JPPIPA 12(7) (2026)

Jurnal Penelitian Pendidikan IPA

http://jppipa.unram.ac.id/index.php/jppipa/index

Implementation of Technological Pedagogical Content Knowledge (TPACK) to Enhance Learning Quality in Support of SDG 4: A Case Study at SDN 01 Kendawangan

Riyadhul Jannah[1*], Dian Hidayati[1], Muhammad Zuhaery[1]

[1] Manajemen Pendidikan, Universitas Ahmad Dahlan, Yogyakarta, Indonesia.

Received: May 04, 2026
Revised: June 07, 2026
Accepted: July 25, 2026
Published: July 31, 2026

Corresponding Author:
Riyadhul Jannah
2408046045@webmail.uad.ac.id

DOI: 10.29303/jppipa.v12i7.15541

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Abstract: This study aimed to analyze the implementation of Technological Pedagogical Content Knowledge (TPACK) in enhancing learning quality at SDN 01 Kendawangan as a contribution to achieving Sustainable Development Goal 4 (SDG 4: Quality Education). A qualitative case study approach was employed involving one principal and three classroom teachers representing lower and upper grades. Data were collected through classroom observations, semi-structured interviews, and document analysis. Data were analyzed using the interactive model of Miles and Huberman, including data reduction, data display, and conclusion drawing and verification. The findings revealed that teachers integrated technological, pedagogical, and content knowledge into lesson planning, classroom instruction, and assessment by utilizing digital learning media, interactive presentations, and online educational resources. This implementation enhanced students' participation in classroom activities, facilitated their understanding of abstract concepts through visual and interactive learning materials, and encouraged more active learning interactions. However, challenges remained, including limited technological infrastructure, uneven digital competencies among teachers, and unstable internet connectivity. Continuous professional development and institutional support are therefore essential to strengthen teachers' TPACK competencies. In conclusion, the implementation of TPACK contributes to improving learning quality and supports the achievement of SDG 4 by promoting inclusive, technology-integrated, and student-centered learning practices in primary education.

Keywords: Learning quality; Primary education; SDG 4; Technological Pedagogical Content Knowledge (TPACK); TPACK implementation

Introduction

The rapid advancement of digital technology has transformed educational practices and requires teachers to integrate technology meaningfully into classroom instruction. In the context of twenty-first century education, learning is no longer limited to the transmission of knowledge but increasingly emphasizes active student participation, collaboration, critical thinking, and meaningful learning experiences. Consequently, teachers are expected to integrate technology with appropriate pedagogical approaches and subject matter knowledge to create effective and meaningful learning experiences. This transformation is closely aligned with the objectives of Sustainable Development Goal (SDG) 4, which promotes inclusive, equitable, and quality education through innovative teaching practices and improved teacher competencies (Afriliandhi et al., 2022; UNESCO, 2023; Mishra & Koehler, 2006; Nafia et al., 2023; Scherer et al., 2019).

Teachers' digital literacy extends beyond the ability to operate technological devices. It also includes the capacity to access, evaluate, manage, and utilize digital information critically, creatively, and ethically to

How to Cite:
Jannah, R., Hidayati, D., & Zuhaery, M. (2026). Implementation of Technological Pedagogical Content Knowledge (TPACK) to Enhance Learning Quality in Support of SDG 4: A Case Study at SDN 01 Kendawangan. *Jurnal Penelitian Pendidikan IPA*, *12*(7), 544–553. https://doi.org/10.29303/jppipa.v12i7.15541

improve learning effectiveness (Afriliandhi et al., 2022; Falloon, 2020). Alongside digital literacy, teachers' readiness to adopt educational technology is another essential factor influencing successful technology integration. The Technology Readiness Acceptance Model (TRAM) explains that teachers' readiness is shaped by optimism, innovativeness, discomfort, insecurity, and perceptions of technology usefulness and ease of use. These dimensions influence teachers' confidence in integrating digital technology into classroom instruction and ultimately affect the quality of learning (Nafia et al., 2023) Therefore, successful technology integration depends not only on the availability of digital infrastructure but also on teachers' readiness and competence to use technology effectively in instructional practice (Ertmer & Ottenbreit-Leftwich, 2010; Scherer et al., 2019).

