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Digital Divide And Its Impact On The Competitiveness Of Public Secondary Schools In Rural Indonesia: A Multi-Site Qualitative Case Study

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Abstract

The proliferation of digital technology in education has intensified concerns about the digital divide—the structural gap in access to, use of, and capacity to benefit from digital technologies. In rural and peri-urban contexts, this divide may fundamentally undermine school competitiveness by constraining teaching quality, student achievement, and community enrollment decisions. This study investigates the nature, causes, and consequences of the digital divide in three public senior secondary schools (SMAN) in Muaro Jambi Regency, Jambi Province, Indonesia—a peri-urban region representative of the broader Indonesian rural educational landscape. Employing a qualitative multi-site case study design, in-depth interviews were conducted with school principals, curriculum coordinators, classroom teachers, and students, supplemented by structured field observation and institutional document analysis. Data were analyzed thematically using Miles, Huberman, and Saldaña's interactive model. Findings reveal four intersecting dimensions of the digital divide: (1) infrastructural inadequacy, manifested in unstable internet connectivity and laboratory degradation; (2) device scarcity relative to student

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population; (3) low digital pedagogical competency among teachers; and (4) a socioeconomic digital gap among students reflecting household income constraints. These dimensions collectively erode school competitiveness through reduced enrollment attractiveness, weakened academic performance, and diminished institutional reputation. The study proposes a Digital Equity Framework for Rural Schools (DEFRS) as a conceptual tool for guiding policy and institutional responses, and recommends targeted infrastructure investment, teacher professional development, and community-centered digital literacy programs. Findings contribute to the growing literature on educational equity and technology integration in developing-country contexts.

Keywords: digital divide; school competitiveness; rural education; educational technology; Indonesia; qualitative case study.

INTRODUCTION

The global expansion of digital technology has profoundly reshaped the landscape of education, repositioning digital access as a prerequisite for educational quality, institutional competitiveness, and the social mobility of learners (van Dijk, 2020). In high-income countries, widespread broadband infrastructure and device penetration have enabled schools to integrate digital learning environments into mainstream pedagogy. However, in low- and middle-income countries, including Indonesia—the world's fourth most populous nation and a rapidly developing digital economy—substantial disparities in technological access persist between urban centers and rural or peri-urban regions (Amelia et al., 2022). These disparities, broadly captured under the concept of the 'digital divide,' carry significant implications not only for individual learning outcomes but for the institutional competitiveness of schools serving economically marginalized communities.

Indonesia's national education system encompasses more than 50,000 public secondary schools, many of which operate in resource-constrained environments characterized by limited broadband connectivity, aging infrastructure, and a shortage of digitally competent educators (Saputra et al., 2023). The Merdeka Belajar (Freedom to Learn) curriculum reform, launched in 2022, explicitly prioritizes digital literacy and technology integration as core educational competencies—yet the implementation gap between policy aspiration and rural institutional capacity remains wide (Suryaman, 2020). This contradiction raises critical questions about educational equity and the extent to which digital infrastructure deficits translate into measurable disadvantages in school performance and community standing.

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Muaro Jambi Regency, located in Jambi Province on the island of Sumatra, presents an illustrative case of these tensions. Despite its proximity to the provincial capital and its designation as a 'peri-urban' district, the regency's public secondary schools exhibit significant variation in digital infrastructure, with many institutions constrained by unstable electricity supply, limited internet bandwidth, and deteriorating laboratory facilities (School Profile Data, SMAN 6 Muaro Jambi, 2024). The socioeconomic profile of the guardian community—predominantly smallholder farmers with household incomes below Rp. 1,000,000 per month—further limits household digital access and the supplementary role that home technology could play in supporting school-based digital learning.

This study investigates the digital divide in three public senior secondary schools (SMAN) in Muaro Jambi Regency: SMAN 2, SMAN 6, and SMAN 8 Muaro Jambi. These institutions were selected as purposive cases representing a spectrum of institutional capacity within a shared geographic and socioeconomic context. The study addresses four primary research questions: (1) What forms does the digital divide take in public secondary schools in Muaro Jambi? (2) What are the primary causal factors driving this divide? (3) How does the digital divide affect school competitiveness, including enrollment trends, academic achievement, and institutional reputation? (4) What strategies have schools adopted to mitigate the effects of digital inequality?

