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CHALLENGES AND ADAPTIVE STRATEGIES IN THE USE OF TECHNOLOGY-BASED LEARNING MEDIA IN ELEMENTARY SCHOOL

Zanubah Aura Saleh[1)], A. Ardiansyah[2)], Anisa[3)]
[1,2,3] UIN Datokarama Palu, Palu, Indonesia
E-mail: zanubahaurasaleh31@gamil.com

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Abstract

Technology integration in rural elementary schools depends on how available resources are used under local constraints. This descriptive qualitative study examined challenges in technology-based learning media and the teacher's adaptive strategies in Grade V at SD Inpres Pombewe, Indonesia. Data were collected through non-participant observations, semi-structured interviews with the principal, the Grade V teacher, and three students, and document analysis. The findings identified eight interconnected challenges: shared-device access, limited student access to devices, unreliable electricity and internet, infrequent formal technology training, additional teacher preparation time, difficulties operating devices among some students, differences in family support as perceived by school participants, and concerns about unsupervised digital use outside school. The teacher responded by selecting media flexibly, prioritizing laptops, engaging in school-based and self-directed professional learning, preparing offline materials, and using printed worksheets and local environmental resources. These responses illustrate how instructional decisions were adapted to device availability, infrastructure reliability, and classroom conditions to support learning continuity. This single-classroom case highlights the importance of addressing access, opportunities for direct technology use, professional support, and pedagogical adaptation together.

Keywords: Digital Divide, Learning Media, Rural Elementary School, Educational Technology, Teacher Adaptation
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INTRODUCTION

The use of technology in elementary schools offers various opportunities to support the learning process, but its implementation is not always easy, particularly in rural schools. Limited infrastructure and digital resources can affect how technology is used in learning. A systematic review by Mustafa et al. (2024) identified several challenges to technology integration in rural schools, including limited devices, internet access, digital competence, and teacher professional development. In Indonesia, Dongoran and Aditia (2026), using the PISA 2022 Indonesian school questionnaire dataset from 410 schools, found significant relationships between school location and learning impediments related to physical infrastructure and digital resource availability. Despite these challenges, technology-based learning media can help teachers present visual and audiovisual information that makes abstract concepts easier for students to understand (As'ad et al., 2022). In this study, technology-based learning media refer to digital devices used to support learning, including laptops, computers, Interactive Flat Panels (IFPs), and projectors (Batubara, 2021; Pagarra et al., n.d.). Internet connectivity is treated as supporting infrastructure for accessing digital learning resources.

These inequalities extend beyond the availability of technological devices. Van Dijk (2006) conceptualizes the digital divide through four forms of access: motivational, material, skills, and usage access. Applying this framework to rural schools in South Africa, Shabangu and Jita (2025) identified inadequate infrastructure, limited digital resources, and digital skills as persistent dimensions of the digital divide. Given the focus of this study on device availability, digital skills, and classroom use, three dimensions are particularly relevant: material, skills, and usage access. Material access concerns the availability of devices and supporting infrastructure; skills access refers to teachers' and students' ability to use digital technology; and usage access concerns opportunities to use technology in learning. These dimensions are interrelated, as infrastructure limitations can restrict opportunities for technology use, while differences in digital skills can shape how available technology is used in classroom practice (Mustafa et al., 2024; Ruecker, 2022). Institutional support and pedagogical practices are treated as contextual conditions shaping this process. This framework provides the analytical basis for examining technology-integration constraints and the Grade V teacher's responses to them at SD Inpres Pombewe.

Previous studies in Indonesia have identified several challenges in the use of technology-based learning media, particularly limited devices, internet access, and teacher competence (Hulu, 2023; Rajagukguk & Pratama, 2022; Sihombing et al., 2023). Studies in rural elementary-school contexts have also documented teachers' responses to infrastructure and resource limitations, including the use of available devices and alternative learning resources when technological access is constrained (Azhariadi et al., 2019; Zulfa et al., 2023). While these studies provide important evidence on both technology-integration challenges and teacher

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responses, less attention has been given to how specific constraints are connected to adaptive teacher responses within a particular classroom context. The present study addresses this gap by examining these relationships in Grade V at SD Inpres Pombewe, Sigi Regency, Central Sulawesi.

