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## Management Strategies and Pedagogical Integration in the Optimization of Digital Interactive Whiteboards: A Dynamic Capabilities Perspective in Elementary Schools

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**Abstract:** This study is motivated by the gap between the provision of interactive digital boards and the readiness of infrastructure in elementary schools. This study aims to analyze the dynamic capabilities of school management and pedagogical integration in optimizing the use of interactive digital boards at SDN Padurenan IV, Bekasi City. This research employs a qualitative case study design using interviews, observations, and documentation. The findings show that dynamic capabilities are reflected through sensing in identifying digitalization opportunities, seizing in implementing manual access controls for 18 classes sharing one device, and transforming through reconfiguring the BOSda budget to upgrade electrical capacity from 950 VA to 5,500 VA. Technology integration based on the TPACK framework enhances student engagement through active group rotation games. This study concludes that optimizing digital technology depends on managerial and pedagogical capabilities in sustainably managing technology.

**Keyword:** Dynamic Capabilities, Interactive Digital Board, TPACK, School Management, Interactive Learning

## INTRODUCTION

Digital transformation in education in Indonesia has become a national priority through various schemes for the provision of technology-based facilities and infrastructure, as it is increasingly recognized as a critical driver for improving learning quality and institutional adaptability in the digital era (Haleem et al., 2022; Nguyen et al., 2025). One significant initiative is the distribution of interactive digital boards (Interactive Flat Panels) to educational institutions to support a more interactive and innovative learning ecosystem. However, the implementation of this large-scale procurement policy often encounters challenges due to the heterogeneous readiness of infrastructure at the school level. Field conditions reveal a discrepancy between the availability of advanced hardware and supporting basic infrastructure, such as insufficient electrical capacity, unstable internet connectivity, and limited secure classroom space for storing high-value assets. This gap creates operational barriers for schools

in optimizing the use of educational facilities, thus requiring school-level managerial agility and pedagogical adaptability to bridge the availability of physical assets with their sustainable utilization.

The utilization of interactive whiteboards (IWBs) in school environments has been extensively researched, yet prior works present mixed results regarding pupil achievement and focus primarily on individual teacher competencies. Historically, Higgins et al. (2007) found that while interactive whiteboards are overwhelmingly welcomed by teachers and students, their actual impact on pupil attainment is often negligible unless accompanied by shifts in teachers' underlying pedagogy. On a global scale, Shi et al. (2021) demonstrated through a meta-analysis that IWB-based instruction positively influences students' cognitive learning outcomes, but this effectiveness is highly moderated by pedagogical approaches, showing the highest efficacy when paired with active independent and collaborative learning.

Locally, contemporary researchers have attempted to examine this technological transition in Indonesian primary education, revealing persistent operational and competence bottlenecks. Specifically, Putri et al. (2023) found that in implementing Technological Pedagogical Content Knowledge (TPACK) in elementary schools, many classroom teachers—particularly older ones—frequently struggle to operate technology well and fail to utilize it to create new learning representations, relying instead on basic examples from student textbooks and standard internet searches. To address these integration hurdles, Siregar et al. (2024) found that elementary teachers' TPACK is significantly influenced by their pedagogical knowledge rather than their technical digital literacy, whereas Silvester et al. (2024) demonstrated a highly significant positive relationship between teachers' TPACK competence and their actual skills in implementing digital-based learning. Furthermore, at the organizational level, Muttaqin et al. (2024) found that K-12 school adaptation to unstable policy environments is driven by dynamic capabilities—namely sensing, seizing, and transforming—rooted in leadership agility and strategic resource orchestration rather than the sheer volume of physical resources.

However, despite these valuable insights, limited research has examined institutional strategic orchestration, resource reallocation (such as BOS/BOSda budgeting), physical asset security, and the scheduling of interactive whiteboard use from a dynamic capabilities perspective in elementary schools with limited basic infrastructure, particularly in Indonesia. Most existing studies focus purely on classroom-level pedagogical outcomes or individual teacher competencies without examining how schools overcome severe local infrastructural constraints to make technology use sustainable.

