underscores the importance of curriculum design and professional development that target early-stage teacher education.

The TPACK Strengths and Weaknesses

Technological Knowledge (TK) — Highest ($\bar{x} = 4.30$, $SD = 0.71$): The quantitative results indicate a strong proficiency in using digital tools among the second-year student teachers. Qualitative data from reflections and interviews corroborate this finding: many participants reported frequent and confident use of educational technologies and a willingness to learn new tools. This pattern is consistent with recent preservice teacher studies that document early development of technological fluency, often prior to integrative application with pedagogy and content (Nelson, Voithofer, & Cheng, 2022; Rafiq, 2022). However, interview data also highlighted occasional difficulties with troubleshooting technical issues independently.

Pedagogical Content Knowledge (PCK) — Second highest ($\bar{x} = 4.22$, $SD = 0.66$): Student teachers demonstrated solid ability to align instructional strategies with subject matter. Observations and lesson plan analyses showed careful selection of methods designed to promote student understanding and higher-order thinking. This strength aligns with foundational work on content knowledge for teaching (Ball, Thames, & Phelps, 2008) and indicates that preservice training is supporting the pedagogical translation of content knowledge.

Technological Pedagogical Content Knowledge (TPACK) — Third ($\bar{x} = 4.21$, $SD = 0.68$): The overall TPACK score suggests that many student teachers were able to combine content, pedagogy, and technology into coherent lesson designs. Nonetheless, the qualitative evidence indicates that such integration was often achieved during or after lesson delivery rather than consistently during the planning phase. This finding suggests that while the capacity for integrative practice exists, more structured scaffolding during lesson planning is necessary to secure stable TPACK (Koehler & Mishra, 2009; Brianza et al., 2022).

Content Knowledge (CK) — Fourth ($\bar{x} = 4.18$, $SD = 0.63$): The results demonstrate a satisfactory mastery of subject matter across disciplines. In practice, some student teachers encountered challenges in sequencing complex topics and in diagnosing gaps in learners' prior knowledge. These issues point to the need for explicit training in curriculum sequencing and scaffolding techniques to ensure students' readiness before introducing new content (Wang, Schmidt-Crawford, & Jin, 2018).

Technological Pedagogical Knowledge (TPK) — Fifth ($\bar{x} = 4.18$, $SD = 0.68$): Participants showed competence in selecting tools that supported pedagogical aims, using interactive platforms and digital resources to facilitate engagement. Yet, TPK integration was not consistently aligned with instructional objectives, and occasional mismatches between tool affordances and pedagogical intent were observed. These inconsistencies reflect broader findings that technological selection alone does not guarantee pedagogically effective use (Willermark, 2018).

Pedagogical Knowledge (PK) — Sixth ($\bar{x} = 4.17$, $SD = 0.69$): While student teachers employed diverse instructional strategies and student-centered approaches, classroom management and the consistent use

of higher-order questioning were areas requiring further development. Strengthening classroom management techniques and questioning strategies would likely enhance the effectiveness of their pedagogical practice (Ball et al., 2008).

Technological Content Knowledge (TCK) — Lowest ($\bar{x} = 4.16$, $SD = 0.67$): The lowest scores in TCK indicate difficulty in selecting and using technologies that are well matched to complex or abstract content. Qualitative notes and interview excerpts suggest that participants found it challenging to identify digital tools that deepen subject-specific understanding, particularly for higher cognitive tasks. This gap resonates with literature highlighting contextual constraints and the need for targeted TCK development (Brianza et al., 2022; Wang et al., 2018). This key finding reveals a critical gap: while student teachers are adept at using technology (TK is high), they struggle to align specific technology with specific content (TCK is low), which is a prerequisite for holistic TPACK.

Overall, the pattern observed in this study echoes several recent syntheses of preservice TPACK research: technological fluency often emerges early, whereas integrative knowledge that tightly links technology with content (TCK) tends to develop later and requires deliberate pedagogical support (Vermunt et al., 2019; Nelson et al., 2022; Rafiq, 2022). The importance of context as a shaping factor for TPACK is underscored by Brianza et al. (2022), who argue for situating teacher knowledge within specific affordances and constraints. The present findings therefore suggest that teacher education programs should prioritize structured, contextualized opportunities for planning and practice that explicitly connect technology and disciplinary content.

