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Investigating Novice & Experienced Elementary Teachers' Perceptions of TPACK: A Case From Papua Pegunungan

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Abstract
This study examined the perceptions, practices, and challenges of novice and experienced Papuan elementary school teachers in integrating technology through the Technological Pedagogical Content Knowledge (TPACK) framework. A mixed-method approach combined quantitative data from 151 teachers across twelve schools with semi-structured interviews with 12 participants. Novice and experienced teachers showed complementary strengths while sharing similar challenges. Novice teachers were more confident in Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK), reflecting their familiarity with digital tools and willingness to experiment, but their integration remained superficial and focused on engagement rather than instructional alignment. Experienced teachers scored higher in Pedagogical Knowledge (PK), Content Knowledge (CK), and Pedagogical Content Knowledge (PCK), showing stronger teaching strategies and classroom management, but often hesitated to adopt unfamiliar digital tools. Both groups performed lowest in Technological Content Knowledge (TCK), indicating difficulties in aligning technology with subject-specific content. Both relied on basic tools such as PowerPoint, YouTube, and WhatsApp, with limited use of subject-specific applications, and faced systemic challenges, including unstable internet, inadequate infrastructure, limited devices, and insufficient professional development. Nevertheless, teachers showed resilience and motivation to adapt, collaborate, and improve. These findings suggest that novice teachers' digital skills and experienced teachers' pedagogical expertise can complement each other. Collaboration in professional learning communities, supported by better infrastructure and ongoing training, could help teachers integrate technology more effectively in Papuan classrooms.

Keywords: elementary school; experienced teachers; novice teachers; papuan pegunungan; TPACK

INTRODUCTION

Nowadays, technology has grown rapidly around the world. It is undeniable that the development of technology influences many aspects of life, such as the economy, business, science, health, and so on. Indeed, it also brings positive impacts on the academic context. In this case, technology has been considered as a tool or media that should be integrated into the curriculum. Designing learning materials using technology will make the learning process enjoyable for students (Asfar & Zainuddin, 2015). It indicates that technology can be utilized by teachers to design enjoyable learning materials and activities in the classroom. Moreover, Ciroma (2014) asserts that designing learning materials with technology enables teachers to provide contextual materials that can easily stimulate students' interest in learning. Thus, the learning goals will be reached effectively. It means that teachers and educators should have technology

integration competence to support their teaching practice (Abidin, 2023; Agustina et al., 2025; Loi, 2021).

However, many teachers consider technological knowledge not as necessary as content knowledge (Akun & Mohamad, 2021; Pamuk, 2012). It indicates they often ignore the use of technology in designing learning materials, whereas it should be integrated into their teaching materials (Carpenter et al., 2020; Nuraini et al., 2021). In order to deal with this phenomenon, Mishra & Koehler (2006), proposed technological pedagogical content knowledge (TPACK) as a framework for combining the three important elements in teaching, namely TPK (technology and pedagogy), TCK (technology and content), and PCK (pedagogical content knowledge). These three elements are designed to emphasize the dynamic and strong relationship among technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK) that should be integrated into teaching practice to achieve teaching effectiveness (Baser et al., 2016; Rosenberg & Koehler, 2015; Shiyao, 2021). According to Hidayat (2019), these three pieces of knowledge enable teachers to determine the most effective ways to encourage and motivate students to actively engage in the learning process. Consequently, students will be triggered to be successful in achieving learning goals (Blackmore et al., 2003; Ning et al., 2022; Nuraini, et al., 2021).

Since this topic is crucial in academic settings, several existing studies tried to investigate it. For example, Hofer and Harris (2017) measured English novice and experienced teachers' perceptions of TPACK in the USA context and found that experienced teachers did not often employ technology in their teaching because they were still struggling to learn how to use it properly. Meanwhile, novice teachers tend to use it in providing learning activities for their students. In line with this, Shiyao (2021), conducted a study to measure the differences between Chinese EFL novice and experienced teachers. The results revealed that experienced teachers often performed better in combining content and pedagogical knowledge, while novice teachers were good at technological knowledge. Similarly, Jang and Tsai (2013) found that Taiwanese experienced teachers' content knowledge (CK) and pedagogical content knowledge (PCK) were significantly higher than novice teachers. However, other studies showed different results. It can be seen from Wetzel et al.'s (2007) study which found that experienced teachers tended to incorporate a wider range of educational technologies into their classroom instruction, more than novice teachers. It indicates that experienced teachers usually made higher-quality instructional decisions about technology integration (Hava & Babayiğit, 2025; Palacio-Cayetano et al., 2002).