To address this gap, this study simultaneously examines institutional facility management and classroom-level technology integration. We integrate two distinct theoretical lenses: the Dynamic Capabilities Theory (DCT) (sensing, seizing, and transforming) to analyze how school management reconfigures resources to overcome local infrastructural bottlenecks, and the Technological Pedagogical Content Knowledge (TPACK) framework to evaluate how teachers align advanced digital tools with the curriculum to enhance student engagement. By bridging these managerial and pedagogical perspectives, this study provides actionable insights for managing sustainable digital transformation under resource constraints.

Based on this background, this study addresses the following explicit research questions:

1. How do the dynamic capabilities of school management optimize the use of interactive digital boards amid infrastructure limitations?
2. How are interactive digital boards integrated into instructional planning and implementation to support student engagement?

## METHOD

### Research Approach and Design

This study employs a qualitative approach with a single holistic case study design (Yin, 2018). This design was selected to explore in depth the complexities of educational facility management, particularly the optimization and pedagogical integration of a single interactive digital board, within the real-life, bounded context of an elementary school. By focusing on SDN Padurenan IV as a single holistic case, the study examines both managerial decisions at the institutional level and pedagogical practices in the classroom as interconnected components of a single unit of analysis.

### Research Site and Participant Selection

Field data collection was conducted on April 15, 2026, at SDN Padurenan IV, Bekasi City. The research site was selected purposively because the school represents a unique, critical case: it is one of only three elementary schools in Bekasi City designated by the central government as a national pilot project for the socialization and implementation of interactive digital boards.

### Research Informants and Selection Criteria

The informants in this study were selected using **purposive sampling techniques** to ensure they possessed direct experience and relevant authority regarding the implementation of the digital board. To ensure transparency, the specific selection criteria for each informant category are detailed below:

1. **School Principal (Mrs. Sulastri):** Selected as the key administrative informant because she holds the formal decision-making authority over school facility management, budget planning, Regional School Operational Assistance (BOSda) fund reallocation, and the supervision of teaching staff.
2. **Pilot Teacher (Mr. Anjar):** Selected as a key operational informant because he was the designated teacher from the school who participated in the intensive four-day national-level training (Bimtek) on the utilization of interactive digital boards. He is responsible for disseminating this technical knowledge to other teachers within the school.
3. **Classroom Teachers:** Selected based on their active involvement in integrating the digital board into daily instructional activities or their participation in the school's internal teacher collaborative learning community, "Sahabat Ilmu Padurenan Empat" (Si Padupat).

To adhere to research ethics and protect participant privacy, the names of individual informants (including Mrs. Sulastri and Mr. Anjar) and institutional references are kept confidential or represented as pseudonyms, unless explicit consent was obtained for institutional representation.

### Data Collection Techniques

Data were collected through four primary techniques to ensure comprehensive methodological triangulation:

1. **In-depth Interviews:** Conducted in a semi-structured manner with the principal and the pilot teacher to explore the management of resources, infrastructure adaptation, teacher readiness, and operational challenges from both managerial and pedagogical perspectives.
2. **Observation:** The researcher conducted direct, structured observations of the physical condition and storage of the interactive digital board, the readiness of basic infrastructure (such as electricity and internet connectivity), and the interactions of students during lessons in the multipurpose room.

3. **Document Analysis (Teaching Module/RPM):** Instructional planning documents were analyzed to verify how the interactive digital board (Interactive Flat Panel) was integrated into the curriculum, specifically examining the Mathematics Teaching Module on weight measurement where the board is explicitly designated as the primary learning medium.
4. **Video Documentation:** Video recordings of classroom learning activities were systematically analyzed to objectively evaluate students' levels of physical (kinesthetic) participation, enthusiasm, and collaborative dynamics during interactive lessons.

### Data Analysis Techniques and Triangulation

Qualitative data analysis was conducted following the interactive model of Miles, Huberman, and Saldaña (2014), which involves three concurrent flows of activity:

1. **Data Condensation (Reduction):** Selecting, focusing, simplifying, abstracting, and transforming raw field notes, interview transcripts, and document analyses to highlight the core themes of school management dynamic capabilities (sensing, seizing, and transforming) and pedagogical integration (TPACK).
2. **Data Display:** Organizing the condensed data into structured narrative descriptions, matrices, or thematic summaries to allow easy comprehension of how managerial decisions supported classroom technology integration.
3. **Conclusion Drawing and Verification:** Generating meaning from the displayed data by identifying patterns, relationships, and explanations, followed by continuous verification against the available evidence.

