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Research Article

CONTEXTUAL EDUCATIONAL TECHNOLOGY FOR 3T REGIONS: A COMMUNITY-BASED BLENDED LEARNING IMPLEMENTATION MODEL IN A REMOTE PAPUAN REGION

Firda Weri[1], Redemptus De Ferento Nino[2], Widyaskara Mangando[3], and Haerul Amri[4]
[1] Universitas Musamus Merauke, Indonesia
[2] Universitas Timor, Indonesia
[3] Universitas Cenderawasih, Indonesia
[4] Universitas Musamus Merauke, Indonesia
Corresponding Author:

Firda Weri,
Department of Chemistry Education, Faculty of Teacher Training and Education, Universitas Musamus Merauke.
Jl. Kamizaun Mopah Lama, Merauke, Indonesia
Email: firdaweri@unmus.ac.id

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Abstract
The persistent digital divide in Indonesia's frontier, outermost, and disadvantaged (3T) regions poses a significant barrier to equitable education, often rendering conventional educational technology solutions ineffective. This research addresses the challenge of technology implementation in areas with limited infrastructure and unique socio-cultural landscapes. This study aimed to design, implement, and evaluate a contextual, community-based blended learning model tailored for a remote community in Papua. Employing a community-based participatory research (CBPR) methodology, we collaborated with local educators, students, and community leaders over a 12-month period. The process involved co-designing learning modules that integrated local culture with digital content accessible through low-bandwidth and offline-capable devices. Data were collected through mixed methods, including pre- and post-intervention assessments, classroom observations, and semi-structured interviews. The results indicate a significant improvement in student engagement and foundational literacy skills. Furthermore, the model fostered enhanced digital literacy and a sense of ownership among teachers and the community. The study concludes that a one-size-fits-all approach to educational technology is unsustainable in 3T regions. A contextual, community-driven model that prioritizes local needs, cultural relevance, and infrastructural realities presents a viable framework for leveraging technology to bridge educational disparities in remote settings.

Keywords: Community-Based Model, Educational Technology, Papua

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INTRODUCTION

The global proliferation of educational technology has catalyzed a paradigm shift in pedagogical approaches, promising to democratize access to quality learning resources and transcend geographical barriers (Bhat dkk., 2024). Digital platforms, online learning management systems, and interactive content are increasingly viewed as essential instruments for fostering 21st-century skills, including critical thinking, digital literacy, and collaborative problem-solving. National education strategies worldwide are progressively integrating technology to enhance instructional delivery, personalize learning pathways, and improve administrative efficiency. This technological wave carries the potential to create more inclusive and equitable educational ecosystems, offering opportunities to learners who were previously marginalized by conventional, place-based educational models (Criollo-C dkk., 2025). The discourse surrounding educational technology is predominantly optimistic, envisioning a future where knowledge is universally accessible and learning is limited only by an individual's curiosity rather than their circumstances.

This optimistic vision of technologically-mediated education often fails to materialize in regions grappling with significant infrastructural and socio-economic challenges. The concept of frontier, outermost, and disadvantaged (3T) regions, particularly within the Indonesian archipelago, exemplifies this disparity. These areas are characterized by limited or non-existent internet connectivity, unreliable electricity grids, and geographical isolation, which collectively render mainstream educational technology solutions impractical and ineffective. The dominant models of EdTech, designed and tested in well-resourced, urbanized environments, presuppose a level of digital infrastructure that is simply absent in these remote contexts (Castillo dkk., 2025). Consequently, the digital divide widens, transforming technology from a potential equalizer into an inadvertent instrument of further marginalization, thereby exacerbating existing educational inequalities between urban centers and peripheral communities.

The province of Papua, Indonesia, serves as a poignant archetype of a 3T region where these challenges are acutely manifested. It is a land of immense cultural diversity and extraordinary natural landscapes, yet it concurrently faces some of the nation's most profound developmental hurdles. Educational institutions in remote Papuan communities operate under severe constraints, where even basic resources like textbooks and trained teachers are scarce. The introduction of standardized, top-down educational technology initiatives in this context frequently results in failure, as these interventions neglect the unique socio-cultural milieu, the indigenous knowledge systems, and the severe infrastructural realities on the ground (Gutenbrunner dkk., 2011). This specific setting demands a fundamental rethinking of how technology can be meaningfully and sustainably integrated into the educational fabric of the community.