Beyond access to devices and infrastructure, teachers' digital competence also shapes how technology is used in the classroom. Lin et al. (2023) found that differences in digital teaching competence between rural and urban teachers were particularly associated with ICT skills and data literacy. However, digital competence extends beyond the technical ability to operate devices. From a TPACK perspective, effective technology integration requires teachers to connect technological, pedagogical, and content knowledge so that technology supports learning objectives (Jiménez Sierra et al., 2023). In rural schools, teacher competence is also embedded in broader conditions, including access to technological resources, professional support, and pedagogical conditions (Mustafa et al., 2024). Prinanda (2025) similarly identified limited equipment, technical constraints, and teacher competence as interconnected challenges in implementing technology-based learning media. Thus, the availability or frequent use of technology does not necessarily indicate meaningful pedagogical integration; attention must also be given to how teachers select, adapt, and use available resources according to learning needs and classroom conditions.

Within this broader context, SD Inpres Pombewe is a public elementary school located in Pombewe Village, Sigi Biromaru District, Sigi Regency, Central Sulawesi. The school serves 113 students across six classes, including 23 students in Grade V, the focus of this study, and is staffed by nine teachers. Technology-supported learning in Grade V was supported by six laptops, including school-owned devices and the teacher's personal laptop used during instruction. At the school level, one Interactive Flat Panel (IFP) and four projectors were shared across classes, requiring teachers to coordinate their use according to device availability. Although electricity and internet connectivity are available, disruptions can affect their use during lessons. The school is situated in a highland village characterized by hilly terrain and a substantial agricultural land base. Pombewe Village data from 2024 record approximately 685 hectares of rice fields and farmland and 356 hectares of plantation land, while agriculture and plantation activities constitute important local livelihood sectors. These geographical and livelihood characteristics provide the basis for situating the school within a rural context. Rather than treating this single case as representative of rural elementary schools in Indonesia, the study examines how context-specific constraints are connected to the Grade V teacher's adaptive responses under the technological and classroom conditions of SD Inpres Pombewe.

Building on previous rural digital-divide studies, this study examines how specific technology-integration constraints are connected to the adaptive responses of the teacher within a bounded Grade V classroom. The challenges are examined through material access, skills

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access, and usage access, while institutional and pedagogical conditions are considered as part of the context in which technology is used. Rather than identifying barriers alone, the study examines how the teacher responds to particular constraints through the continued use, adaptation, or substitution of available learning resources. Examining this constraint–response relationship provides a context-sensitive account of how classroom technology use is adjusted to available conditions while maintaining continuity in the learning process. Accordingly, the study addresses two research questions: (1) What challenges are encountered in the use of technology-based learning media in Grade V at SD Inpres Pombewe? and (2) How does the teacher adapt learning strategies in response to these challenges?

METHODS

Research Design and Setting

This study employed a descriptive qualitative design to examine challenges in the use of technology-based learning media and the adaptive responses of a Grade V teacher at SD Inpres Pombewe, Sigi Regency, Central Sulawesi, Indonesia. The inquiry was bounded to one Grade V classroom, with technology-supported teaching practices as the unit of analysis. The study was conducted from May to July 2026 in a rural school where laptops, projectors, and an Interactive Flat Panel (IFP) had already been incorporated into classroom instruction. The site was purposively selected because preliminary observations indicated that technology use coexisted with constraints related to device availability, internet connectivity, and teachers' use of digital tools, providing a relevant context for examining technology integration in practice.

Participants

Five participants were purposively selected: the school principal, the Grade V teacher, and three Grade V students. The principal provided information concerning infrastructure, school policy, and institutional support, while the teacher provided accounts of classroom technology use, implementation challenges, and adaptive strategies. The three students, aged 9–10 years, contributed perspectives on their experiences of technology-supported learning. They were selected as information-rich participants rather than as representatives of the entire Grade V class of 23 students. Student accounts were therefore interpreted as individual experiences within the bounded classroom context.

