

Pedagogical Innovations of Vocational Teachers in Border Areas: A Case Study of SMK N 1 Entikong, Indonesia

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Abstract: SMK Negeri 1 Entikong, located in the Indonesia–Malaysia border area, faces complex challenges such as policy disparities, limited practice infrastructure, and a lack of industrial partners. This study aims to explore the pedagogical innovations and strategies employed by teachers to maintain learning quality in a border-area vocational school. This qualitative case study was designed to document the strategies and pedagogical innovations developed by teachers in response to these constraints. Data were collected through in-depth interviews, observations, and document analyses involving six teachers from SMK Negeri 1 Entikong. The data were analyzed using reduction, display, and thematic conclusion-drawing techniques. The findings reveal that teachers developed contextual innovations through the use of digital media, community-based project learning, and local partnerships. The study concludes that teacher resilience and creativity serve as critical factors in sustaining educational quality, making these practices a viable model for vocational education development in 3T (frontier, outermost, and disadvantaged) regions. The implications of the study highlight the importance of strengthening teachers' capacity in adaptive learning design, providing flexible policy support, and expanding cross-sector partnership networks to ensure the sustainability of educational innovations in border-area schools. These findings can serve as a foundation for designing competency improvement programs based on local needs and establishing a vocational ecosystem that is more responsive to the conditions of 3T regions.

Keywords: Border Area, Entikong, Infrastructure, Pedagogical Innovation, Vocational Education

Introduction

In the era of disruption characterized by rapid technological advancement, automation, and evolving industrial demands, vocational education—particularly *Sekolah Menengah Kejuruan* (SMK)—plays a strategic role in preparing adaptive and competitive human resources. The world of work continuously demands new and changing skills; therefore, vocational schools must not only produce graduates who are job-ready but also individuals capable of learning quickly, innovating, and solving problems.

Consequently, pedagogical innovation has become an urgent necessity to ensure that learning is more contextual, project-based, and relevant to industrial dynamics. This urgency becomes even more critical in regions with limited infrastructure and geographical challenges, such as the Indonesia–Malaysia border area. Through pedagogical innovation, vocational schools can maintain learning quality, overcome limitations, and ensure that graduates remain competitive in an ever-changing environment.

SMK Negeri 1 Entikong, located in Entikong District, Sanggau Regency, West Kalimantan, represents a concrete manifestation of vocational education positioned at the nation's frontline—in a border region. Geographically, it occupies a highly strategic location at the *Entikong State Border Post (PLBN)*, a vital gateway connecting Indonesia with Sarawak, Malaysia. This unique and strategic position elevates the school's function beyond that of a formal educational institution. Its presence carries multidimensional significance—it serves as a strategic stronghold for developing and empowering human resources in the border region who are not only skilled but also competent and competitive at the regional level.

Operating within a geographically challenging environment—with limited transportation access, long distances between areas, and unstable digital infrastructure—SMK Negeri 1 Entikong faces serious obstacles. The lack of facilities and industrial partners in the surrounding area restricts practical and technology-based learning activities. This situation compels the school to pursue pedagogical innovation to keep learning relevant, adaptive, and aligned with the competency needs of students in the border area.

Amid geographical disparities and infrastructural limitations, teachers at SMK N 1 Entikong act as agents of innovation who ensure that learning remains relevant and meaningful. They do more than teach; they design creative strategies, adapt methods to on-the-ground realities, and motivate students who face long travel distances and limited transportation access. Their resilience is reflected in their consistency in maintaining learning quality despite being in a resource-constrained environment. From these challenges emerges a strong work ethic and high commitment, positioning teachers as the primary pillars of educational resilience in the border area.

Although teachers at SMK N 1 Entikong have developed various context-based pedagogical innovations, these practices have not been systematically studied. Most research on vocational education still focuses on schools with adequate industrial access and infrastructure, leaving adaptive strategies in border regions underdocumented.