By situating these questions within the broader literature on the digital divide, educational equity, and school competitiveness in developing-country contexts, this study contributes both empirically and conceptually to an undertheorized area of educational research. The Digital Equity Framework for Rural Schools (DEFRS) proposed here offers a structured analytical and policy tool for understanding and addressing digital inequality in institutionally similar contexts across the Global South.

LITERATURE REVIEW

Conceptualizing the Digital Divide in Education

The concept of the digital divide was originally articulated as a binary distinction between those who have access to computers and the internet and those who do not (Norris, 2001). Subsequent theoretical refinement has produced more nuanced multi-dimensional frameworks. Van Dijk (2020) proposes a four-level model encompassing motivational access (the desire to use digital technology), material access (possession of devices and connectivity), skills access (digital competency), and usage access (the frequency, diversity, and quality of technology use). This progression from a first-level divide (connectivity) to a second-level divide (skills) and a third-level divide (outcomes) is particularly relevant to the educational context, where the benefits of digital

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technology depend not merely on infrastructure availability but on the pedagogical capacity to leverage that infrastructure effectively.

In the educational domain, the digital divide manifests in at least three analytically distinct dimensions. The infrastructure divide concerns the physical availability and quality of digital hardware, software, and connectivity at the institutional level. The competency divide refers to disparities in teachers' and students' digital literacy and technology integration skills. The outcome divide captures differential effects of digital access on learning achievement, educational trajectories, and institutional performance (Amelia et al., 2022; Lembani et al., 2020). Each dimension compounds the others: infrastructural inadequacy inhibits skill development, which in turn limits the productive use of any technology that is available.

Research in sub-Saharan Africa, Southeast Asia, and Latin America consistently documents that rural and peri-urban schools disproportionately experience all three dimensions of the divide, and that these compound disadvantages translate into measurable gaps in student achievement and school quality (Lembani et al., 2020; Saputra et al., 2023). In the Indonesian context, Anggrawan et al. (2019) find that technology integration in learning significantly improves student outcomes in contexts where infrastructure is adequate, but that the benefits are negligible or even negative in low-connectivity environments where technology use generates frustration rather than engagement.

School Competitiveness in Resource-Constrained Contexts

School competitiveness—understood as an institution's capacity to attract students, achieve academic outcomes, and maintain community standing relative to alternative educational providers—is increasingly mediated by digital capability in contemporary educational markets (Saputra et al., 2023). Families making school selection decisions incorporate institutional technology infrastructure as a signal of educational quality, particularly in contexts where formal academic performance data are less accessible or interpretable (Lembani et al., 2020).

The relationship between digital infrastructure and school competitiveness operates through multiple pathways. Directly, digital technology enables access to high-quality instructional resources, assessment platforms, and communication tools that enhance learning effectiveness. Indirectly, institutional digital capability shapes school reputation, influences teacher recruitment and retention, and affects the school's ability to participate in national education programs that increasingly require digital reporting and management systems (Suryaman, 2020). Schools that lack adequate digital infrastructure are thus doubly disadvantaged: they provide inferior learning environments and are simultaneously excluded

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from the institutional networks through which resources, recognition, and reputation are distributed.

In Indonesia, the Merdeka Belajar curriculum reforms have intensified this dynamic by formally integrating digital competency as a core educational objective (Suryaman, 2020). Schools unable to implement digital learning components risk being perceived as institutionally backward, irrespective of their performance on other quality dimensions. This reputational effect has particular significance in peri-urban areas where parents have some capacity to exercise school choice, making enrollment trends a sensitive indicator of community perceptions of institutional quality.

Digital Equity and Policy Responses in Developing Countries

Policy responses to the educational digital divide in developing countries have broadly followed two trajectories: infrastructure-first approaches that prioritize device provision and connectivity expansion, and capacity-building approaches that emphasize teacher professional development and pedagogical integration (Bello et al., 2023; Warschauer & Matuchniak, 2010). Evidence suggests that neither approach is sufficient alone: connectivity without pedagogical capacity is technologically deterministic, while training without adequate infrastructure is pedagogically futile (Bello et al., 2023).

