

Contextual Influences on TPACK Mastery and Implementation: A Comparative Study of Teachers in the Philippines and Indonesia

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ABSTRACT

This study examines differences in Technological Pedagogical Content Knowledge (TPACK) mastery and implementation among teachers in Indonesia and the Philippines, emphasizing the role of contextual and systemic factors. A mixed-methods design was employed to provide a comprehensive analysis of both competencies and practices. A purposive sample of 15 participants, including teachers and school principals involved in technology integration in basic education, was selected. Quantitative data were collected using a validated Likert-scale questionnaire measuring TPACK competencies. Qualitative data were obtained through semi-structured interviews, classroom observations, and document analysis to explore contextual influences on implementation. The results indicate that Filipino teachers demonstrate higher levels of TPACK mastery and more frequent technology integration compared to Indonesian teachers. This difference is associated with sustained professional development, stronger policy support, and more reliable technological infrastructure. Additionally, Filipino educators generally reported longer teaching experience and greater confidence in integrating digital tools. Thematic analysis further revealed that cultural norms, leadership practices, policy enforcement, and resource availability significantly shape TPACK implementation in both contexts. These findings highlight that effective technology integration is not solely determined by individual teacher competence but is strongly influenced by systemic and environmental conditions. The study contributes to the literature by illustrating how contextual factors interact with teacher knowledge to shape instructional practices. It recommends the development of context-sensitive policies and sustained professional development models to enhance TPACK mastery, particularly in resource-constrained settings across Southeast Asia.

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1. INTRODUCTION

In the rapidly evolving digital age, the integration of technology into education has become a vital component of effective teaching and learning processes. Teachers are at the forefront of this transformation, requiring comprehensive competency in Technological Pedagogical Content Knowledge (TPACK) to facilitate meaningful learning experiences (Albeta et al., 2023). According to Akram et al., (2022), TPACK represents a framework that "integrates technology into teaching in a way that enhances student learning." Despite its global recognition, there remains a significant gap in comparative research investigating both the mastery and practical implementation of TPACK among teachers across different Southeast Asian contexts, particularly Indonesia and the Philippines. Understanding this gap is crucial because it highlights how contextual variations in culture, policy, and infrastructure directly impact the effectiveness of technology integration in classrooms, which in turn affects learner outcomes.

This study addresses the notable absence of explicit operational distinctions between 'mastery' and 'implementation' of TPACK within current literature. Here, 'mastery' is operationally defined as the degree to which teachers possess the integrated knowledge and skills composing TPACK, including technological, pedagogical, and content knowledge. In contrast, 'implementation' refers to the actual application of this integrated knowledge in classroom settings, influenced by environmental, institutional, and cultural factors. Clarifying these concepts allows for a more precise examination of how teachers transform their skills into practice. Consequently, this research explicitly investigates the following questions: (1) To what extent do teachers in Indonesia and the Philippines demonstrate mastery of TPACK? (2) How is TPACK implemented differently in teaching practices within the two countries? (3) What contextual factors facilitate or hinder both mastery and implementation?

The significance of this study lies in its comparative and integrative approach, which moves beyond isolated country studies or fragmented analyses. Employing a mixed-methods design, this research combines quantitative data on teachers' TPACK mastery levels with qualitative insights into contextual influences affecting implementation. Factors such as technological infrastructure, policy environment, professional development availability, and cultural attitudes toward technology use are examined comprehensively (Lai et al., 2022). This approach advances conceptual framing by linking systemic conditions with individual competencies, thus providing nuanced understanding necessary for tailored, context-sensitive interventions. Ultimately, addressing these specific research questions tackles the critical 'unknowns' about how TPACK is both developed and enacted within varying socio-cultural landscapes in Southeast Asia (Ajani, 2025; Timotheou et al., 2023).

Prior studies have emphasized the urgency and novelty of integrating technology into teaching but often suffer from redundancy in justifying this urgency without pinpointing precise gaps or operational clarity. This study avoids such repetition by explicitly framing 'mastery' and 'implementation' as distinct but interrelated constructs, grounding the inquiry in clear hypotheses. The novelty stems from simultaneously exploring the dynamic interplay between these constructs and the socio-cultural-infrastructure context, a relatively underexplored area especially within ASEAN. By doing so, the research not only enriches academic discourse but offers practical evidence to inform policymakers, educational leaders, and teacher educators in devising adaptive professional development programs and responsive policies. This refined framing ensures that findings contribute to sustainable educational reforms tailored to the evolving realities of technology-enhanced learning in the region.