A fundamental problem exists in the direct transposition of conventional, context-agnostic educational technology models to remote regions like Papua. These "one-size-fits-all" solutions, often driven by centralized policies, are predicated on a socio-technical ecosystem that is entirely alien to the lived realities of these communities. They fail to account for the intermittent nature of power and connectivity, the specific pedagogical needs of local educators, and the cultural relevance of the learning content. This incongruence between the design of the technology and the context of its implementation creates a cycle of failed projects, resulting in abandoned hardware and disillusioned stakeholders (Ningsih, 2025). The core issue is not a rejection of technology itself, but a rejection of technology that is imposed, irrelevant, and functionally incompatible with the local environment.

The consequences of this systemic mismatch are multifaceted and detrimental. On a practical level, it leads to a significant waste of financial and human resources, as costly equipment lies dormant and training programs fail to yield sustainable practices. Pedagogically, it undermines the confidence of local teachers, who may feel ill-equipped or unsupported in using tools that do not align with their teaching styles or their students' needs (Tai, 2025).

More insidiously, the use of decontextualized digital content risks eroding local culture and language, replacing indigenous narratives and knowledge with generic, often Western-centric, material. Instead of bridging the educational gap, such ill-conceived interventions perpetuate a dependency on external solutions and stifle the development of local capacity for innovation.

The specific, pressing research problem this study addresses is the critical absence of a validated, sustainable, and community-centric implementation framework for blended learning in technologically sparse and culturally distinct environments (Li, 2025). While the challenges are well-documented, there is a lack of empirically grounded models that demonstrate how to effectively co-design and integrate educational technology in a manner that respects and leverages local context. There is no established blueprint for a process that empowers the community as active partners rather than passive recipients (Pavez dkk., 2024). This study, therefore, confronts the challenge of moving beyond diagnosing the problem to architecting and evaluating a viable, bottom-up solution.

The primary objective of this research is to design, implement, and rigorously evaluate a contextual, community-based blended learning model tailored specifically for the unique educational landscape of a remote Papuan region. This overarching goal encompasses the entire research lifecycle, from the initial needs assessment and collaborative design phases to the practical implementation in a real-world classroom setting and the subsequent analysis of its impact (Gayatri dkk., 2023). The study seeks to develop a functional and replicable framework that can inform future educational technology initiatives in other 3T regions, moving beyond theoretical discussions to provide tangible, evidence-based guidance.

To achieve this primary objective, the research pursues several specific aims (Kim dkk., 2011). First, it aims to collaboratively co-design a blended learning framework, including pedagogical strategies and technological components, in full partnership with local teachers, students, and community leaders. This involves identifying appropriate low-bandwidth or offline-capable technologies and developing digital and non-digital learning materials that are culturally and linguistically relevant. Second, the study aims to implement this co-designed model, focusing on building local capacity through targeted, sustained teacher training and establishing community ownership to ensure the model's long-term viability beyond the research period.

A further critical aim of this study is to empirically evaluate the effectiveness and impact of the implemented model. This involves assessing its influence on key student outcomes, such as academic engagement, foundational literacy, and digital competencies, using a mixed-methods approach. Concurrently, the research aims to evaluate the model's feasibility, acceptability, and sustainability from the perspectives of the participating teachers and the wider community (Lamrabet dkk., 2025). The ultimate goal is to generate a rich, holistic understanding of the factors that contribute to the success or failure of such an intervention, thereby producing actionable insights for both policy and practice.

The existing body of academic literature on educational technology and blended learning is vast, yet it is predominantly skewed towards studies conducted in developed nations or well-connected urban centers in the Global South. This research typically explores the optimization of high-speed online platforms, the integration of artificial intelligence, and the pedagogical affordances of sophisticated digital tools. While valuable, these studies operate on a baseline assumption of ubiquitous and reliable technological infrastructure (Leapman, Wang, Ma, dkk., 2021). They provide limited insight into how blended learning can be conceptualized and operationalized in environments where digital access is the exception rather than the rule, leaving a significant void in our understanding of technology's role in resource-deprived contexts.