Data Collection

Data were generated through non-participant observations, semi-structured interviews, and document analysis. Fieldwork comprised 14 school visits, including seven classroom observations and four observations of *Komunitas Belajar* (Kombel) activities. Classroom observations covered Indonesian language, mathematics, natural and social sciences (IPAS), and Pancasila Education and focused on the use of digital learning media, constraints occurring

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during instruction, and the teacher's responses. Kombel observations provided additional evidence regarding professional learning and institutional support.

Semi-structured interviews were conducted face-to-face with the principal, teacher, and students using participant-specific interview guides. Interviews lasted approximately 20–30 minutes and were conducted in everyday Indonesian. Follow-up questions were used to clarify earlier responses and compare information across data-collection sessions. The three students were interviewed together using age-appropriate language. Interviews were audio-recorded and converted into written records for analysis. Documentary sources included the school profile, school-level curriculum, teaching modules, student worksheets, the Pombewe Village profile, and photographs of relevant activities. These materials were used to contextualize and corroborate interview and observational evidence.

Data Analysis and Trustworthiness

Data were analyzed iteratively through data reduction, data display, verification, and conclusion drawing (Qomaruddin & Sa'diyah, 2024). Interview records, field notes, and documents were reviewed and compared to identify recurring patterns related to technology use, implementation challenges, and teacher responses. Initial coding was data-driven and resulted in eight categories of technology-integration challenges. These empirically derived categories were subsequently interpreted using the digital-divide dimensions of material access, skills access, and usage access. Thus, the digital-divide framework functioned as an interpretive lens rather than as a predetermined coding structure.

Trustworthiness was strengthened through prolonged and repeated field engagement, triangulation across participants, methods, and time, and member checking. Information from the principal, teacher, and students was compared with observational and documentary evidence, while repeated visits enabled the researcher to examine consistency and clarify contradictory information. Member checking was conducted by restating key interpretations during interviews and asking participants to confirm or correct the researcher's understanding. Because the researcher had prior familiarity with the school from academic observations in 2024, reflexive attention was given to possible interpretive bias by systematically comparing prior assumptions with evidence from multiple data sources.

Ethical Considerations

Formal permission to conduct the study was obtained through a university research permission letter and authorization from the school. Participation was voluntary, and the purpose of the study was explained to participants before data collection. For student participants, parental or guardian permission was communicated through the school, and students' willingness to participate was confirmed using age-appropriate explanations before the interviews. Student identities were anonymized as *Student 1*, *Student 2*, and *Student 3*, and identifying information was excluded from the research report.

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RESULTS AND DISCUSSION

Problems in the Use of Technology-Based Learning Media

The findings identified eight interconnected constraints in the use of technology-based learning media in Grade V at SD Inpres Pombewe. These constraints were related not only to the availability of technological devices and supporting infrastructure but also to students' opportunities for direct interaction with technology, teacher preparation and professional learning, students' digital skills, family support, and concerns about students' digital use outside school. Table 1 summarizes the eight empirically derived constraints and the evidence supporting each finding.

Table 1. Summary of Technology-Integration Constraints in Grade V at SD Inpres Pombewe

Category	Field Findings	Data Source
Constrained classroom access to shared devices	One IFP and four projectors are shared across six classes. Their use is managed through a rotating schedule, requiring the Grade V teacher to adjust technology use according to device availability.	P, OBS, DOC
Limited student access to available devices	Six laptops, including school-owned devices and the teacher's personal laptop used during instruction, were available to support learning activities involving 23 Grade V students. The teacher supplemented the available laptops with mobile phones and organized device use in sessions during technology-supported learning.	T, OBS
Electricity and internet reliability constraints	Power outages prevented the use of devices that depended directly on electricity, while unstable internet connectivity hindered access to online learning materials. The disruptions occurred unpredictably, although their frequency was not systematically recorded.	T, OBS
Limited access to regular formal technology training	Competence development is primarily supported through the Learning Community (Kombel) and internal sharing of practices.	P, T, OBS
Additional preparation time for technology integration	The teacher requires additional time to learn how to use applications and prepare learning content.	T, OBS
Difficulties in operating devices among some students	Some students experienced difficulty operating devices but were able to use them with teacher guidance and supervision.	S, OBS
Differences in family support as perceived by school participants	The principal and teacher reported differences in family economic conditions, parental attitudes toward education, and support for learning at home.	P, T