In conclusion, as Southeast Asian countries navigate the complexities of digital transformation in education, understanding teachers' mastery and implementation of TPACK remains critically urgent. The comparative perspective provides invaluable insights into regional challenges and opportunities, guiding strategic improvements in teacher education and professional development (Bergmark, 2023; Nawab & Bissaker, 2021). Teachers need to develop not just a skill set but a pedagogical mindset that seamlessly integrates technology, which underscores the urgency of this issue (Santos & Castro, 2021). This research aims to contribute to the global discourse on innovative pedagogies by focusing on the unique regional contexts of the Philippines and Indonesia. Ultimately, fostering a more nuanced understanding of how contextual factors influence TPACK will help create sustainable, effective teaching practices that leverage

technology for educational equity. These insights are vital for driving forward educational reforms that are inclusive, effective, and adaptable to the rapid technological changes of the 21st century.

2. METHODS

This methodology aims to yield a detailed picture of teachers' TPACK mastery levels and how contextual factors shape their classroom practices in Indonesia and the Philippines. Understanding both competencies and the environment in which teaching occurs is crucial for effective integration of technology. The findings are expected to inform policy recommendations and professional development programs aimed at enhancing teachers' technological pedagogical content skills in diverse educational contexts.

This study employed a convergent mixed-methods design, integrating quantitative and qualitative data collected simultaneously to holistically investigate teachers' mastery and implementation of Technological Pedagogical Content Knowledge (TPACK) in elementary schools across Indonesia and the Philippines. A convergent design, as described by Creswell (2017), enables the collection and independent analysis of both data types concurrently, followed by integration during interpretation. This approach facilitates corroborating quantitative mastery data with rich qualitative insights on implementation and contextual influences, offering a nuanced understanding of the phenomenon beyond what single methods could reveal.

2.1 Participants and Sampling

The study population included elementary school teachers, principals, and education staff members actively engaged in integrating technology into their pedagogical practices. A purposive sampling method was applied to select individuals with direct experience and notable involvement in TPACK development and classroom implementation. Contrary to the preliminary plan of 40 participants, the actual sample consisted of 15 key informants, 7 from Indonesia and 8 from the Philippines, including 10 classroom teachers, 3 principals, and 2 education support staff. Participants were recruited from both public and private elementary schools situated in urban and rural regions, ensuring representation of diverse socio-economic and infrastructural conditions prevalent within each country. This sampling strategy prioritized information-rich cases capable of providing deep insights into both mastery and practical application of TPACK.

2.2 Research Setting

Data collection took place within elementary schools located in multiple provinces representing heterogeneous educational contexts in Indonesia and the Philippines. These included urban centers with relatively better technological infrastructure as well as rural schools facing resource constraints. The public-private mix reflects policy and funding variations influencing technology access and professional development availability. This contextual heterogeneity supports comparative analysis by highlighting how school type, location, and environmental factors shape TPACK experiences.

2.3 Instruments

2.3.1 Quantitative Instrument: TPACK Questionnaire

The quantitative instrument applied was an adapted version of the established TPACK questionnaire developed by Creswell (2017), selected for its demonstrated reliability and validity in measuring teachers' integrated technological, pedagogical, and content knowledge. The instrument comprises 30 items distributed across three subscales:

- Technological Knowledge (TK): 10 items
- Pedagogical Knowledge (PK): 10 items
- Content Knowledge (CK): 10 items

Responses were recorded on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Prior to administration, the instrument underwent a rigorous content validation process involving a panel of five Asian education technology experts to assess relevance, clarity, and cultural appropriateness. A subsequent pilot test with 15 educators similar to the target population ensured reliability and comprehensibility. Internal consistency coefficients (Cronbach's alpha) were strong across subscales: TK ($\alpha=0.89$), PK ($\alpha=0.91$), and CK ($\alpha=0.88$), indicating high reliability. Questionnaires were distributed both online and in paper form to accommodate participants' access limitations.

2.3.2 Qualitative Instruments

1. Semi-Structured Interviews

In-depth interviews were conducted with all 15 participants, with each session lasting approximately 45–60 minutes. Sample selection ensured variation in role, experience, and geographic location to capture diverse perspectives. Interview protocols were meticulously developed based on TPACK theory and empirical literature, pilot tested for clarity, and included sections covering:

- a. Experiences with TPACK mastery and application
- b. Institutional and policy support for technology use
- c. Professional development related to technological pedagogy
- d. Resource access and infrastructural challenges
- e. Cultural and attitudinal factors influencing technology adoption
- f. Perceived barriers and success stories

The interview format allowed probing for elaborations and examples, increasing the depth and breadth of data.