Furthermore, this topic has been investigated as well in the Indonesian context. A study conducted by Surayya et al. (2021) entitled "Scrutiny on Indonesian EFL Teachers' Willingness to Understand and Implement the TPACK in VLE". The results suggested that Indonesian EFL teachers were at a moderate level of willingness to learn and integrate technology into teaching. Besides that, Irwanto et al. (2022) examined pre-service teachers' perspectives of TPACK and found that they had the highest level of self-confidence in pedagogy knowledge and the lowest in technology knowledge. In line with this Ringotama (2020) tried to investigate pre-service teachers' perceptions toward TPACK and the results revealed that Indonesian pre-service teachers often used technology in the classroom, but they still encountered difficulties in properly implementing it. Most of the participants claimed that sometimes they were afraid of using technology because it might decrease students' attention and classroom interaction. Similarly, Cahyono et al.'s (2016) study reported that Indonesian EFL novice teachers have created a positive

perception of TPACK, yet they still doubted their abilities to implement it in their teaching practice. It indicates that they need to put more effort to practice in integrating technological tools into learning materials and activities.

So far, there are still limited studies that have investigated the different perspectives of TPACK between novice and experienced elementary teachers in the Indonesian context, specifically in Wamena, Papua Pegunungan. The researchers chose this topic because the majority of Indonesian researchers only focused on novice teachers' perceptions of TPACK (Cahyono et al., 2016; Irwanto et al., 2022; Ringotama, 2020), pre-service teachers' perceptions (Habibi et al., 2020; Putri et al., 2022; Setiyanti & Hunt, 2017), in-service teachers' perceptions (Prasojo et al., 2020; Novita et al., 2022), teachers' perspectives in general (Drajati et al., 2018; Surayya et al., 2021), and developing TPACK instruments and modules (Hidayat, 2019; Nuraini et al., 2023). Therefore, this study needs to be conducted to fill the gap by investigating Papuan Elementary novice and experienced teachers' perceptions toward TPACK in their teaching practice. In investigating this issue, the researchers formulated three research questions: 1). How do novice and experienced elementary school teachers in Papua perceive their levels of Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), and their intersections (TCK, TPK, PCK, and TPACK)? 2). What are the main similarities and differences between novice and experienced teachers in integrating technology into their classroom practices? 3). What challenges do novice and experienced teachers face in integrating technology, pedagogy, and content knowledge (TPACK) into their teaching, and how do they attempt to overcome these challenges?

METHOD

This study employed a mixed-method approach that combined both quantitative and qualitative data collection and analysis. As Creswell (2014) points out, a mixed-method design enables researchers to obtain richer and more valid findings by integrating the strengths of both quantitative and qualitative approaches. The research was conducted in twelve elementary schools in Wamena, Papua Pegunungan. To gain access, the researchers first contacted the headmasters of each school to request permission and cooperation. A total of 151 elementary school teachers participated in the study, representing SD Koinonia, SD Sinar Baliem, SD YPPK St. Matius Kurulu, SD YPPK Bunda Maria Pikhe, SD YPPK St. Agustinus Waga-waga, SD INPRES Aikima, SD YPK Tiranus, SD Athahiriyah Yapis Wamena, SD YPK Betlehem, SD Yapari Alom Wamena, SD Advent Wamena, and SD Kristen Efata.

The participants consisted of 69 novice and 82 experienced elementary school teachers from twelve elementary schools in Wamena, Papua Pegunungan. A purposive sampling technique was employed to recruit participants who met the study criteria and were willing to participate. This sampling technique was considered appropriate because the study specifically aimed to compare the TPACK perceptions of novice and experienced teachers. The categorization was determined based on years of teaching experience. Teachers with more than five years of teaching experience were classified as experienced teachers, whereas those with fewer than five years of teaching experience were categorized as novice teachers (Tsui, 2012) . This distinction enabled the researchers to capture perspectives from teachers at different stages of professional development and classroom practice.

In obtaining the data, two instruments were used to collect the data, namely a questionnaire and semi-structured interviews. The questionnaire was adapted from Baser et al. (2016) and consisted of 39 items arranged on a five-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The items were designed to measure different knowledge domains, including technological knowledge (TK), content knowledge (CK), pedagogical knowledge (PK), pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK), and technological pedagogical content knowledge (TPACK). Minor contextual modifications were made to adapt the wording of several items to the context of elementary school teachers in Papua Pegunungan while maintaining the original constructs and item structure. The original instrument demonstrated satisfactory internal consistency, with Cronbach's alpha coefficients ranging from .81 to .92 across the seven TPACK constructs (Baser et al., 2016), indicating good to excellent reliability. Since only minor contextual adaptations were made, the original reliability evidence was used to support the application of the adapted questionnaire in this study. Furthermore, the adapted instrument was reviewed by experts in educational technology and elementary education to ensure its content validity and contextual appropriateness before data collection.