This study therefore focuses on how teachers design and implement learning innovations under limited geographical and infrastructural conditions. The aim is to identify the forms of innovation, the factors contributing to teacher resilience, and their impact on learning quality—ultimately serving as a foundation for developing vocational learning models that are relevant to other border and 3T (frontier, outermost, and disadvantaged) regions.

Specifically, this study seeks to describe and analyze two main aspects influencing the learning process at SMK N 1 Entikong. First, it examines the characteristics of geographical challenges and infrastructural limitations that directly affect teaching and learning effectiveness. Second, it documents various adaptive strategies and pedagogical innovations developed by teachers in response to these challenges as expressions of professional resilience in maintaining educational quality and relevance. Accordingly, this research is guided by two key questions: 1. What are the forms and impacts of geographical and infrastructural challenges on the learning process?. 2. What strategies and innovations do teachers apply to overcome these challenges and ensure the continuity of quality learning?

By documenting the narratives of resilience and creativity among educators at SMK N 1 Entikong, this research is expected to make two significant contributions. First, it provides valuable empirical insights for formulating and developing contextual and sustainable vocational education models in 3T regions (*Terdepan, Terluar, Tertinggal*), serving as an operational source of inspiration for other border-area educational communities. Second, and more strategically, the findings are expected to stimulate critical reflection among policymakers and stakeholders to design more proportional and comprehensive education policies.

To establish such policies, a deep understanding of the unique conditions faced by vocational schools in border regions is essential. Strengthening these policies is urgent, considering the strategic role of border vocational schools—not only as educational institutions but also as the nation's frontline in reinforcing national identity and enhancing competitiveness in border regions. Several studies emphasize that vocational schools in 3T regions require differentiated policy approaches due to geographical, infrastructural, and industrial access limitations (Direktorat Jenderal Pendidikan Vokasi, 2020; Kemdikbudristek, 2021; Tilaar, 2014). Furthermore, border areas possess unique social and economic dynamics that demand educational strategies capable of strengthening national resilience and empowering local

communities (Suryono & Hariyanto, 2019; Badan Nasional Pengelola Perbatasan, 2020; Soedijarto, 2008). Hence, strengthening vocational education policies in border regions becomes a strategic step to ensure equitable educational quality while optimizing the role of vocational schools as agents of competency development and national identity formation (UNESCO, 2016; World Bank, 2020; Kusnandar, 2015).

Research Method

This study employed a qualitative approach with a case study design as recommended by Yin (2018) and Creswell (2014). Data analysis followed the stages of reduction, presentation, and conclusion drawing in accordance with the model of Miles, Huberman, and Saldaña (2014). Data were collected through interviews, observations, and document analyses, guided by the frameworks of Merriam & Tisdell (2016) and Patton (2015), ensuring that the interpretation of findings could comprehensively represent teachers' pedagogical innovation practices in border areas.

Research Location and Subjects

The locus of this research was *SMK Negeri 1 Entikong*, located in Entikong District, Sanggau Regency, West Kalimantan Province. The site was purposively selected as it represents a real example of a vocational school operating in a national gateway area (*Pintu Lintas Batas Negara – PLBN*) with its unique dynamics and challenges.

The research subjects consisted of six teachers from various areas of expertise (multi-disciplinary), selected through purposive sampling based on their direct involvement not only in classroom learning but also in adaptive curriculum development and in building school partnerships with *Dunia Usaha dan Dunia Industri (DUDI)*.

Out of a total of forty teachers at *SMK Negeri 1 Entikong*, six were purposively selected because of their significant involvement in the teaching process, adaptive curriculum development, and *DUDI* collaboration. These six teachers were identified as key informants capable of providing the most relevant and in-depth data concerning pedagogical innovation in the border context. In qualitative research, sample size is determined by the depth of information rather than population size; thus, six teachers from diverse fields were deemed adequate to yield rich, representative data and achieve data saturation.

Data Collection Techniques

To obtain comprehensive data, four data collection techniques were employed over a period of four weeks, with the duration, frequency, and context specified as follows.

1. In-depth Interviews

Interviews were conducted twice with each informant, lasting 45–60 minutes per session. The sessions took place after school hours to avoid disrupting regular activities. All interviews were recorded and transcribed to ensure accuracy and allow verification of the collected data.

