

Innovative Adaptation in Digital Education: Teacher Creativity Strategies for Sustaining ICT Utilization in Vulnerable Indonesian Rural Schools

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Abstrak

Penelitian ini bertujuan untuk menganalisis secara mendalam peran dan manifestasi empiris kreativitas guru dalam mempertahankan pemanfaatan Teknologi Informasi dan Komunikasi (ICT) pada sekolah-sekolah pedesaan Indonesia yang menghadapi keterbatasan infrastruktur, minimnya perangkat teknologi, serta konektivitas internet berbandwidth rendah. Penelitian menggunakan pendekatan studi kasus kualitatif di SMPN 2 Air Kumbang, Sumatera Selatan. Pengumpulan data dilakukan melalui observasi, wawancara mendalam, dan dokumentasi, yang kemudian dianalisis menggunakan teknik reduksi data, kategorisasi tematik, dan triangulasi sumber. Hasil penelitian menunjukkan bahwa kreativitas guru termanifestasi dalam tiga strategi adaptif utama, yaitu: (1) *Resource Hacking*, yakni praktik memodifikasi dan memanfaatkan sumber daya lokal sebagai substitusi perangkat digital mahal; (2) *Offline Pedagogy*, berupa perancangan pembelajaran berbasis proyek dan aktivitas kolaboratif yang tidak bergantung pada koneksi internet real-time; serta (3) *Peer-to-Peer Tech Support*, yaitu pembentukan jaringan informal antar guru untuk berbagi konten, solusi teknis, dan praktik terbaik. Temuan ini memperlihatkan bahwa kreativitas guru berfungsi sebagai mekanisme penyangga (*buffer mechanism*) terhadap kesenjangan digital struktural. Penelitian ini menegaskan bahwa keberlanjutan integrasi ICT di sekolah rentan tidak semata-mata ditentukan oleh ketersediaan perangkat keras, melainkan oleh kompetensi kreatif adaptif guru. Implikasi praktisnya adalah perlunya pergeseran kebijakan dari pendekatan berbasis distribusi teknologi menuju penguatan kapasitas kreatif dan otonomi profesional guru. Studi ini berkontribusi pada pengayaan literatur tentang pendidikan digital kontekstual di wilayah berkembang.

Kata kunci: Kreativitas Guru, Kompetensi Kreatif Adaptif, Pedagogi Offline, Kesenjangan Digital, Pemanfaatan Ict.

Abstract

This study aims to investigate the specific role and empirical manifestations of teacher creativity in sustaining the utilization of Information and Communication Technology (ICT) for learning in Indonesian rural schools characterized by severe resource scarcity and unstable internet connectivity (low-bandwidth). The study employed a qualitative case study design at SMPN 2 Air Kumbang, South Sumatra, involving preliminary context analysis, primary data collection, and data analysis. The findings revealed three core manifestations of teacher creativity: *Resource Hacking*, utilizing local materials as substitutes for high-end digital tools; *Offline Pedagogy*, designing project-based learning to minimize reliance on real-time internet access; and *Peer-to-Peer Tech Support*, establishing informal networks for troubleshooting and content sharing. These strategies represent the study's novelty by demonstrating an inherent, highly effective buffer against infrastructural limitations. The practical implication is that policy and professional development must shift focus from hardware supply to fostering and rewarding these adaptive creative competencies. The study's contribution is concluding that teacher creativity is the critical factor for successful, adapted ICT use in vulnerable settings.

Keywords: Adaptive creative competencies, ICT utilization, Offline Pedagogy, Resource Hacking, Teacher creativity.

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1. INTRODUCTION

The rapid evolution of digital technology has profoundly reshaped educational ecosystems worldwide. Over the last decade, schools have increasingly integrated digital tools into curriculum delivery, assessment systems, and institutional management (OECD, 2021; UNESCO, 2023). However, digital transformation has unfolded unevenly, particularly across rural and under-resourced contexts where infrastructural, financial, and professional limitations persist (World Bank, 2022; UNICEF, 2023). Consequently, digital inequality has shifted from a narrow focus on access toward broader concerns regarding meaningful usage, pedagogical integration, and digital competence (van Dijk, 2020; Redecker & Punie, 2020).