Meanwhile, the semi-structured interviews were conducted with 12 teachers who were purposely selected from the quantitative participants. The interview participants consisted of six novice and six experienced teachers representing different participating schools to ensure that diverse perspectives were captured. The interviews were intended to complement the quantitative findings by providing deeper insights into teachers' experiences, perceptions, and challenges in integrating technology into classroom instruction. Each interview lasted between 30 and 40 minutes and was conducted via Zoom in the Indonesian language to ensure that participants could clearly understand the questions and express their opinions freely. All interviews were recorded with participants' consent for later transcription and analysis.

Before collecting data, the researchers informed participants about the purpose and procedures of the study, and consent was obtained through a formal consent form. The quantitative data obtained from the questionnaire were first tabulated in Microsoft Excel and then analyzed using SPSS version 26.0. The analysis focused on calculating percentages, mean scores, and standard deviations. The results were presented in tables to facilitate interpretation. The qualitative data obtained from the interviews were analyzed through thematic analysis. The researchers repeatedly listened to and reviewed the recordings, transcribed them into structured paragraphs, and identified emerging themes to capture the overall meaning of teachers' responses.

The integration of quantitative and qualitative findings allowed for a more comprehensive understanding of the data. The quantitative results provided measurable patterns of teachers' knowledge, while the qualitative findings offered deeper insights into their perspectives and experiences. Together, these two strands of data complemented each other and ensured the credibility and richness of the study's outcomes.

FINDINGS AND DISCUSSION

Findings

This section presents the results based on the research questions. The quantitative findings from the questionnaire are presented first, followed by qualitative findings from the interviews to support and explain the statistical results. Since there were 3 research questions, the researchers provided 3 subtopics of these findings that consist of novice and experienced Papuan elementary teachers' perceptions of TK, PK, CK, and TPACK domains, the similarities and differences in technology integration practices, and the challenges and strategies in integrating Technology, Pedagogy, and Content Knowledge (TPACK). The results of this study can be seen as follows:

Teachers' Perceptions of TPACK Domains

To address the first research question, teachers' self-reported levels of Technological Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), and their intersections (TCK, TPK, PCK, and TPACK) were compared. Its comparison can be seen in the following table.

Table 1. Mean Scores of Novice and Experienced Teachers across TPACK Domains

No.	TPACK Domains	Mean score & Percentage of Novice Teachers (n=69)	Std Deviation	Mean score & Percentage of Experienced Teachers(n=82)	Std Deviation
1.	Technological Knowledge (TK)	3.78 (75.6%)	0.62	3.21 (64.2%)	0.71
2.	Pedagogical Knowledge (PK)	3.52 (70.4%)	0.68	4.20 (84.0%)	0.59
3.	Content Knowledge (CK)	3.45 (69.0%)	0.70	4.12 (82.4%)	0.63
4.	Pedagogical Content Knowledge (PCK)	3.40 (68.0%)	0.65	4.15 (83.0%)	0.61
5.	Technological Content Knowledge (TCK)	2.95 (59.0%)	0.74	2.88 (57.6%)	0.77
6.	Technological Pedagogical Knowledge (TPK)	3.70 (74.0%)	0.66	3.25 (65.0%)	0.72
7.	Overall TPACK	3.54 (70.8%)	0.67	3.69 (73.8%)	0.68

The comparison between novice and experienced teachers across TPACK domains revealed distinct strengths and weaknesses. Novice teachers demonstrated stronger confidence in Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK). Their mean scores were 3.78 (75.6%) for TK and 3.70 (74.0%) for TPK, compared with 3.21 (64.2%) and 3.25 (65.0%) for experienced teachers. This indicated that novices were nearly 10–11% more confident in using digital tools for teaching. However, the standard deviations (SD = 0.62 for TK and 0.66 for TPK) inferred that not all novices were equally confident. Some were advanced in digital skills, while others remained hesitant. This result gained support from the interview section. During interviews, novices often shared their enthusiasm but admitted to shallow integration. One novice explained,

> *"I often show short videos from YouTube to make the topic more lively, but sometimes I don't connect it directly with the lesson objectives." (Novice teacher 3).*

Another teacher added,

> *"When the internet is slow, I feel stuck because I rely too much on online videos." (Novice teacher 5).*

These statements confirm that while novices were fluent in experimenting with technology, their pedagogical grounding and adaptability remain limited. On the other hand, experienced teachers excelled in Pedagogical Knowledge (PK), Content Knowledge (CK), and Pedagogical

Content Knowledge (PCK). Their mean scores were 4.20 (84.0%) for PK, 4.12 (82.4%) for CK, and 4.15 (83.0%) for PCK, compared with 3.52 (70.4%), 3.45 (69.0%), and 3.40 (68.0%) for novices. This showed a consistent 13–15% advantage for experienced teachers in areas requiring classroom management, teaching strategies, and content mastery. However, their technological confidence was weaker, as one teacher admitted,