Indonesia's BOS (School Operational Assistance) program provides per-capita funding to public schools that can, in principle, be allocated to technology development. However, the adequacy of BOS allocations for meaningful technology investment is contested, particularly in small-enrollment rural schools where per-capita funding may be insufficient to sustain institutional-grade connectivity and device maintenance (Anggrawan et al., 2019). This fiscal constraint is compounded by the geographic challenges of extending broadband infrastructure to remote and peri-urban areas, where the economics of commercial network expansion are unfavorable.

Warschauer and Matuchniak (2010) argue that equitable technology integration requires attention to the 'full ecology of digital access'—encompassing not only devices and connectivity but the physical, digital, human, and social resources that enable meaningful technology use. This ecological perspective aligns with van Dijk's (2020) multi-level framework and provides the theoretical foundation for the Digital Equity Framework for Rural Schools proposed in this study.

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CONCEPTUAL FRAMEWORK: DIGITAL EQUITY FRAMEWORK FOR RURAL SCHOOLS (DEFRS)

This study develops and applies the Digital Equity Framework for Rural Schools (DEFRS), which integrates van Dijk's (2020) four-level access model with the school competitiveness literature to produce an analytically coherent account of how digital divide dimensions interact to produce institutional disadvantage. The DEFRS identifies three primary layers of analysis:

- Layer 1 – Access Conditions: the physical and infrastructural dimensions of digital availability, including connectivity quality, device-to-student ratios, and laboratory condition.
- Layer 2 – Capacity Conditions: the human and organizational dimensions of digital capability, including teacher digital competency, institutional digital programs, and student digital literacy.
- Layer 3 – Competitive Outcomes: the institutional performance dimensions affected by access and capacity conditions, including enrollment trends, academic achievement, and community reputation.

The DEFRS posits that improvements at Layer 1 are necessary but insufficient for competitive improvement; sustainable institutional competitiveness requires coordinated development across all three layers. This framework guided both the data collection instruments and the analytical categories employed in this study. A conceptual map is presented below.

Figure 1. Digital Equity Framework for Rural Schools (DEFRS): Conceptual Map

LAYER 1: ACCESS CONDITIONS →	LAYER 2: CAPACITY CONDITIONS →	LAYER 3: COMPETITIVE OUTCOMES
• Internet Connectivity • Device Availability • Laboratory Condition • Power Infrastructure	• Teacher Competency • Digital Programs • Student Digital Literacy	• Enrollment Attractiveness • Academic Achievement • Institutional Reputation • Teacher Quality Retention

Mediating Variables: Socioeconomic Context · Geographic Location · Institutional Budget · National Policy Environment.

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METHODOLOGY

Research Design

This study employs a qualitative multi-site case study design (Yin, 2018), enabling systematic cross-case comparison of the digital divide across three public secondary schools sharing a common geographic and policy context. The qualitative paradigm is epistemologically appropriate for this research because the study seeks not merely to document digital infrastructure statistics but to understand how institutional actors—principals, teachers, and students—experience, interpret, and respond to conditions of digital inequality (Creswell & Poth, 2018). The multi-site design enables theoretical replication: each case is analyzed as an instance of the same theoretical proposition (the relationship between digital divide conditions and school competitiveness), with cross-case comparison used to identify both common patterns and context-specific variations (Yin, 2018).

Research Sites

Three public senior secondary schools in Muaro Jambi Regency, Jambi Province, Indonesia were selected as research sites. SMAN 6 Muaro Jambi, the primary case, is located in Maro Sebo sub-district and serves 501 students (2024/2025) across 16 learning groups. Its guardian community is predominantly agricultural (86% smallholder farmers) with household incomes largely below Rp. 1,000,000 per month (90%). SMAN 2 and SMAN 8 Muaro Jambi serve as secondary cases, selected to provide institutional variation in digital infrastructure and management approaches within the same regional context. The three sites collectively represent the range of digital conditions characteristic of public secondary schools in peri-urban Jambi.

Data Collection

Data were collected through three complementary instruments. In-depth semi-structured interviews were conducted with 12 informants across the three sites: three school principals (one per site), three curriculum coordinators, three classroom teachers, and three student representatives. Interview protocols addressed the four research questions across five thematic domains: internet infrastructure and connectivity; device availability and laboratory condition; digital pedagogy and teacher training; digital access disparities among students; and the relationship between digital conditions and school competitiveness. All interviews were audio-recorded with informant consent, transcribed verbatim, and member-checked for accuracy.