2. Participant Observation

Observations were carried out during 6–8 learning sessions, each lasting approximately 90 minutes, aligned with the school's regular class schedule. Observations took place during face-to-face learning, practicum activities, and project supervision to ensure that the data reflected actual conditions in both classroom and school environments.

3. Document Analysis

Document collection and analysis were conducted over two weeks, examining lesson plans (*RPP*), reflective journals, teaching materials, student project outputs, and partnership reports. The documents were analyzed in stages to map patterns of pedagogical practices and to verify the consistency of data from interviews and observations.

4. Questionnaire

Questionnaires were distributed to all six teacher participants during the first week of the study to obtain an initial quantitative overview of their perceptions regarding geographical challenges, innovation practices, and curriculum development involvement. The questionnaires were completed offline within 15–20 minutes after a teachers' meeting. This instrument served as a complementary tool to enhance the validity of findings through data triangulation.

Data Analysis

The collected data were analyzed inductively using the interactive model of Miles, Huberman, and Saldaña (2014), which involves three cyclical and iterative stages:

1. Data Reduction

This stage involved selecting, focusing, simplifying, and transforming raw field data. Irrelevant data were discarded, while significant data were abstracted and thematically categorized for presentation. The theme of “pedagogical innovation” emerged from this process by identifying only information related to how teachers designed and implemented learning under constrained conditions. Relevant data from interviews, observations, and documents were grouped into subthemes such as method adaptation, utilization of local resources, creation of creative media, project-based learning, and collaboration with partners. From these recurring patterns, researchers

abstracted that teachers systematically created new, contextual, and solution-oriented learning strategies responsive to geographical and infrastructural challenges. This abstraction was then synthesized into the main theme, “Context-Based Pedagogical Innovation in Border Areas.”

2. Data Display

After reduction, the data were presented in an organized structure using matrices, flowcharts, and thematic networks. This visual arrangement allowed researchers to identify patterns, relationships, and gaps more clearly, facilitating further analytical interpretation.

3. Conclusion Drawing and Verification

This research adhered to strict ethical principles by ensuring that participants received a clear explanation of the study’s purpose and provided informed consent. The confidentiality of identities was protected through data anonymization, and participants retained the right to withdraw at any stage.

Participant validation was conducted through member checking, confirming the accuracy of summaries, interpretations, and provisional conclusions with participants to ensure consistency with their experiences. This process complemented triangulation across sources, methods, and timing, ensuring that the conclusions drawn were accurate, valid, and reliable.

Findings and Discussion

Profile of Respondents and Teaching Context

Based on the results of in-depth interviews, all respondents in this study were active educators at *SMK Negeri 1 Entikong*, located in Sanggau Regency, West Kalimantan. The school’s unique and challenging position at Indonesia’s frontline border with Malaysia provides the central context that frames the teachers’ entire teaching experience.

In terms of disciplinary composition, the respondents represented a diverse range of expertise essential to vocational education, including teachers from the *Automotive Engineering* and *Electronics Engineering* departments, as well as a *Guidance and Counseling* teacher. This variety allowed for a holistic and multidimensional understanding of both the challenges and pedagogical innovations observed in the study.

The academic and professional qualifications of the teachers reflected a solid foundation. Most respondents held undergraduate degrees in Technical Education relevant to their teaching fields, and several had participated in the government’s *Dual*

Expertise Program designed to enhance flexibility and alignment between teacher competencies and the specific needs of their departments. Furthermore, all participating teachers held professional certification, confirming that they had met the nationally mandated competency standards.

Beyond formal qualifications, the teachers' deep motivation was evident in their strong moral and professional commitment to serve. Their choice to teach at *SMK N 1 Entikong* was not merely administrative but driven by a moral awareness to contribute to the education of children in the border region. They perceived their school as more than an educational institution—it symbolized the presence and dignity of Indonesian education at the frontier, facing Malaysia directly. One respondent remarked, "We realize that *SMK N 1 Entikong* is not just a school, but a symbol of Indonesia's educational existence at the border" (Respondent 1, Automotive Engineering Teacher). This statement reflects the collective consciousness among teachers regarding their strategic role at the nation's outermost edge.