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Category	Field Findings	Data Source
Perceived effects of unsupervised out-of-school digital use	The principal expressed concern that unsupervised social media use outside school may be associated with students quickly forgetting lessons and reduced learning focus.	P

Note. P = Principal; T = Grade V Teacher; S = Grade V Students; OBS = Observation

First, the availability of technology-based learning devices at the school level does not always ensure their availability in the classroom. SD Inpres Pombewe has one Interactive Flat Panel (IFP) and four projectors that are shared among classes. The principal explained, "Because there is only one digital board, all classes have to take turns using it, and there is already a schedule." Classroom observations also showed that when a particular device was being used by another class, the Grade V teacher used the available device or adjusted the learning media accordingly. These findings indicate that the constraint concerns classroom-level access rather than the complete absence of technology at the school. From a digital-divide perspective, this condition reflects material access, as institutional availability does not necessarily ensure that particular devices are accessible when needed for classroom learning. This pattern is consistent with previous research showing that technology integration in rural schools is shaped by the availability, access, and use of technological resources (Mustafa et al., 2024; Ruecker, 2022).

Second, students' direct access to technology-based learning devices was constrained by the number of devices available for classroom use. Classroom observations showed that six laptops, including school-owned devices and the teacher's personal laptop used during instruction, were available to support learning activities involving 23 Grade V students. To address this limitation, the teacher supplemented the laptops with mobile phones and organized device use in sessions, allowing students to participate in technology-supported activities despite limited simultaneous access. This finding indicates that the constraint concerned not simply the absence of individual devices, but the limited opportunities for students to interact directly with technology. Although six laptops were available for learning activities, their shared use did not provide every student with individual access during instruction. These limited hands-on opportunities may also be related to differences in students' familiarity with operating devices, as one Grade V student reported difficulty using a laptop. Thus, meaningful access depends not only on device availability but also on opportunities to use available devices directly, reflecting the broader digital-divide dimensions of material access, skills access, and usage access (Ibda, 2023; Lestari et al., 2025).

Third, power outages and unstable internet connectivity disrupted the use of technology-based learning media in Grade V. The teacher stated, "As a teacher, I experience several difficulties in using technology-based learning media in the classroom, for example when

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the power goes out or the internet connection has problems." Classroom observations showed that sudden power outages could prevent devices requiring a continuous electricity supply from being used, while unstable internet connectivity could hinder access to online learning materials. Because the frequency and duration of these disruptions were not systematically recorded, the findings indicate their occurrence and immediate classroom consequences rather than their overall severity during the fieldwork period. This suggests that technology access in this case depended not only on the availability of electricity and internet infrastructure but also on their reliability during classroom use, consistent with previous studies identifying infrastructure and connectivity constraints in rural technology integration (Azhariadi et al., 2019; Mustafa et al., 2024; Purba et al., 2025; Tempur, 2024).

Fourth, the Grade V teacher had participated in technology-related training provided by the local education authority, but reported that such training was still limited in frequency and continuity. To complement this training, the school developed several forms of professional learning, including the Learning Community (Komunitas Belajar/Kombel), practical support from the school operator and more proficient colleagues, invited resource persons from other schools, and self-directed learning through instructional videos. The principal reported that Kombel was held weekly, providing teachers with opportunities to share knowledge and practice the use of technology-based learning media. These practices indicate that school-based peer learning and self-directed learning functioned as adaptive mechanisms that complemented the limited frequency of external formal training and supported the development of teachers' practical digital competence. This finding aligns with research showing that digital teaching competence is associated with ICT skills and that technology availability alone does not ensure meaningful use in classroom practice (Lin et al., 2023; Ruecker, 2022).

Fifth, technology integration required additional preparation time for the Grade V teacher. The teacher reported, "I need more time to learn how to use learning applications and to prepare media that are appropriate to the lesson materials, which sometimes takes quite a long time." Classroom observations also showed that preparation involved selecting materials, adjusting visual presentations to the lesson content, and ensuring that the media were ready for classroom use. These findings indicate that technology-supported learning involved additional preparatory tasks, particularly when the teacher needed to learn applications and adapt digital media to instructional needs. However, because the study did not track preparation time across repeated technology-supported lessons, it cannot determine whether this additional time represented an initial adoption cost or a recurring workload. The finding therefore reflects the focal teacher's experience of additional preparation time rather than a persistent workload burden, consistent with studies highlighting the technical preparation and pedagogical adjustment involved in integrating technology-based media into learning (Hulu, 2023; Prinanda, 2025).