> *"I know how to manage my class and explain materials, but with new applications, I feel unsure." (Experienced teacher 2).*

Another reinforced this hesitation:

> *"I am not sure with new tools and prefer my old ways." (Experienced teacher 4).*

This reveals that although experienced teachers bring depth in pedagogy and subject knowledge, their limited digital fluency constrains their ability to integrate technology. In addition, both groups performed weakest in Technological Content Knowledge (TCK), with novices scoring 2.95 (59.0%) and experienced teachers 2.88 (57.6%). This similarity highlights a widespread difficulty in aligning technology with subject-specific content. The relatively higher SDs (0.74 and 0.77) indicated inconsistent abilities within both groups. Some teachers attempted basic alignment, while many did not attempt it at all. For instance, one teacher admitted,

> *"I only use PowerPoint and videos. I don't know how to use apps for math or science specifically." (Novice teacher 6).*

Another also stated that,

> *"When I teach, I rarely use technology for the content itself, because I don't know the tools." (Experienced teacher 5).*

This gap in TCK suggested a systemic challenge rather than an individual weakness, showing that neither enthusiasm nor experience alone is sufficient for meaningful integration. In accordance with overall TPACK, the scores were similar: novices averaged 3.54 (70.8%) while experienced teachers averaged 3.69 (73.8%), both falling within the moderate range. The small gap indicated that while the two groups possessed complementary strengths, neither demonstrated mastery across all domains. In other words, novices brought energy and digital curiosity, while experienced teachers offered depth in pedagogy and content.

Similarities and Differences in Technology Integration

The second research question focused on the main similarities and differences in how novice and experienced teachers integrate technology into classroom practice.

Table 2. Teachers' Technology Integration

No.	Aspect	Novice Teachers	Experienced Teachers	Similarities
1	Technology use	More frequent, experimental (PowerPoint, WhatsApp, YouTube).	More selective, cautious, limited apps.	Both rely on basic tools.
2	Pedagogical integration	Use tech mainly for attention, less for deep learning.	Strong in pedagogy but hesitant with technology.	Both want stronger integration.
3	Confidence	Higher in digital tools.	Higher in subject mastery and classroom control.	Both moderate in overall TPACK.
4	Practice style	Learn by trial, workshops, peer sharing.	Learn through long-term practice and reflection.	Both rely on collaboration.

The findings above showed that novice and experienced teachers approached technology integration differently, yet they also shared common limitations. Regarding the aspect of technology use, novice teachers reported being more experimental and willing to try out digital platforms. One novice teacher confirmed,

> *"I use online videos to make students pay attention, but I'm not always sure it really helps them learn." (Novice teacher 2).*

Another participant also explained that,

> *"Sometimes I try new apps that I see from friends, but I just learn as I go along." (Novice teacher 1).*

On the contrary, experienced teachers were more cautious. They preferred to use tools they already understood and avoided experimenting with unfamiliar applications. As one put it,

> *"If I don't fully understand the app, I would rather not use it because it might confuse students." (Experienced teacher 3).*

Another echoed this sentiment:

> *"I still prefer chalk and board or printed materials. I feel safer with them than with new technology." (Experienced teacher 1).*

Despite these differences, both groups mainly relied on basic tools such as PowerPoint, videos, or WhatsApp rather than advanced or subject-specific applications. Moreover. in terms of pedagogical integration, novices often used technology to capture attention but admitted it did not always contribute to deep learning. One novice reflected,

> *"Students enjoy watching videos, but sometimes they only get entertained instead of really understanding the topic." (Novice teacher 4).*

Similarly, another also admitted,

> *"When I use slides, students are more active, but I don't always connect it with the lesson plan." (Novice teacher 3).*

Experienced teachers, in contrast, felt confident in their pedagogy but hesitant about blending it with technology. One pointed out,

> *"I know how to explain the lesson clearly, but when I add digital tools, I'm afraid it will break the flow." (Experienced teacher 6).*

Another participant also emphasized that,

> *"Technology is useful, but without proper training, it's hard to combine it with the methods I usually use." (Experienced teacher 2).*

The results showed that both groups wanted to integrate technology better into their teaching, but novices struggled because of limited teaching experience, while experienced teachers struggled because they were less confident with technology. Furthermore, in terms of confidence, novice teachers showed higher confidence in handling digital tools, while experienced teachers demonstrated greater assurance in classroom management and subject mastery. A novice teacher expressed,

> *"I feel comfortable using PowerPoint or WhatsApp with students, even if I make mistakes." (Novice teacher 1).*

On the other hand, an experienced teacher remarked,

> *"I know I can handle the class well and explain the material without technology, so I don't feel pressured to use it." (Experienced teacher 3).*