To guarantee the validity and trustworthiness of the findings, the study employed methodological triangulation (by cross-verifying interview data with direct observations, lesson plans, and video documentation) and source triangulation (by verifying administrative policies reported by the principal with technical and practical accounts from the pilot teacher and classroom teachers).

### Ethical Considerations

This study was conducted in strict adherence to qualitative research ethics. Informed consent was formally obtained from all participants prior to conducting interviews, classroom observations, and video recordings, ensuring their participation was entirely voluntary. To protect the privacy and confidentiality of the school community, pseudonyms have been used for all individual informants, and all research materials, including transcripts and recordings, were stored securely and utilized solely for academic analysis.

## RESULTS AND DISCUSSION

### Results

The empirical findings from the single holistic case study of SDN Padurenan IV are organized into two primary thematic areas: (1) school-level administrative and infrastructure management strategies, and (2) classroom-level pedagogical integration of the interactive digital board.

#### 1. Administrative and Infrastructure Management Strategies

##### A. Strategic Identification of Technology Pilot Opportunities

SDN Padurenan IV was designated by the central government as one of only three elementary schools in Bekasi City to serve as a national pilot project for the socialization and utilization of interactive digital boards. This selection was facilitated by proactive administrative steps taken by the school principal. Specifically, the principal initiated a thorough correction of the school's Basic Education Data (*Dapodik*) system. Rather than

reporting idealized figures, the principal recorded the precise infrastructural deficits and spatial limitations of the school. According to the principal's account, this accurate data reporting increased the school's visibility regarding its infrastructural needs and was associated with its subsequent participation in the national educational assistance program, through which the school received a high-specification interactive digital board.

### ***B. Infrastructure Adaptation and Financial Resource Reallocation***

The introduction of the interactive digital board created immediate operational challenges regarding school infrastructure. Initially, the school's electrical capacity was restricted to 950 VA, which was technically insufficient to support the high energy consumption of the digital board alongside standard school operations. Additionally, stable internet connectivity was unavailable as the partnership with a local fiber-optic provider (*Fibernet*) was still in the pre-installation phase.

To overcome these physical and financial constraints, the school management executed the following actions:

1. **BOSda Fund Reallocation:** In October 2025, during the regional budget revision phase, the principal reallocated a portion of the Regional School Operational Assistance (*BOSda*) funds. These funds were specifically shifted from general central procurement allocations into the school's physical plant maintenance (*pemeliharaan*) budget, which granted the school greater administrative flexibility. This reallocated budget was utilized to fund an electrical power upgrade, successfully increasing the school's capacity from 950 VA to 5,500 VA.
2. **Spatial and Mobility Adjustments:** Because the physical electrical upgrades were initially completed only in a single multipurpose room (Gedung B remained unupgraded, while Gedung A and C had lower capacity), the digital board was permanently stationed in the multipurpose room. Due to the high economic value of the device and the physical safety risks of moving a heavy wheeled unit across uneven school corridors without elevators, the school management decided to relocate the students to the device rather than moving the device to different classrooms.
3. **Physical Asset Security:** To protect the device from theft or structural damage, the school repurposed the principal's office—which is secured with iron window grills—as the primary storage facility for the device when not in use in the adjoining multipurpose room.

### ***C. Access Control and Scheduling Routines***

Operating with a single interactive board for 18 learning groups (totaling 627 students) required strict access control. In the absence of an automated digital scheduling system, the principal established a centralized, manual scheduling protocol. Teachers wishing to utilize the board were required to submit an oral or informal written request directly to the principal. The principal then mapped out the schedule to prevent classroom conflicts, prioritizing the device for subject matters that demanded high visual representation and advising other teachers to temporarily use standard projectors.

