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Socio-Adaptive TPACK in Rural Schools: Teachers' Experiences and Challenges

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Abstract: The integration of Technological, Pedagogical, and Content Knowledge (TPACK) has become a fundamental prerequisite for 21st-century education. However, existing literature remains predominantly focused on resource-rich urban environments, leaving a significant gap in understanding how TPACK is constructed within infrastructure-scarce rural contexts. This study aims to explore the lived experiences of teachers in Muaro Jambi Regency in negotiating technological constraints and to propose a contextualized adaptation model. Utilizing a qualitative Interpretative Phenomenological Analysis (IPA) approach, data were collected over a three-month period through semi-structured in-depth interviews with nine teachers from SMPN 1, SMPN 7, and SMPN 30 Muaro Jambi. Data collection continued until thematic saturation was achieved. The analysis focused on interpreting emergent themes related to teachers' socio-adaptive TPACK practices within limited technological environments. The findings reveal that infrastructural limitations, rather than functioning solely as barriers, act as catalysts for the emergence of "Socio-Adaptive TPACK." This model consists of three interconnected dimensions: (1) Technical Adaptation through low-tech optimization and teacher agency, (2) Pedagogical Adaptation through collaborative interaction with students, and (3) Collaborative Adaptation through intergenerational knowledge sharing and social cohesion among teachers. The study concludes that, in developing regions, TPACK should not be understood merely as an individual cognitive competence, but as a communal asset shaped through resilience, collaboration, and social capital. These findings imply that professional development programs should move beyond top-down technical training and instead foster sustainable communities of practice within rural schools.

Abstrak: *Integrasi Pengetahuan Teknologi, Pedagogi, dan Konten (TPACK) telah menjadi prasyarat mendasar untuk pendidikan abad ke-21. Namun, literatur yang ada sebagian besar masih berfokus pada lingkungan perkotaan yang kaya sumber daya, sehingga meninggalkan kesenjangan yang signifikan dalam memahami bagaimana TPACK dibangun dalam konteks pedesaan yang kekurangan infrastruktur. Studi ini bertujuan untuk mengeksplorasi pengalaman hidup guru di Kabupaten Muaro Jambi dalam mengatasi kendala teknologi dan untuk mengusulkan model adaptasi yang kontekstual. Dengan menggunakan pendekatan Analisis Fenomenologi Interpretatif (IPA) kualitatif, data dikumpulkan selama tiga*

bulan melalui wawancara mendalam semi-terstruktur dengan sembilan guru dari SMPN 1, SMPN 7, dan SMPN 30 Muaro Jambi. Pengumpulan data dilanjutkan hingga tercapai saturasi tematik. Analisis difokuskan pada interpretasi tema-tema yang muncul terkait dengan praktik TPACK sosio-adaptif guru dalam lingkungan teknologi yang terbatas. Temuan menunjukkan bahwa keterbatasan infrastruktur, alih-alih hanya berfungsi sebagai penghalang, bertindak sebagai katalisator bagi munculnya "TPACK Sosio-Adaptif". Model ini terdiri dari tiga dimensi yang saling berhubungan: (1) Adaptasi Teknis melalui optimasi teknologi rendah dan peran guru, (2) Adaptasi Pedagogis melalui interaksi kolaboratif dengan siswa, dan (3) Adaptasi Kolaboratif melalui berbagi pengetahuan antar generasi dan kohesi sosial di antara guru. Studi ini menyimpulkan bahwa, di wilayah berkembang, TPACK tidak boleh dipahami hanya sebagai kompetensi kognitif individu, tetapi sebagai aset komunal yang dibentuk melalui ketahanan, kolaborasi, dan modal sosial. Temuan ini menyiratkan bahwa program pengembangan profesional harus melampaui pelatihan teknis dari atas ke bawah dan sebaliknya mendorong komunitas praktik yang berkelanjutan di sekolah-sekolah pedesaan.

Keywords: Socio-Adaptive TPACK, Rural Education, Digital Divide, Interpretative Phenomenological Analysis, Teacher Agency

INTRODUCTION

In the landscape of 21st-century education, the Technological Pedagogical Content Knowledge (TPACK) framework remains highly dynamic and continuously evolves to accommodate emerging instructional paradigms. The integration of digital technologies into modern classrooms is no longer optional but has become a core mandate to equip students with critical thinking, collaboration, and digital literacy. Recent literature underscores that evaluating teachers' design and application of TPACK must transition toward domain-specific and highly contextualized assessments (Mölgen et al., 2024), considering that the operationalization and requirements of TPACK facets can differ fundamentally depending on the specific content area and the quality of the test instruments used (Kadluba et al., 2024). Furthermore, with the rapid proliferation of advanced digital tools, contemporary extensions of the framework emphasize that integration is no longer restricted to traditional educational software, but heavily encompasses competencies in artificial intelligence (AI-TPACK) and sophisticated prompt engineering (Feldman-Maggor et al., 2025). Consequently, teachers are demanded to structurally transform content delivery and actively convert traditional textbook tasks into dynamic digital activities to enhance their overall technological-pedagogical reasoning (Segal, 2026).