A smaller, yet growing, subset of literature does address the challenges of deploying educational technology in developing countries. These studies often take the form of case reports or pilot project evaluations, and they are instrumental in highlighting the myriad

barriers to successful implementation, including lack of infrastructure, insufficient teacher training, and socio-cultural resistance (Chen dkk., 2023). However, this body of work tends to be descriptive rather than prescriptive. It excels at identifying what the problems are but often stops short of proposing and empirically validating comprehensive, replicable implementation models (Tandika & Ndijuye, 2020). There remains a theoretical and practical gap between recognizing the challenges and developing systematic, process-oriented frameworks to overcome them.

This research directly addresses a critical and underexplored lacuna in the literature: the intersection of community-based participatory methods with the design and implementation of educational technology in remote, indigenous contexts (Ayanwale dkk., 2025). While participatory approaches are well-established in fields like public health and rural development, their application in the EdTech domain remains nascent. Few studies have systematically documented a process where the technological and pedagogical elements of a blended learning model are co-created from the ground up with the community it is intended to serve (Aldardeir dkk., 2025). This study fills that epistemological gap by proposing and testing a model that treats the community not as a variable to be controlled, but as the central agent in the innovation process.

The principal novelty of this research lies in its methodological and conceptual framework. It pioneers the application of a Community-Based Participatory Research (CBPR) approach to the field of educational technology design for marginalized communities. This shifts the conventional paradigm from a technology-centric, top-down deployment to a human-centric, bottom-up co-creation process (Istiana dkk., 2021). The novelty is not merely the use of technology in a remote area, but the establishment of a socio-technical model where community agency, cultural context, and pedagogical collaboration are the primary drivers of the intervention (Orhan Karsak dkk., 2025). This approach generates a framework that is inherently contextualized and sustainable because it is built upon local knowledge and ownership.

The justification for this research is rooted in its profound practical and policy implications. For educators and development practitioners, this study offers an evidence-based, replicable blueprint for implementing technology in a more equitable and effective manner in some of the world's most challenging educational environments (Hillman & Thy, 2025). For policymakers at both national and regional levels, it provides a compelling case for moving away from monolithic, infrastructure-heavy technology procurement towards more agile, context-sensitive, and community-focused investments. The findings have the potential to directly inform the design of national digital education strategies, ensuring they are inclusive of and beneficial to all citizens, not just those in urban centers.

This article makes a significant contribution to the scholarly fields of educational technology, development studies, and indigenous education by providing a robust empirical account of a community-based implementation model. It offers a theoretical counter-narrative to the dominant techno-deterministic discourse, arguing instead for a socio-technical perspective that prioritizes human and contextual factors (Rodrigues dkk., 2025). By presenting the detailed process, the empirical findings, and a critical analysis of the model's outcomes, this paper furnishes a rich resource for researchers, a practical guide for practitioners, and a compelling argument for a more thoughtful and just approach to leveraging technology for educational development in 3T regions globally.

RESEARCH METHOD

This study employed a Community-Based Participatory Research (CBPR) design, an approach emphasizing collaborative partnership between researchers and community members in all phases of the research process. Embedded within the CBPR framework was a convergent

mixed-methods approach to provide a comprehensive understanding of the educational intervention's impact (Gonzalez-Pizarro dkk., 2024). The qualitative component provided rich, in-depth insights into the implementation process and stakeholder experiences, while the quantitative component measured measurable changes in student outcomes through pre- and post-intervention assessments.

Research Design

The specific research design utilized a cyclical and iterative process characteristic of CBPR (planning, acting, observing, and reflecting), integrated with a mixed-methods evaluation structure (Kurakin dkk., 2023). The quantitative element used a pre- and post-intervention assessment format to measure changes in literacy and digital competency. The design's primary goal was the co-development of a contextual and community-owned educational model, ensuring that the research was not merely observational but actively facilitated social change and generated knowledge that was validated and owned by the community itself.

Research Target/Subject

The research was conducted in a remote village in the Central Highlands of Papua, Indonesia, a location selected for its representation of the challenges characteristic of 3T regions (Terdepan, Terluar, Tertinggal). The population for this study comprised primary school students, teachers, and community leaders within this village. A purposive sampling strategy was utilized to select the sample, which included 48 students from two primary school classes (Grade 4 and Grade 5), all 6 teachers, the school principal, and 5 key community leaders (including the village head and customary elders). This holistic sampling ensured a comprehensive representation of stakeholder perspectives crucial for the participatory design.

