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Bridging educational inequities in border regions: A qualitative inquiry into mathematics instruction in vocational high schools

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Abstract

Background: Vocational schools in border areas face systemic challenges such as limited infrastructure and poor curriculum-context alignment, hindering effective mathematics instruction and student engagement.
Aims: This study investigates how mathematics learning is organized and implemented in a vocational high school situated in the Entikong border area of West Borneo, Indonesia. The research seeks to identify instructional patterns, contextual challenges, and adaptive strategies used by educators under constrained conditions.
Method: Using a qualitative case study design, data were gathered through direct classroom observation, semi-structured interviews with teachers and school leaders, and review of official teaching documents. Thematic analysis and data triangulation were employed to ensure rigor and credibility.
Results: The analysis highlights a continued reliance on teacher-centered instruction, minimal use of contextual or vocationally integrated methods, and limited student engagement. Assessment practices predominantly measure cognitive outcomes, lacking elements that support student reflection or vocational competencies. Curriculum delivery is often disrupted by time limitations and infrastructural shortfalls.
Conclusion: Improving mathematics instruction in border-based vocational schools necessitates flexible teaching models tailored to the local context. Strengthening professional development, embedding authentic assessments, and enhancing school-community collaboration are crucial steps toward addressing educational disparities in underserved regions.

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INTRODUCTION

There is an urgent need to examine how mathematics instruction is managed in vocational schools located in Indonesia's border regions. These schools often face a disconnect between policy expectations and on-the-ground realities. Without empirical insights that reflect local challenges, national educational reforms risk becoming ineffective. The findings of this study aim to inform teacher training initiatives, curriculum contextualization, and equitable policy-making. Border regions like Entikong represent unique educational ecosystems shaped by socio-economic limitations and geographic isolation. These contexts require tailored instructional approaches, particularly in mathematics, where abstract content must meet practical vocational needs (Büscher & Prediger, 2024; Rich, 2021). In such environments, understanding how learning is organized and delivered becomes crucial. This study therefore serves as a necessary response to the growing demand for equity and relevance in frontier education (Li et al., 2024; Wargo et al., 2021).

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In vocational education, mathematics plays a vital role in equipping students with quantitative reasoning skills necessary for workplace applications. However, in schools located far from urban centers, instructional practices often rely on conventional methods such as lectures and repetitive exercises. These approaches rarely connect mathematical concepts with students' vocational tracks, leading to disengagement and perceived irrelevance (Leyva et al., 2022; Skilling et al., 2021). Students in these settings frequently struggle to relate classroom content to practical challenges in fields like engineering, agriculture, or technology. This disconnect limits both academic performance and career readiness (Benson & Owens, 2022; Duncheon, 2021). Meanwhile, teachers have limited access to training programs that emphasize contextual and applied teaching methods. Infrastructural barriers also prevent the integration of digital learning tools or project-based activities. As a result, mathematics education becomes disconnected from its vocational potential, weakening its impact on students' long-term development.

The literature consistently emphasizes the importance of contextual learning, especially in underserved educational environments (Menberu, 2024; Williams et al., 2022). Approaches such as inquiry-based learning, problem-solving, and interdisciplinary integration are known to increase engagement and comprehension. Despite this, their implementation remains rare in many border-region schools. Teachers face structural barriers including overcrowded classrooms, rigid schedules, and limited planning time. In addition, they often lack instructional autonomy or materials adapted to their students' socio-cultural realities. Educational authorities may provide standardized lesson plans, but these often fail to reflect the specific demands of vocational contexts. Consequently, students are exposed to generic instruction that neither supports critical thinking nor fosters practical skill development (Tan et al., 2023; Tuononen et al., 2022). This misalignment calls for deeper investigation into actual teaching management practices in such areas.

Instructional management in frontier schools is a complex task that requires flexibility, creativity, and sensitivity to local dynamics. Teachers must overcome logistical hurdles while also responding to linguistic and cultural diversity within their classrooms. Many students in border areas speak local dialects or indigenous languages, creating communication challenges in mathematics instruction (Allen & Trinick, 2021; Edmonds-Wathen & Gumurdal, 2024). Additionally, inadequate transportation infrastructure often leads to attendance irregularities and shortened learning time. Teachers are further burdened by high teaching loads, sometimes handling multiple subjects across grade levels. These conditions limit their ability to implement differentiated instruction or monitor student progress consistently. The result is a cycle in which both learners and educators struggle to meet curriculum expectations (Picton et al., 2022; Trinter & and Hughes, 2021). Breaking this cycle demands institutional commitment and instructional strategies grounded in local experience.