However, the actual translation of theoretical TPACK proficiency into sustained classroom practices is often hindered by complex systemic and psychological barriers, particularly in developing educational contexts. Research indicates that a teacher's digital proficiency serves as a critical predictor of their advanced pedagogical readiness, yet many educators still demonstrate below-average competencies when navigating complex technological frameworks (Hava & Babayiğit, 2025). This discrepancy is heavily influenced by the intricate interplay between a teacher's intrinsic intentions and their actual behavioral integration of digital tools (Li & Li, 2024). Additionally, the development of technology-related professional knowledge is heavily structured by the teacher's specific professional career path, their teaching experience, and the targeted professional education programs they encounter during their service (Chang et

al., 2025). On an institutional level, teachers' developmental trajectories are deeply tied to school-level profiles, where supportive and empowering school environments—coupled with high levels of individual technological self-efficacy—consistently generate better instructional outcomes and continuous usage intentions (Li & Bai, 2025).

The structural challenges of technology integration become significantly more pronounced when examining the widening digital divide in primary and secondary education. Prior empirical studies reveal stark disparities between urban and rural educators, demonstrating that urban teachers consistently exhibit higher TPACK proficiency and more favorable attitudes toward technological tools due to superior resource accessibility and robust institutional support (Li, 2025). In rural regions, such as Muaro Jambi Regency, teachers frequently grapple with a multi-layered digital divide characterized by unstable internet connectivity, inadequate hardware, and a lack of localized professional training. These technical constraints do not merely hinder lesson delivery but also induce socio-emotional anxiety among educators who are pressured to adopt 21st-century teaching models without the prerequisite infrastructural ecosystem. Therefore, understanding science and general teachers' TPACK within rural schools requires a multi-dimensional lens that captures how educators build contextual resilience to adopt digital alternatives in under-resourced environments (Shambare & Jita, 2024).

While extensive research has investigated TPACK development in well-resourced urban schools or controlled laboratory settings, there remains a critical research gap concerning how rural teachers practically negotiate these layered infrastructure limitations and context-specific constraints. Most existing literature relies heavily on quantitative surveys to measure self-reported TPACK scores, which often fail to capture the nuanced, lived experiences and internal resilient mechanisms of teachers in resource-constrained environments. To bridge this gap, this study employs an Interpretative Phenomenological Analysis (IPA) approach to explore the profound experiences and challenges faced by nine elementary and secondary school teachers in Muaro Jambi Regency. By capturing their authentic voices, instructional designs, and coping strategies, this study aims to provide a deeper understanding of how rural educators adapt global technological mandates into localized pedagogical realities.

METHOD

1. Research Design and IPA Commitment

This study employed a qualitative research design using Interpretative Phenomenological Analysis (IPA). IPA was chosen because it enables researchers to explore participants' lived experiences and the meanings they construct from those experiences within a particular context. Technology integration in education is closely related to teachers' experiences, pedagogical practices, and contextual realities in the teaching and learning process (Koh et al., 2015). In addition, teachers' professional interactions and educational challenges influence the development and implementation of technological pedagogical content knowledge (Mahlo & Waghid, 2026). Therefore, IPA was considered appropriate for this study because it provides an in-depth understanding of teachers' perceptions, interpretations, and experiences regarding technology integration in educational settings.

2. Participants and Research Context

The study was conducted in Muaro Jambi Regency, Indonesia, an area characterized by unequal technological access and infrastructural disparities among schools. Participants were selected using purposive sampling based on the following inclusion criteria: (1) having a minimum of five years of teaching

experience, (2) actively attempting to integrate digital tools into classroom instruction, and (3) teaching in schools with varying levels of technological resources.

A total of nine teachers from SMPN 1, SMPN 7, and SMPN 30 Muaro Jambi participated in this study. In qualitative research, participant selection emphasizes the depth of information and contextual understanding of participants' experiences within a particular educational setting rather than statistical representation (Peñaojas & Palomar, 2025). Data collection was conducted intensively to explore teachers' perceptions, experiences, and interpretations regarding technology integration in classroom practices. Teachers' professional experiences and interactions within different school environments are important for understanding how educational contexts influence the development of technological pedagogical content knowledge (Mahlo & Waghid, 2026). Furthermore, teachers' perceptions and reflective experiences provide meaningful insights into educational practices and professional development processes within the TPACK framework (Yang & Wei, 2025).