Responding to these challenges requires teachers to possess professional competencies that integrate content knowledge, pedagogical knowledge, and technological knowledge. One of the most widely recognized frameworks addressing this need is Technological Pedagogical Content Knowledge (TPACK), introduced by Mishra & Koehler (2006). TPACK emphasizes the integration of technological knowledge, pedagogical knowledge, and content knowledge to design learning experiences that are relevant to curriculum objectives, students' characteristics, and the demands of digital-age education (Koehler et al., 2013; Mishra & Koehler, 2006). Teachers with strong TPACK competencies are more capable of selecting appropriate instructional strategies, utilizing technology effectively, and creating effective learning environments (Scherer et al., 2019). Previous studies have consistently reported that effective implementation of TPACK contributes to higher instructional quality, greater student engagement, and continuous professional development among teachers (Ahaya et al., 2024; Handini, 2025; Mishra & Koehler, 2006; Oktaviani & Utami, 2024; Scherer et al., 2019).

The implementation of TPACK is closely associated with improvements in learning quality. Learning quality is reflected not only in well-designed lesson planning but also in effective instructional implementation, meaningful teacher–student interaction, and the appropriate use of learning media and digital technology. Teachers with strong TPACK competencies are generally better able to adapt instructional strategies to students' learning characteristics while creating learning environments that are interactive, contextual, and student-centered. Consequently, strengthening teachers' TPACK competencies has become an important strategy for improving learning quality, particularly at the elementary school level where learning experiences should be meaningful and responsive to students' developmental needs (Anggraini et al., 2025; Rachmawati & Sutikno, 2024; Koehler et al., 2013; Maharani et al., 2021; Rahmadi, 2019; Scherer et al., 2019).

Despite the growing emphasis on technology integration in education, the implementation of TPACK in classroom practice remains inconsistent (Ertmer & Ottenbreit-Leftwich, 2010; Scherer et al., 2019). In many elementary schools, digital technology is still primarily used to facilitate the delivery of instructional materials rather than being integrated with pedagogical strategies that promote active learning, collaboration, and critical thinking (Filina et al., 2024; Nurdin et al., 2023). Consequently, the potential of technology to improve learning quality has not been fully realized. Previous studies have also shown that teachers often understand the concept of TPACK theoretically but continue to experience difficulties in implementing it effectively during classroom instruction (Amelia et al., 2023; Putri et al., 2023; Saputri & Sukmawati, 2024). This condition indicates that the effectiveness of technology integration depends not only on the availability of technological facilities but also on teachers' competencies in integrating technological, pedagogical, and content knowledge in a balanced and contextual manner (Amelia et al., 2023; Filina et al., 2024; Nurdin et al., 2023; Sudiarti et al., 2025).

Previous studies have predominantly examined TPACK from the perspectives of teachers' digital competence, technology acceptance, learning effectiveness, and students' learning outcomes (Ahaya et al., 2024; Handini, 2025; Oktaviani & Utami, 2024; Scherer et al., 2019). However, relatively limited attention has been given to how teachers implement TPACK comprehensively to improve learning quality within the context of elementary education, particularly through qualitative investigations that explore classroom practices in real educational settings (Maharani et al., 2021; Rahmadi, 2019). To support the identification of this research gap, a preliminary bibliometric mapping of publications from 2023 to 2025 was conducted using VOSviewer, a widely used software for bibliometric visualization and science mapping (Donthu et al., 2021; Eck & Waltman, 2010). The mapping indicated that existing studies remain largely concentrated on Pedagogical Content Knowledge (PCK) and quantitative analyses of learning outcomes, while qualitative studies examining teachers' implementation of TPACK to improve learning quality remain relatively limited. These findings highlight the need for further empirical evidence explaining how teachers translate TPACK competencies into classroom practice to improve learning quality, particularly in elementary school settings. Based on these considerations, this study aims to analyze the implementation of teachers' TPACK competencies in

improving learning quality at SDN 01 Kendawangan. Unlike previous studies that mainly focused on learning outcomes or teachers' digital competence, this study explores how teachers integrate technological, pedagogical, and content knowledge throughout the planning, implementation, and evaluation of learning. The findings are expected to enrich empirical evidence regarding TPACK implementation in elementary education and provide practical recommendations for strengthening teacher professionalism in support of Sustainable Development Goal (SDG) 4, particularly in improving the quality of learning through effective technology integration (Adelya et al., 2025; Mardati et al., 2024).