### ***D. Collaborative Teacher Capacity Building***

To bridge the competence gap between younger, technology-fluent teachers and senior educators, the school established a weekly collaborative forum named "Sahabat Ilmu Padurenan Empat" (*Si Padupat*), held every Saturday. The forum was led by the school's designated pilot teacher (Mr. Anjar), who had completed a four-day national technical training (*Bimtek*) in Jakarta. Within *Si Padupat*, teachers engaged in peer-mentoring, lesson-planning simulations, and hands-on practice. To support senior teachers who experienced technical anxiety when initiating lessons, the school adopted an asymmetrical co-teaching model: younger teachers

assisted senior colleagues with the initial setup and software configuration, allowing the senior teachers to focus on delivering the pedagogical content.

## **2. Technology-Based Pedagogical Practices**

### ***A. Instructional Planning and Curriculum Alignment***

Analysis of the Mathematics Teaching Module (*Modul Ajar*) for the topic of Weight Measurement revealed that the Interactive Flat Panel (IFP) was structurally embedded as the primary instructional medium. Instead of utilizing the digital board as a static screen to project PDF textbooks, the lesson plans designed by the teachers incorporated interactive weight-scale software, interactive student worksheets (*LKPD*), and digital gamification applications.

### ***B. Classroom Implementation and Student Engagement Dynamics***

During the weight measurement lessons observed in the multipurpose room, the pilot teacher managed a class size of approximately 36 to 40 students using a structured group rotation strategy to compensate for the single-device limitation. The pedagogical process proceeded as follows:

- 1. Heterogeneous Grouping:** The teacher divided the class into small, heterogeneous groups of 5–6 students, intentionally distributing high-performing students across all groups to serve as peer leaders.
- 2. Gamified Learning Tasks:** The teacher projected mathematical weight-matching puzzles onto the touch screen. Using gamification software (such as *Kahoot*), groups competed in real-time.
- 3. Physical Rotation Game:** Students from competing groups lined up in front of the board. The first student in line physically interacted with the touch-screen interface to solve a portion of the math equation, then immediately rotated to the back of the line, allowing the next teammate to step forward. This rotation ensured that every student physically operated the board's tactile interface rather than passively watching.

### ***C. Qualitative Evaluation of Student Learning and Engagement***

Classroom observations and video analyses indicated a marked shift in classroom dynamics. When compared to lessons delivered via conventional digital projectors, the tactile, touch-screen interactions significantly altered student participation. In post-lesson interviews, both the pilot teacher and the principal noted that:

1. The immediate physical response of the board (e.g., dragging and dropping virtual weights) stimulated curiosity and active participation among previously passive or hesitant students.
2. When prompted to summarize the lesson, students who physically interacted with the board demonstrated immediate verbal recall, actively describing the steps they performed (e.g., "*first we dragged the 2kg weight, then we balanced the scale*"). In contrast, lessons conducted with standard projectors resulted in students passively listening, with lower rates of spontaneous explanation during follow-ups.
3. No pretest-posttest quantitative examinations were administered to measure long-term cognitive retention; thus, the observed positive outcomes are limited to immediate conceptual engagement and verbal articulation of mathematical steps.

### ***D. Supporting Device Policies***

To facilitate the gamified quizzes, the school principal established a strict supporting device contract with parents. Students were permitted to bring mobile phones to school exclusively on scheduled digital learning days. The teacher collected all mobile devices at the beginning of the school day, distributed them only during the active gamified learning segment,

and immediately locked them back in storage once the lesson concluded, preventing classroom distraction or asset loss.

## DISCUSSION

The discussion interprets the empirical findings of this study by linking them to the theoretical frameworks of Dynamic Capabilities Theory (DCT) and the TPACK framework, comparing them with existing international and national literature.

### ***The Sensing Dimension and Strategic Agility in the Public Sector: Proactive Innovation Sensing Under Severe Resource and Spatial Constraints***

The integration of advanced educational technologies within public schools is frequently examined as a linear consequence of top-down governmental procurement. However, applying the lens of Dynamic Capabilities Theory (DCT) reveals that the successful onboarding of technological innovations in resource-constrained public schools is fundamentally mediated by institutional agility and strategic orchestration. In Teece's (2019) conceptualization, dynamic capabilities are categorized into three core pillars: sensing environmental opportunities, seizing these opportunities through the mobilization of resources, and transforming operational routines to maintain alignment with a dynamic environment. While this theory was originally formulated to evaluate how private-sector firms capture market opportunities to sustain competitive advantages, this study demonstrates its profound applicability to public elementary education. At SDN Padurenan IV, the strategic journey of adopting the interactive digital board was not a passive receipt of public resources but a highly active, orchestrated manifestation of these three capability dimensions, starting with a deeply analytical sensing phase.

