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TEACHER-REPORTED LEARNING TECHNOLOGY INTEGRATION IN ELEMENTARY SCHOOLS: A MULTI-SITE QUALITATIVE STUDY IN CENTRAL JAVA, INDONESIA

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Abstract

This study looked at how elementary school teachers use technology in places in Central Java. We used a qualitative method and interviewed eight teachers who use technology (n=8) in urban suburban and rural elementary schools and we also examined teaching materials. We used the SAMR and TPACK models to guide our work. The results show that technology use is not a step-by-step skill ladder but a social and material negotiation shaped by local technology and teaching plans. In rural sites teachers perform "pedagogical bricolage " meaning technology creatively mixes offline visual media to keep lessons going. In contrast high-readiness urban settings use AI and interactive displays to drive inquiry-based learning. The cross-case comparison confirms that hardware alone is not enough for technology integration without teachers feeling confident in their teaching. This study shows that educational policy needs to shift from hardware distribution, toward localized technology support and context-sensitive teaching scaffolding. In conclusion teacher adaptive capacity thrives when technology tools match material realities and clear instructional goals.

Keywords: elementary education, learning technology, TPACK, teacher adaptation, qualitative study
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INTRODUCTION

Technology is a key factor in enabling education to transform and advance, while the changing societal context serves as an important driving force behind the adoption of new technologies in education systems and the transformation and advancement of educational practices (Wang et al., 2024). Technology has had a positive impact on education, and the integration of technology with pedagogical innovation is essential for enhancing learning experiences (Çelik & Baturay, 2024). Even though digital transformation in education is being pushed everywhere the way learning technology is actually used in schools is still very uneven. This is mostly because of differences in schools' infrastructure and the unique challenges each place faces. ICT or Information and Communication Technology can help make classrooms more interactive and allow teachers to teach in ways that fit students' needs. How well it works depends a lot on how teachers deal with the technical problems they face in their own schools. Technology isn't a one-size-fits-all solution, for learning. In education using it well is a complicated process that depends on each school's situation. Often what teachers want to do with technology doesn't line up with what the school's technology can support.

A substantial part of the research on information and communication technology or ICT in primary education mostly looks at how well specific digital tools work by themselves. It also checks how technology is adopted in areas that have plenty of resources. In rural and under-resourced schools integrating technology is often difficult. These difficulties come from problems at levels. At the level there is a lack of basic infrastructure like reliable electricity and internet. At the meso level schools may not have support from institutions or proper management systems. At the level teachers and students often lack the skills to use digital tools effectively (Mustafa et al., 2024). These challenges together make the digital divide worse between rural areas. For example in classrooms about 40% of schools use interactive smartboards. In schools only 20% have them and many still depend on traditional blackboards. Even though these gaps are well documented most studies focus on how ready urban schoolsre for technology or test digital tools on their own. Few studies explore how teachers adapt their teaching methods or how they show resilience in classrooms where the physical infrastructure is poor (Sukhpreet, 2025). More attention is needed on how teachers, in these settings cope and innovate despite the challenges.

In the countrys situation the introduction of the Merdeka Curriculum puts a lot of focus on using Information and Communication Technology (ICT) in a way. This is done to create learning environments that are centered around students and that suit types of learners. (Kemdikbud, 2022). The use of technology starts with planning lessons. It moves on to building teaching modules. Then comes the hands-on part. Using displays like Interactive Flat Panels (IFPs) and Smart TVs in class. Finally, it includes checking student progress, through platforms. This whole process helps make learning more engaging and modern (Izhar et al., 2025).

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Equitable access to digital infrastructure, stable internet connectivity, and teachers' adaptive pedagogical expertise are anticipated to cultivate interactive learning spaces (Rincon-Flores et al., 2024), stimulate critical-thinking skills and computational thinking (Ho et al., 2023), and facilitate the development of digital literacy from an early age without being constrained by geographical boundaries (Soyoof et al., 2024).