Although the Merdeka Curriculum promotes contextualization and student agency, its practical adoption in remote vocational schools is limited (Yoto et al., 2024). Teachers often use pre-designed lesson plans without adapting them to specific vocational needs or student profiles. As a result, instruction remains abstract and disconnected from workplace applications. There is also a lack of specific pedagogical guidance for integrating mathematics into vocational education. Policies encourage innovation but do not provide sufficient operational frameworks or resources for implementation. This policy-practice gap is particularly pronounced in frontier regions where oversight is minimal (Kassem, 2024; Mekasha et al., 2025). Government programs targeting border-area education often lack sustainability and alignment with classroom needs. These conditions point to the need for empirical studies that bridge policy intentions with real classroom practices.

Assessment is another major concern in mathematics instruction across remote vocational schools. Teachers tend to rely on standardized tests that emphasize factual recall and algorithmic problem-solving (Hamerská et al., 2024; Hartman et al., 2023). Such assessments do not measure students' ability to apply mathematical reasoning in practical or interdisciplinary settings.

Furthermore, formative assessment and constructive feedback are rarely used due to time constraints and teacher workload. Students are seldom involved in self-assessment or reflection, missing opportunities to develop metacognitive skills (Dennis & Somerville, 2023). Affective and vocational competencies remain largely unmeasured, even though they are central to the mission of vocational education. Assessment thus becomes an administrative requirement rather than a meaningful component of the learning process. This lack of authentic evaluation reinforces passive learning and widens the gap between instruction and employability.

The lack of collaboration between academic and vocational teachers also hinders the development of integrated instruction. Mathematics is typically treated as an isolated subject with little connection to students' technical training. Cross-disciplinary planning is rare, despite the potential for designing math problems based on real vocational scenarios (Goos et al., 2023; Klein, 2022). Institutional structures often discourage collaboration due to scheduling conflicts and compartmentalized curricula. School leaders may lack the vision or capacity to promote such integration systematically (Ketikidou & Saiti, 2025; Leithwood, 2021). As a result, students miss out on learning experiences that could enhance both their academic and vocational competence. The absence of coherent school-wide strategies for contextualizing mathematics instruction is a critical shortcoming. Addressing this requires organizational change and a shared pedagogical vision among all stakeholders.

Finally, the lived experiences of students in border regions differ significantly from those in urban schools and should shape instructional practices. These students often lack exposure to technology, industry engagement, and diverse learning resources (Abid et al., 2021; Jackson et al., 2022). Yet they are evaluated using the same academic standards as their urban counterparts. This uniform approach disregards the contextual disadvantages they face, perpetuating systemic educational inequality. Teachers are under pressure to meet performance benchmarks while managing resource limitations, creating stress and burnout. National policies often overlook these localized struggles, assuming a level playing field that does not exist (Bailey et al., 2023; van Duijn et al., 2022). Thus, there is a need for grounded research that captures the complexity of teaching and learning in these settings. By focusing on mathematics instruction in border-region vocational schools, this study contributes to a more equitable and context-aware vision of educational improvement.

Current research underscores the critical role of fostering educational equity in mathematics instruction. Beroíza-Valenzuela (2025), Master et al. (2025), and Trinter & and Hughes (2021) reveal how implicit biases and systemic barriers continue to shape learning experiences in mathematics and STEM fields. Digital interventions offer potential solutions, as demonstrated by Joshi et al. (2025), Saldivar et al. (2025) and Li (2025), though disparities in access remain a concern. The influence of language and cultural background on mathematics performance is explored by Salloum et al. (2025) and Naseer & Khawaja (2025). Adaptive technologies, highlighted by Naseer & Khawaja (2025), and AI-driven feedback systems Ogut et al. (2025) show promise in supporting diverse learners. Instructional and curricular adaptations, as examined by Huffaker et al. (2025) and Ryan et al. (2025), contribute to more inclusive mathematics pathways. Robinson et al. (2025) emphasizes the value of ethnographic approaches for understanding student experiences. Integrated STEAM education, promoted by Gonzales et al. (2025), Alkhatib (2025), and Meaders et al. (2025), offers pathways for enriching mathematics learning. Authentic assessment and personalized feedback are critical, as noted by Mosia et al. (2025), Johnston & Brewer (2025). Finally, broader systemic and spatial considerations, examined by Quesel et al. (2025) and Meng et al. (2025), highlight the importance of context in shaping equitable educational outcomes. Despite these insights, there is limited research on how mathematics instruction is managed in vocational schools within border regions, pointing to an important gap this study seeks to address.