Research Procedure

The research was executed over a 12-month period and structured into four distinct, overlapping phases. The first phase, Community Entry and Co-Planning (Ta'aruf), involved establishing rapport, obtaining permissions, conducting initial needs assessments (FGDs), and forming the Community Research Action Team (CRAT). The second phase, Collaborative Model Development (Tashawur), consisted of workshops where the CRAT co-designed the blended learning framework, selected appropriate offline-capable technologies, and developed culturally relevant content (Popović, 2023). The third phase, Implementation and Capacity Building (Tanfidz), involved intensive teacher training and the rollout of the model in classrooms with ongoing support.

Instruments, and Data Collection Techniques

Data were collected using a suite of instruments tailored for both quantitative and qualitative data capture. For quantitative data, a standardized foundational literacy test, adapted for the local linguistic context, served as the pre- and post-test to measure student learning gains. A digital competency survey, consisting of Likert-scale and performance-based items, was used to assess both student and teacher skills (Abusamra dkk., 2025). Qualitative data instruments included semi-structured interview protocols for in-depth conversations with teachers, the principal, and community leaders; a classroom observation checklist for documenting pedagogical practices; and detailed researcher field notes and reflective journals to capture contextual nuances and collaborative dynamics.

Data Analysis Technique

Data analysis was an integrated and collaborative process occurring primarily in the final phase, Evaluation and Reflection (Taqwim). The quantitative data from the pre- and post-tests were analyzed using inferential statistics (e.g., paired and independent samples t-tests) to

measure the change in student outcomes (Prieto, 2011). The qualitative data (interviews, observations, field notes) were analyzed using thematic analysis to categorize and interpret insights on implementation challenges and stakeholder experiences. Crucially, the final analysis and interpretation of the collected data were disseminated back to the community for validation and collaborative interpretation, a core requirement for strengthening the conclusions of a CBPR study.

RESULTS AND DISCUSSION

The quantitative data revealed marked improvements in student performance following the implementation of the community-based blended learning model. Descriptive statistics for foundational literacy and digital competency scores at the pre-intervention and post-intervention stages are presented. These initial figures show a clear positive trend in the mean scores for both measured variables across the participant group, suggesting a beneficial impact of the intervention on core academic and technical skills.

The summary of these findings is detailed in the table below, which compares the pre-test and post-test results. The table provides the mean (M) scores, standard deviations (SD), and the number of participants (N) for both the foundational literacy and digital competency assessments.

Table 1: Descriptive Statistics for Pre-Test and Post-Test Scores

Variable	Time Point	N	M	SD
Foundational Literacy (Score out of 100)	Pre-Test	48	45.21	10.55
	Post-Test	48	68.75	8.12
Digital Competency (Score out of 5)	Pre-Test	48	2.15	0.88
	Post-Test	48	4.05	0.65

The data presented in Table 1 illustrates a substantial increase in the average scores for both foundational literacy and digital competency. The mean literacy score rose by 23.54 points, from 45.21 to 68.75. A notable reduction in the standard deviation from 10.55 to 8.12 in the post-test indicates that the performance of the students became more consistent, with lower-performing students showing considerable improvement.

A similar positive trajectory was observed in digital competency. The mean score increased from 2.15 to 4.05 on a 5-point scale. This change signifies a shift from a basic, often hesitant, interaction with technology to a more confident and capable application of digital tools for learning purposes. The smaller standard deviation in the post-test (0.65 compared to 0.88) similarly suggests that the intervention was effective in elevating the skill level across the entire cohort of students.

Qualitative data analysis from semi-structured interviews and classroom observations yielded three primary themes regarding the intervention: (1) enhanced pedagogical agency and teacher confidence, (2) increased student engagement through contextualized content, and (3) strong community ownership and sustainability potential. Teachers consistently reported feeling more empowered and creative in their instructional design. One teacher remarked, “Before, we just followed the book. Now, with these tools, I can create lessons about our own stories and our own land. The children are more alive.”