Government Policy and Affirmation Toward Border Schools

The findings reveal a policy paradox that directly affects the quality of educational services at *SMK N 1 Entikong*. Teachers consistently reported the absence of affirmative policies specifically designed to support schools in border regions. Existing educational policies are general and uniform, failing to consider the distinctive geographical and logistical constraints of such areas. As a result, the specific needs of schools that face social, logistical, and cross-border challenges remain inadequately addressed.

This situation worsened after Entikong's designation as a *3T* area (*Terdepan, Terluar, Tertinggal*) was revoked during President Joko Widodo's administration. The revocation halted several affirmative support schemes that had previously strengthened border schools. As one teacher noted, "After the *3T* status was revoked, the special attention also diminished." The consequences were multi-layered—limited infrastructure improvement, reduced support for vocational program development, and stagnation of cross-border collaboration opportunities with Sabah and Sarawak. In fact, geographically, the school holds great potential to become a regional hub for border vocational education.

Challenges in Aligning with the National Curriculum

Teachers' experiences highlighted a fundamental dichotomy between the expectations of the *Kurikulum Merdeka* and the realities of teaching in a border area. The nationally standardized curriculum often fails to align with the socio-economic background of *SMK N 1 Entikong* students, who generally come from low-income families, have varied academic readiness, and limited technological literacy.

This misalignment creates operational pressure for teachers, who must comply with national administrative requirements while simultaneously ensuring that learning remains practical and understandable for students. One teacher explained, “Most students are not familiar with technology, so it takes a long time for them to adjust.” Consequently, teachers act not only as curriculum implementers but also as adaptive curriculum designers, modifying and contextualizing teaching materials to suit local conditions, geographical realities, and the economic potential of the border region.

Impact of Infrastructure on Learning

Contrary to common perception, basic infrastructure such as electricity and internet access in Entikong is relatively stable. However, the main challenge lies in logistics and materials—the difficulty in obtaining essential practicum supplies, electronic components, and vocational tools. These logistical barriers, compounded by high distribution costs and long procurement times, hinder practical learning effectiveness. As one teacher stated, “We still struggle to get practicum materials and components for our classes.”

This finding underscores that the existing gap is no longer limited to a *digital divide* but has evolved into a *logistical and material divide* that directly affects the quality of hands-on vocational education.

Integration of Policy, Geography, and Pedagogical Innovation

Across the findings above, a strong cause-and-effect relationship emerges: The lack of affirmative policy results in inadequate contextual support for border schools. The geographical isolation of the border area causes logistical, material, and social challenges not faced by urban schools. The standardized national curriculum remains misaligned with students’ readiness and local realities. These three factors interact to produce a single major consequence: Teachers are compelled to become pedagogical innovators—designing adaptive methods, media, and learning strategies to bridge structural, geographical, and curricular gaps.

Thus, pedagogical innovation in this context is not a matter of choice but a form of adaptive response to systemic, environmental, and infrastructural constraints.

Strategies for Industrial Internship (Praktik Kerja Lapangan/PKL)

In implementing *Praktik Kerja Lapangan (PKL)*—a critical component of vocational education—teachers at *SMK N 1 Entikong* faced significant structural challenges. The root cause lies in the scarcity of *DUDI* (industrial partners) near Entikong that match the school’s areas of expertise. This lack forces the school to send students for internships in larger cities such as Pontianak or Sanggau, which introduces new challenges—long distances, high transportation costs, and accommodation expenses. These financial burdens limit opportunities for

economically disadvantaged students, reducing equitable access to industrial experience.

To address this, teachers designed and implemented several contextual strategies, including: Building Inclusive Local Partnerships. Teachers proactively collaborated with local workshops and small community enterprises (*UKM*)—though limited in scale—to create practice environments relevant to the community’s real-world context while fostering local ownership of education.