In the context of public sector educational administration, the sensing dimension refers to a school leadership's capability to continuously monitor, interpret, and translate external opportunities—such as national digitalization policies or central government initiatives—into direct institutional benefits. The empirical data from this case study indicate that the school's selection as one of only three national pilot schools in Bekasi City for the implementation of the central government's interactive board program was directly preceded by proactive, cognitively agile administrative steps taken by the school principal. This selection was not an arbitrary administrative default. Rather, the school principal initiated a systematic, transparent correction and update of the school's Basic Education Data (Dapodik). Under traditional public school routines in developing administrative climates, school leaders often engage in "idealized reporting" to avoid negative bureaucratic scrutiny, which inadvertently masks the actual, on-the-ground deficits of the institution. Bypassing this routine, the principal adopted an "honesty policy" in database management, documenting the precise physical limitations, the lack of class availability, the structural constraints, and the real-life spatial and infrastructural deficits of the school.

This database correction serves as a clear empirical manifestation of a sensing microfoundation. By organizing and aligning internal information with extreme accuracy, the school management successfully constructed a visible distress signal within the national database. When the central government scanned the region for pilot sites that could serve as critical testbeds for socializing advanced digital technology under realistic, resource-constrained conditions, SDN Padurenan IV stood out as a prime candidate. The principal's database correction acted as an administrative filter that successfully matched the school's acute needs with the central government's strategic digitalization aims. Consequently, the school captured a highly valuable, state-of-the-art interactive digital board directly from the Ministry of Education during a national ground-breaking ceremony. This process confirms that the sensing phase in educational organizations is a highly active strategic search routine.

This empirical pattern significantly expands the contemporary literature on public school adaptability in developing countries. Specifically, Muttaqin et al. (2024) argued that school

adaptation in Indonesia is not a linear, passive reaction to top-down policy shifts but is heavily driven by school leaders' internal dynamic capability to actively question and understand unstable external public policy times, subsequently leveraging local networks and reconfiguring internal routines. The sensing capability displayed at SDN Padurenan IV directly validates this assertion. Proactively correcting the Dapodik database represents a sophisticated form of questioning and understanding the institutional position relative to national educational policies.

Furthermore, this finding challenges the conventional resource-based view (RBV) which posits that technological optimization is primarily determined by the pre-existence of abundant physical assets. On the contrary, the sensing phase of SDN Padurenan IV demonstrates that strategic cognitive agility and administrative transparency can effectively bypass physical resource deprivation. The school sensed and captured a cutting-edge technological opportunity because its leadership had the strategic capacity to turn severe local infrastructure deficits into a structured, visible, and authentic pilot opportunity. In educational management science, this establishes a vital theoretical precedent: the initial stage of digital transformation in public schools is not driven by the volume of physical budgets, but by the intellectual and managerial capabilities of school leaders to scan, align, and position their institutions within the broader policy landscape.

### ***The Seizing Dimension: Administrative Gatekeeping, Resource Rationing, and Spatial-Physical Adaptation under Extreme Device Scarcity***

Once an educational innovation is sensed and acquired, the subsequent challenge under the Dynamic Capabilities Theory (DCT) lies in seizing the opportunity. In Teece's (2019) framework, seizing involves mobilizing resources, establishing operational business models, and securing complementary assets to prevent bottlenecks from stalling the innovation's value. In typical technology implementation literature, the acquisition of a digital tool assumes a supportive physical environment or a reasonable student-to-device ratio. However, at SDN Padurenan IV, the reality of a 1:18 device-to-classroom ratio (627 students sharing a single interactive digital board) meant that "seizing" could not rely on standard market-based or textbook deployment strategies. Instead, the school had to invent highly localized, defensive administrative routines to manage extreme resource scarcity.