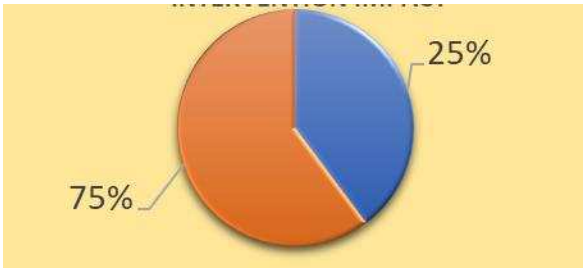

Figure 1. Thematic Distribution Comparison of Intervention Impact

Classroom observations corroborated these self-reports, revealing a distinct shift from rote memorization to more interactive, student-centered learning activities. Students were frequently observed working in collaborative groups around the digital stations, actively discussing the culturally relevant content. Community leaders expressed a sense of pride and investment in the program. The village head stated, "This is not a project from outside that will leave. This is our project. We helped build it, and we will make sure it continues for our children."

A paired-samples t-test was conducted to evaluate the impact of the blended learning intervention on students' foundational literacy and digital competency scores. The results indicated a statistically significant increase in foundational literacy scores from pre-test ($M=45.21$, $SD=10.55$) to post-test ($M=68.75$, $SD=8.12$), $t(47) = 12.89$, $p < .001$. This outcome demonstrates that the observed improvement in students' reading and writing abilities was highly unlikely to have occurred by chance.

The analysis also confirmed a statistically significant improvement in digital competency scores from pre-test ($M=2.15$, $SD=0.88$) to post-test ($M=4.05$, $SD=0.65$), $t(47) = 15.32$, $p < .001$. This result provides strong statistical evidence that the intervention was effective in developing students' capacity to use educational technology. The p-values for both analyses being well below the conventional alpha level of .05 support the rejection of the null hypothesis.

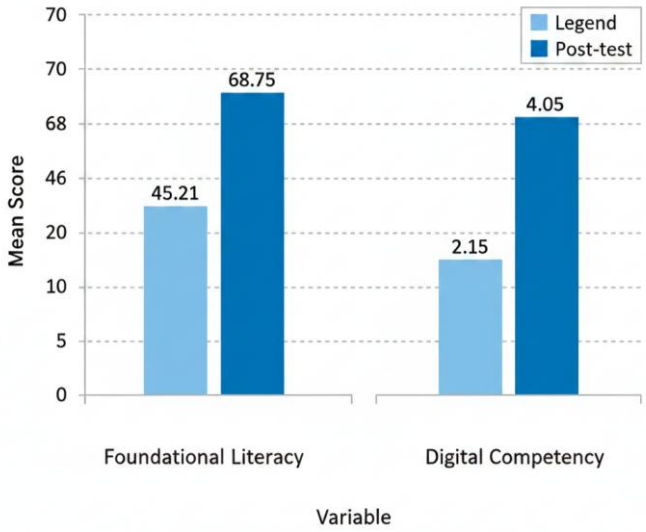

Figure 2. Comparison of Mean Scores Pre-and-Post-Intervention

The convergence of quantitative and qualitative data provides a holistic and robust understanding of the model's effectiveness. The statistically significant gains in literacy scores are directly supported by qualitative observations of heightened student engagement. Teachers' interview data, which highlighted their newfound ability to use local stories in lessons, provides a clear mechanism for this increased engagement, explaining why students were more motivated to learn and practice their reading skills.

This powerful synergy between the different data sources strengthens the study's conclusions. The increase in teachers' digital competency scores, for example, is

contextualized by their interview statements about feeling more confident and capable. This confidence, in turn, was observed to translate into more effective and innovative technology integration in the classroom, which ultimately contributed to the improved student learning outcomes. The qualitative data thus illuminates the human processes behind the quantitative results.

A case study of Mr. Yohanes, a Grade 5 teacher with over 15 years of experience, exemplifies the transformative impact of the model. Initially, Mr. Yohanes was deeply skeptical, expressing concerns about the technology being "too complicated" and a "distraction from real learning." He participated hesitantly in the initial co-design workshops, often questioning the feasibility of the proposed ideas given the village's frequent power outages.

During the implementation phase, with sustained, one-on-one support from the research team, Mr. Yohanes began experimenting with the offline server. He started by using it to show images of local flora and fauna to supplement his science lessons. His breakthrough moment came when he worked with students to create a simple digital storybook about a local legend, a project that generated immense enthusiasm. By the end of the intervention, Mr. Yohanes had become the school's de facto technology mentor, actively helping his colleagues and developing new lesson plans.