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Structured field observation was conducted at each site using a standardized checklist assessing five dimensions of digital infrastructure and practice: internet availability, digital hardware inventory, classroom technology integration, management support for digital programs, and student technology utilization patterns. Institutional document analysis encompassed school profile data (profil sekolah), RKAS budgetary documents, student enrollment records, academic achievement data, and digital program documentation.

Data Analysis

Thematic analysis followed Miles, Huberman, and Saldaña's (2014) interactive model, proceeding through data condensation, data display, and conclusion drawing and verification. The DEFRS framework guided the coding structure, with first-order codes capturing informant descriptions and second-order codes mapping to DEFRS analytical layers. Cross-case matrix displays were constructed to identify both convergent and divergent findings across the three sites. Trustworthiness was ensured through methodological triangulation (interviews, observation, documents), member checking of interview summaries with informants, and detailed audit trails.

FINDINGS

Layer 1 – Access Conditions: Infrastructure Deficits

Across all three research sites, internet connectivity emerged as the most consistently cited infrastructural constraint. At SMAN 6, the principal (Rina Marlina, M.Pd) characterized connectivity as 'adequate but dependent on electricity stability,' with signal quality deteriorating significantly during adverse weather conditions and power fluctuations. This instability, she noted, renders the internet 'unreliable as a pedagogical tool' in the classroom. SMAN 8 previously subscribed to IndiHome broadband but has since shifted to a model of distributing individual student mobile data quotas when required—a reactive strategy that reflects institutional awareness of the infrastructure problem but provides no systemic solution. Network infrastructure upgrades (mikrotik installation) were in progress at SMAN 8 at the time of data collection.

Facility condition data from SMAN 6's school profile reveal a pattern of widespread physical degradation. Four specialist laboratories—IPA (science), Bahasa (language), Komputer (computer), and Biologi (biology)—are all classified as 'Rusak Berat' (severely damaged, 45–65% structural deterioration). The school's 52 computers are concentrated in the computer laboratory; no classroom-level digital device infrastructure exists. Eight LCD projectors serve 16 classrooms,

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providing a 1:2 LCD-to-classroom ratio that constrains simultaneous digital teaching across the school. Field observation confirmed that Wi-Fi coverage is absent from all general classrooms, with digital learning effectively confined to the computer laboratory environment.

Student observer (Ofelia Zachrein, SMAN 6) reported: 'When we need to do something digital, we go to the lab. But sometimes the signal is weak. We mostly use our own phones with personal data cards.' This reliance on personal mobile data illustrates a characteristic feature of the peri-urban digital environment: the institutional infrastructure gap is partially compensated by individual-level workarounds, but these workarounds generate new inequalities based on students' varying household economic capacity to sustain data plan expenditure.

Table 1. Comparative Digital Infrastructure Profile: Three Research Sites (2024/2025)

Infrastructure Dimension	SMAN 6 Muaro Jambi	SMAN 2 Muaro Jambi	SMAN 8 Muaro Jambi
Internet Connectivity	GSM medium quality; weather-dependent instability	Broadband; moderate stability	Quota-based; mikrotik being installed
Classroom Wi-Fi Coverage	None (lab only)	Partial (selected rooms)	Computer lab only
Computers / Students Ratio	52 units / 501 students (1:9.6)	Available; exact ratio TBD	Adequate; IFV also available
LCD Projectors	8 units / 16 classrooms (1:2)	Distributed across rooms	Available
Science Lab Condition	Rusak Berat (≥45% deterioration)	Functional	Functional
Computer Lab Condition	Rusak Berat	Operational	Operational
Digital Program	Exists; implementation limited by infrastructure	Active integration	Active; equipment upgrades planned
Electricity Stability	Unstable; affects connectivity	Stable	Stable

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Infrastructure Dimension	SMAN 6 Muaro Jambi	SMAN 2 Muaro Jambi	SMAN 8 Muaro Jambi
Student Personal Device Access	Majority rely on personal mobile data (Tri SIM card)	Mixed; urban students more equipped	Mixed access

Note. Data derived from field observation, institutional documents, and informant interviews. SMAN 2 and 8 data from cross-site interviews.