Although considerable research has addressed innovative methods for teaching mathematics, much of the existing literature centers on urban schools or settings with adequate resources. Little is known about how mathematics instruction is managed in vocational schools situated in Indonesia's border regions, where educators face distinct geographical, infrastructural, and cultural challenges. Current studies on the implementation of the Merdeka Curriculum generally focus on national policy outcomes or broad pedagogical practices, often overlooking the realities encountered by teachers working in remote vocational environments. Furthermore, there is a notable lack of detailed analysis regarding how instructional management, assessment methods, and cross-disciplinary integration are adapted—or left unaddressed—in these frontier contexts. This creates a significant gap in understanding the practical dimensions of mathematics teaching in such complex educational landscapes. Without addressing this knowledge gap, efforts to reform education in border regions may fail to deliver equitable and contextually relevant improvements. Consequently, research that offers empirical insights into mathematics instruction in vocational schools at the periphery is both necessary and urgent.

This study aims to explore how mathematics instruction is planned, implemented, and evaluated within a vocational high school in the Entikong border area of West Kalimantan, Indonesia. It investigates the instructional strategies used by teachers under the constraints of limited resources and infrastructure, and examines the barriers that affect the delivery of contextual and meaningful mathematics learning. Additionally, the study seeks to understand how learning activities and assessment practices align with vocational competencies, and to highlight instructional practices that could inform teacher training and policy development. Rather than testing specific hypotheses, this research adopts an exploratory qualitative approach designed to generate a rich, evidence-based understanding of mathematics instructional management in border-region vocational schools.

METHOD

Research Design

This study adopted a descriptive qualitative case study design to investigate the management of mathematics instruction in a vocational high school located in the Entikong border region of West Kalimantan, Indonesia. The case study approach enabled an in-depth exploration of instructional strategies, classroom practices, and organizational processes within the school's unique geographical and socio-economic context. A qualitative methodology was deemed suitable for capturing the complex realities of teaching and learning in a resource-constrained environment.

Participant

Participants were selected purposively to ensure that data reflected diverse perspectives on instructional management. The study involved the school principal, vice principal for curriculum, two mathematics teachers, three heads of vocational departments, approximately fifteen vocational students, and the school's quality assurance coordinator. These participants represented key stakeholders in the planning, delivery, and evaluation of mathematics instruction, offering insights into both institutional policies and classroom-level practices.

Instrument

Three primary instruments were employed to collect qualitative data: observation guides, semi-structured interview protocols, and document analysis checklists. Classroom observations focused on teaching methods, student engagement, and the integration of vocational content into mathematics lessons. Interviews explored participants' experiences, perceptions of instructional challenges, and views on assessment practices. Document analysis included a review of lesson plans (RPP), syllabi, assessment records, and institutional policies. The combination of these instruments ensured data triangulation and enhanced the depth and validity of the study's findings.

Data Analysis

Data were analyzed using an interactive model adapted from Miles and Huberman. The analysis process comprised data reduction through coding and theme identification, data display using thematic matrices, and conclusion drawing through iterative synthesis of patterns across data sources. Triangulation of observation, interview, and document data strengthened the credibility of the analysis. Thematic analysis allowed for the emergence of nuanced insights into how mathematics instruction is managed, adapted, and evaluated in the context of a vocational school situated in a border region.