From a strategic management perspective, the school's physical and spatial adaptations—repurposing the principal's office as a secure storage depot and requiring students to physically migrate to the multipurpose room—represent the deliberate mobilization of complementary physical assets. A state-of-the-art interactive flat panel is an inherently fragile, high-value asset. In an environment characterized by uneven school pathways, a lack of elevators, and classrooms lacking iron window grills (teralis), attempting a mobile device-to-classroom model would introduce high risks of physical degradation and theft.

By modifying spatial logistics—moving the human capital (students and teachers) to the stationary device rather than moving the device to the users—the administration secured the physical integrity of the board. This defensive mobilization illustrates that seizing under resource constraints requires prioritizing asset sustainability over immediate operational convenience. The spatial adaptation transformed a potential physical hazard into a controlled, centralized learning lab.

Furthermore, the implementation of a centralized, manual booking and gatekeeping system managed directly by the principal represents a critical administrative governance mechanism to resolve the resource bottleneck. Under conditions of resource scarcity, decentralized teacher coordination could potentially create scheduling conflicts, underutilization, or unequal access. The principal's manual gatekeeping acted as a non-market rationing mechanism, ensuring that the single board was allocated to subjects with the highest

curriculum-based visual demands (such as Mathematics) while directing other classes to standard projectors.

In terms of public sector capability, this manual rationing proves that when formal digital scheduling infrastructures are absent, the school leader's personal, relational authority serves as the vital microfoundation that keeps the technology operational. Rather than a sign of administrative backwardness, this manual gatekeeping is a highly rational seizing strategy that maintained institutional equilibrium and prevented resource friction in a highly constrained environment.

### ***The Transforming Dimension: Financial Reconfiguration and the Socio-Technical Institutionalization of Teacher Capacity***

The final and most sustainable phase of Teece's (2019) dynamic capabilities framework is transforming (or reconfiguring). This dimension represents an organization's ability to continuously realign its structural assets, operational routines, and human capital to maintain long-term synchronization with technological changes. Without a successful transforming phase, initial technology adoption remains a temporary rather than a permanent institutional capability. At SDN Padurenan IV, the transforming capability was manifested through two distinct reconfigurations: the structural reallocation of public school operational funds and the collaborative socio-technical engineering of teacher professional development.

The reallocation of the Regional School Operational Assistance (BOSda) funds from general procurement to physical plant maintenance to upgrade the school's electrical capacity is a clear manifestation of financial asset reconfiguration. In public educational systems in developing regions, financial management is typically characterized by rigid, highly centralized regulatory constraints that discourage administrative risk-taking.

By proactively exploiting the flexibility within the regional budget revision window, the school principal demonstrated highly agile financial orchestration. This strategic maneuver broke the hard physical energy bottleneck (950 VA) that would have otherwise rendered the high-tech interactive board completely useless. This demonstrates that in public schools, transforming capabilities are not merely abstract leadership qualities; they must be backed by a school leader's willingness and competence to reconfigure formal budgets to support technological survival. These findings support Situmorang's (2018) perspective that dynamic capabilities are reflected in an organization's ability to continuously reconfigure its resources.

At the human resource level, the institutionalization of the weekly Saturday learning community, "Sahabat Ilmu Padurenan Empat" (Si Padupat), represents a transition from sporadic, individualized teacher training to a permanent, collective organizational routine. In resource-constrained public schools, schools cannot easily acquire technology-fluent teachers from the external labor market. Therefore, the transforming capability must be built internally by creating learned patterns of collective action.

The peer-mentoring routine led by the certified pilot teacher allowed the school to internalize external technical knowledge from the national level (Bimtek) and distribute it systematically across the entire teaching staff. This aligns with the argument of Muttaqin et al. (2024) that sustainable school adaptation in Indonesia relies on maximizing internal school resources and communication networks to structuralize adaptation.

Furthermore, the implementation of the asymmetrical co-teaching model—where younger, technically proficient teachers scaffolded the technical setup for senior teachers—served as a highly sophisticated socio-technical reconfiguration of labor. This model directly dismantled what organizational theorists call the competency trap or technical anxiety, where experienced teachers' deep pedagogical content expertise is neutralized by their fear of operating new devices.