3. Data Collection Procedures and Ethical Statement

The interview data were analyzed using Interpretative Phenomenological Analysis (IPA), which focuses on exploring how participants make sense of their experiences within a particular context. The analysis process involved several stages, including repeated reading of the interview transcripts, initial noting, identification of emergent themes, clustering of related themes, and interpretation of the meanings constructed by participants. This approach enabled the researcher to gain a deeper understanding of teachers' experiences and perspectives regarding technology integration and TPACK development in their teaching practices. Teachers' knowledge sharing, professional experiences, and interactions within educational environments are important in understanding how technology integration practices are developed and interpreted in the digital age (Zeng et al., 2025). Furthermore, the integration of technology in educational settings is closely related to teachers' pedagogical understanding, technological competencies, and contextual teaching experiences (Zhu et al., 2026).

Ethical Statement

Before the data collection process, all participants received a detailed explanation regarding the objectives and procedures of the research. Participation was entirely voluntary, and informed consent was obtained from each participant (Mafa & Govender, 2025). To ensure confidentiality and protect participants' identities, pseudonyms (e.g., Teacher C, Teacher D, and Teacher G) were used throughout the manuscript (Hava & Babayiğit, 2025). Participants were also informed of their right to withdraw from the study at any point without negative consequences.

4. Data Analysis

The data analysis process began with repeatedly reading the interview transcripts to gain a comprehensive understanding of participants' experiences and perspectives. Initial coding was conducted by identifying meaningful statements related to teachers' experiences in technology integration and classroom practices. Similar codes were then grouped into broader themes and interpreted to understand how participants constructed meanings from their professional experiences. This interpretative process enabled the researcher to explore teachers' perceptions, contextual experiences, and

pedagogical practices related to technology integration in educational settings (Zhao & Wang, 2024). Furthermore, teachers' professional experiences, technological competencies, and pedagogical understanding are important aspects in understanding the development of TPACK and technology integration practices within educational contexts (Su et al., 2025).

For example, statements such as *"I use my own hotspot and simplify materials into light PDF files because the school internet often fails"* were initially interpreted as forms of *personal technological adjustment* and *teacher resilience*. These preliminary interpretations were then clustered into the broader theme of Technical Adaptation. Similarly, narratives describing how students assisted teachers in operating digital applications were interpreted as indicators of collaborative classroom interaction and were categorized under the theme of Pedagogical Adaptation. In addition, participants' accounts emphasizing peer mentoring, emotional solidarity, and informal knowledge sharing among colleagues contributed to the emergence of the theme Collaborative Adaptation. After themes were identified within individual participant accounts, cross-case analysis was conducted to explore conceptual similarities and differences across participants and school contexts. These interconnected themes were subsequently organized into superordinate categories that formed the basis of the proposed "Socio-Adaptive TPACK" model.

To ensure trustworthiness and analytical rigor, member checking was conducted by returning interview summaries and preliminary interpretations to participants for validation and clarification (Birt et al., 2016). In addition, triangulation through interviews, classroom observations, lesson-plan analysis, and field notes was employed to strengthen the credibility and consistency of the findings, which effectively neutralizes subjective researcher bias and establishes cross-case empirical validity (Jacoob et al., 2025). The researchers also continuously reflected on their own assumptions and interpretations throughout the analytical process to minimize subjective bias and maintain interpretative sensitivity.

RESULTS AND DISCUSSION

The findings of this study demonstrate that the integration of TPACK in rural schools is not merely a technical activity associated with digital tools, but rather a socio-emotional process shaped by infrastructural limitations, teacher agency, and collaborative adaptation. Teachers in Muaro Jambi do not perceive technological barriers as absolute deadlocks; instead, they continuously negotiate these constraints to maintain instructional effectiveness.

The interpretative analysis reveals that the nature of these negotiations varies significantly depending on the specific school context and the individual resilience of the teacher. To provide a clear overview of these variations, the following table summarizes the cross-case analysis across the three research sites.

Table 1. Cross-Case Analysis of Infrastructural Challenges and Socio-Adaptive Responses

Research Site	**Infrastructural Characteristics**	**Typology of Challenges**	**Dominant Socio-Adaptive Response**
SMPN 1	Stable electricity, fluctuating internet.	High expectations with inadequate facilities.	**Pedagogical Adaptation** (Collaboration with tech-savvy students).
SMPN 7	Weak signal, limited devices.	Intergenerational digital gap among teachers.	**Collaborative Adaptation** (Peer mentoring and informal WhatsApp groups).

SMPN 30	Blank spot, frequent power outages.	Total technical failure during instruction.	**Technical Adaptation** (Use of offline modules and personal data quotas).