Mobilizing Social and Financial Support: Teachers engaged families in consistent communication to build parental commitment for supporting out-of-town internships, thus reducing financial barriers through collective participation. Implementing Community-Based Project Learning. When access to industry was restricted, teachers encouraged students to undertake real projects in their communities—such as vehicle repairs or household electrical installations. These activities not only honed technical skills but also strengthened the school’s social contribution to the border community.

As one teacher stated, “We look for *DUDI* near the school, but when none are available, students can do *PKL* outside the region with parental support” (Respondent 1, Automotive Engineering Teacher).

This community-based *PKL* approach marks a new direction in border vocational education strategy. Teachers no longer passively wait for formal industrial partners but actively mobilize social capital, local networks, and real community needs as alternative learning resources. Hence, *PKL* becomes not merely an industrial placement but a meaningful learning practice that transforms the community into a “living laboratory” for skill development.

This aligns with the concept of Community-Based Learning, which positions the community as an authentic source of knowledge (Furco, 2021), and Contextual Teaching and Learning, which emphasizes the connection between education and students’ social realities (Johnson, 2019). Therefore, the community-based *PKL* model at *SMK N 1 Entikong* represents a form of contextual innovation—educational innovation emerging from local constraints and evolving into adaptive, culturally relevant pedagogical practice.

Pedagogical Innovation and Technological Adaptation

Adaptation and innovation became evident when the structural limitations surrounding *Praktik Kerja Lapangan (PKL)* were transformed into new learning opportunities. All teachers at *SMK N 1 Entikong* consistently demonstrated creativity and a high capacity for adaptation by leveraging digital technology as a transformational solution to overcome the scarcity of physical learning resources. Platforms such as YouTube, various digital simulation applications, and interactive

videos were utilized as instructional media to represent practical experiences that could substitute or complement the absence of physical tools at school.

An Automotive Engineering teacher explained, “We teach based on the conditions at school, supported by YouTube media and simulation apps to compensate for the lack of practice tools.” (Respondent 1)

In addition to technology use, teachers implemented a *Project-Based Learning (PjBL)* approach that positioned the community as an active learning partner. Within this model, students produced tangible outcomes or provided real services—such as vehicle repairs or fixing local residents’ electronic equipment—allowing project-based learning to take root in authentic community contexts.

The integration between *PKL* strategies and pedagogical innovation was reflected in the dual orientation of teachers’ practices: strengthening industrial experience through community collaboration and utilizing technology to simulate practical work environments. This dual approach not only bridged the shortage of resources and industrial partners but also gave rise to contextual innovation—a form of educational innovation that emerges from local realities, maximizes available resources, and delivers direct social benefits to the surrounding community.

Through the integration of digital technology and community-based learning, vocational education at *SMK N 1 Entikong* not only maintained its relevance but also expanded its social function as an agent of community empowerment in the border area.

This adaptive process aligns with the concept of *necessity-driven innovation*, where innovation is not triggered by abundance but by the need to find practical solutions within restrictive environments. The teachers’ practices illustrate how resilience and creativity can transform scarcity into a catalyst for sustainable pedagogical transformation.

In this context, digital technology acts not merely as a supplementary teaching aid but as a medium that reconstructs learning experiences, allowing students to engage with practical tasks virtually before applying them in real-life community projects. As a result, the teaching process becomes more interactive, visual, and meaningful—bridging the gap between conceptual understanding and hands-on vocational practice.

Consequently, the synergy between technological adaptation and community-based learning in *SMK N 1 Entikong* represents an innovative pedagogical model rooted in local wisdom, responsive to contextual constraints, and sustainable amid structural limitations. This approach demonstrates how vocational education can thrive even in geographically isolated regions, ensuring that learning remains relevant, experiential, and socially transformative.