Method

This study employed a descriptive qualitative approach to explore the implementation of teachers' Technological Pedagogical Content Knowledge (TPACK) competencies in improving learning quality at the elementary school level. A descriptive qualitative approach was selected because it enables researchers to obtain an in-depth understanding of participants' experiences, instructional practices, and the contextual processes underlying a particular educational phenomenon in its natural setting. Through this approach, the study seeks to capture how teachers integrate technological, pedagogical, and content knowledge during classroom instruction and how these practices contribute to improving learning quality (Creswell & Creswell, 2018).

The study was conducted at SDN 01 Kendawangan, located in Kendawangan District, Ketapang Regency, West Kalimantan, Indonesia. The school was selected as the research site because it has implemented technology-supported learning and represents an elementary school context relevant to the objectives of this study. In addition, the school has encouraged teachers to integrate digital technology into classroom instruction, providing an appropriate setting for exploring the implementation of Technological Pedagogical Content Knowledge (TPACK) in improving learning quality.

The participants consisted of one principal and three classroom teachers selected through purposive sampling. This sampling technique was employed to identify participants who possessed direct experience and substantial knowledge regarding the implementation of technology-supported learning and the integration of Technological Pedagogical Content Knowledge (TPACK) in classroom instruction. The selected participants were considered capable of providing rich and relevant information to address the objectives of this study (Creswell & Creswell, 2018).

The study utilized both primary and secondary data. Primary data were collected through classroom observations and semi-structured interviews. Classroom observations were conducted to examine teachers' instructional practices, technology integration, and teacher–student interactions during the learning process, while the interviews explored participants' experiences, perceptions, and challenges related to the implementation of Technological Pedagogical Content Knowledge (TPACK). Secondary data were obtained from lesson plans, teaching modules, school documents, and relevant literature to complement and support the primary data. The use of multiple data sources enabled the researcher to obtain a more comprehensive understanding of the phenomenon under investigation (Creswell & Creswell, 2018).

The collected data were analyzed using the interactive model developed by Miles et al. (2014). The analysis began with data condensation by selecting, simplifying, and organizing information obtained from interviews, classroom observations, and documentation. The condensed data were subsequently presented in the form of descriptive narratives to facilitate interpretation and identify emerging patterns related to the implementation of teachers' Technological Pedagogical Content Knowledge (TPACK). Finally, conclusions were drawn and continuously verified throughout the research process to ensure that the findings accurately reflected the participants' experiences and the actual conditions observed in the field (Miles et al., 2014).

To ensure the trustworthiness of the findings, this study employed triangulation by comparing data obtained from interviews, classroom observations, and documentation. The integration of multiple data sources enabled the researcher to verify the consistency of the findings, minimize potential researcher bias, and provide a more comprehensive understanding of the implementation of teachers' Technological Pedagogical Content Knowledge (TPACK) in improving learning quality. Triangulation was applied throughout the data collection and analysis processes to enhance the credibility and dependability of the research findings (Creswell & Creswell, 2018; Miles et al., 2014).

Result and Discussion

Result

The findings revealed that teachers at SDN 01 Kendawangan implemented Technological Pedagogical Content Knowledge (TPACK) by integrating content knowledge, pedagogical strategies, and digital technology into classroom instruction. This implementation was reflected in lesson planning, classroom teaching practices, and the selection of digital learning media that were adapted to students'

characteristics and curriculum objectives. Classroom observations, interviews, and document analysis consistently indicated that technology was used as a pedagogical tool to facilitate meaningful learning rather than as the primary focus of instruction. Furthermore, the implementation of TPACK was supported by school leadership through the provision of digital facilities, professional development activities, and policies that encouraged teachers to integrate technology into the learning process. These findings provide empirical evidence that effective technology integration depends not only on teachers' competencies but also on institutional support that enables sustainable instructional improvement.