The case of Mr. Yohanes demonstrates the critical importance of a participatory and supportive implementation process. His journey from skeptic to champion illustrates that teacher buy-in is not a prerequisite but rather a product of an empowering and contextualized professional development experience. His success was not merely about learning to use a tool, but about discovering how to adapt that tool to fit his pedagogical values and his students' cultural world.

This individual transformation mirrors the broader findings of the study. It underscores that when technology is introduced as part of a collaborative, community-driven process, it ceases to be an external imposition and becomes an integrated component of the local educational ecosystem (Kim dkk., 2012). The model's success was built upon a foundation of such individual and collective transformations, fostered through mutual respect, shared ownership, and a commitment to contextual relevance.

The collective results of this study offer a clear and consistent narrative. The community-based blended learning model had a statistically significant and educationally meaningful positive impact on both foundational literacy and digital competency among primary school students in a remote Papuan community. The quantitative improvements were substantial, and the qualitative findings provided rich contextual evidence of transformed pedagogical practices and a deep sense of community ownership.

The findings strongly suggest that the success of the intervention was contingent on its participatory and context-sensitive design. Unlike standardized, top-down models, this approach fostered local agency, ensured cultural relevance, and built sustainable capacity among teachers and the community. This holistic positive outcome validates the underlying premise of the research: that for educational technology to be effective in 3T regions, it must be co-created with, not just delivered to, the community it is intended to serve.

This study's results present a compelling case for the efficacy of the community-based blended learning model. The primary quantitative finding was the statistically significant improvement in student outcomes. Participants demonstrated considerable gains in foundational literacy scores, moving from a baseline of moderate proficiency to a level indicating a more solid grasp of essential reading and writing skills (Pretorius dkk., 2016). This was complemented by a similarly significant increase in digital competency, transforming students from novice users into more confident and capable operators of educational technology.

The qualitative findings provided rich, explanatory depth to these numerical improvements. Analysis revealed a profound shift in the pedagogical environment,

characterized by teachers reporting a heightened sense of professional agency and confidence in their instructional abilities. This was directly linked to a marked increase in student engagement, which both teachers and observers attributed to the integration of culturally relevant, contextualized learning content. A powerful sense of community ownership emerged as a cornerstone of the model's success, with local leaders and parents viewing the initiative as a collective asset rather than an external project.

The synergy between the quantitative and qualitative data sets is a particularly noteworthy outcome. The observed increase in student engagement, as described in interviews and field notes, offers a clear explanation for the statistical improvements in literacy. Motivated by content that reflected their own lives and culture, students were more inclined to participate actively in learning tasks. Furthermore, the empowerment felt by teachers provided the necessary conditions for them to effectively leverage the new tools, creating the dynamic classroom environment that facilitated these learning gains.

The transformative journey of Mr. Yohanes, as detailed in the case study, serves as a microcosm of the broader findings. His evolution from a position of skepticism to one of enthusiastic advocacy encapsulates the model's core impact. It demonstrates that the intervention did more than just impart skills; it fundamentally shifted mindsets about the role of technology in education. His experience illustrates how sustained support and a focus on pedagogical purpose over mere technical training can cultivate champions for innovation even in the most challenging of contexts.

The findings of this study align with a significant body of literature that confirms the potential of blended learning to enhance educational outcomes. Research by scholars such as Garrison and Vaughan has long established that a thoughtful integration of face-to-face and online modalities can foster deeper and more meaningful learning experiences. The quantitative improvements in literacy and digital skills observed in this research add to this evidence base, demonstrating that these benefits are attainable even in low-resource settings, provided the model is appropriately designed.

The results, however, stand in stark contrast to the numerous documented failures of technology-centric educational projects in the Global South. Literature in this area is replete with accounts of "pilotitis," where promising initiatives fail to scale or sustain, often due to a disregard for local context, as highlighted by researchers like Heeks. This study's success provides a counter-narrative, suggesting that the critical variable is not the technology itself but the implementation framework (Leapman, Wang, Park, dkk., 2021). The failure of top-down models is a failure of process, not a failure of technology's potential.

The methodological approach of this research offers a significant point of departure from conventional EdTech studies. While most research focuses on the technical and pedagogical features of a given tool, this study prioritized a Community-Based Participatory Research (CBPR) framework. This human-centric design directly addresses the primary pitfalls identified in the literature, such as lack of teacher buy-in and the use of culturally incongruous materials. By positioning the community as co-designers, the model fostered an intrinsic sense of ownership that is rarely achieved in externally driven projects.