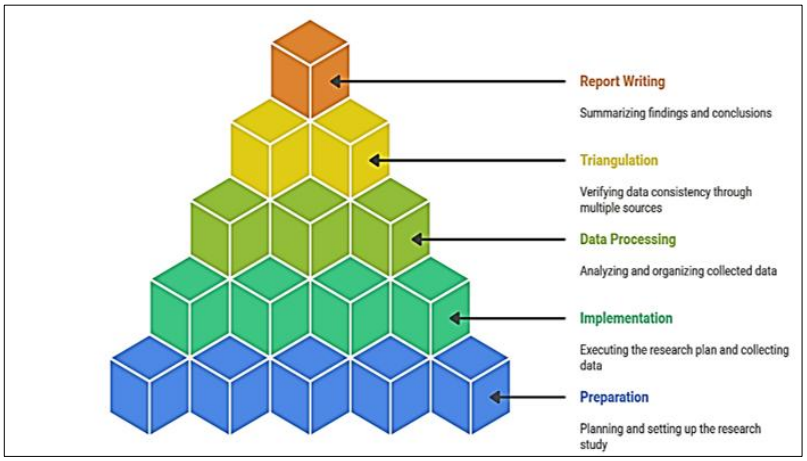

Figure 1. procedure in this research

Figure 1 presents the overall research procedure followed in this study. The process began with preparation activities, which included planning the study and developing research instruments. This was followed by the implementation phase, where data collection was carried out through observations, interviews, and document analysis. The data processing stage involved organizing and analyzing the collected information using thematic analysis. Triangulation was conducted to validate data consistency across multiple sources, thereby enhancing the credibility of the findings. Finally, the research concluded with the report writing phase, where key insights were synthesized and presented. This structured approach ensured a rigorous and systematic exploration of mathematics instructional management in a border-region vocational school.

RESULTS AND DISCUSSION

Results

The analysis of data collected through classroom observations, interviews, and document analysis revealed several key patterns in the management of mathematics instruction at SMKN 1 Entikong. The findings indicate that teaching practices remain predominantly teacher-centered, with limited student engagement and minimal use of contextual or vocationally integrated methods. There is a noticeable disconnect between curriculum expectations and classroom implementation, and assessment practices continue to focus largely on cognitive outcomes. To provide a clear overview of these findings, the initial coding process was used to derive key themes from the data. These themes capture the core challenges and instructional dynamics observed during the study.

This figure presents six key themes identified through the coding process, illustrating the main challenges and patterns in the management of mathematics instruction at the research site.

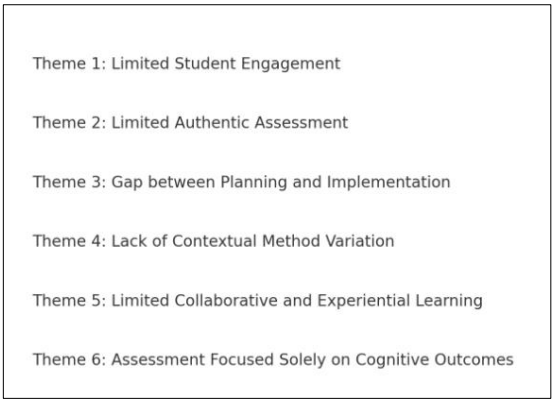

Figure 2. Initial Coding Themes of Mathematics Instruction

In addition to thematic analysis, triangulation of data sources was conducted to ensure the credibility and validity of the findings. Figure 3 summarizes how key findings were supported across observations, interviews, and document analysis.

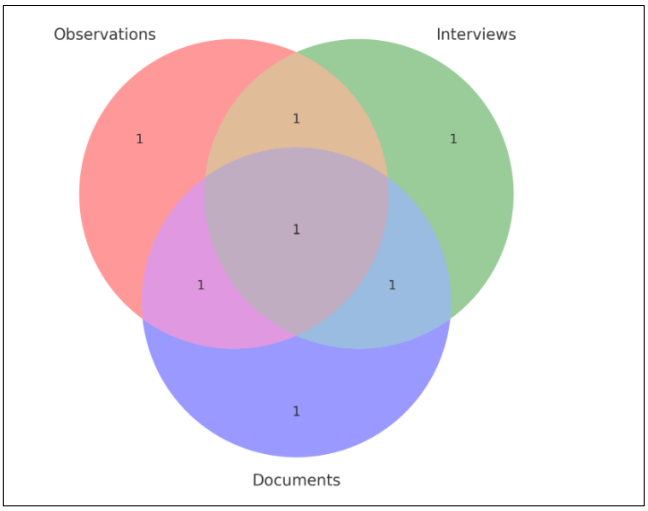

Figure 3. Data Triangulation across Data Sources

This Venn diagram illustrates the overlap of findings across different data sources. Consistent patterns such as teacher-centered instruction, gaps between planned and actual instructional delivery, and limited authentic feedback were corroborated across observations, interviews, and documents. The triangulation process reinforced that while individual teachers made efforts to engage students and contextualize learning, systemic barriers—such as limited resources, high teaching loads, and lack of institutional support—constrained their ability to implement more student-centered and vocationally relevant instructional practices. Furthermore, assessment methods remained largely traditional, failing to capture students' affective and vocational competencies.