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Sixth, some students experienced difficulty in operating technology-based learning devices, particularly because they were not yet accustomed to using them directly. One Grade V student specifically reported difficulty when using a laptop, stating, "When I have difficulty using technology like that, it is when using a laptop." Classroom observations confirmed that students did use the available devices and, although some initially experienced difficulties, they were able to operate them with the teacher's guidance and supervision. This finding therefore indicates limited familiarity with device operation rather than an inability to use technology or a measured lack of digital proficiency. It also suggests that opportunities for hands-on practice accompanied by teacher guidance may help students become more familiar with using technology for learning, although the study did not measure changes in their digital skills over time. This interpretation is consistent with Wulandari and Aslam (2022), who emphasize the importance of digital literacy for elementary school students in supporting the learning process.

Seventh, the principal and teacher perceived differences in the family circumstances surrounding students' learning and digital-device use. Their accounts referred to distinct aspects, including family economic conditions, parental attitudes toward education, and support for learning at home. Because parents were not interviewed, these accounts represent school participants' perceptions rather than directly verified family conditions. The findings therefore suggest that students' experiences with technology may also be shaped by conditions beyond the school environment, without establishing how particular family factors affect students' motivation or technology use. This interpretation is consistent with Cita Putri et al. (2025), who discuss economic and cultural disparities in rural education, while Ardiansyah and Rejeki (2024) highlight the role of parental involvement in guiding children's technology use.

Eighth, the principal expressed concern that students' social media use outside school may be associated with quickly forgetting what they had learned and reduced learning focus. This account represents the principal's perception rather than evidence of a causal effect of social media use. The study did not collect data on students' screen time, specific platform use, memory performance, or supervision at home; therefore, it cannot establish whether or how social media use affects students' learning. What the finding does indicate is the school's concern about students' digital-device use outside the learning context and the perceived need for guidance toward more productive uses of technology. This interpretation is relevant to Ardiansyah and Rejeki (2024), who emphasize parental guidance in children's technology use, including supervision of device use and access to appropriate content. Taken together, the eight findings show that the challenges in this case extend across material access, skills access, technology use, and contextual social support, which interact in shaping technology-supported learning in Grade V.

Teacher Adaptive Responses to Technology-Integration Constraints

Flexible Media Selection

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The teacher adapted the choice of learning media to both instructional needs and the resources available at the time of teaching. Classroom observations showed that the school required teachers to use learning media, either conventional or digital, while the specific media selected depended on the lesson material and the availability of shared technological devices. Because devices such as the IFP and projectors were used across classes, the Grade V teacher also considered whether a particular device was available or being used by another teacher. When digital media could not be used because of device unavailability, power outages, or internet disruptions, the teacher shifted to relevant non-digital learning resources. This observed pattern indicates a flexible media-selection strategy in which instructional relevance, device availability, and technical conditions shaped the choice between digital and non-digital resources, helping learning activities continue despite technological constraints. This interpretation is consistent with Zulfa et al. (2023), who highlight the use of concrete and locally available resources in responding to technological limitations, and Sihombing et al. (2023), who discuss adaptive use of technology as a supporting rather than exclusive learning resource.

Infrastructure-Resilient Technology Selection

Among the available technological devices, laptops were prioritized partly because their battery power allowed them to remain usable for some time during power outages. Classroom observations showed that the teacher checked that the laptop was ready and its battery was charged before the lesson; when an outage occurred, materials stored on the device could still be accessed while subsequent learning activities were adjusted to the classroom situation. The laptop was also used to store prepared materials and access additional resources from the internet when textbook content was considered insufficient. The Grade V teacher reported that textbooks generally provided the main points of the subject matter, prompting the use of online resources to obtain more detailed materials across several subjects. Examples included ecosystems in IPAS and the application of Pancasila values in everyday life in Pendidikan Pancasila. These practices reflect infrastructure-resilient technology selection, in which operational reliability and the capacity to access and store learning resources shaped the teacher's choice and use of technology. This interpretation is consistent with Azhariadi et al. (2019), who discuss low-power devices, including laptops, as an adaptive option for technology-supported learning under infrastructure constraints.