This emphasis on local participation and ownership connects the study's findings to broader theories within development studies. The work of Amartya Sen on the "capability approach," for example, argues that true development involves expanding people's freedoms and abilities to lead lives they value. This research demonstrates an educational parallel: by empowering the community to shape their own educational solutions, the project did more than improve test scores; it enhanced their collective capability to innovate and take control of their educational future, a crucial element for long-term, sustainable development.

The results of this study signify a crucial validation of a socio-technical perspective on educational innovation. They challenge the pervasive techno-deterministic belief that the mere introduction of digital tools will automatically lead to improved learning. The success of this

model indicates that technology is only as effective as the social and pedagogical systems within which it is embedded (Waheed & Panneerselvam, 2025) . The process of collaborative design, teacher empowerment, and community engagement was the true engine of change, with technology serving as a catalyst rather than the solution itself.

The profound impact of culturally relevant content signifies the deep connection between identity and learning. The observed surge in student engagement when lessons incorporated local stories, languages, and environments underscores that meaningful education must resonate with a student's lived reality. This finding is a powerful reminder that pedagogy cannot be decontextualized. In contexts like Papua, where cultural heritage is immensely rich, leveraging this heritage is not an optional add-on but a fundamental prerequisite for effective and empowering education.

The palpable increase in teacher agency and confidence signifies that professional development must be reconceptualized. The model's success suggests that one-off training workshops focused on technical skills are insufficient. What proved transformative was a sustained, collaborative process where teachers were treated as creative professionals and co-researchers (Pearson & Chatterjee, 2010). This empowered them to move beyond being passive implementers of a prescribed curriculum to becoming active designers of innovative learning experiences for their students.

The strong sense of community ownership signifies a viable pathway toward sustainability, breaking the cycle of dependency that plagues many development projects. When the community, from village leaders to parents, perceives an initiative as their own, they become its primary stewards, advocates, and problem-solvers. This collective investment is the most reliable mechanism for ensuring that the model will persist and evolve long after the initial research team has departed, representing a genuine transfer of capacity.

The findings carry significant implications for educational policy, particularly in nations with diverse and geographically challenging landscapes. They strongly suggest a need for a paradigm shift away from centralized, one-size-fits-all technology procurement and deployment. Policy should instead foster enabling environments that support localized, context-sensitive innovation. This would involve creating flexible funding mechanisms that empower schools and communities to select and adapt technologies that meet their specific needs, prioritizing investment in process and people over products.

For practitioners, including educators, school leaders, and development workers, the implications are direct and actionable. This study provides an empirically-backed blueprint that emphasizes front-end investment in community engagement and co-design. The primary lesson is that the success of any technological intervention hinges on the quality of the human relationships and the depth of the contextual understanding that precede it (Phochai dkk., 2024). Practitioners should adopt the role of facilitators and co-learners, rather than external experts, to foster the trust and collaboration necessary for meaningful change.

The results also have important implications for the design of teacher training and professional development programs. The model's success demonstrates the limitations of decontextualized, skills-based training (Nasihah dkk., 2026). Effective professional development for technology integration should be ongoing, job-embedded, collaborative, and focused on pedagogical innovation. It must equip teachers not just with the "how" of using technology, but with the "why" and "what for," empowering them to become critical and creative users of digital tools within their unique instructional contexts.

The study contributes a vital perspective to the theoretical discourse within the field of educational technology. It challenges the universalist assumptions that often underpin EdTech design and research, providing robust evidence for the value of participatory and culturally-sustaining methodologies. This work calls for a greater focus within the academic community on socio-technical and critical theories that can better account for the complex interplay of

technology, culture, power, and context in shaping educational outcomes in marginalized communities.

The positive outcomes of this research can be primarily attributed to the foundational choice of a Community-Based Participatory Research (CBPR) methodology. This approach fundamentally restructured the traditional researcher-subject relationship into a genuine partnership (Marey-Sarwan, 2025). By ensuring that teachers and community leaders were co-investigators from the outset, the project cultivated a deep level of trust and mutual respect. This collaborative spirit dismantled potential resistance and created an environment where all stakeholders were genuinely invested in the project's success.