Thematic Data Analysis

Based on the thematic analysis of the interview, observation, and document data, this study identified five key themes that represent the dynamics of education at *SMK N 1 Entikong*. These themes and their corresponding findings are summarized in the following table:

Table 1. Thematic Findings

Main Theme	Description of Findings	Impact on Learning
1. Disparity in Educational Policy	The absence of consistent affirmative policies from the government for border schools, despite their strategic geopolitical role.	Encourages teacher independence and innovation, though it burdens them due to the lack of systemic support.
2. Rigidity of the National Curriculum	The standardized national curriculum is perceived as insufficiently responsive to the social, economic, and geographical realities of border areas.	Teachers act as “curriculum translators,” contextualizing content to ensure relevance to students’ daily lives.
3. Deficit in Vocational Practice Infrastructure	Shortage of practicum materials, components, and supporting tools due to long supply chains and high logistical costs.	Prompts substitution strategies through community-based project learning and the use of locally available resources.
4. The Role of Social Capital in Education	Parental and community involvement serve as critical enablers of successful <i>Praktik Kerja Lapangan (PKL)</i> programs.	Builds a collaborative educational ecosystem that extends students’ access to practical experience beyond formal structures.
5. Digital Transformation in Learning	Intensive use of digital platforms (YouTube, simulations) as a response to the shortage of physical learning aids.	Enhances efficiency, visualization, and learning engagement, though it cannot fully replace hands-on experience.

The thematic analysis confirms that sustaining learning quality in border vocational schools is a complex process involving dynamic interactions between structural limitations, teacher creativity, and the mobilization of local potential.

Discussion

Teacher Resilience and Pedagogical Transformation

The findings indicate that teachers at *SMK N 1 Entikong* embody the concept of the resilient teacher—educators who not only survive under constraints but actively adapt, innovate, and grow in response to structural challenges.

From a broader theoretical perspective, their practices align with the principles of Contextual Pedagogy (Johnson, 2002), which asserts that meaningful learning occurs when there is a strong bridge between abstract curricular knowledge and students' real-life experiences. At *SMK N 1 Entikong*, this bridge is built through a layered process of pedagogical transformation that not only adapts but converts limitations into opportunities for innovation.

First, teachers engage in resource mapping, identifying local assets instead of focusing on the absence of formal *DUDI* (industrial partners). Small workshops, home-based entrepreneurs, and local service needs are transformed into entry points for vocational practice. This process represents curriculum translation—turning generic national content into learning activities tied directly to the social realities of the border community.

Second, teachers apply pedagogical substitution strategies, replacing unavailable tools or practice environments with functional alternatives. The use of technical videos, simulation software, and digital tutorials serves as representational substitutes for physical tools. In this stage, technology functions not merely as a visual aid but as a medium that reshapes the structure of practical learning experiences.

Third, innovation is strengthened through a reflective and iterative cycle. Teachers observe student responses, collect feedback from community beneficiaries, and modify their teaching approaches accordingly. This continuous cycle demonstrates the development of *tacit knowledge* that underpins sustainable contextual pedagogy.

Teacher resilience manifests in multiple dimensions. Technologically, teachers exhibit adaptability by utilizing digital resources to bridge material and infrastructural gaps. Socially, they cultivate community networks and partnerships to establish an inclusive and sustainable learning ecosystem, even within a context often overlooked by central educational policies.

Consistent with Diffusion of Innovation Theory (Rogers, 2003), the practices developed by these teachers exemplify the diffusion of innovation within peripheral educational contexts. Innovation arises not from resource abundance but from necessity-driven innovation, a pragmatic response to urgent challenges. Within Rogers' framework, teachers function as early adopters, testing and refining methods

such as digital simulations and community-based *Project-Based Learning (PjBL)* to address real-world problems encountered in daily teaching.

Importantly, this process is systematic rather than incidental. Innovation adoption does not proceed linearly but cyclically and participatively: ideas are tested, evaluated, revised, and reapplied in broader contexts. These innovations possess clear relative advantages, as they are easy to learn, compatible with local conditions, and effective in maintaining the quality of practical learning despite infrastructural constraints.

Thus, what initially appeared as barriers were ultimately transformed into catalysts—enriching learning experiences and strengthening the social relevance of vocational education in border regions.