Discussion

This study contributes valuable insights into the instructional management of mathematics at a vocational school located in a border region. The predominance of teacher-centered instructional methods was clearly observed in classroom practices at SMKN 1 Entikong. This finding is consistent with Hughes (2025), who asserts that systemic and resource limitations in marginalized educational settings often sustain traditional teaching approaches. Despite national reforms promoting student-centered learning, entrenched institutional cultures and limited professional support continue to reinforce conventional pedagogy. Teachers reported that their instructional choices were shaped by curricular demands and resource constraints. Such conditions make it difficult to implement

innovative teaching methods that engage students actively. Addressing these barriers requires systemic change and targeted teacher support. Assessment practices in the school were similarly traditional, focusing primarily on written tests that evaluate cognitive skills. Ogut (2025) highlights that such assessments overlook vocational competencies, critical thinking, and problem-solving abilities essential in applied mathematics learning.

Teachers acknowledged the limitations of current assessment strategies but cited lack of training and institutional support as barriers to change. Moreover, existing assessments do not adequately reflect the competencies emphasized in the Merdeka Curriculum. Students expressed that mathematics assessments often felt disconnected from their vocational studies. The absence of authentic assessment practices undermines opportunities for applied learning. Moving forward, the integration of authentic assessments aligned with vocational competencies should be prioritized. A clear gap between curricular aspirations and classroom realities emerged from the findings. Teachers struggled to contextualize mathematics instruction in ways that aligned with students' vocational pathways. Robinson et al. (2025) argues that without sufficient operational guidance and resources, curriculum reforms fail to drive meaningful change in classroom practices. Teachers at SMKN 1 Entikong often relied on textbook-driven instruction due to a lack of contextual teaching materials. While the Merdeka Curriculum promotes flexible, adaptive learning, its practical implementation remains inconsistent. Institutional support structures must be strengthened to bridge this policy-practice gap. Providing teachers with concrete examples of contextualized instruction could enhance implementation fidelity.

Language and cultural diversity also influenced mathematics learning outcomes. Many students speak local dialects or indigenous languages, creating challenges for standardized mathematics instruction. Salloum et al. (2025) emphasize the importance of linguistically responsive pedagogy in addressing such challenges. Teachers reported that language barriers contributed to student disengagement and misunderstanding of mathematical concepts. Efforts to incorporate local language support within instruction were limited. Beroíza-Valenzuela (2025) stresses that failing to address linguistic diversity can exacerbate educational inequities. Developing instructional materials and strategies that embrace linguistic diversity is essential. Such efforts would promote more inclusive and equitable learning experiences. Limited collaboration between mathematics and vocational subject teachers was another key finding. Mathematics instruction remained isolated, with minimal integration into vocational learning contexts. Gonzales et al. (2025) advocate for integrated STEAM approaches to enhance instructional relevance and student engagement. However, institutional silos and scheduling constraints hinder cross-disciplinary collaboration. Teachers expressed a desire for greater coordination with vocational departments but lacked structured opportunities to do so. Saldivar et al. (2025) similarly highlight that institutional support is critical for fostering collaboration. Without systemic encouragement for interdisciplinary planning, mathematics instruction risks remaining disconnected from vocational realities. Addressing these structural barriers is crucial for meaningful instructional integration. The study also revealed limited integration of adaptive technologies in mathematics instruction. Naseer & Khawaja (2025) demonstrates that AI-based learning tools can enhance differentiated instruction and support diverse learners. At SMKN 1 Entikong, such tools were largely absent due to infrastructural constraints and limited teacher familiarity. Teachers expressed interest in using technology to personalize instruction but cited lack of training and technical support. Joshi et al. (2025) argue that digital resources can play a transformative role in mathematics education. Bridging the digital divide is therefore a pressing priority for promoting equitable learning opportunities.