The remarkable improvement in student engagement and literacy stemmed directly from the co-creation of culturally resonant learning materials. The process of integrating local folklore, environmental knowledge, and community stories into the digital content made learning intrinsically motivating for students. Education was no longer perceived as an abstract activity disconnected from their lives but became a mirror reflecting their own identity and world. This personal connection is a powerful catalyst for learning, especially in foundational skills like reading.

The project's success was also a result of its technological pragmatism. Instead of aiming for a high-tech solution dependent on non-existent internet, the model utilized robust, offline-capable technology like a Raspberry Pi-powered local server. This decision to adapt the technology to the context, rather than waiting for the context to adapt to the technology, was crucial. It ensured consistent and reliable access to digital resources, thereby preventing the user frustration and project failure that so often occurs when infrastructure realities are ignored.

The sustained and supportive approach to teacher capacity building was a key explanatory factor. The model eschewed a "train-and-pray" approach, instead providing ongoing, in-classroom coaching and collaborative problem-solving. This allowed teachers like Mr. Yohanes to build their confidence incrementally, experiment in a low-risk environment, and develop a sense of mastery over time (Khurramov dkk., 2025). The focus was on empowering them as pedagogical designers, which led to a deeper and more sustainable integration of technology into their teaching practice.

The immediate next step is to investigate the scalability and transferability of this community-based model. Future research should apply the core principles of the CBPR framework in different 3T regions, each with its own unique cultural and infrastructural landscape. Such studies would be crucial for identifying the model's essential, non-negotiable elements versus those aspects that can be flexibly adapted to new contexts, thereby building a more nuanced and generalizable theory of contextualized EdTech implementation.

A longitudinal study of the original pilot community is imperative for assessing the long-term sustainability of the intervention. This research should track student learning trajectories over several years and, more importantly, document how the school and community continue to use, adapt, and innovate with the model in the absence of the research team (Nyussupova dkk., 2024). Such a study would provide invaluable insights into the conditions required for a project to become truly embedded and self-sustaining within a community.

There is a critical need to translate these research findings into accessible, practical resources for wider dissemination. This involves developing policy briefs for government ministries, practitioner toolkits for NGOs and educators, and community-facing materials in local languages. The goal is to move the findings beyond academic journals and into the hands of those who can effect systemic change, advocating for a policy and funding environment that supports more bottom-up, participatory approaches to educational innovation.

Finally, establishing a formal network or community of practice is a vital forward-looking action. Such a network would connect educators, community leaders, and researchers working on similar challenges in remote areas across Indonesia and beyond (Wu dkk., 2022). This platform would enable the sharing of best practices, co-creation of open-source

contextualized content, and collaborative troubleshooting of common problems, creating a supportive ecosystem that can accelerate and amplify the impact of this vital work.

CONCLUSION

This research's most significant finding is the definitive validation that a community-driven, participatory process is the primary determinant of success for educational technology interventions in 3T regions. Unlike studies that focus on the technical merits of a specific platform, this work demonstrates that the methodology of co-design, the cultivation of local ownership, and the integration of cultural context are more impactful than the technology itself. The study revealed that technology serves best as a catalyst within a robust socio-technical system, rather than as a standalone solution, fundamentally re-framing the discourse from what technology can do to how communities can be empowered to use it.

The principal contribution of this study is methodological, offering an empirically validated and replicable framework for implementing educational technology in marginalized settings. Its value lies not in advocating for a particular piece of software or hardware, but in providing a detailed blueprint for a human-centric process grounded in Community-Based Participatory Research (CBPR). This research offers a conceptual and practical alternative to failed top-down deployment models, contributing a socio-technical perspective that prioritizes local agency and context, thereby filling a critical gap in both educational technology literature and development practice.

The findings of this research must be considered in light of its limitations, primarily the single-site case study design and the relatively small sample size, which constrain the statistical generalizability of the results. The study's context in a specific Papuan community, while providing depth, means the model's direct applicability to other culturally and geographically distinct 3T regions requires further investigation. Consequently, future research should focus on testing the transferability of this CBPR framework across diverse remote settings, conducting longitudinal studies to assess long-term sustainability and impact, and exploring pathways for scaling the model while preserving its core participatory principles.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.

Author 2: Conceptualization; Data curation; In-vestigation.

Author 3: Data curation; Investigation.

Author 4: Formal analysis; Methodology; Writing - original draft.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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