Research Findings Based on Research Objectives and Synthesis

The research findings were systematically mapped according to the study's objectives, which aimed to explore the challenges, adaptive strategies, and pedagogical innovations developed by teachers at *SMK N 1 Entikong*. The following table summarizes the alignment between each research objective, the corresponding findings, and their implications.

Table 2. Research Findings Based on Objectives

Research Objectives	Key Findings	Impact / Implication
1. To identify the characteristics of geographical and infrastructural challenges faced by teachers at <i>SMK N 1 Entikong</i> .	- The school's location in a border area results in difficult transportation access and limited vocational practice facilities. - No specific affirmative policies have been implemented for border schools following the revocation of the 3T status. - There is a gap between the national curriculum and local realities, creating administrative pressure for teachers.	- Teaching and learning processes become less optimal due to logistical and facility constraints. - Teachers must continuously adjust instructional methods to ensure relevance to students' contexts and surrounding conditions.
2. To describe the adaptive strategies and pedagogical innovations developed by	- Teachers use digital platforms such as YouTube and simulation applications to address the lack of	- Innovations enhance students' motivation and the social relevance of learning.

Research Objectives	Key Findings	Impact / Implication
teachers in response to these limitations.	- practical tools. - Implementation of community-based <i>Project-Based Learning (PjBL)</i> involving students in real-world projects. - Establishing local partnerships with workshops and small enterprises (<i>UKM</i>) as alternative <i>Praktik Kerja Lapangan (PKL)</i> sites. - Engaging parental and community support in learning activities.	- Formation of a collaborative learning ecosystem linking schools, communities, and local businesses. - Students gain contextual and meaningful practical experience.
3. To analyze the emergence of bottom-up innovation as a necessity-driven process among teachers rather than as a top-down institutional directive.	- Teachers act as creative curriculum agents, connecting national content with local realities. - Innovations emerge organically from pressing needs (<i>necessity-driven innovation</i>) and evolve through participatory collaboration. - Learning practices reflect the theories of <i>Contextual Pedagogy</i> (Johnson, 2002) and <i>Diffusion of Innovation</i> (Rogers, 2003).	- Vocational education quality is sustained despite infrastructural limitations. - A new model of vocational education grounded in teacher resilience and independence is established and can be replicated in other 3T regions.
4. To provide empirical contributions for developing a contextual vocational education model in 3T areas.	- The practices of <i>SMK N 1 Entikong</i> teachers serve as concrete examples of educational resilience and locally-driven pedagogical innovation. - The findings present a replicable model for other	- Encourages policymakers and stakeholders to formulate affirmative policies for border-area schools. - Serves as an inspiration for developing contextual, community-oriented

Research Objectives	Key Findings	Impact / Implication
	border vocational schools, emphasizing community-based and locally resourced learning.	vocational education practices in Indonesia's frontier regions.

Synthesis

Overall, the four research objectives reveal a consistent pattern: structural and geographical challenges in border regions do not merely act as obstacles but serve as catalysts for the emergence of a contextual vocational learning model grounded in teacher resilience and innovation.

Challenges related to infrastructure and policy (Objective 1) gave rise to community-based and technology-assisted adaptive strategies (Objective 2). These adaptive strategies evolved into structured and measurable pedagogical innovations aligned with the theories of *Contextual Pedagogy* (Johnson, 2002) and *Diffusion of Innovation* (Rogers, 2003) (Objective 3). The accumulation of these practices ultimately led to the development of a teacher-driven vocational education model that is locally relevant and replicable in other 3T regions (Objective 4).

Thus, each finding reinforces the others, forming an integrated framework that demonstrates how vocational learning can remain relevant, high-quality, and contextually grounded even under conditions of extreme limitation.

Research Novelty

This study emphasizes that pedagogical innovations at *SMK N 1 Entikong* are bottom-up and necessity-driven, emerging from the teachers' direct experiences and community interactions rather than from formal government programs or top-down institutional mandates. Unlike previous studies that primarily highlighted structural or policy interventions, this research reveals that teachers themselves act as the central agents of innovation—initiating, adapting, and disseminating practices through professional judgment and local social engagement.