School-Based and Self-Directed Professional Learning

Professional learning took place through a combination of school-based support and self-directed learning. The Grade V teacher participated in the Learning Community (Komunitas Belajar/Kombel), which was held every Saturday after students had left school. Kombel functioned as a forum where teachers discussed difficulties encountered during teaching and worked collaboratively to identify possible solutions, with support from colleagues and the school operator who had greater technological proficiency. It also served as a setting

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for technology-related training; for example, training on the use of the Interactive Flat Panel (IFP) was conducted with an external resource person when supported by the school's program and budget. Beyond these school-based activities, the Grade V teacher reported independently watching videos to learn how to use technology-based learning media. These practices indicate that professional learning operated through multiple pathways-peer support, technical assistance, external expertise, and self-directed learning-providing practical opportunities to address difficulties in using technology without implying measurable improvement in pedagogical competence. This interpretation is consistent with Lin et al. (2023), who highlight ICT skills as an important component of teachers' digital teaching competence, and Mustafa et al. (2024), who identify teacher competence and professional support among the factors shaping technology integration in rural educational contexts.

Anticipatory Offline Preparation

To reduce dependence on unstable internet connectivity during lessons, learning materials were prepared and downloaded in advance for offline use. The Grade V teacher reported searching for and updating supplementary materials using a laptop or smartphone before teaching, including the evening before a lesson, to keep the materials current and, where relevant, connect lesson content with recent issues in the surrounding context. Material selection was guided by the curriculum, particularly the subject topics, Capaian Pembelajaran (CP), and Alur Tujuan Pembelajaran (ATP), which provided a basis for identifying additional online resources relevant to the intended learning objectives. This reported practice was supported by classroom observation, which showed that materials, including videos and presentation files, were stored on a laptop or USB flash drive before being used in class. Internet access was therefore concentrated mainly at the preparation stage, while previously stored materials could be accessed during lessons without relying on real-time connectivity. This practice represents anticipatory offline preparation and reflects an offline-first adaptation to low-connectivity conditions, in which curriculum alignment, advance preparation, and local storage reduce dependence on unstable internet access during instruction. This interpretation is consistent with Mukaromah et al. (2023), who discuss the adaptation of learning media to technological limitations in elementary school contexts.

Contextual Resource Substitution

The surrounding environment also functioned as a contextual learning resource when technology-based media could not be used. The Grade V teacher reported selecting locally available objects that were relevant to the lesson theme, allowing students to engage directly with concrete examples in their immediate environment. According to the teacher's observations, learning outside the classroom also provided variation from routine classroom activities, allowed students greater freedom of movement, and was associated with greater enthusiasm when they could directly observe what they were learning. These perceived

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pedagogical benefits indicate that the surrounding environment functioned not merely as a technical fallback when digital resources were constrained, but also as a contextually relevant non-digital learning resource. This practice should therefore be understood as contextual resource substitution within the teacher's broader adaptive approach, rather than as a technology-integration strategy in itself. The general pedagogical value of concrete learning experiences is also discussed by Yuliatin and Kusuma (2024), although their study was conducted in a different grade and learning context.

Taken together, these findings show that the teacher's responses were shaped by the specific constraints encountered during technology-supported learning rather than representing isolated strategies. To clarify how these responses were connected to the conditions that enabled them and their implications for classroom practice, Table 2 maps the identified constraints to the corresponding adaptive responses, enabling conditions, and pedagogical implications.