Despite their different strengths, both groups reflected a moderate overall level of TPACK. It indicated that they still lack balance between technology, pedagogy, and content. In addition, regarding practice style, novices reported learning technology integration through trial and error, workshops, and peer sharing. One novice clarified,

> *"When I don't know how to use something, I ask friends or watch tutorials." (Novice teacher 4).*

One of them also clarified that,

> *"Sometimes workshops help me, but I still need more practice." (Novice teacher 6).*

However, experienced teachers described relying more on long-term classroom practice and reflection. One explained,

> *"Most of what I know comes from years of experience in teaching. I don't depend much on training." (Experienced teacher 4).*

Another highlighted,

> *"I usually learn by observing what works with students and then adjusting over time." (Experienced teacher 1).*

Despite their different approaches, both groups valued collaboration and shared learning, recognizing it as an important way to improve their skills.

Challenges and Coping Strategies

The third research question explored the main challenges novice and experienced teachers face in integrating technology, pedagogy, and content knowledge (TPACK), as well as the strategies they use to overcome these barriers.

Table 3. Main Challenges and Teachers' Strategies

No.	Group	Main Challenges	Coping Strategies
1	Novice Teachers	Difficulty aligning tech with content; limited mentoring; unstable internet	Peer collaboration, workshops, trial-and-error learning
2	Experienced Teachers	Low confidence with new tools; insufficient training; lack of devices	Rely on traditional methods when tech fails; share practices with colleagues
3	Both Groups	Poor infrastructure, unstable internet, lack of continuous professional development	Strong willingness to learn, adapt, and collaborate

In the context of novice teachers, one of the strongest challenges was integrating technology with lesson content. A novice teacher admitted,

> *"Sometimes I just add a video because it looks interesting, but it doesn't always connect to the topic." (Novice teacher 5).*

Another added,

> *"The internet is often slow, so I waste time waiting. When that happens, I feel unprepared." (Novice teacher 2).*

To cope, they often turned to peers or workshops. One explained,

> *"I usually ask my friends how to use an app or watch a tutorial on YouTube." (Novice teacher 4).*

Another shared,

> *"Workshops help, but after that I have to keep practicing on my own because no one guides me." (Novice teacher 1).*

These findings show that novices are enthusiastic but often left to figure things out through trial and error. On the other hand, the main issue for experienced teachers was a lack of confidence with new applications and insufficient training. One teacher said,

> *"I feel unsure with new tools and prefer my old ways." (Experienced teacher 5).*

Another echoed this:

> *"If I don't know how to use an app well, I just avoid it so students won't get confused." (Experienced teacher 6).*

When technology failed or felt unfamiliar, they reverted to traditional methods. As one explained,

> *"When the projector doesn't work, I just return to the blackboard. It's safer." (Experienced teacher 1).*

However, they also sought support from colleagues. One reflected,

> *"I like to discuss with other teachers and slowly try the tools that I understand." (Experienced teacher 3).*

This showed that their strategies focused more on caution and gradual adoption rather than experimentation. Furthermore, both groups shared the same obstacles such as poor infrastructure and lack of continuous professional development. Teachers consistently pointed to unstable internet, insufficient devices, and rare training opportunities as their biggest frustrations. One teacher summarized,

> *"We only get short workshops, and after that, no follow-up. We have to continue learning by ourselves." (Experienced teacher 2).*

Another emphasized,

> *"Even though the facilities are not good, I still want to learn because students enjoy it when I use technology." (Novice teacher 4).*

Despite these limitations, the data also revealed a strong willingness to adapt and collaborate. Both novice and experienced teachers expressed a desire to keep improving, even if conditions were not ideal. Based on the data analysis above, the results indicated that while novices struggled with implementing technology to content and relied on peer learning, experienced teachers faced low confidence and tended to revert to traditional methods when uncertain. However, Both groups were constrained by systemic issues such as poor infrastructure and limited professional development. Yet, their resilience and willingness to collaborate suggested that with stronger training programs and better resources, Papuan teachers could integrate TPACK more effectively into their classrooms.

Discussion

The present study examined the TPACK perceptions of novice and experienced elementary school teachers in Papua Pegunungan and found that both groups demonstrated moderate levels of TPACK development, although they exhibited distinct patterns of professional knowledge. Experienced teachers reported a slightly higher overall TPACK score (M = 3.69; 73.8%) than novice teachers (M = 3.54; 70.8%). However, differences became more apparent when individual TPACK domains were examined. Novice teachers demonstrated stronger technology-related knowledge, whereas experienced teachers exhibited higher levels of pedagogical and content-related knowledge. These findings suggested that effective technology integration was influenced

not only by teaching experience or technological competence but also by the interaction among different forms of professional knowledge developed throughout teachers' careers. This interpretation was consistent with the TPACK framework, which emphasizes that effective technology integration emerges from the interaction among technological, pedagogical, and content knowledge rather than from any single knowledge domain (Mishra & Koehler, 2006). Furthermore, TPACK development is shaped progressively through professional experiences influenced by institutional support, curriculum demands, and authentic classroom contexts (Angeli & Valanides, 2009; Graham, 2011).