By pairing younger teachers' technological fluency with senior teachers' pedagogical mastery, the school reconfigured its classroom roles to create a low-risk, collaborative teaching

environment. In the broader scope of educational management, this proves that individual teacher competencies (such as TPACK) cannot be activated in a vacuum; they require school-level transforming capabilities to structurally reconfigure the social organization of teaching to make collaborative learning possible.

### ***TPACK Integration and Classroom Dynamics: Active Tactile Pedagogy***

As concluded by Chai et al. (2016), the teachers' ability to design TPACK integrated lesson could enhanced students learning. The classroom-level implementation of the interactive digital board at SDN Padurenan IV provides a sophisticated empirical case of how Technological Pedagogical Content Knowledge (TPACK) is manifested under conditions of extreme physical resource scarcity. The integration of digital technology has been shown to significantly enhance student engagement and participation in learning activities (Bond et al., 2020), however in the foundational literature on classroom technology, Higgins et al. (2007) warned of the "glorified projector" trap, wherein advanced interactive whiteboards are welcomed with high practitioner enthusiasm but are ultimately reduced to expensive, passive display screens because the teachers' underlying pedagogy remains unchanged. This pedagogical bottleneck was similarly documented in the contemporary Indonesian context by Putri et al. (2023), who found that elementary school teachers—particularly those with longer teaching tenures—frequently struggle to translate technology into original learning representations, instead relying on basic internet searches and static textbook projections due to a lack of deep, integrated TPACK competencies. The pedagogical dynamics observed in this study, however, demonstrate how these historical and local barriers can be systematically dismantled.

By explicitly embedding the interactive digital board (referred to as the Interactive Flat Panel or IFP) within the Mathematics Teaching Module (Modul Ajar) for weight measurement, the educators demonstrated a robust command of Technological Content Knowledge (TCK). Rather than projecting flat, non-interactive PDF documents—a practice that Putri et al. (2023) identified as a common failure of basic technology integration—the teachers selected digital software specifically engineered to visually represent abstract weight scales. This TCK alignment allowed abstract mathematical concepts to be translated into dynamic, visual representations that could be manipulated in real-time.

The most critical academic insight, however, lies within the Technological Pedagogical Knowledge (TPK) dimension, where teachers had to bypass the physical constraint of having only one device for 18 classes. To resolve this bottleneck, the teacher designed a structured group rotation game. This pedagogical intervention represents a profound TPK adaptation to large class sizes in a resource-constrained environment. Instead of a teacher-centric lecture model where students passively observe the screen, the class was divided into small, heterogeneous teams.

Students lined up, physically stepped forward to execute a specific mathematical step on the touch screen, and immediately rotated to the back of the line to let their teammates proceed. This rotation routine ensured that every single student in a large classroom of 36 to 40 pupils engaged in direct tactile and physical interaction with the digital interface, completely bypassing the passive viewing-only dynamic that typically limits the cognitive value of school technology.

This active, collaborative approach finds strong theoretical support in the global meta-analysis by Shi et al. (2021), which demonstrated that the cognitive effectiveness of interactive whiteboards is highly moderated by the pedagogical approaches used, achieving its peak efficacy when paired with independent and collaborative learning strategies rather than teacher-centered lecturing. The rotation game designed by the SDN Padurenan IV teachers directly operationalized this collaborative moderation.

Furthermore, from a cognitive perspective, the direct tactile interaction with the digital screen served as a superior sensory trigger. Because students physically dragged and dropped virtual weights to balance the digital scale, they built an experiential association with the content. This active cognitive processing explains why both the principal and the pilot teacher observed immediate, highly detailed conceptual verbal recall during post-lesson interviews. Students were not merely recalling a visual slide; they were verbally articulating a physical sequence of actions they had personally executed.

This deep pedagogical integration aligns perfectly with the quantitative findings of Siregar et al. (2024), who demonstrated that an elementary teacher's pedagogical knowledge is a significantly stronger predictor of successful technology integration than basic, technical digital literacy, which has no statistically significant influence on its own. This statistical reality underscores why the school's internal, peer-led Saturday community—Sahabat Ilmu Padurenan Empat (Si Padupat)—was so critical. Si Padupat did not focus on technical button-pushing; instead, led by the certified pilot teacher, it focused on the pedagogical orchestration of the device and co-teaching simulations.