1. **Technical Adaptation: Negotiating Agency Amid Fragility**

One of the most dominant findings concerns teachers' efforts to adapt technologically within unstable conditions. However, this adaptation is deeply personal. For instance, Teacher C from SMPN 30 described a recurring emotional struggle when digital plans failed. Instead of surrendering, the participant interpreted this failure as a challenge to their professional identity, leading to the use of personal mobile data and simplified smartphone-based instruction. This highlights that technical adaptation is an act of agency fueled by contextual resilience.

The findings were analyzed and interpreted systematically to ensure that the themes accurately represented participants' experiences and perspectives regarding technology integration in educational settings. The interpretation process focused on understanding how teachers constructed meanings from their professional and contextual experiences related to TPACK development and classroom practices. This analysis enabled the researcher to explore teachers' perceptions, contextual experiences, and pedagogical practices associated with technology integration in educational settings (Elnara et al., 2026). This highlights the importance of technological competencies and pedagogical understanding in explaining the implementation of technology integration practices within educational contexts (Gonscherowski & Rott, 2025).

2. **Pedagogical Adaptation: Reconstructing Classroom Interaction**

Pedagogical adaptation involves a shift in classroom authority. In environments where teachers feel technically limited, they reposition students as active partners. Teacher G explained that involving students in troubleshooting technical problems—which was initially perceived as a threat to authority—eventually became a productive form of collaborative learning. Within the Socio-Adaptive TPACK framework, Pedagogical Knowledge (PK) involves flexibility and openness toward reciprocal learning processes. The trustworthiness of the data was enhanced through member checking, where participants were given the opportunity to review and confirm the accuracy of the interview findings and interpretations (Masry-Herzallah, 2025). In addition, credibility was strengthened by repeatedly reviewing the interview transcripts and ensuring that the interpretations reflected participants' actual experiences and perspectives regarding technology integration in educational settings (Li et al., 2025).

3. **Collaborative Adaptation: Social Cohesion as a Support System**

The findings further reveal that teachers rely heavily on informal communities of practice. Teacher D, a senior educator, described how initial feelings of insecurity were mitigated by the emotional solidarity and technical guidance provided by younger colleagues. This suggests that social cohesion is an essential component of technology integration in rural settings, where TPACK functions as a communal rather than an individual asset. The trustworthiness of the data was enhanced through member checking, where participants were given the opportunity to review and confirm the accuracy of the interview findings and interpretations (Birt et al., 2016). In addition, credibility was strengthened by repeatedly reviewing the interview transcripts and ensuring that the interpretations reflected participants' actual experiences and perspectives

regarding technology integration in educational settings (Li & Bai, 2025).

Table 2. Components of the Socio-Adaptive TPACK Model

Model Component	Operational Definition	Empirical Evidence (Key Quotes)	Relation to Original TPACK Theory
Technical Adaptation	Optimization of low-cost devices and personal agency.	*"I use my own hotspot and modify materials into light PDFs..."* (Teacher C)	Expands **Technological Knowledge (TK)** toward contextual resilience.
Pedagogical Adaptation	Repositioning students as technical partners.	*"Students help operate the apps, while I focus on the content..."* (Teacher G)	Deconstructs **Pedagogical Knowledge (PK)** from authoritative to collaborative.
Collaborative Adaptation	Knowledge transfer through social cohesion.	*"Without the younger teachers' help, I would have given up..."* (Teacher D)	Transforms TPACK from an individual capacity into **Social Capital**.

CONCLUSION

This study concludes that the implementation of TPACK in rural schools, specifically within the Muaro Jambi Regency, is not a static technical achievement but a dynamic, socio-emotional process of negotiation. The findings deconstruct the conventional view of technology integration by introducing the Socio-Adaptive TPACK model. This model demonstrates that when faced with chronic infrastructural scarcity, teachers' proficiency is sustained through three interconnected dimensions: Technical Adaptation (resilience and personal agency), Pedagogical Adaptation (reciprocal learning with students), and Collaborative Adaptation (social cohesion and informal peer support).

The theoretical implication of this research is a call to shift the TPACK paradigm from a purely individualistic cognitive construct to a communal asset. In resource-scarce environments, the success of 21st-century learning depends less on the availability of high-end hardware and more on the strength of social capital and teacher agency. Practically, this study suggests that educational authorities and policymakers should move away from top-down, standardized technical training. Instead, professional development programs should prioritize fostering organic "Communities of Practice" (CoP) that empower teachers to share local, adaptive strategies.

Despite its contributions, this study is limited by its specific geographical and cultural context in Muaro Jambi. Future research should explore the longitudinal impact of Socio-Adaptive TPACK on student learning outcomes and examine how this model could be integrated into formal teacher education curricula to better prepare educators for the realities of rural teaching. Ultimately, the resilience shown by these teachers proves that while infrastructure may be limited, pedagogical innovation remains boundless through collaboration and agency.

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