Despite the focus on the Merdeka Curriculum, the real success of learning technology integration in classrooms depends a lot on teacher ability to adapt and the local infrastructure they have. When problems like internet or not enough devices come up digital learning stops being just about using a platform. It becomes about changing teaching methods on the spot. Most research looks at technology adoption as a simple yes or no either its used or its not. That misses the ongoing real-world work teachers do to keep digital learning going. So there is a need to study how primary school teachers, in different regions deal with technical problems and use creative ways to keep teaching with technology.

To answer this real-world question this study looks at teacher adaptation by focusing on two ideas: adaptive capacity and teacher resilience. In this view adaptive capacity is not the same as tech fixes like turning routers off and on or swapping hardware. Adaptive capacity means teachers carefully and flexibly change how they teach adjust their lesson plans and quickly use ways when online tools do not work. Teacher resilience on the hand means that teachers keep their professional power and keep using technology-rich, interactive lessons even when the school faces long-lasting problems with the system. By using this way of thinking this study goes past just listing what devices are in classrooms. It asks how elementary teachers, in Central Java actually put strategies into practice when the infrastructure is not reliable.

To address this gap this multi-site qualitative study investigates learning technology use among elementary school teachers across five regencies and municipalities in Central Java, Indonesia. Specifically this study is guided by four research questions; 1) what types of learning technologies and digital platforms are used by elementary school teachers across different regional contexts?; 2) how do elementary school teachers integrate digital technologies into their pedagogical planning, instructional execution and assessment, under the Merdeka Curriculum?; 3) what physical and technical challenges do teachers encounter, and how do they perceive the impact of technology on student engagement?; and 4) what adaptive strategies do teachers deploy to overcome infrastructure constraints and maintain digital learning continuity?.

METHODS

This study employed a multi-site qualitative study design to examine learning technology utilization and teacher adaptive strategies under infrastructure constraints (Mtisi, 2022). To set study limits the focus was limited by three specific rules: (1) primary school teachers who are

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using the Merdeka Curriculum, (2) teaching happening in elementary schools (SD/MI) in Central Java and (3) dealing with different levels of access, to regional ICT infrastructure.

Participant and site selection was done using a sampling method across seven elementary schools (SD/MI) that are located in five administrative areas of Central Java (Kota Semarang, Kabupaten Semarang, Demak, Brebes and Banjarnegara). These sites were purposefully selected to capture a diverse spectrum of geographical contexts and ICT infrastructure readiness, ranging from well-equipped urban schools to resource-constrained rural institutions. Within these sites eight teachers, named P1 to P8 were chosen because the main rule for picking these teachers was that these teachers use technology actively in these teachers teaching. These teachers work under the Merdeka Curriculum. The focus was, on technology integration. A sample size of eight participants was determined to be methodologically sufficient guided by the concept of information power (Malterud et al., 2016). The participant characteristics are presented in Table 1.

Table 1. The Participant Characteristics

Participant	Gender	Teaching Experience	Grade	Prior ICT Training	Regency	Regional Context
P1	Female	12 years	5	National/Regency Workshops	Demak	Suburban (Moderate Access)
P2	Male	5 years	1	Self-Taught (YouTube/MOOCs)	Demak	Suburban (Moderate Access)
P3	Female	18 years	2	School-Level In-House Training	Demak	Suburban (Moderate Access)
P4	Male	8 years	4	Regency ICT Training	Demak	Suburban (Moderate Access)
P5	Female	15 years	3	Ministry Platform Training (PMM)	Semarang Regency	Suburban (Moderate Access)
P6	Female	3 years	4	University & Online Courses	Brebes	Rural (Low Access)
P7	Male	10 years	3	Self-Taught	Banjarnegara	Rural (Low Access)
P8	Female	14 years	5	Regency ICT Training	Semarang City	Urban (High Access)

Data collection took place during a four-month period. Data collection used semi-in-depth interviews, as the main source of information. Data collection was also supported by an analysis of documents to provide triangulation. An interview protocol was developed based on existing literature on ICT integration and teacher adaptation, covering four main thematic domains: (1) core digital tools utilized, (2) pedagogical integration practices under the Merdeka Curriculum,

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(3) physical and technical infrastructure barriers, and (4) adaptive coping mechanisms. Researcher saw the protocol undergo expert validation by two researchers, in educational technology before we launched protocol in the field.