Table 2. Teacher Adaptive Responses to Technology-Integration Constraints in Grade V at SD Inpres Pombewe

Constraint	Adaptive Response	Enabling Condition	Pedadogical Implication
Shared technological devices and changing technical conditions limit consistent access to digital media.	**Flexible Media Selection:** selecting digital or non-digital resources according to lesson needs, device availability, and technical conditions.	Availability of alternative learning resources and the teacher's ability to adjust media choices.	Enables learning activities to continue when particular digital media cannot be used.
Power outages can interrupt the use of electricity-dependent devices.	**Infrastructure-Resilient Technology Selection:** prioritizing laptops that can operate temporarily on battery power and store learning materials.	Laptop battery capacity, local storage, and preparation before lessons.	Reduces immediate dependence on continuous electricity and supports continued access to prepared learning materials.
Limited structured external training and difficulties in using technology create a need for professional support.	**School-Based and Self-Directed Professional Learning:** Kombel, peer and operator support, external resource persons, and independent learning.	Weekly Kombel, collegial support, school-operator expertise, external expertise, school program and budget, and teacher initiative.	Provides practical opportunities to address technology-use difficulties and develop context-relevant professional knowledge.
Unstable internet connectivity can disrupt access to online learning	**Anticipatory Offline Preparation:** searching for, updating, downloading, and	Curriculum guidance (CP and ATP), internet access during preparation, laptops or	Keeps curriculum-aligned materials accessible without real-time internet connectivity and

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materials during lessons.	storing materials before instruction.	smartphones, and local storage.	supports continuity of instruction.
The use of technology-based media is constrained by limited device availability or infrastructure disruptions.	**Contextual Resource Substitution:** shifting to relevant objects and resources from the surrounding environment.	Availability of local resources and the teacher's ability to align them with the lesson theme.	Provides concrete and contextually relevant learning experiences while maintaining lesson continuity when digital resources are constrained.

The pattern presented in Table 2 suggests a form of adaptive pedagogy in which the teacher adjusted instructional decisions to technological constraints and contextual conditions while maintaining the intended learning objectives. This adaptation was not supported by a single resource or strategy, but by the interaction of teacher initiative, available technological resources, support from other teachers and the school, and learning resources available in the surrounding environment. This pattern can be understood as a process of adjusting instruction to the conditions encountered, in which the teacher considered learning needs and existing constraints, selected a feasible form of instruction, anticipated possible disruptions, and adjusted learning resources when conditions changed. Technology was therefore not treated as a fixed requirement for instruction, but as one of several learning resources that could be selected and adjusted according to classroom conditions. In this single-school case, adaptive pedagogy was reflected in the teacher's efforts to maintain instructional continuity and relevance by aligning pedagogical choices with the opportunities and limitations of the local context, rather than through the continuous use of digital technology.

CONCLUSION

his study shows that technology integration in Grade V at SD Inpres Pombewe was shaped by interconnected constraints related to device access, infrastructure reliability, digital skills, professional learning opportunities, preparation demands, and differences in students' access and support beyond school. Rather than responding to these constraints through a single strategy, the teacher adapted instruction by using technology selectively, preparing materials for offline use, strengthening digital competence through the Learning Community (Kombel) and self-directed learning, and combining digital media with printed modules, student worksheets (LKPD), and locally available learning resources. These findings indicate that technology-supported learning in this rural classroom depended not only on the availability of devices, but also on how effectively available resources could be accessed, used, and pedagogically adapted.

The study further highlights the central role of teacher agency in sustaining learning continuity under uneven technological conditions. The teacher's adaptive responses were

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primarily practical and contextual, aimed at maintaining access to learning when digital resources were limited or unreliable rather than demonstrating measurable gains in student outcomes. From a digital-divide perspective, the findings suggest that material access, skills access, and usage access were closely intertwined in shaping classroom technology use.

Because this study was limited to one rural elementary school, one Grade V teacher, and three student participants, the findings should be interpreted as context-specific rather than broadly generalizable. Future studies should include schools with different levels of technological readiness, broader participant groups, parental perspectives, and longer observation periods. For schools facing similar conditions, the findings underscore the importance of addressing infrastructure, device availability, teacher professional learning, opportunities for students to engage directly with technology, and the use of contextual non-digital resources as complementary components of sustainable technology integration.

AUTHOR CONTRIBUTION

ZAS contributed to the research conceptualization, data collection, data analysis, preparation of the original manuscript, and manuscript revision. AA contributed to methodological guidance, manuscript review, and revision. A contributed to the interpretation of findings, manuscript review, and revision. All authors reviewed and approved the final version of the manuscript. The authors declare that they have no conflicts of interest related to the research, authorship, or publication of this article. All the writers, agreed to the final version of the paper and say there are no problems, with the way this study is being shared.

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