Teachers' TPACK Competency Implementation

The findings indicated that teachers demonstrated strong Content Knowledge (CK) and Pedagogical Knowledge (PK) by adapting learning materials to curriculum objectives while considering students' learning characteristics and everyday experiences. Rather than delivering learning materials in a rigid manner, teachers contextualized concepts to make them more understandable and relevant to students' prior knowledge. One teacher explained:

"*We adapt the materials to students' conditions so that they are easier to understand.*" (T1, Interview)

This interview finding was supported by classroom observations, which showed that teachers frequently connected lesson content with real-life examples, encouraged classroom discussions, and adjusted instructional activities according to students' responses during the learning process. Lesson plans and teaching documents also demonstrated that learning objectives, instructional materials, and learning activities were systematically aligned with curriculum requirements and students' needs.

These findings demonstrate that teachers' mastery of Content Knowledge and Pedagogical Knowledge was not limited to understanding subject matter but also involved the ability to transform knowledge into meaningful learning experiences. This practice reflects the fundamental principles of the TPACK framework proposed by Mishra & Koehler (2006), which emphasizes that effective teaching requires the integration of subject content and appropriate pedagogical strategies. The present findings are also consistent with previous studies reporting that teachers with strong pedagogical competencies are better able to design contextual, student-centered learning environments that enhance learning quality (Handini, 2025; Maharani et al., 2021; Rahmadi, 2019).

The findings further revealed that teachers integrated technological knowledge into classroom instruction by utilizing digital learning media, including instructional videos, presentation slides, and interactive quizzes. Technology was selected based on instructional objectives and students' learning needs rather than being used merely to demonstrate digital competence. As one teacher explained:

"We use technology to help explain the material, not as the main objective of learning." (T2, Interview)

This finding was supported by classroom observations, which showed that teachers employed digital media to facilitate concept explanation, stimulate classroom interaction, and encourage students' active participation during learning activities. Students appeared more engaged when digital resources were integrated with discussion and collaborative learning activities. Document analysis of lesson plans also indicated that technology was intentionally incorporated into instructional activities to support learning objectives rather than functioning as a standalone component.

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These findings indicate that technology functioned as an integral component of teachers' pedagogical practices rather than as an end in itself. This reflects the essence of the TPACK framework, which emphasizes the meaningful interaction among technological, pedagogical, and content knowledge to improve instructional effectiveness (Mishra & Koehler, 2006).

Consistent with previous studies, effective technology integration enables teachers to create more interactive, contextual, and student-centered learning environments, thereby supporting improvements in learning quality (Maharani et al., 2021; Oktaviani & Utami, 2024; Rahmadi, 2019). Unlike studies that primarily evaluate teachers' TPACK quantitatively, the present study provides qualitative evidence illustrating how teachers integrate technology into authentic classroom practices to enhance learning quality.

Table 1 summarizes the implementation of teachers' Technological Pedagogical Content Knowledge (TPACK) identified through interviews, classroom observations, and document analysis. The findings indicate that teachers demonstrated the integration of content knowledge, pedagogical strategies, and technological resources throughout lesson planning,

classroom instruction, and learning assessment. Rather than applying these competencies separately, teachers integrated them according to instructional objectives, classroom contexts, and students' learning needs. This integrated practice was reflected in the use of contextual teaching strategies, appropriate digital learning media, and interactive classroom activities that supported meaningful learning experiences. The following sections present these findings in greater detail.

Table 1. Summary of teachers' implementation of Technological Pedagogical Content Knowledge (TPACK)