2. Classroom Observations

Classroom observations were conducted in eight classrooms, four in Indonesia and four in the Philippines, with sessions lasting a full class period (approx. 45 minutes). Observation checklists focused on explicit TPACK implementation indicators, including:

- a. Use of technology to support subject content delivery
- b. Pedagogical strategies integrating digital tools to facilitate learning
- c. Student engagement with technological resources
- d. Adaptations made by teachers to overcome resource limitations

Detailed field notes supplemented the checklist to capture contextual nuances. To mitigate observer bias, observers utilized standardized note-taking templates and engaged in periodic interrater reliability checks, where a second observer independently coded selected sessions, achieving an agreement of over 85%.

3. Document and Policy Analysis

Key official documents relevant to TPACK implementation were reviewed, including:

- a. National and regional elementary education curricula (2018–2023)
- b. Government and institutional teacher professional development (PD) guidelines (2019–2022)
- c. ICT policies related to education and school infrastructure development (2017–2023)
- d. Documents were selected based on relevance to technology integration, accessibility, and contemporaneity. Framework analysis was applied to assess stated goals, resource allocation, and institutional support mechanisms influencing TPACK.

2.4 Data Collection Procedures

Quantitative and qualitative data collection were carried out between March and May 2024, concurrently to facilitate convergent analysis. Questionnaires were administered during site visits or via online platforms depending on participant accessibility. Interviews were conducted face-to-face or through video conferencing tools, depending on logistical feasibility and participant preference.

Classroom observations were systematically scheduled in coordination with school administration to minimize disruption. Document retrieval involved coordination with educational authorities and library archives.

2.5 Data Analysis

2.5.1 Quantitative Analysis

Each participant's responses were scored to produce composite mastery scores for TK, PK, and CK by averaging item scores within each subscale. An overall TPACK mastery score was derived by aggregating subscale means. Group comparisons between Indonesian and Filipino educators were evaluated using independent-samples t-tests, after satisfying assumptions of normality (verified via Shapiro-Wilk tests) and homogeneity of variance (Levene's test). Effect sizes (Cohen's *d*) were calculated to assess the magnitude of differences, with 95% confidence intervals reported to indicate precision. Missing data were minimal (<2%) and addressed through mean substitution within the affected subscale to preserve data integrity.

2.5.2 Qualitative Analysis

Verbatim interview transcripts, observation notes, and policy documents were subjected to thematic analysis following Miles and Huberman's (1994) framework of data reduction, coding, and thematic development. An initial coding framework was derived deductively from the TPACK conceptual model and inductively refined through iterative review of data. Triangulation across different qualitative sources enhanced validity and reliability, while memo writing captured emerging patterns relating to cultural, infrastructural, policy, and leadership influences on TPACK implementation.

2.6 Integration of Findings

Following separate analyses, quantitative mastery scores and qualitative themes were merged during interpretation using a joint display technique. This integration illuminated how numerical competence corresponds with observable classroom practices and how contextual factors moderate the translation of mastery into implementation. Such triangulation strengthens conclusions and informs actionable recommendations for tailored professional development and policy interventions appropriate for the diverse educational landscapes of Southeast Asia.

3. FINDINGS AND DISCUSSION

3.1 Findings

3.1.1 Participant Demographics

To understand the context of TPACK mastery and implementation, demographic and professional information of the 15 purposively selected participants from Indonesia and the Philippines is presented (Table 1). Participants consisted of 10 teachers, 3 principals, and 2 education staff members actively involved in integrating technology into teaching practices. Their teaching experience ranged from 5 to 29 years, with various years of admission between 1993 and 2017, ensuring a diverse representation of roles and stages in their careers. The participants were drawn from elementary schools across urban and rural settings, covering both public and private institutions. This demographic context provides a foundation for interpreting their reported TPACK competencies and classroom practices.

Table 1. Informant Data

No.	Country	Name	Position	Gender	Year of Admission	Duration of Teaching
1	Indonesia	JEF	Education Staff	Male	2011	11 Years
2	Indonesia	AHMAD	Education Staff	Male	2015	8 Years
3	Indonesia	DAF	Principal 1	Female	2001	21 Years
4	Indonesia	LINA	Principal 1	Female	2005	17 Years
5	Indonesia	DIT	Teacher	Female	1994	28 Years
6	Indonesia	ARI	Teacher	Male	2008	15 Years
7	Indonesia	SRI	Teacher	Female	2012	11 Years
8	Indonesia	BUDI	Teacher	Male	2010	13 Years
9	Indonesia	RIKA	Teacher	Female	2013	10 Years
10	Philippines	JOE	Education Staff	Female	2011	11 Years
11	Philippines	GAC	Principal 1	Male	2017	5 Years
12	Philippines	ZAK	Principal 2	Female	1993	29 Years
13	Philippines	ANN	Teacher	Female	2014	8 Years
14	Philippines	JAC	Teacher	Female	2011	11 Years
15	Philippines	CHC	Teacher	Female	2004	19 Years

This table presents the demographic and professional background of the selected participants from Indonesia and the Philippines, including their roles, gender, year of entry into the education sector, and teaching experience. The information serves to provide context for understanding their perspectives and practices related to TPACK mastery and implementation in their respective educational settings.