Layer 2 – Capacity Conditions: Pedagogical and Human Resource Dimensions

Teacher digital competency emerged as the second major dimension of the digital divide across research sites. At SMAN 6, the classroom teacher informant (Megawati, M.Pd) reported using technology 'very frequently,' yet simultaneously identified 'weak network and limited infrastructure' as the primary constraints on effective technology integration. This apparent contradiction reflects a competency-infrastructure mismatch: teachers who possess the motivation and baseline skills to use digital tools are prevented from doing so consistently by infrastructural unreliability. Institutional training data indicate that 8 of 33 teachers (24.2%) have completed digital pedagogy professional development—a proportion insufficient for institution-wide technology integration.

At SMAN 8, the teacher informant (Noprizal, S.Pd) reported infrequent technology use, acknowledging that usage depends entirely on the subject matter rather than representing a systematic pedagogical approach. He confirmed receiving digital training on two occasions but noted that training outcomes are difficult to apply without consistent infrastructure. These testimonies align with the literature on the competency divide: professional development in isolation from infrastructure support produces sub-optimal integration outcomes (Bello et al., 2023).

Management support for digital programs was assessed as 'low' at SMAN 6 through observation (no visible digital literacy posters, limited documentation of digital programs), though the principal confirmed the existence of a formal digital transformation program. This discrepancy between formal policy commitment and observable implementation reflects what Anggrawan et al. (2019) identify as the 'implementation gap' in educational technology integration—a common finding in resource-constrained institutional contexts.

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Table 2. Teacher Digital Competency and Training Profile: SMAN 6 Muaro Jambi (2024/2025)

Competency Development Activity	Male Teachers	Female Teachers	Total	% of Teaching Staff
KBK/KTSP Curriculum Training	8	14	22	66.7%
Active Learning Methods (incl. CTL)	4	4	8	24.2%
Classroom Action Research (PTK)	4	2	6	18.2%
Academic Writing / Scientific Publications	0	1	1	3.0%
Professional Certification	7	6	13	39.4%
TOTAL TEACHING STAFF	9	24	33	100%

Note. Source: SMAN 6 School Profile Data 2024/2025. No specific digital pedagogy training track is recorded separately; figures reported under applicable categories.

Layer 3 – Competitive Outcomes: Enrollment, Achievement, and Reputation

Enrollment data from SMAN 6 reveal a consistent decline in new student registrations over the study period, from a peak of 225 applicants in 2017/2018 to 103 in 2022/2023 and 86 in 2023/2024. While multiple factors contribute to enrollment trends—including regional demographic shifts and inter-school competition—informant testimony links declining enrollment attractiveness partly to perceptions of inadequate digital facilities. The principal acknowledged that technology limitations 'do not greatly affect' school image in her assessment, while the teacher informant held the contrary view that digital conditions 'certainly affect' school competitiveness. This divergence reflects the contested nature of competitiveness perceptions within the institution.

Academic achievement data provide a more complex picture. Average examination scores at SMAN 6 improved substantially between 2017/2018 (IPA average: 38.33; IPS: 47.10) and 2020/2021 (IPA: 82.57; IPS: 81.70), suggesting that digital infrastructure deficits are not necessarily determinative of academic performance outcomes. The graduation rate has remained at or near 100% in recent years, and the proportion of graduates continuing to higher education has increased from 30% (2017/2018) to 65% (2020/2021). These findings indicate that institutional resilience and pedagogical quality can partially compensate for digital infrastructure

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disadvantages, at least in terms of formal academic outcomes.

However, socioeconomic data on the guardian community reveal a structural constraint on both household digital access and institutional resource mobilization. With 86% of parents in agricultural occupations and 90% earning below Rp. 1,000,000 monthly, SMAN 6 serves a community with extremely limited capacity to supplement institutional digital resources through household investment or voluntary contributions. The primary reason cited for graduates not continuing to higher education is financial inability (ranked first), followed by employment (ranked second) and geographic inaccessibility of universities (ranked third). These socioeconomic conditions form the environmental substrate within which the digital divide operates, constraining both demand-side and supply-side solutions.