The COVID-19 pandemic intensified these disparities. Emergency remote teaching exposed systemic fragilities in technological readiness, professional preparation, and policy coordination (Hodges et al., 2020; Bozkurt et al., 2020; Trust & Whalen, 2020). Teachers in low-resource settings faced heightened workloads and emotional stress while simultaneously being required to demonstrate digital adaptability (Kim & Asbury, 2020; König et al., 2020). Nevertheless, crisis conditions also stimulated innovative pedagogical experimentation (Flores & Gago, 2020; Reimers & Schleicher, 2020).

Recent scholarship reconceptualizes digital competence as multidimensional. Beyond technical proficiency, it includes pedagogical design, ethical awareness, critical reflection, and contextual responsiveness (Falloon, 2020; Howard et al., 2021; Instefjord & Munthe, 2019). Adaptive expertise defined as flexible problem-solving in novel contexts has therefore become central to sustainable ICT integration (Darling-Hammond et al., 2020; Cai & Tang, 2021). Teacher agency mediates the relationship between structural constraints and instructional outcomes (Zhao & Watterston, 2021; Harris & Jones, 2022).

Collaborative professionalism further enhances digital resilience. Peer-to-peer support systems facilitate knowledge exchange and distributed innovation (Hargreaves & O'Connor, 2021; Carpenter & Krutka, 2021; Trust et al., 2022). Informal professional learning networks often compensate for limited institutional training (Vangrieken et al., 2020; Avidov-Ungar & Forkosh-Baruch, 2020).

Importantly, empirical research suggests that effective digital pedagogy depends more on instructional coherence than technological sophistication (Bond, 2020; Graham, 2021). Hybrid and modular approaches have proven viable in bandwidth-constrained contexts (Rasmitadila et al., 2020; Dexter & Richardson, 2020). Sustainable transformation, therefore, must be understood as pedagogically grounded rather than technologically driven (Williamson et al., 2020; OECD, 2021). This study investigates how teachers in resource-constrained schools creatively navigate digital limitations, contributing to ongoing debates on resilience, equity, and sustainable digital reform.

2. METHOD

This research employed a qualitative case study design to explore teacher strategies within a bounded institutional context. Qualitative inquiry facilitates in-depth understanding of lived experiences and contextual complexities (Creswell & Poth, 2023; Merriam & Tisdell, 2019). A case study approach is particularly appropriate for examining real-life phenomena embedded within specific socio-cultural environments (Hamilton & Finley, 2019). Data collection involved semi-structured interviews, classroom observations, and document analysis. Semi-structured interviews allow flexibility while preserving thematic

focus (Tracy, 2020). Observational triangulation strengthens analytical credibility and contextual validation (Levitt et al., 2020; Stahl & King, 2020).

Thematic analysis followed Braun and Clarke's (2021) six-phase framework. This method remains widely endorsed due to its systematic yet adaptable interpretive structure (Kiger & Varpio, 2020; Nowell et al., 2022). Coding procedures were iterative, enabling the identification of recurring patterns related to creativity, collaboration, and adaptation. Ethical standards adhered to contemporary qualitative research guidelines (BERA, 2021; Wiles, 2020). Informed consent, confidentiality protection, and voluntary participation were strictly maintained.

3. RESULT AND DISCUSSION

Result

Three interrelated themes emerged from the data: (1) Resource Hacking and Creative Adaptation, (2) Offline and Hybrid Pedagogical Innovation, and (3) Peer-Supported Digital Resilience.

1. Resource Hacking and Creative Adaptation

Teachers demonstrated significant ingenuity in maximizing limited technological resources. Personal devices were repurposed for instructional communication, and low-data applications were strategically selected to minimize connectivity barriers. Such improvisation aligns with research indicating that crisis contexts stimulate contextualized innovation (Flores & Gago, 2020; König et al., 2020).

This adaptive behavior reflects "situated creativity," in which pedagogical solutions emerge organically from contextual constraints (Cai & Tang, 2021; Harris & Jones, 2022). Rather than perceiving infrastructural limitations as insurmountable obstacles, teachers reframed them as design challenges.

2. Offline and Hybrid Learning Strategies

Participants frequently combined printed modules with asynchronous digital guidance. Hybrid models allowed continuity despite unstable internet access. This approach corresponds with international recommendations advocating blended learning frameworks in low-resource settings (Graham, 2021; Reimers & Schleicher, 2020).