The domain-level analysis further revealed that novice teachers reported greater confidence in technology-related knowledge, particularly Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK). Their mean scores for TK (M = 3.78; 75.6%) and TPK (M = 3.70; 74.0%) exceeded those of experienced teachers, who reported mean scores of 3.21 (64.2%) and 3.25 (65.0%), respectively. These findings indicated that novice teachers were more comfortable exploring digital technologies and incorporating them into classroom instruction. Their stronger technological confidence may have resulted from greater exposure to digital technologies during teacher education and more frequent interaction with digital applications in their everyday lives (Hava & Babayiğit, 2025; Tondeur et al., 2017). As early-career teachers, they may also have demonstrated greater willingness to experiment with digital tools and explore alternative instructional approaches (Scherer et al., 2019).

However, greater technological confidence alone was insufficient to support meaningful technology integration. Although novice teachers appeared proficient in operating digital tools, these technologies were primarily used to present instructional materials, facilitate classroom communication, or increase student engagement rather than transform learning processes. In many cases, technology functioned as a supplementary instructional resource instead of supporting inquiry-based learning, collaborative knowledge construction, or higher-order thinking. Therefore, technological competence needed to be complemented by strong pedagogical knowledge to ensure that digital technologies were meaningfully aligned with instructional objectives and learning activities. Similar patterns have been reported in previous studies, which found that novice or younger teachers generally demonstrate greater confidence in using technology but require stronger pedagogical foundations to achieve more transformative forms of technology integration (Chai et al., 2013; Scherer et al., 2019; Sumarsono, 2022). In this sense, technology often remains at the substitution level when teachers lack opportunities to redesign learning through technology-supported pedagogical strategies (Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017).

In contrast, experienced teachers demonstrated stronger Pedagogical Knowledge (PK), Content Knowledge (CK), and Pedagogical Content Knowledge (PCK). Their mean scores for PK (M = 4.20; 84.0%), CK (M = 4.12; 82.4%), and PCK (M = 4.15; 83.0%) exceeded those of novice teachers, indicating that years of classroom experience had strengthened their instructional expertise. Through sustained teaching practice, experienced teachers developed a deeper understanding of students' learning characteristics, classroom management, curriculum implementation, and instructional decision-making. This accumulated professional knowledge enabled them to select instructional strategies that were better aligned with students' learning needs and curricular objectives. Such expertise represented an essential foundation for meaningful technology integration because digital technologies became educationally valuable only when

they were connected with appropriate pedagogical decisions and disciplinary understanding. These findings were consistent with previous research indicating that teaching experience contributed to stronger pedagogical competence, professional judgment, and instructional effectiveness (Hasibuan et al., 2022; Shiyao, 2021).

Despite their stronger pedagogical expertise, experienced teachers reported lower confidence in technology-related domains. Their comparatively lower scores in Technological Knowledge (TK) and Technological Pedagogical Knowledge (TPK) suggested that adopting unfamiliar digital tools presented greater challenges than it did for novice teachers. However, this pattern should not be interpreted as resistance to technology. Rather, experienced teachers appeared to evaluate technology more critically based on its practicality, reliability, and instructional value. When technological resources were unstable, difficult to manage, or insufficiently supported, they tended to rely on instructional approaches that had previously demonstrated effectiveness in achieving learning outcomes. Such decisions reflected adaptive professional judgment developed through years of classroom experience rather than reluctance to embrace innovation. This interpretation was consistent with previous research indicating that technology integration was influenced by teachers' beliefs, perceived usefulness of technology, and technological self-efficacy (Romrome, 2024; Nazari et al., 2019; Nuraini et al., 2024). Consequently, the lower technological confidence reported by experienced teachers may have reflected limited opportunities for continuous technological engagement and professional development rather than a lack of professional commitment or openness to innovation.

Instead of viewing these differences as deficiencies, the findings suggested that novice and experienced teachers possessed complementary forms of expertise that could support collective professional growth. Novice teachers contributed technological familiarity, curiosity, and willingness to explore emerging digital tools, whereas experienced teachers contributed pedagogical expertise, classroom management skills, and deeper understanding of curriculum implementation. These complementary strengths demonstrated the potential value of collaborative professional learning, in which teachers with different backgrounds could learn from one another. Through mentoring, peer coaching, and collaborative lesson design, novice teachers could strengthen their pedagogical decision-making, while experienced teachers could gradually enhance their confidence and competence in integrating technology into classroom practice. This reciprocal learning process suggested that balanced TPACK development was more likely to occur when teachers' different areas of expertise were recognized and connected through collaborative professional activities. Similar conclusions were reported in previous studies, which emphasized that collaboration and peer learning supported sustainable teacher professional development and strengthened technology integration (Novita et al., 2022; Romrome & Sari, 2025).