TPACK Component	Implementation in Learning	Observed Contribution to Learning Quality
Content Knowledge (CK)	Teachers aligned learning materials with curriculum objectives and students' prior knowledge by relating concepts to everyday life situations.	Students demonstrated better understanding because learning materials became more contextual and meaningful.
Pedagogical Knowledge (PK)	Teachers implemented student-centered learning through discussion, questioning, and collaborative activities while managing classroom interaction effectively.	Students participated more actively and classroom interaction became more engaging.
Technological Knowledge (TK)	Teachers used instructional videos, presentation slides, and interactive digital applications to support concept explanation and classroom activities.	Digital media attracted students' attention and increased learning engagement during classroom activities.
Pedagogical Content Knowledge (PCK)	Teachers selected instructional strategies that matched both the characteristics of the learning content and students' learning needs.	Learning activities became more effective in facilitating students' conceptual understanding.
Technological Content Knowledge (TCK)	Teachers utilized digital technology to visualize abstract concepts and simplify complex learning materials.	Students understood difficult concepts more easily through visual and interactive learning resources.
Technological Pedagogical Knowledge (TPK)	Teachers integrated digital technology with appropriate instructional methods to encourage interaction and active participation.	Learning activities became more interactive, adaptive, and responsive to students' learning characteristics.
Technological Pedagogical Content Knowledge (TPACK)	Teachers integrated technology, pedagogy, and subject content coherently throughout lesson planning, classroom instruction, and learning assessment.	The integration supported meaningful learning experiences and contributed to improving the overall quality of classroom learning.

School Leadership as a Supporting Factor for TPACK Implementation

The findings indicated that school leadership played a significant role in supporting teachers' implementation of TPACK through institutional policies, professional development, and the provision of digital learning facilities. The principal emphasized that technology should not be viewed as the primary objective of learning but as a tool that supports pedagogical practices and the achievement of learning objectives. In addition, teachers were encouraged to integrate technological, pedagogical, and content knowledge into lesson planning and classroom instruction.

The principal explained:

"*The school always emphasizes that technology is only a tool. The most important aspect remains pedagogy. In lesson planning, teachers are required to include TPACK elements so that from the beginning they have planned the content, the teaching strategies, and the technology that will support classroom learning.*" (Principal, Interview)

This finding was supported by school documentation and interviews, which showed that the school organized regular teacher discussions, internal workshops, and peer-learning activities to strengthen teachers' competencies in integrating technology into classroom instruction. Furthermore, teachers had access to digital facilities, including internet connectivity, projectors, laptops, computer laboratories, and educational platforms such as Canva for Education, Quizizz, and Google Workspace. These resources enabled teachers to design more interactive learning materials and implement technology-supported instructional activities.

These findings suggest that effective TPACK implementation depends not only on teachers' individual competencies but also on the support provided by school leadership. By establishing policies that encourage technology integration, facilitating continuous professional learning, and providing adequate digital infrastructure, school leaders create an environment that enables teachers to implement TPACK more effectively. This finding is consistent with previous studies reporting that supportive school leadership contributes to teachers' professional development and

promotes the successful integration of technology into classroom practices.

Despite these supportive initiatives, several challenges were identified in implementing TPACK. The principal acknowledged that teachers required additional time to prepare digital learning materials, possessed varying levels of digital competence, and occasionally encountered technical problems such as unstable internet connections and electricity disruptions. To address these challenges, the school implemented peer mentoring by pairing technologically proficient teachers with those requiring additional support, organized practice-oriented workshops, and provided recognition for teachers who demonstrated innovation in technology-integrated learning. These initiatives illustrate that school leadership not only provides resources but also actively facilitates teachers' continuous professional development.

Table 2. Summary of school leadership support for TPACK implementation

School Leadership Support	Implementation in School	Contribution to TPACK Implementation
School policy	Professional development	The school organized regular teacher discussions, peer mentoring, and practice-oriented workshops to strengthen teachers' digital competencies.
Professional development	Digital infrastructure	The school provided internet access, projectors, laptops, a computer laboratory, and educational platforms such as Canva for Education, Quizizz, and Google Workspace.
Digital infrastructure	Academic supervision	The principal conducted regular lesson plan reviews, classroom supervision, and monthly discussions to evaluate technology integration in teaching.
Academic supervision	Innovation support	Teachers were encouraged to share successful teaching practices and received recognition for innovative technology integration.
Innovation support	Challenges and improvement strategies	The school addressed differences in teachers' digital competence through peer tutoring and practical workshops while anticipating technical constraints such as internet connectivity and electricity interruptions.
Challenges and improvement strategies	Professional development	The school organized regular teacher discussions, peer mentoring, and practice-oriented workshops to strengthen teachers' digital competencies.