Each participant completed one to two interview sessions lasting between 45 and 75 minutes. Interviews were conducted in Bahasa Indonesia to allow participants to express experiences naturally either in person at school sites or through video conferencing platforms such as Zoom or Google Meet depending on geographic accessibility. All Interviews were audio-recorded with consent and transcribed word for word. To ensure data triangulation and reduce self-reporting bias the researcher also. Examined instructional artifacts, such as teachers digital lesson plans (Modul Ajar) platform usage logs and photographs of classroom digital activity. Ethical approval and clearance were obtained before data collection began. Participation remained fully voluntary. Written informed consent was secured from each of the eight teachers. Strict measures were taken to protect confidentiality: all personal names and school identities were fully anonymized using codes (P1 to P8) and generic regional descriptors, throughout the manuscript.

Data was analyzed using Braun and Clarkes Reflexive Thematic Analysis combined with Miles, Huberman and Saldañas' site data display matrix across six steps: verbatim transcription, open coding, within-site categorization, cross-site matrix synthesis, theme refinement and finalization using Microsoft Excel (Moncada, 2025). Trustworthiness was achieved through source and document triangulation by comparing teacher interview accounts with artifacts like Modul Ajar and digital activity photos, from urban suburban and rural sites. To perform member checking all eight participants reviewed their transcripts and initial thematic summaries to check interpretive validity. Some small differences related to context were explained through follow-up communications to make sure full member validation was achieved. The research flowchart is shown in Figure 1.

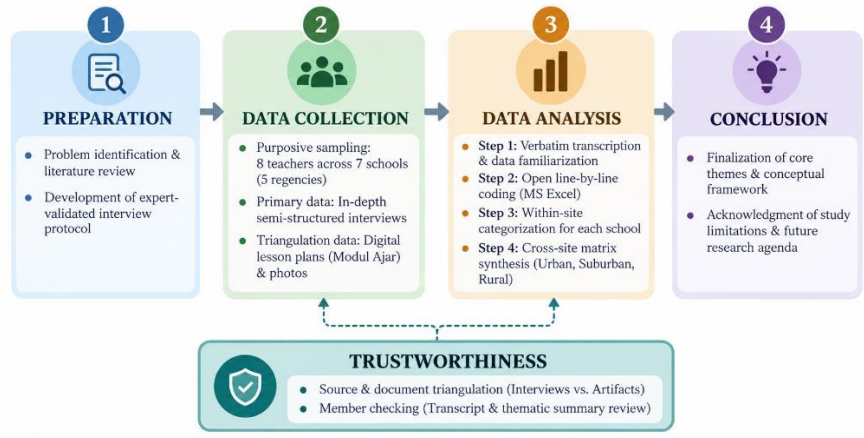


Figure 1. The research flowchart

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Figure 1 shows the research process. It has five stages: preparation, data collection, data analysis, trustworthiness and conclusion. To keep the analysis clear and open the researchers kept a journal. This helped them track their personal assumptions. These assumptions came from their backgrounds in technology. They needed to manage these views carefully. An audit trail recorded every step. It included transcripts, codebooks and cross-site comparison matrices. These documents were kept in order. They showed how the study was conducted. The researchers also reviewed their coding schemes. They looked at site classifications too. They did this through peer debriefing. They talked with two experts, in methodology. These experts helped examine the work. This review helped confirm that the findings were based on the data. It also made sure the interpretations came from the participants experiences. The process helped reduce the influence of researcher bias. The results were more likely to reflect what the participants actually said and felt.