Another notable finding was that Technological Content Knowledge (TCK) represented the weakest TPACK domain for both novice and experienced teachers. Novice teachers obtained a mean score of 2.95 (59.0%), while experienced teachers reported a slightly lower mean score of 2.88 (57.6%). These findings indicated that teachers experienced similar difficulties in connecting technology with subject-specific content regardless of their professional experience. Although many participants were familiar with general-purpose digital applications such as PowerPoint, WhatsApp, and YouTube, they appeared to have limited experience using technologies specifically designed to support disciplinary learning. Consequently, technology

was more frequently employed to supplement instruction than to represent complex concepts, facilitate inquiry, or promote discipline-specific thinking. This finding was consistent with previous studies identifying TCK as one of the most challenging components of TPACK because it requires teachers to understand how particular technologies can represent disciplinary concepts and support subject-specific learning processes (Nazari et al., 2019; Setiyanti & Hunt, 2017; Tsui, 2012). The consistently low TCK scores indicated that future professional development should move beyond general digital literacy by providing teachers with opportunities to explore subject-specific technologies that enhance conceptual understanding across different curriculum areas.

In accordance with these findings, technology integration should also be interpreted within the broader educational context of Papua Pegunungan, where it was shaped not only by teachers' professional knowledge but also by the conditions in which they worked. Although the TPACK framework emphasizes the interaction among technological, pedagogical, and content knowledge, opportunities to develop these forms of knowledge are strongly influenced by contextual factors. In Papua Pegunungan, geographical isolation, limited technological infrastructure, cultural and linguistic diversity, and unequal access to professional development collectively shaped teachers' experiences with technology and influenced how digital tools were incorporated into classroom practice. Consequently, differences in TPACK development reflected not only individual competence but also the interaction between teacher capacity and the educational environment that either enabled or constrained professional learning. This interpretation was consistent with previous research indicating that technology integration is inherently context-dependent and that contextual factors represent an integral component of TPACK development (Mishra & Koehler, 2006; Prasojo et al., 2020). Previous studies also demonstrated that infrastructure availability, institutional support, and opportunities for sustained professional learning significantly influenced teachers' ability to integrate technology effectively (Bingimlas, 2009; Karchmer-Klein & Konishi, 2023; Novita et al., 2022; Pamuk, 2012).

One of the most significant contextual challenges identified in this study was geographical isolation. Many schools were located in remote areas where stable internet connectivity, electricity, digital devices, and instructional resources remained limited. These conditions reduced teachers' opportunities to explore emerging technologies, participate in technology-focused professional development, and strengthen technological competence through sustained practice. Compared with teachers in urban areas, who generally benefited from greater access to technological resources and professional learning networks, teachers in Papua Pegunungan frequently encountered structural barriers that restricted continuous engagement with digital innovation. These findings were consistent with previous research indicating that inadequate infrastructure represented one of the principal barriers to ICT integration in schools and that access to technological resources and institutional support significantly influenced teachers' technology integration practices (Bingimlas, 2009; Tondeur et al., 2017).

These contextual conditions also helped explain the comparatively lower TK and TPK scores reported by experienced teachers. Rather than indicating resistance to technology, their lower confidence may have reflected limited opportunities to engage with digital tools and participate in ongoing technology-focused professional learning. In environments where internet connectivity was inconsistent and technological resources were unreliable, adopting unfamiliar digital applications may have introduced additional instructional challenges and uncertainty. Consequently, experienced teachers often relied on instructional approaches that had proven

effective under existing classroom conditions. Such decisions reflected adaptive professional judgment rather than reluctance to innovate. This interpretation was consistent with previous research indicating that technology integration was influenced by both teachers' beliefs and contextual conditions, while technological self-efficacy played an important role in shaping teachers' intentions to adopt digital technologies (Ertmer & Ottenbreit-Leftwich, 2010; Mama & Hennessy, 2021).

Beyond infrastructure, the sociocultural characteristics of Papua Pegunungan also influenced teachers' technology integration practices. Classrooms represented culturally and linguistically diverse learning environments in which students brought distinct experiences, traditions, and local knowledge to the educational process. Under these circumstances, technology could not simply be introduced as a neutral instructional tool without considering its relevance to students' social and cultural realities. Digital learning resources developed for other educational contexts may not adequately reflect local experiences or support meaningful learning for Papuan students. Therefore, effective technology integration required teachers to critically evaluate whether digital resources were accessible, pedagogically appropriate, and culturally responsive to the needs of their learners. This perspective was consistent with contextualized TPACK discussions, which emphasize that successful technology integration depends not only on teachers' knowledge but also on their ability to adapt digital resources to the cultural, linguistic, and environmental characteristics of their classrooms (Angeli & Valanides, 2009; Habibi et al., 2020; Irwanto et al., 2022). It is also aligned with culturally responsive teaching perspectives, which highlight the importance of connecting academic learning with learners' cultural identities and lived experiences (Novita et al., 2022).