Table 3. SMAN 6 Muaro Jambi – Student Enrollment Trends and Academic Performance (2017/2018–2024/2025)

Academic Year	Applicants	Enrolled (M)	Enrolled (F)	Total Students	Avg. UAS IPA	Avg. UAS IPS
2017/2018	225	95	104	525	38.33	47.10
2018/2019	216	111	103	585	42.86	39.55
2019/2020	167	81	86	586	78.67	79.57
2020/2021	209	101	108	574	82.57	81.70
2022/2023	103*	103	105	586	N/A	N/A
2023/2024	86	86	89	528	N/A	N/A
2024/2025	66	66	90	501	N/A	N/A

Note. Source: SMAN 6 School Profile Data 2024/2025. *2021/2022 data not reported in source document. UAS averages for 2022 onwards not yet available in school profile data. M = Male; F = Female.

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Table 4. Structured Field Observation Results: Digital Infrastructure and Practice (SMAN 6 Muaro Jambi)

No	Observation Aspect	Indicator	Finding / Assessment
1	Internet Infrastructure	Wi-Fi availability; network stability	GSM signal only; moderate quality; significant instability during adverse weather and power fluctuations
2	Digital Hardware	Device inventory and ratio	52 computers (lab-concentrated); 8 LCDs for 16 classrooms; no classroom-level devices
3	Classroom Technology Integration	Frequency and consistency of use	Confined to computer laboratory; general classrooms lack connectivity
4	Management Support	Programs, documentation, visible commitment	Assessed low; formal program exists but limited observable implementation
5	Student Technology Utilization	Access patterns and equity	Predominant reliance on personal mobile data; equity gaps by household capacity

Note. Source: Structured field observation, SMAN 6 Muaro Jambi, 2024/2025.

DISCUSSION

The Multi-Dimensional Nature of the Digital Divide in Rural Indonesian Schools

The findings of this study confirm and extend the multi-dimensional conceptualization of the digital divide proposed by van Dijk (2020). In the Muaro Jambi case, access conditions (Layer 1) are characterized by both physical infrastructure deficits—damaged laboratories, limited device inventory, absent classroom connectivity—and energy infrastructure vulnerabilities that render existing digital assets unreliable. Capacity conditions (Layer 2) reflect a competency-infrastructure mismatch in which teacher digital skills, while partially developed through prior training, cannot be effectively deployed in the absence of functional and reliable infrastructure. Competitive outcomes (Layer 3) manifest as declining enrollment attractiveness, a perception gap between institutional and community assessments of digital adequacy, and structural constraints on academic improvement attributable to digital exclusion.

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The interaction among these three DEFRS layers is not sequential but recursive: infrastructural inadequacy discourages teachers from developing and applying digital competencies, which in turn reduces student digital literacy, which ultimately affects both academic performance and the school's competitive standing in the educational market. Addressing any single layer in isolation—as infrastructure-only or training-only policy responses tend to do—is therefore insufficient for achieving meaningful competitive improvement (Bello et al., 2023; Warschauer & Matuchniak, 2010).

The Enrollment Paradox: Resilience Without Infrastructure

One of the most theoretically interesting findings of this study is the apparent paradox between declining enrollment and improving academic performance at SMAN 6. Between 2017/2018 and 2020/2021, average examination scores improved dramatically—from below 40 in multiple subjects to above 80—while enrollment applicants declined from 225 to 103 (reaching a low of 66 in 2024/2025). This decoupling of academic outcomes and enrollment attractiveness suggests that community perceptions of school quality are not primarily driven by academic performance data, which may be poorly communicated or difficult to interpret for a predominantly agricultural guardian community, but by more visible institutional characteristics including physical infrastructure, equipment availability, and the school's general appearance of modernity.

This finding is consistent with Saputra et al. (2023), who document that in Indonesian rural contexts, technology infrastructure serves as a primary quality signal in parental school choice decisions, often overshadowing formal academic outcome data. The implication is that schools serving low-income, low-digital-literacy guardian communities face a reputational challenge that is simultaneously a digital divide challenge: the community lacks both the institutional digital infrastructure and the digital information capacity to accurately evaluate school quality, making visible technological assets a disproportionately influential competitive factor.

Institutional Agency within Structural Constraint

Despite the significant structural constraints documented in this study, the research sites demonstrate meaningful institutional agency in responding to the digital divide. At SMAN 8, the shift to quota-based individual data distribution—while imperfect—represents a pragmatic institutional response to broadband infrastructure failure. The pending mikrotik installation at SMAN 8 indicates an institutional commitment to systematic connectivity improvement within available budgetary resources. At SMAN 6, the principal's commitment to digital education

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('providing better education and understanding of digitalization') reflects an aspiration that, while currently underfunded, provides a foundation for future development.