RESULTS AND DISCUSSION

Thematic analysis of interviews with eight teachers from seven schools in Demak Regency, Semarang Regency, Brebes Regency, Banjarnegara Regency and Semarang City showed that the use of learning technology happens in different kinds of settings. These differences appear not in the kinds of devices and platforms teachers use, but also in how often they use them. There are also differences in how teachers integrate technology into their teaching methods. Some use it for assessments while others do not. Teachers also use ways to deal with problems like poor internet access or limited equipment. Each teacher faces their challenges and finds their own way, around them. Importantly, these regional categories serve to highlight localized contextual nuances rather than claim statistical representativeness, as specific contexts are represented by a targeted sample size. The matrix of learning technology utilization across different regional contexts is presented in Table 2.

Table 2. Cross-Site Matrix of Learning Technology Utilization

Dimension	Urban (n=1)	Suburban (n=5)	Rural (n=2)	Interpretation
Hardware	Smart TV, Laptop, IFP (P8)	IFP, Smart TV, Projector (P1, P2, P3, P4, P5)	IFP, Tablet, Interactive Board (P6, P7)	Hardware presence across sites reflects government aid, but usage depends heavily on infrastructure readiness.
Platforms	Canva, Generative AI, Wordwall, Simulation (P8)	Classroom, Canva Sites, YouTube (P1, P3, P4, P5)	Educaplay, Wordwall, PowerPoint (P6, P7)	Platform selection shifts from complex, cloud-based tools in urban sites to offline/low-bandwidth tools in rural sites.

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Dimension	Urban (n=1)	Suburban (n=5)	Rural (n=2)	Interpretation
Pedagogical Interaction	High (Complex simulations, interactive tasks) (P8)	Moderate (Quizzes, instructional videos) (P1, P3, P4)	Emerging (Basic interactive drills, structured media) (P6, P7)	Interactive depth is constrained by network stability rather than teacher pedagogical intent.
AI Integration	Active generation & lesson design (P8)	Emerging utilization for teaching materials (P4, P5)	Basic exploration (P6)	AI adoption is driven by individual digital agency rather than institutional policy.
Internet	Stable connectivity (P8)	Intermittent instability (P1, P2, P3, P4, P5)	Severe connectivity barriers (P6, P7)	Infrastructure remains the primary structural bottleneck shaping technology integration
Student Devices	Moderate / Individual (P8)	Variable / Group sharing (P1–P5)	Low / Teacher-centered display (P6, P7)	Device scarcity forces a transition from personalized digital learning to collaborative group learning.
Adaptation	Media enrichment & advanced prompts (P8)	Collaboration/device management (P1-P5)	Asynchronous & offline adaptation (P6, P7)	Teachers develop localized improvisational strategies tailored to regional infrastructure limits.

Note: Urban (n=1: P8); Suburban (n=5: P1, P2, P3, P4, P5); Rural (n=2: P6, P7). Participant counts (n) show the intended number of people, in the study. These numbers are chosen to capture insights and local differences. They do not mean the results can be applied to groups or different areas.

Table 2 shows that technology utilization patterns differ depending on context at each of the sites. It does not show a ranking of digital capability from one region to another. Instead, the way teachers interact with learning and the tools they use are closely linked to infrastructure and the choices each teacher makes. For example, at the level P8 in an urban context used complex instructional design with interactive platforms such as Canva, simulation tools and Generative AI thanks to reliable network access. By contrast suburban teachers P1–P5 mainly used media and quiz apps, like Google Classroom and YouTube while dealing with spotty connectivity. Meanwhile, rural teachers (P6 and P7) adapted to severe network limitations by leveraging offline tools and asynchronous materials (e.g., PowerPoint, Educaplay). The patterns at each site show that technological integration in suburban and rural settings is shaped by material constraints and improvisational strategies. Technological integration is not driven by differences in quality, across urban, suburban and rural settings.