Table 2 summarizes the forms of school leadership support that facilitated teachers' implementation of Technological Pedagogical Content Knowledge (TPACK) at SDN 01 Kendawangan. The findings indicate that school leadership support extended beyond the provision of digital infrastructure to include institutional policies, continuous professional development, academic supervision, and collaborative learning among teachers. These initiatives created a supportive environment that encouraged teachers to integrate technology, pedagogy, and content knowledge into their instructional practices. In addition, the school addressed implementation challenges by providing peer mentoring and practice-oriented workshops, demonstrating its commitment to strengthening teachers' professional competencies and sustaining the implementation of TPACK. The following discussion presents these findings in greater detail through interview excerpts and supporting evidence from classroom observations and document analysis.

Contribution of TPACK Implementation to Learning Quality

One teacher explained:

"*Students become more enthusiastic when learning activities include instructional videos or interactive quizzes because they can understand the material more easily and are willing to participate in classroom discussions.*" (Teacher B, Interview)

Another teacher stated:

"*Technology helps students understand difficult concepts because they can see real examples through videos and visual presentations rather than only listening to explanations.*" (Teacher C, Interview)

Classroom observations supported these interview findings. Students showed greater attention during technology-supported learning activities, actively participated in classroom discussions, and demonstrated higher engagement when teachers integrated digital media with collaborative learning strategies. Document analysis also indicated that lesson plans incorporated learning objectives, instructional activities, and assessment methods that reflected the integration of technological, pedagogical, and content knowledge.

These findings indicate that the implementation of TPACK contributed positively to improving learning quality by enabling teachers to integrate technology, pedagogy, and subject content in a coherent and meaningful manner. Rather than using technology merely as a presentation tool, teachers employed digital resources to facilitate student participation, strengthen classroom interaction, and support conceptual understanding. This practice reflects the principles of the

TPACK framework proposed by Mishra & Koehler (2006), which emphasizes that effective technology integration occurs when technological knowledge is combined with appropriate pedagogical approaches and relevant subject content.

The findings are also consistent with previous studies reporting that teachers with well-developed TPACK competencies are better able to create student-centered learning environments, increase student engagement, and improve the overall quality of classroom instruction (Rahmadi, 2019; Maharani et al., 2021; Oktaviani & Utami, 2024). Unlike previous studies that primarily examined the relationship between TPACK and learning outcomes using quantitative approaches, the present study provides qualitative evidence demonstrating how teachers implement TPACK in authentic classroom settings to improve learning quality through meaningful instructional practices.

Table 3. Summary of the contribution of TPACK implementation to learning quality

Learning Quality Indicator	Findings from Classroom Practice	Contribution to Learning Quality
Lesson planning	Teachers integrated technological, pedagogical, and content knowledge into lesson plans that aligned with curriculum objectives and students' learning needs.	Learning activities became more structured and relevant to instructional objectives.
Learning implementation	Teachers applied student-centered instructional strategies supported by digital learning media and interactive learning activities.	Students participated more actively during classroom learning.
Teacher–student interaction	Teachers encouraged discussion, collaboration, and communication through technology-supported learning activities.	Classroom interaction became more meaningful and responsive to students' learning needs.
Learning assessment	Teachers used formative assessment and provided continuous feedback during learning activities.	Assessment supported students' understanding and continuous learning improvement.
Student engagement	Students showed greater enthusiasm and participation when technology was integrated appropriately into classroom instruction.	Learning became more interactive and meaningful.

Table 3 summarizes the contribution of teachers' TPACK implementation to learning quality at SDN 01 Kendawangan. The findings indicate that the integration of technological, pedagogical, and content knowledge contributed to several aspects of classroom learning, including lesson planning, instructional implementation, classroom interaction, learning assessment, and student engagement. Rather than functioning solely as a technological innovation, TPACK enabled teachers to design learning experiences that were more interactive, contextual, and responsive to students' learning needs. These findings suggest that meaningful technology integration supports the improvement of learning quality when it is combined with appropriate pedagogical strategies and relevant learning content.

Discussion

The findings of this study demonstrate that teachers implemented Technological Pedagogical Content Knowledge (TPACK) by integrating technological, pedagogical, and content knowledge throughout lesson planning, classroom instruction, and learning assessment. Rather than positioning technology as the primary focus of instruction, teachers utilized digital resources to support pedagogical strategies that addressed curriculum objectives and students' learning needs. This finding is consistent with the TPACK framework proposed by Mishra & Koehler (2006), which emphasizes that effective technology integration depends on the balanced interaction among technological knowledge, pedagogical knowledge, and content knowledge rather than on technological proficiency alone.