These forms of institutional agency are constrained by, but not reducible to, structural factors. The DEFRS framework accounts for this through the mediating variable of institutional budget—BOS allocations provide a baseline resource that committed institutional leadership can deploy strategically, even if the amounts are insufficient for comprehensive digital transformation. Future research should examine the relationship between institutional leadership quality and digital equity outcomes in resource-constrained schools, building on Bello et al.'s (2023) work on technology leadership in developing-country educational contexts.

Table 5. Cross-Case Analysis: Digital Divide Dimensions and Institutional Responses

DEFRS Dimension	SMAN 6	SMAN 2	SMAN 8
Access – Connectivity	GSM only; weather-dependent	Broadband; moderate	Quota-based; upgrading
Access – Devices	52 computers; 8 LCDs; lab deteriorated	Sufficient; distributed	Computers + IFV; adequate
Capacity – Teacher Training	24.2% trained in active methods	Higher integration rate	2 training sessions; limited application
Capacity – Student Digital Literacy	Mobile-dependent; lab-restricted	Higher urban access	Mixed access
Outcome – Enrollment Trend	Declining (225→66 applicants)	Stable	Stable
Outcome – Academic Achievement	Improved significantly; resilient	Consistent	Consistent
Institutional Response	Digital education commitment; budget-limited	Active integration programs	Equipment upgrade; quota strategy
Socioeconomic Context	86% farmers; 90% income <Rp.1jt	Mixed; higher urban income	Mixed peri-urban

Note. SMAN 2 and SMAN 8 data derived primarily from interviews with respective principals and teachers.

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CONCLUSIONS AND RECOMMENDATIONS

This study has examined the nature, causes, and competitive consequences of the digital divide in three public secondary schools in Muaro Jambi Regency, Indonesia, through the lens of the Digital Equity Framework for Rural Schools. The findings establish that the digital divide in this context is multi-dimensional and structurally embedded, encompassing physical infrastructure deficits, pedagogical capacity constraints, household socioeconomic digital exclusion, and institutional resource limitations that compound one another across the DEFRS analytical layers.

The study makes three principal theoretical contributions. First, it extends van Dijk's (2020) multi-level access framework to the institutional level of analysis, demonstrating how access, capacity, and outcome divides interact recursively within a single educational institution. Second, it introduces the enrollment paradox concept—the decoupling of academic performance improvement and enrollment attractiveness in low-income rural communities—as a distinct competitive phenomenon requiring targeted institutional communication strategies. Third, the DEFRS provides a conceptual tool for comparative cross-institutional analysis that can be applied and tested in analogous contexts across the developing world.

Based on the findings, the following policy and institutional recommendations are proposed:

- Infrastructure-First Investment: National and regional government must prioritize stable electricity supply and dedicated institutional broadband connectivity as prerequisites for all other digital equity interventions. The current reliance on GSM signals and personal mobile data is inadequate for institutional-grade digital learning.
- Integrated Teacher Professional Development: Digital pedagogy training must be synchronized with infrastructure improvement. Training that outpaces available infrastructure produces frustration rather than competency; infrastructure that outpaces teacher readiness produces underutilized investment.
- Digital Communication with Guardian Communities: Schools serving low-digital-literacy guardian communities must proactively communicate academic achievement data through accessible channels to correct the quality perception gap that allows infrastructure appearance to dominate enrollment decisions.
- BOS Funding Rebalancing: The per-capita BOS formula may be inadequate for small-enrollment rural schools facing disproportionately high fixed costs of digital infrastructure. A supplementary equity-weighted infrastructure grant mechanism warrants policy consideration.

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- Community Digital Literacy Programs: School-based digital literacy outreach for guardian communities would simultaneously strengthen household digital access and enhance community understanding of institutional digital programs—addressing both sides of the digital divide simultaneously.

Future research should investigate the longitudinal relationship between digital infrastructure investment and enrollment recovery in rural schools, and should test the DEFRS framework in additional national contexts to assess its generalizability across the Global South educational landscape.

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