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Diversity of the Learning Technology Ecosystem

Than, just having a group of devices the technology setup in the seven elementary schools works like a living system. Here choosing the tools happens along with making sure the network is strong teachers know how to use the tech and the lessons match the goals. At each school using technology depended on what the teachers wanted to teach. What space and resources were available. For example, in a school located in a city with fiber-optic internet and support, from the school leaders P8 used interactive screens and artificial intelligence tools to help students learn in their own way as they said:

"We don't just show slides anymore. I use Canva and AI tools to create simulations. This lets students directly manipulate concepts, on the Smart TV during lessons." (P8, Urban)

Conversely, in areas where bandwidth is very low and technical help is almost none high-end hardware was turned into low-bandwidth, teacher-led display tools so that basic instructional continuity could still happen. As P6 explained about their improvisational strategy:

"We have the board from government assistance but because the interactive board signal drops often I prepare offline PowerPoint modules and Wordwall exercises on flash drives, before class. Otherwise, the lesson stops entirely." (P6, Rural)

To keep track of case-level details, about adoption patterns we carefully recorded how often technology was used by each participant (see Table 3). The intensity of technology utilization frequency varied a deal depending on local infrastructure and the individual teaching choices of each participant not just on institutional mandates.

Table 3. Technology Integration Frequency and Primary Pedagogical Purpose by Participant

Participant ID	Site Context	Utilization Frequency	Primary Platforms / Tools	Operational Mode
P8	Urban	Daily (5x / week)	Canva, Generative AI, Simulations	Interactive / Learner-centered
P1, P4	Suburban	High (3–4x / week)	Google Classroom, Canva, YouTube	Blended / Group tasks
P3, P5	Suburban	Moderate (1–2x / week)	WhatsApp, YouTube, PPT	Supplemental instruction
P2	Suburban	Low (2–3x / month)	Basic PPT, WhatsApp	Administrative / Basic display
P6, P7	Rural	Intermittent (1–2x / week)	Offline PPT, Educaplay, Wordwall	Offline display / Asynchronous

This study uses Puentedura's SAMR framework to bring integration practices into life. The SAMR framework helps to guide the changes without forcing a maturity order (Franco, 2019). Rather, than showing that teachers lack skills moving between these levels shows how teachers adjust their teaching goals while working within the limits set by the system. It's not about what teachers can't do. How they adapt what they want to do with what they're allowed to do. Every day they make choices based on rules, resources and time. They find ways to teach well even

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when the system doesn't make it easy. This movement reflects teaching flexible, thoughtful and shaped by reality (Grapin, 2021; Moriau et al., 2022).

In areas with network access, such as P2, P3, P6 and P7 technology mainly works at the substitution level and at the augmentation level. Teachers use tools, like projected Educaplay drills or offline PowerPoint modules to keep continuity. This is not a sign that teachers are passive. Instead this practical approach shows a form of bricolage. (McGarr & Johnston, 2021; Nuraeni et al., 2026), wherein teachers resourcefully reconfigure available low-bandwidth tools to overcome severe infrastructural constraints (Mali et al., 2026). Conversely, in high-readiness contexts (P1, P4, P8), technology transitions toward Modification and Redefinition through AI-assisted instructional design and interactive co-construction of knowledge (Hao et al., 2026).

These findings extend current literature on digital agency (Chiu, 2022; Li, 2025) by demonstrating that technology integration is not a linear continuum of skill acquisition, but a socio-material negotiation mediated by regional infrastructure and institutional scaffolding.

Integration of Technology with Pedagogical Objectives

Framed using the Technological Pedagogical Content Knowledge (TPACK) framework as a concept that helps people get ready, for something (Arstorp et al., 2024), this study looked at how teachers worked to make sure digital tools (T) teaching methods (P) and the actual subject they teach (C) all fit together. Of looking at the results of learning or saying that technology works well this part looks at the way teachers said they used technology in different classroom situations.