The study also highlights the importance of school leadership in creating an environment that supports teachers' implementation of TPACK. Institutional policies, continuous professional development, academic supervision, and the provision of digital infrastructure enabled teachers to integrate technology more confidently into classroom instruction. These findings suggest that successful technology integration is influenced not only by teachers' individual competencies but also by organizational support that encourages innovation and continuous professional learning. This finding is consistent with previous studies reporting that supportive school leadership facilitates teachers' professional development and strengthens technology-enhanced teaching practices.

Furthermore, the findings indicate that the implementation of TPACK contributed to improvements in learning quality by promoting more interactive classroom activities, meaningful teacher–student interaction, and higher levels of student

engagement. Classroom observations and interview data demonstrated that technology became more effective when integrated with appropriate pedagogical strategies rather than being used solely for presenting instructional materials. This finding supports previous studies that reported TPACK contributes to creating student-centered learning environments and improving instructional quality (Maharani et al., 2021; Oktaviani & Utami, 2024; Rahmadi, 2019).

Unlike many previous studies that primarily examined the relationship between TPACK and learning outcomes using quantitative approaches, this study provides qualitative evidence describing how teachers implement TPACK in authentic classroom settings. By combining interview, observation, and document analysis, this study demonstrates that the quality of technology integration depends on teachers' ability to align technological resources with pedagogical approaches and curriculum content while considering students' learning characteristics and classroom contexts. Therefore, this study extends existing TPACK research by providing a contextual understanding of how TPACK is translated into everyday teaching practice in elementary education.

The findings also have practical implications for educational policy and teacher professional development. Strengthening teachers' TPACK competencies should not focus solely on improving digital skills but should also emphasize pedagogical innovation, collaborative professional learning, and institutional support from school leadership. Such efforts are essential for promoting meaningful technology integration and improving the quality of learning in elementary schools.

Conclusion

This study analyzed the implementation of teachers' Technological Pedagogical Content Knowledge (TPACK) in improving learning quality at SDN 01 Kendawangan. The findings demonstrate that teachers integrated technological, pedagogical, and content knowledge throughout lesson planning, classroom instruction, and learning assessment. Rather than using technology merely as a medium for delivering instructional materials, teachers employed digital resources to support student-centered learning, encourage classroom interaction, and facilitate students' conceptual understanding. School leadership also played a crucial role by establishing supportive policies, providing professional development opportunities, facilitating academic supervision, and ensuring access to available digital learning resources. These institutional supports strengthened teachers' capacity to implement TPACK in everyday classroom practice. However, the implementation of TPACK was not without challenges. The study identified several contextual constraints, including variations in teachers' digital competencies, limited availability of digital infrastructure, occasional technical disruptions, and differences in students' digital readiness. To address these challenges, the school adopted contextual strategies such as scheduling the use of available digital devices, implementing peer mentoring among teachers, and organizing practice-oriented professional development activities. These findings indicate that meaningful technology integration depends not only on teachers' competencies but also on continuous institutional support and context-sensitive strategies that accommodate local school conditions. This study contributes qualitative evidence regarding how TPACK is implemented in an authentic elementary school context and enriches the existing literature by explaining the processes through which teachers integrate technology, pedagogy, and content knowledge to improve learning quality. The findings may serve as a practical reference for schools and educational policymakers seeking to strengthen technology-integrated learning in contexts with similar characteristics.

Acknowledgments

The authors would like to express their sincere gratitude to Universitas Ahmad Dahlan and SDN 01 Kendawangan, including all teachers who provided access, information, and support during the data collection process and field observations.

Author Contributions

Conceptualization, R.J., D.H., and M.Z.; methodology, R.J. and D.H.; formal analysis, R.J. and D.H.; investigation, R.J.; resources, D.H. and M.Z.; data curation, R.J.; writing—original draft preparation, R.J.; writing—review and editing, D.H. and M.Z.; visualization, R.J.; supervision, D.H. and M.Z.; project administration, R.J. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

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