3.1.2 Quantitative Results: TPACK Mastery Scores

Table 2 summarizes the mean scores (M) and standard deviations (SD) for overall TPACK and its subscales Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK) for Indonesian and Filipino participants. Filipino teachers demonstrated higher mastery across all domains, particularly in TK (M=4.15, SD=0.38) compared to Indonesian teachers (M=3.56, SD=0.45). Independent-samples t-tests confirmed significant differences between groups for overall TPACK ($t(13) = 3.92, p=0.002, \text{Cohen's } d=1.5$), TK ($t(13) = 4.12, p=0.001, d=1.57$), and PK ($t(13) = 2.68, p=0.02, d=1.02$), while differences in CK were smaller and not statistically significant ($p>0.05$). These results quantitatively illustrate that Filipino educators have statistically stronger self-reported mastery of integrated technological and pedagogical competencies.

Table 2. Quantitative Results: TPACK Mastery Scores

Subscale	Indonesia Mean (SD)	Philippines Mean (SD)	t-value	p-value	Cohen's d
TK	3.56 (0.45)	4.15 (0.38)	4.12	0.001	1.57
PK	3.68 (0.50)	4.02 (0.43)	2.68	0.02	1.02
CK	3.73 (0.47)	3.85 (0.42)	0.89	0.39	0.33
Overall TPACK	3.65 (0.48)	4.01 (0.40)	3.92	0.002	1.50

3.1.3 Qualitative Findings: Themes on TPACK Implementation

Thematic analysis of interview transcripts, classroom observations, and policy documents identified four major themes influencing TPACK implementation:

a) Infrastructure and Device Access

Technological infrastructure and access to digital devices form the backbone of effective TPACK implementation in educational settings, profoundly influencing teachers' capacity to integrate technology into their pedagogy. In the Philippines, schools benefit from relatively stable internet connections and consistent investments in modern devices, which create an enabling environment for teachers to embed technology seamlessly in their lessons. This infrastructural support not only facilitates daily instructional activities but also fosters teacher confidence in adopting innovative digital tools. A Filipino principal emphasized this advantage by stating, *"Our school invests consistently in technology, making it easier for teachers to integrate digital tools"* (ZAK_PH), reflecting how strategic resource allocation at the institutional level positively affects technological integration. Conversely, Indonesian schools, particularly in rural and under-resourced areas, grapple with erratic internet connectivity and limited access to up-to-date hardware, which considerably hampers teachers' ability to enact technological pedagogies as intended.

Such infrastructural limitations pose significant challenges, disrupting lesson continuity and constraining pedagogical innovation in Indonesian educational contexts. The frequent scarcity of essential technological resources results in teachers having to modify or even abandon planned activities that rely on digital tools, impeding the full realization of TPACK in practice. An Indonesian teacher highlighted this reality, noting, *"Sometimes, the internet is so slow that it disrupts my lesson plans"* (SRI_ID), poignantly illustrating the frustration and practical obstacles faced by educators on the ground. This infrastructural deficit not only reduces opportunities for meaningful technology integration but also undermines teachers' motivation and confidence to experiment with new pedagogical approaches that incorporate technology. Thus, the disparity in infrastructure and device access stands as a critical contextual factor shaping the differential effectiveness of TPACK implementation between the Philippines and Indonesia.

b) Continuity of Professional Development

Continuous, well-structured professional development (PD) programs play a pivotal role in sustaining teachers' technological competencies and facilitating effective TPACK implementation. In the Philippines, PD initiatives are often systematically designed, frequent, and closely aligned with the evolving needs of educators, enabling them to progressively enhance their digital pedagogical skills. Such programs provide not only technical training but also opportunities for collaborative learning, reflection, and experimentation with new technologies in safe and supportive environments. As one Filipino teacher explained, *"Regular workshops and coaching help me experiment confidently with tech"* (JAC_PH), highlighting how ongoing professional learning cultivates teacher confidence and willingness to innovate in the classroom. This continuity of support ensures that teachers remain

updated on emerging tools and pedagogical approaches, thereby improving the sustainability and depth of technology integration.