Teachers decision-making sequences showed that choosing tools was mostly guided by teaching goals, not just what technology was available. When planning lessons teachers matched media to specific parts of instruction, like introducing new ideas practicing with guidance and checking understanding. To show this step-by-step thinking P1, from the school explained how teaching purpose shapes tool choice:

> *" I start by figuring out what the main goal is in math, like understanding geometry. After that I pick the tools. I use quizzes on Quizizz for practicing skills and animated slides to help with visualizing shapes and space. I don't just use technology for the lesson, only when it makes sense"* (P1, Suburban).

Than showing a clear level of maturity teachers used different ways to integrate technology based on what was happening around them. In places that're more suburban teachers used digital tools that are organized like Google Classroom or Wordwall. They mainly used these for keeping things in order, in the classroom and checking how well students were learning (P1, P3, P4). In areas that're more rural (P6, P7) where it is hard to get good internet teachers found ways to teach better by using pictures and other materials that don't need the internet. They used these to help make complicated science ideas easier to understand.

> *"For human anatomy lessons static textbook images are not enough. I put animated videos onto a flash drive and show them on the screen so students can see blood circulation clearly."* (P7, Rural).

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P8 shows how advanced integration can work in a resourced setting but its not a model, for what happens in most cities. In P8 stable fiber-optic internet and strong administrative backing allowed the use of AI and interactive displays. These tools helped support and guide thinking skills.

> *"I ask AI to create opinions about local environmental issues. Then I show those opinions, on the Smart TV. Everyone can discuss them together in a group debate. We then evaluate each view critically."* (P8, Urban).

Using the TPACK model research shows that technology integration depends on how it fits the context not just on skill levels. At the level where Technological Knowledge and Content Knowledge meet, rural teachers (P6, P7) used offline digital tools to teach abstract science ideas. This proves that using technology in places with resources relies on strategic fit rather than tool complexity (Rofiah et al., 2024). In contrast in high-readiness settings (P8) the TPACK model was fully in place. Interactive AI tools (T) helped students debate in an inquiry-based way, in science (C) (Rong, 2025).

However, having the hardware alone does not guarantee integration as shown by the poor example of P2 (Suburban). Even though P2 had an Interactive Flat Panel P2 used it for static document projection showing that simply having the device without confidence, in teaching does not produce integrated TPACK practices (Howard et al., 2021). In the end the success of integration depends on teachers ability to match the technology with teaching goals and material limits (Uçar & Sahin, 2026).

CONCLUSION

Among the participating teachers and schools the use of learning technology was shaped by a negotiation between pedagogical goals, individual teacher agency, localized infrastructure stability and institutional support mechanisms. Framed through the SAMR and TPACK models findings show that technology adoption, across these -site contexts did not follow a uniform maturity scale. Instead in resource-constrained settings teachers performed "pedagogical bricolage" using whatever tools were available to reconfigure offline visual media in order to sustain core instructional continuity. In high-readiness contexts educators leveraged platforms and generative AI to foster student-centered inquiry. Teachers accounts suggest that hardware availability alone does not guarantee integration without corresponding pedagogical intentionality and contextual self-efficacy.

These insights show that educational policy should move away from a focus on hardware distribution and instead rely on teaching support that fits the context and on building infrastructure support that is local. The study uses a evidence-based framework that can be applied to many cases to study how people use digital adoption tools in regions that are still developing. The research is limited because it only looked at eight teachers who're active, with

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technology. This small group gives insight into the local situation but does not provide wide statistical confidence. To build on this work future studies should listen to student perspectives watch classrooms directly use comparative samples and carefully evaluate how to use Generative AI responsibly in elementary classrooms.

AUTHOR CONTRIBUTION

WP was the researcher in charge of looking at the data and making the findings of the study while NT, INA, MN and SMN helped collect information in Semarang City, Demak Regency, Brebes Regency and Banjarnegara Regency respectively. 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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