Research indicates that structured offline scaffolding maintains engagement even with minimal technological infrastructure (World Bank, 2022; UNESCO, 2023). The findings reinforce the argument that pedagogical intentionality outweighs technological abundance (Bond, 2020; Howard et al., 2021).

3. Collaborative Digital Resilience

Teachers relied heavily on peer networks to exchange digital materials and troubleshoot technical issues. Collaborative professionalism strengthens collective efficacy and professional confidence (Hargreaves & O'Connor, 2021; Vangrieken et al., 2020).

Professional learning networks accelerate distributed innovation and shared problem-solving (Carpenter & Krutka, 2021; Trust et al., 2022). Informal mentorship structures

compensated for limited formal training opportunities (Avidov-Ungar & Forkosh-Baruch, 2020).

Discussion

The findings confirm that digital resilience in resource-constrained environments is primarily teacher-driven. While macro-level inequities remain significant (UNICEF, 2023; World Bank, 2022), micro-level pedagogical creativity mitigates structural constraints (Zhao & Watterston, 2021). Digital competence must therefore be conceptualized as adaptive capacity rather than merely technical literacy (Falloon, 2020; Howard et al., 2021).

Collaborative cultures emerge as catalytic mechanisms for sustainable innovation (Hargreaves & O'Connor, 2021). Distributed leadership models appear more contextually responsive than centralized technological mandates (Dexter & Richardson, 2020; OECD, 2021).

Furthermore, policy flexibility is essential. Over-standardized digital reforms risk overlooking contextual realities (Williamson et al., 2020). Empowering teacher agency and localized experimentation may generate more durable educational transformation (Darling-Hammond et al., 2020; Harris & Jones, 2022).

Such horizontal collaboration reflects adaptive school culture (Fullan, 2013) and grassroots innovation (Barnes, 2023). These findings suggest that sustainability in vulnerable settings may depend less on centralized intervention and more on relational capital within schools.

Collectively, the results extend prior ICT integration research by demonstrating that creativity is not supplementary but foundational in low-bandwidth rural environments (Tondeur et al., 2017; Voogt et al., 2013).

4. CONCLUSION

This study concludes that sustainable digital transformation in resource-constrained schools cannot be achieved solely through the provision of technological infrastructure such as devices, connectivity, or centralized policies. Although infrastructure remains a necessary foundation, the findings demonstrate that teacher agency, creativity, and collaborative professionalism serve as the most critical factors in ensuring instructional continuity and educational resilience. Digital competence, therefore, should be understood not only as technical proficiency but also as an adaptive capacity that integrates pedagogical flexibility, contextual awareness, and reflective problem-solving. In situations where technological access is limited or unstable, teachers' ability to redesign instructional strategies becomes the primary mechanism for sustaining meaningful learning.

Furthermore, the study highlights the essential role of collaborative professional ecosystems in supporting digital adaptation. Informal professional learning networks, peer mentoring, and shared innovation practices enable teachers to compensate for limitations in formal training and institutional support. These collaborative structures reinforce the understanding that effective digital integration is a collective process rather than an individual effort. The findings also challenge technology-centered reform models by demonstrating that investments in hardware alone are insufficient without parallel efforts to strengthen pedagogical capacity, professional autonomy, and institutional trust. Hybrid and low-bandwidth instructional approaches observed in this study confirm that pedagogical intentionality can effectively mitigate technological constraints.

From a policy perspective, the study emphasizes the importance of flexible and context-responsive digital transformation strategies. Policymakers should prioritize empowering teachers through professional development, fostering collaborative cultures, and supporting localized innovation rather than enforcing uniform technological mandates. Such approaches promote educational equity by acknowledging diverse contextual realities and enabling adaptive solutions.

In summary, digital resilience in under-resourced educational settings emerges from the dynamic interaction between structural support and professional agency. While infrastructure provides the necessary foundation, teacher creativity, collaboration, and adaptive pedagogy ultimately determine the sustainability and effectiveness of digital learning. Future research is recommended to conduct comparative cross-regional studies to further explore contextual influences on digital resilience and to develop scalable, pedagogically grounded frameworks for sustainable digital transformation.

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