This novelty contributes not only to the theoretical understanding of pedagogical innovation in marginalized educational settings but also to practical strategies for developing resilient, community-anchored vocational education systems in Indonesia's border regions.

Conclusion

This study demonstrates that teachers at *SMK Negeri 1 Entikong* have successfully transformed structural limitations into relevant and sustainable pedagogical innovations. Geographical challenges, the scarcity of practical facilities, and the absence of affirmative policies have instead become catalysts for systematic adaptation through curriculum contextualization, the integration of digital technology, and community-based learning.

The evolution from survival strategies to innovative practices signifies the emergence of strong teacher agency—a bottom-up, necessity-driven process born out of professional judgment and local engagement rather than top-down policy mandates. Teachers have proven capable of bridging gaps between curriculum expectations and local realities, ensuring that learning remains meaningful, context-sensitive, and socially impactful even in geographically isolated settings.

The findings of this study offer a realistic and replicable model for contextual vocational education in border regions and other *3T* areas (*Terdepan, Terluar, Tertinggal*). This model highlights the critical role of teacher resilience and creativity as central pillars in maintaining the quality and relevance of vocational learning, despite minimal institutional and infrastructural support.

Ultimately, this research reaffirms that innovation in border vocational schools does not depend solely on resources or government intervention, but rather on the professionalism, adaptability, and commitment of teachers who transform constraints into opportunities for educational excellence and community empowerment.

Research Implications

Based on the conclusion that pedagogical innovation at *SMK Negeri 1 Entikong* emerged from teachers' initiatives and evolved through a bottom-up process, this study highlights the need for structural support to ensure that such practices can be strengthened, institutionalized, and replicated.

The findings—particularly those related to curriculum contextualization, community-based learning, and the use of digital technology—demonstrate that teacher creativity plays a vital role in maintaining the quality of vocational education despite severe limitations. However, this capacity for innovation requires supportive policies, institutional ecosystems, and flexible curricular frameworks to develop further.

Therefore, the implications of this study are articulated as strategic recommendations for the government, educational institutions, and local stakeholders in building a sustainable model of contextual vocational education in border regions.

1. Policy Development and Affirmative Support

The government should establish targeted and flexible policies for vocational schools in border and 3T regions. These policies must consider geographical constraints, logistical challenges, and the need for adaptive learning ecosystems. Affirmative measures—such as special funding schemes, incentive programs for teachers in remote areas, and regulatory flexibility in curriculum implementation—are crucial to sustaining educational innovation in these contexts.

2. Teacher Capacity Building

Professional development programs should focus on enhancing teachers' competencies in adaptive learning design, digital pedagogy, and community partnership management. Continuous training and reflective learning opportunities will enable teachers to design more contextually relevant and technology-integrated instruction, fostering long-term innovation capacity.

3. Strengthening Cross-Sector Partnerships

Expanding collaboration among schools, local governments, *DUDI*, and community organizations is essential. The creation of local partnership networks will not only provide alternative learning resources but also ensure that vocational education remains aligned with the economic and social realities of the border region.

4. Institutionalization of Community-Based Learning Models

The success of *SMK N 1 Entikong* in transforming local community engagement into a learning resource should be formalized as part of the school's management system. This institutionalization will ensure the sustainability of community-based *Project-Based Learning (PjBL)* and prevent the innovation from depending solely on individual teacher initiatives.

5. Integration of Local Context in Vocational Curriculum Design

Curriculum authorities should allow border vocational schools to incorporate local economic potential, cultural knowledge, and regional development needs into curriculum content. This integration will make learning more authentic and responsive to the realities of 3T regions, while still aligning with national competency standards.

By implementing these strategic implications, the creative and resilient practices developed by teachers at *SMK N 1 Entikong* can serve as a foundation for broader educational transformation. Strengthening institutional, policy, and partnership support will not only enhance the sustainability of pedagogical innovation but also contribute to the creation of a responsive, inclusive, and context-driven vocational education ecosystem across Indonesia's borders and disadvantaged regions.

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