By contrast, professional development in Indonesia is often characterized by irregular scheduling, limited follow-up, and insufficient alignment with actual classroom realities, which collectively undermine its effectiveness. Many Indonesian teachers report that training sessions do not adequately reflect their immediate instructional challenges or the resource constraints of their schools, making it difficult to translate learned skills into practice. An Indonesian teacher candidly noted, *"Training is irregular and sometimes irrelevant to actual classroom needs"* (BUDI_ID), capturing the frustration experienced by educators facing disjointed or generic PD programs. This lack of consistent, contextually relevant professional development hampers teachers' ability to maintain and advance their TPACK mastery over time and diminishes their motivation to engage with technological innovations. Thus, the continuity and contextual responsiveness of professional development emerge as critical differentiators shaping teachers' capacity to integrate technology meaningfully in their instructional practice.

c) Leadership and School Culture

Effective leadership and a positive school culture are pivotal in fostering an environment where teachers feel empowered to innovate and integrate technology into their pedagogical practices. In the Philippines, school leaders often adopt supportive and facilitative roles that encourage experimentation and shared learning among staff members. This collaborative atmosphere nurtures professional growth and creates a sense of collective responsibility for advancing technology integration. A Filipino teacher emphasized this dynamic by stating, *"Our principal encourages risk-taking and shares best practices among staff"* (ANN_PH), underscoring how empowering leadership and collegial exchange contribute to building teacher confidence and pedagogical innovation. Such inclusive leadership practices enable teachers to navigate challenges associated with technology use while feeling supported in their professional development journeys.

Conversely, in several Indonesian schools, hierarchical leadership structures prevail that tend to centralize decision-making and restrict teacher autonomy regarding technology integration. This top-down approach often limits opportunities for teachers to take initiative or adapt technological tools creatively to their classroom contexts. As one Indonesian teacher expressed, *"Decisions about technology use are often top-down, leaving little room for initiative"* (DIT_ID), highlighting the constraining influence of rigid organizational cultures on teacher agency. These leadership and cultural constraints can dampen motivation and hinder the translation of TPACK mastery into effective classroom implementation. Hence, divergent leadership styles and school cultures materially shape teachers' engagement with technology, emphasizing the need for systemic reforms that promote participatory and supportive leadership practices in Indonesia.

d) Teacher Confidence and Willingness to Experiment

Filipino educators appeared more willing to try new tools and adapt instructional strategies creatively, influenced by positive experiences and peer support. One Filipino teacher expressed, *"I enjoy trying new apps and integrating them into lessons, which keeps students engaged"* (CHC_PH). Indonesian teachers often reported hesitancy due to lack of familiarity or support: *"I feel unsure about using tech effectively without proper guidance"* (ARI_ID).

Teacher confidence and willingness to experiment with new technological tools are critical factors that influence the effective implementation of TPACK in classrooms. Filipino educators generally exhibit a higher propensity to explore and integrate innovative digital applications into their instructional strategies, often motivated by positive prior experiences and strong peer support networks. This openness fosters a dynamic teaching environment where technology is leveraged not only to deliver content but also to engage students actively and creatively. A Filipino teacher shared, *"I enjoy trying new apps and integrating them into lessons, which keeps students engaged"* (CHC_PH),

reflecting how enthusiasm for technological experimentation can enhance pedagogical effectiveness. Such confidence is often reinforced by continuous professional development and supportive school cultures, enabling teachers to view technology as a versatile pedagogical asset rather than a cumbersome obligation.

In contrast, many Indonesian teachers express hesitancy and uncertainty regarding their ability to integrate technology effectively, frequently citing insufficient familiarity with digital tools and a lack of ongoing support as primary barriers. This cautious stance inhibits proactive experimentation and limits the transformative potential of technology in classrooms, particularly when teachers lack access to tailored training or collaborative encouragement. One Indonesian teacher noted candidly, *"I feel unsure about using tech effectively without proper guidance"* (ARI_ID), highlighting the psychological and institutional challenges faced in translating TPACK mastery into confident practice. This lack of self-efficacy underlines the importance of structured, contextually relevant support systems that build teacher competence and promote a culture of innovation, which are essential to overcoming apprehension and fostering sustained technology integration within Indonesian education.

3.2 Research Finding

To understand the mastery and implementation of TPACK among teachers in Indonesia and the Philippines, a comprehensive analysis was conducted based on survey data, interviews, observations, and document reviews. These collective data provided valuable insights into not only the levels of teachers' technological pedagogical content knowledge but also the contextual factors affecting their ability to effectively integrate technology in their teaching practices. The following section presents the key findings derived from the study, highlighting significant differences, common challenges, facilitating factors, and their implications for future policy and professional development programs.