These findings highlighted the importance of culturally responsive technology integration in strengthening teachers' TPACK. Teachers needed to integrate technological knowledge with an understanding of students' cultural backgrounds, linguistic diversity, and community contexts so that technology enriched learning rather than merely introduced new digital resources. Local knowledge therefore became an essential foundation for selecting, adapting, and developing instructional materials that reflected students' lived experiences and cultural identities. Within the educational context of Papua Pegunungan, meaningful technology integration depended not only on teachers' technical competence but also on their ability to adapt digital resources to local educational realities.

The findings also reinforced the importance of collaborative professional learning in supporting sustainable TPACK development. Although novice and experienced teachers demonstrated different areas of strength, their expertise was complementary rather than hierarchical. Novice teachers' technological familiarity and willingness to explore emerging digital tools could support experienced teachers in developing greater confidence with technology, while experienced teachers' pedagogical expertise and contextual understanding could assist novice teachers in making more meaningful instructional decisions. Therefore, technology integration should be viewed as a collective professional process rather than an individual competency developed in isolation.

Professional collaboration was particularly important in Papua Pegunungan, where geographical distance and limited infrastructure restricted teachers' opportunities to participate in formal professional learning activities. Teachers working in remote schools frequently had fewer

opportunities to observe colleagues' instructional practices, attend professional development workshops, or engage in sustained professional dialogue with educators from other schools. Under these conditions, professional learning communities, mentoring relationships, and peer collaboration provided valuable alternatives for continuous professional growth. Through these collaborative processes, teachers could exchange instructional experiences, address shared challenges, and develop practical solutions that were responsive to their local contexts. This finding was consistent with previous research demonstrating that collaborative professional learning enhanced instructional practice by promoting reflection, knowledge sharing, and collective problem solving (Darling-Hammond et al., 2017; Romrome & Mbato, 2022).

The complementary expertise identified in this study therefore provided an important foundation for designing context-responsive professional development programs. Rather than implementing identical technology training for all teachers, professional development initiatives should recognize differences in teachers' existing knowledge and provide opportunities for reciprocal learning. Novice teachers could support experienced colleagues in exploring digital tools and emerging technologies, whereas experienced teachers could guide novice teachers in integrating technology with effective pedagogy, classroom management, and curriculum implementation. Such an approach would support more balanced TPACK development by strengthening technological, pedagogical, and content knowledge within teachers' specific educational contexts. For geographically remote regions such as Papua Pegunungan, sustainable technology integration depends not only on improving individual teacher competence but also on developing collaborative professional systems that respond to local educational realities.

CONCLUSION

This study examined the perceptions and practices of novice and experienced Papuan elementary school teachers in integrating technology through the TPACK framework. Novice teachers showed greater confidence in technological knowledge and technological pedagogical knowledge, reflecting enthusiasm for using digital tools, although their application was often superficial and not fully aligned with lesson goals. Experienced teachers demonstrated stronger mastery of pedagogy, content, and pedagogical content knowledge, highlighting the value of years of practice. However, they were less confident with digital tools and tended to rely on traditional methods. Both groups shared a weakness in technological content knowledge, suggesting that linking technology with subject matter remains a common challenge.

Recommendations

Despite these differences, both groups also showed notable similarities. Teachers relied mainly on basic tools such as PowerPoint, YouTube, and WhatsApp, with limited use of subject-specific applications. Novices reported learning through workshops, peer collaboration, and trial and error, while experienced teachers relied on long-term classroom practice and reflection. Both faced similar barriers, including unstable internet, limited access to devices, and a lack of continuous professional development. Even so, teachers expressed strong motivation and a willingness to adapt and collaborate, suggesting that with proper support, their capacity to integrate technology could be significantly improved. Based on these findings, collaboration between novice and experienced teachers should be encouraged to combine digital fluency with pedagogical and content expertise. Therefore, policymakers should prioritize systemic

improvements, such as providing reliable internet access, adequate digital resources, and sustained professional development programs. Besides that, training should be continuous, practice-based, and supported by mentoring rather than limited to short workshops. This study has several limitations, including its reliance on self-reported data, a focus on a localized sample, and the absence of classroom observations or student learning outcomes. Future research should examine teachers' TPACK development over time, investigate subject-specific practices, and explore the direct effects of technology integration on student achievement.

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