Conclusion and implications

The findings demonstrated that second-year student teachers possess a strong foundation in Technological Pedagogical Content Knowledge (TPACK), a critical competency for effective teaching in the digital age. Their overall proficiency is high, reflecting their readiness to meet the demands of modern classrooms. However, the area of Technological Content Knowledge (TCK) and the consistency of Technological Pedagogical Knowledge (TPK) suggest the need for further development, particularly in the planning and implementation phases of instruction. Implications for teacher education programs include the need for targeted professional development to enhance TCK, additional support for instructional planning, and ongoing training in technological integration. Encouraging reflective practice and revising curriculum design to emphasize TPACK as a core competency are also critical for ensuring that future educators are fully equipped to deliver high-quality, technology-rich instruction. Practical implications: Based on both quantitative and qualitative evidence, three priority implications emerge. First, teacher education curricula should incorporate targeted modules and workshops on TCK to help student teachers select and adapt technologies for subject-specific learning. Second, instructors should scaffold lesson-planning processes with explicit prompts for technology-content alignment and

troubleshooting practice. Third, adopting collaborative, practice-based professional development models such as Lesson Study can provide sustained opportunities for iterative design, observation, and feedback.

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References

- Ait Ali, D., Mühling, A., & Schaumburg, H. (2023). Empirical research on technological pedagogical content knowledge (TPACK): A systematic review of survey studies. *Education and Information Technologies*, 28(5), 6169–6197. <https://doi.org/10.1007/s10639-023-11523-4>
- Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPACK: Advances in technological pedagogical content knowledge (TPACK). *Computers & Education*, 52(1), 154–168. <https://doi.org/10.1016/j.compedu.2008.07.006>
- Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, 59(5), 389–407. <https://doi.org/10.1177/0022487108324554>
- Bloom, B. S. (1956). *Taxonomy of educational objectives, Handbook I: The cognitive domain*. New York: David McKay.
- Brianza, E., Schmid, M., Tondeur, J., & Petko, D. (2022). Situating TPACK: A systematic literature review of context as a domain of knowledge. *Contemporary Issues in Technology and Teacher Education*, 22(4), 707–753. <https://citejournal.org/volume-22/issue-4-22/general/situating-tpack-a-systematic-literature-review-of-context-as-a-domain-of-knowledge/>
- Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Thousand Oaks, CA: Sage.
- Koehler, M. J., & Mishra, P. (2008). Introducing TPACK. In AACTE Committee on Innovation & Technology (Ed.), *Handbook of technological pedagogical content knowledge (TPACK) for educators* (pp. 3–30). New York, NY: Routledge.
- Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)? *Contemporary Issues in Technology and Teacher Education*, 9(1), 60–70. <https://citejournal.org/volume-9/issue-1-09/general/what-is-technological-pedagogical-content-knowledge/>

- Mouza, C., Nandakumar, R., Yilmaz Ozden, S., & Karchmer-Klein, R. (2014). Investigating the impact of an integrated approach to the development of pre-service teachers' technological pedagogical content knowledge (TPACK). *Computers & Education*, 71, 206–221. <https://doi.org/10.1016/j.compedu.2013.09.020>
- Nelson, M. J., Voithofer, R., & Cheng, S. L. (2022). Measuring TPACK in preservice teacher education: Updating instruments and practices. *Computers & Education*, 176, 104359. <https://doi.org/10.1016/j.compedu.2021.104359>
- Rafiq, K. R. M. (2022). Re-envisioning technological pedagogical content knowledge and online teaching readiness of EFL preservice teachers. *Frontiers in Psychology*, 13, 927835. <https://doi.org/10.3389/fpsyg.2022.927835>
- Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4–14. <https://doi.org/10.3102/0013189X015002004>
- Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, 57(1), 1–22. <https://doi.org/10.17763/haer.57.1.j463w79r56455411>
- Soto Gómez, E., Serván Núñez, M. J., & Pérez Gómez, A. I. (2015). Cooperative research: A critical strategy in university teacher training—A case study of Lesson and Learning Studies. *International Journal for Lesson and Learning Studies*, 4(1), 56–71. <https://doi.org/10.1108/IJLLS-05-2014-0011>
- Tondeur, J., van Braak, J., Sang, G., Voogt, J., Fisser, P., & Ottenbreit-Leftwich, A. (2012). Preparing pre-service teachers to integrate technology in education: A synthesis of qualitative evidence. *Computers & Education*, 59(1), 134–144. <https://doi.org/10.1016/j.compedu.2011.10.009>
- Vermunt, J. D., Vrikk, M., van Halem, N., Warwick, P., & Mercer, N. (2019). The impact of Lesson Study professional development on the quality of teacher learning. *Teaching and Teacher Education*, 81, 61–73. <https://doi.org/10.1016/j.tate.2019.02.009>
- Wang, W., Schmidt-Crawford, D., & Jin, Y. (2018). Preservice teachers' TPACK development: A review of literature. *Journal of Digital Learning in Teacher Education*, 34(4), 234–258. <https://doi.org/10.1080/21532974.2018.1498030>
- Willermark, S. (2018). Technological pedagogical and content knowledge: A review of empirical studies published from 2011 to 2016. *Journal of Educational Computing Research*, 56(3), 315–343. <https://doi.org/10.1177/0735633117713114>