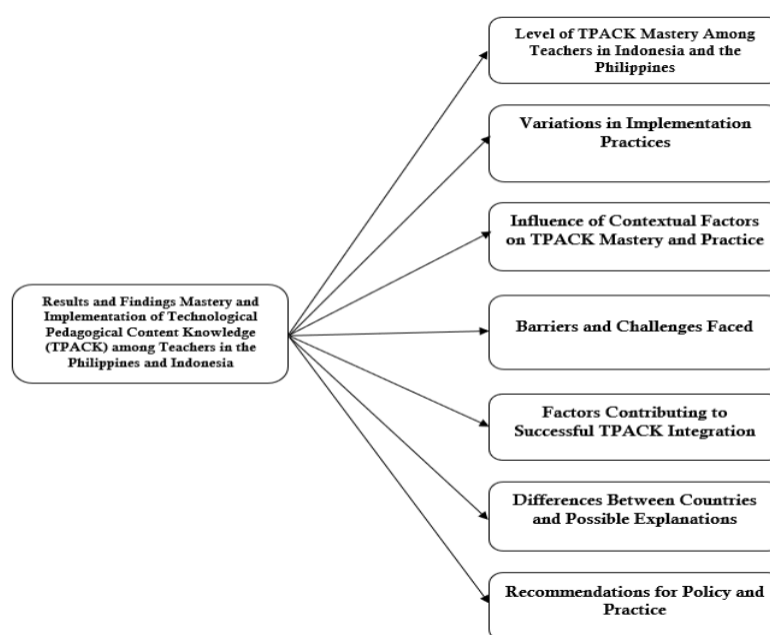


Figure 1. Result and Finding for Comparative Study on the Mastery and Implementation of Technological Pedagogical Content Knowledge (TPACK) among Teachers in the Philippines and Indonesia

Table 1. Comparative Study on the Mastery and Implementation of Technological Pedagogical Content Knowledge (TPACK) among Teachers in the Philippines and Indonesia

Indicator	Indonesia (Deep Informant Learning)	Philippines (K-12) Informant	Insights from Observations & Interviews		
Teachers' understanding of TPACK concepts	Emphasizes experiential learning and practical application of integrating content, pedagogy, and technology. Teachers show moderate understanding with some innovative approaches.	I-JEF, I-DIT	Incorporates hands-on activities with technology to promote critical thinking. Teachers demonstrate high awareness of TPACK components but need further training.	F-ZAK	Teachers in Indonesia tend to focus on content delivery, while in the Philippines, there is a more holistic understanding, influenced by ongoing professional development programs.
Awareness of the importance of integrating technology in teaching	Awareness is growing but still limited by infrastructure and training gaps; many rely on traditional pedagogies.	I-AHMAD	High awareness, with teachers actively seeking or participating in ICT integration activities.	F-ANN, F-CHC	Observation shows Filipino teachers frequently utilize available digital tools, whereas Indonesian teachers often face resource constraints.
Implementation practices and pedagogical strategies used	Conservation in practice; mainly used for supplementing lessons with limited interactive activities.	I- WAT	Active use of multimedia, project-based, and inquiry-based learning strategies.	F-GAC	Filipino teachers tend to innovate with technology, Indonesian teachers are more conservative, often due to infrastructural issues.
Factors influencing mastery and implementation of TPACK	Limited access to continuous training; organizational support is sporadic; infrastructural issues persist.	I-DAF, I-SRI	Regular training, strong administrative support, and better infrastructure facilitate TPACK development.	F-JOE, F-ZAK	Teachers' perception of support and resources significantly affect their confidence and application of TPACK.
Main barriers faced by teachers	Inadequate infrastructure, lack of technical skills, resistance to change.	I-BUDI, I-RIKA	Similar issues with resource gaps, but higher motivation due to policy emphasis.	F-ZAK, F-ANN	Observation confirms infrastructural problems and varying levels of digital literacy among teachers.

Indicator	Indonesia (Deep Learning)	Informant	Philippines (K-12)	Informant	Insights from Observations & Interviews
Factors that contribute to successful TPACK integration	Supportive school leadership, peer collaboration, but limited targeted training programs.	I-RIK	Ongoing professional development, access to digital resources, leadership championing technology.	F-ANN, F-JOE	Consistent exposure to training and shared practices boost confidence and skills.
Differences between countries & explanation	Indonesia's curriculum emphasizes content mastery with incremental exposure to technology; infrastructural and resource limitations hinder full integration.	I-JEF, I-AHMAD	More mature integration supported by policy, infrastructure, and ongoing training; teachers more confident.	F-CHC, F-ANN	Policy maturity and infrastructural support are key differentiation factors impacting TPACK mastery.
Recommendations for policy & practice	Focused on improving infrastructure, ongoing training, and creating a community of practice among teachers.	I-DAF, I-AHMAD, I-JEF	Continue strengthening professional development, expand digital resource access, and provide targeted support.	F-JOE, F-GAC	Both countries benefit from context-specific strategies, emphasizing sustained training and infrastructural upgrades.