This systematic, collaborative scaffolding translated individual teacher anxieties into collective confidence, directly validating the findings of Silvester et al. (2024), who proved that a significant positive correlation exists between high TPACK competence and a teacher's actual skill in delivering successful digital-based instruction.

Finally, the pedagogical ecosystem was supported by a critical socio-technical administrative contract established with parents regarding smartphone usage. By permitting students to bring mobile devices to school exclusively on scheduled digital learning days, collecting them at the start of the day, and distributing them solely during the gamified quiz segments (such as Kahoot), the school integrated personal student devices as complementary pedagogical tools. This strict gatekeeping routine allowed the school to leverage gamification to reinforce the math lesson while completely neutralizing the risks of digital distraction or device loss.

Ultimately, this case demonstrates a powerful theoretical principle: under conditions of extreme resource scarcity, the physical bottleneck of a single device can act as a direct catalyst for pedagogical innovation. The severe hardware limitation forced the development of collaborative, physically active, and highly interactive group dynamics, transforming what could have been a passive, top-down technology distribution into an authentic, highly engaged, and sustainable student-centered learning environment.

## CONCLUSION

This study concludes that the successful integration of advanced educational technology under conditions of severe resource constraints is fundamentally driven by the systematic alignment of institutional dynamic capabilities and active, student-centered pedagogy. In response to the first research question, the school management optimized the utilization of a single interactive digital board by orchestrating its internal capabilities: sensing national pilot opportunities through transparent database corrections, seizing resources through spatial adaptation, manual booking protocols, and secure storage in the principal's office, and transforming institutional routines through the strategic reallocation of Regional School Operational Assistance (BOSda) funds to upgrade electrical power alongside the establishment of the Si Padupat collaborative peer-mentoring community. In response to the second research question, the technological integration was successfully aligned with the curriculum by embedding the device within formal teaching modules and executing a structured group rotation game during lessons. This pedagogical innovation transformed a potential hardware bottleneck into a highly collaborative learning dynamic, stimulating students' direct tactile interaction and immediate conceptual verbal recall.

This study offers significant theoretical and practical contributions to the field of educational management and technology integration in developing countries. Theoretically, it extends Teece's Dynamic Capabilities Theory (DCT) to public primary education, demonstrating that school-level strategic agility and administrative reconfiguration can effectively mitigate severe physical asset scarcity. It also enriches the TPACK framework by illustrating that extreme resource constraints can serve as a catalyst for pedagogical creativity, prompting a shift from passive, teacher-centric presentation models to active, collaborative tactile learning. Practically, this study provides a concrete, replicable blueprint for school principals and policymakers on how to leverage local budgetary flexibility (BOSda), implement asymmetrical peer-coaching models to dissolve teacher technical anxiety, and establish supportive socio-technical contracts with parents to manage digital devices safely in classroom ecosystems.

Despite these insights, several limitations of this study must be acknowledged. First, because this research employed a single holistic case study design conducted at SDN Padurenan IV, the findings represent a localized reality and possess limited generalizability to schools with different socio-economic or geographical profiles. Second, the study was characterized by a short research duration, capturing classroom dynamics and management policies during a specific, bounded observation period on April 15, 2026. Third, this study relied entirely on qualitative data collection techniques, such as interviews, observations, and video analyses; consequently, no quantitative pretest-posttest examinations were administered to empirically measure long-term student cognitive retention or learning outcomes.

To address these limitations, future research should adopt a more extensive and diversified methodological agenda. Future studies could employ longitudinal mixed-methods designs to track the sustainable impact of interactive digital boards on both student academic achievement and teachers' TPACK development over multiple academic years. Additionally, conducting multi-site comparative case studies across urban, suburban, and rural elementary schools in Indonesia would provide a more comprehensive, generalizable understanding of how different institutional environments adapt to technological disruption. Finally, future works should investigate the scalable design of digital scheduling and resource-sharing platforms to automate access management in highly populated school environments.

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