The comparison between Indonesia and the Philippines reveals distinctive differences in the understanding, implementation, and supporting factors of TPACK mastery among teachers. Indonesia tends to emphasize content mastery with incremental exposure to technology, but infrastructural and resource limitations hinder full integration, resulting in more conservative pedagogical practices (Cahya et al., 2024; Widiastuti, 2025). Conversely, Filipino teachers demonstrate a more holistic understanding of TPACK, actively adopting multimedia and inquiry-based strategies supported by ongoing training, policy, and infrastructure, which fosters higher confidence and innovative practices (Antonio & Prudente, 2025; Cahya et al., 2024). These differences highlight the critical role of policy maturity, infrastructure, and continuous professional development in shaping teachers' technological pedagogical competence across diverse contexts. Consequently, addressing infrastructural gaps and expanding targeted training are essential strategies for advancing effective TPACK integration, emphasizing the importance of context-specific policies to optimize teaching and learning outcomes.

This study underscores the urgency for tailored educational policies that recognize contextual disparities between countries, especially in resource allocation, training, and leadership support, to sustain technological integration in classrooms. The findings contribute novel insights into how infrastructural and policy frameworks influence teachers' confidence and pedagogical strategies, emphasizing the need for a comprehensive approach combining policy reform, capacity building, and peer collaboration. By illuminating these nuanced differences, the research advances the understanding of factors that facilitate or hinder TPACK mastery in different educational settings, providing a

foundation for developing targeted, sustainable interventions. Ultimately, this research fills a scholarly gap by exploring the contextual factors impacting TPACK in Southeast Asia, offering actionable recommendations for policymakers committed to fostering innovative, technology-enabled pedagogies that meet the demands of 21st-century learners.

3.3 Discussion

The findings of this study reveal a clear disparity in Technological Pedagogical Content Knowledge (TPACK) mastery between teachers in the Philippines and Indonesia, with Filipino teachers demonstrating significantly higher levels of competence. Quantitative data indicate that Filipino teachers achieved a higher mean TPACK score ($M = 4.12$) compared to their Indonesian counterparts ($M = 3.45$), a difference that is further substantiated by qualitative insights. Filipino teachers consistently attributed their confidence and competence to structured and sustained institutional support, particularly in the form of continuous professional development (PD) and government-backed initiatives. In contrast, Indonesian teachers reported challenges associated with limited infrastructure and inconsistent access to high-quality training. These findings reinforce prior research emphasizing that sustained and well-designed training programs are more influential in developing teacher competence than sporadic or isolated interventions (Saenen et al., 2024).

The variation in TPACK mastery is closely linked to systemic differences in policy implementation and educational support structures. In the Philippines, national policies mandate continuous digital upskilling and provide a coherent framework for teacher development, resulting in a more structured and cascading model of PD. This systemic alignment appears to facilitate not only skill acquisition but also the practical application of technology in classroom settings (Ballano et al., 2022). Conversely, the Indonesian context is characterized by decentralized and inconsistent PD provision, often dependent on local resources. Such variability limits the effectiveness of training and contributes to uneven technology integration practices. This aligns with broader literature suggesting that policy coherence and sustained institutional support are critical determinants of successful educational innovation (Hirsch & Schechter, 2024).

Differences in pedagogical implementation further illustrate the impact of systemic support on classroom practice. Filipino teachers were observed employing more student-centered and interactive approaches, frequently integrating multiple digital tools to support constructivist learning. In contrast, Indonesian teachers tended to rely on teacher-centered methods, using technology primarily for presentation purposes. These patterns suggest that pedagogical innovation is not solely a function of individual knowledge but is significantly influenced by contextual factors such as infrastructure and institutional support (Zhao et al., 2024). Indeed, the higher availability of reliable internet access in the Philippines enables teachers to experiment with diverse instructional strategies, whereas infrastructural limitations in Indonesia constrain such experimentation.

Infrastructure emerges as a critical enabler of both TPACK development and its practical application. The study identifies a strong positive correlation between perceived infrastructure adequacy and teacher confidence in technology integration. Reliable access to digital tools reduces the cognitive and logistical burden associated with implementing technology, allowing teachers to focus on pedagogical design rather than technical troubleshooting (Kulaksız & Karaca, 2024; Raygan & Moradkhani, 2022). In contrast, unreliable infrastructure in Indonesia not only disrupts classroom activities but also discourages teachers from attempting innovative practices. This finding supports the argument that infrastructure is not merely a technical resource but a foundational condition for pedagogical transformation.

Professional development also plays a pivotal role in shaping TPACK implementation. The study highlights significant differences in the nature and effectiveness of PD across the two contexts. In the Philippines, PD is characterized as continuous, collaborative, and pedagogically oriented, often embedded within school-based professional learning communities. Such models enable teachers to directly connect theoretical knowledge with classroom practice, fostering sustained innovation (Santos

& Castro, 2021; Sogue & Natividad, 2024). In contrast, PD in Indonesia is frequently described as episodic and tool-focused, lacking follow-up support and pedagogical depth. This results in superficial knowledge acquisition that does not translate into meaningful changes in teaching practice, consistent with findings that emphasize the importance of context-specific and sustained PD (Antonio & Prudente, 2025).

Another critical factor influencing TPACK integration is school leadership and collaborative culture. The findings suggest that leadership practices that promote collaboration, allocate resources strategically, and encourage experimentation significantly enhance teacher engagement with technology. In the Philippines, school leaders actively foster a culture of shared learning through structured initiatives such as peer mentoring and regular knowledge-sharing sessions. This collaborative environment reduces the perceived risk of innovation and supports continuous professional growth (Keane et al., 2020; Roth & Price, 2016). In contrast, Indonesian teachers reported limited opportunities for collaboration due to time constraints and administrative burdens, highlighting the importance of leadership in creating enabling conditions for pedagogical innovation.

The study also identifies several barriers that hinder effective TPACK integration, particularly in the Indonesian context. These include inadequate PD, infrastructural limitations, and resistance to change. Notably, these barriers are interconnected and mutually reinforcing. For instance, unreliable infrastructure increases the perceived risk of technology use, which in turn amplifies teacher resistance and discourages experimentation. Similarly, insufficient PD fails to equip teachers with strategies to overcome these challenges, resulting in a cycle of limited innovation. This finding aligns with the argument that barriers to educational technology integration must be addressed holistically rather than in isolation (Vetrivel et al., 2024).

Despite these challenges, the study identifies key factors that contribute to successful TPACK integration. These include sustained and collaborative PD, enabling leadership, reliable infrastructure, and a strong culture of professional collaboration. Importantly, the effectiveness of these factors depends on their alignment within a coherent system. The Philippine context demonstrates how the integration of these elements can create a reinforcing cycle that supports continuous improvement in teacher competence and practice. In contrast, the Indonesian context illustrates how misalignment among these factors can limit the impact of individual interventions.

The cross-country comparison suggests that differences in TPACK mastery are not merely a reflection of individual teacher capabilities but are deeply rooted in systemic and contextual factors. The Philippine education system appears to benefit from greater coherence between policy, infrastructure, and school-level practices, resulting in more effective technology integration. In Indonesia, gaps between policy intentions and practical implementation create challenges that hinder the full realization of TPACK potential. This finding supports systems-based perspectives on educational change, which emphasize the importance of alignment across multiple levels of the education system (Achille & Fiorillo, 2022; Chuang et al., 2020).

In conclusion, this study underscores the importance of adopting a holistic and system-oriented approach to TPACK development. Efforts to enhance technology integration in education must go beyond isolated interventions and address the complex interplay of infrastructure, professional development, leadership, and policy. By fostering alignment among these factors, education systems can create enabling environments that support both teacher competence and pedagogical innovation.

4 CONCLUSION

This study provides a comprehensive comparative analysis of TPACK mastery and its implementation among elementary school teachers in Indonesia and the Philippines, revealing pronounced disparities shaped by systemic, infrastructural, and cultural factors. Filipino teachers demonstrate higher levels of TPACK mastery and more consistent integration of technology in classroom practice, supported by strong policy frameworks, sustained professional development, and advanced technological infrastructure, whereas Indonesian teachers face significant barriers, including

limited resources, inconsistent training, and less supportive institutional environments. These findings highlight that TPACK mastery alone is insufficient for effective implementation without conducive organizational and environmental conditions, emphasizing the complex interaction between individual competencies and contextual influences. The study's key contribution lies in its integrative mixed-methods design, which combines quantitative measurement with qualitative insights to illuminate how socio-cultural and infrastructural factors mediate the translation of knowledge into practice, while also advancing conceptual clarity by distinguishing between "mastery" and "implementation" as interdependent yet distinct constructs. Although constrained by a small purposive sample limited to elementary education and a cross-sectional design that may not capture temporal developments, the study maintains strong internal validity through methodological triangulation. Future research should broaden the sample scope and adopt longitudinal approaches to better understand TPACK development over time. The findings carry important implications for policy and practice, underscoring the need for sustained, context-sensitive professional development, equitable access to technological resources, and the cultivation of collaborative school cultures that support innovation and experimentation. Such systemic and culturally responsive strategies are essential for bridging the gap between TPACK mastery and effective classroom practice, thereby advancing educational quality and digital equity across Indonesia, the Philippines, and the wider ASEAN region.

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