Investments in infrastructure and teacher capacity-building are essential. Doing so would empower teachers to harness technology effectively in their practice. Student engagement in

mathematics lessons was uneven, with active participation largely limited to a small group of students. Master et al. (2025), Tang, D., Meltzoff, A.N., and Cheryan, S. (2025) highlight that classroom climate and perceptions of subject relevance significantly influence student engagement in STEM education. At SMKN 1 Entikong, students reported that mathematics often felt abstract and disconnected from their vocational interests. Teachers noted that lack of contextual relevance contributed to disengagement. Efforts to link mathematical concepts with vocational applications were sporadic. Incorporating real-world problem-solving activities could enhance student motivation. Creating a more inclusive and relevant learning environment remains a critical goal. Institutional barriers further constrained instructional innovation. Teachers faced high workloads, limited access to contextual teaching materials, and scarce opportunities for professional development. Huffaker et al. (2025) underscores that flexible curriculum pathways and robust professional support are essential for fostering instructional innovation. At SMKN 1 Entikong, opportunities for peer collaboration and professional learning were limited. Teachers expressed a need for ongoing training in contextualized instruction and authentic assessment. Building a strong professional learning community could help address these gaps. Such efforts would support teachers in refining and expanding their instructional practices.

Despite systemic challenges, examples of teacher agency and innovation were observed. Some educators demonstrated strong commitment to contextualizing mathematics instruction and enhancing student engagement. Saldivar (2025) emphasizes that fostering teacher leadership is critical for driving instructional change in resource-constrained contexts. At SMKN 1 Entikong, teacher-led initiatives included integrating local examples and promoting active learning. However, such efforts were largely individual and lacked institutional recognition. Supporting teacher leadership through formal structures and incentives could amplify these initiatives. Encouraging a culture of innovation would further strengthen instructional quality. Institutional culture also shaped instructional dynamics. The absence of structured collaboration between academic and vocational departments limited opportunities for interdisciplinary learning. Li, M. (2025) argues that overcoming institutional silos is essential for promoting effective STEAM integration. Teachers highlighted that scheduling constraints and administrative priorities often impeded collaborative planning. Addressing these barriers requires intentional leadership and systemic reform. Establishing regular opportunities for interdisciplinary collaboration could enhance instructional coherence. Doing so would better align mathematics instruction with vocational learning objectives. Digital equity remains a pressing concern for mathematics education in border-region schools. Students at SMKN 1 Entikong had limited access to technology, constraining opportunities for innovative and interactive learning. Quesel et al. (2025) and Meng et al. (2025) document that spatial and systemic inequities contribute to persistent digital divides in marginalized educational contexts. Teachers expressed frustration with the lack of digital resources and infrastructure. Addressing these inequities requires coordinated investments at multiple levels. Ensuring equitable access to technology is fundamental for fostering inclusive mathematics learning. Such efforts would support the development of 21st-century skills among all students. Gender dynamics in mathematics learning also warrant attention. Master et al. (2025) underscore that stereotypes and classroom interactions can influence students' confidence and engagement in mathematics. At SMKN 1 Entikong, teachers observed gender differences in participation and performance. Addressing these dynamics requires creating an inclusive classroom climate.

Promoting gender-responsive teaching strategies is critical. Providing professional development on equity and inclusion can support teachers in this effort. Fostering a supportive learning environment will benefit all students. The study also highlighted the importance of fostering a growth mindset among students. Beroíza-Valenzuela (2025) emphasizes that promoting growth-oriented beliefs can enhance student resilience and motivation. Teachers reported that students

often lacked confidence in their mathematical abilities. Integrating strategies that build mathematical self-efficacy could support student learning. Encouraging positive learning dispositions is an essential component of effective instruction. Professional development in growth mindset strategies would be valuable. Embedding such practices within mathematics instruction can promote greater student success. In conclusion, this study reinforces the importance of equity-driven and contextually responsive approaches to mathematics instruction in vocational education. Bridging the gap between national policy aspirations and classroom realities remains a critical challenge. Hughes (2025) and Johnston & Brewer (2025) assert that advancing inclusive, adaptive, and collaborative pedagogies is essential for ensuring that all students have access to meaningful mathematics learning opportunities. Addressing systemic and institutional barriers is fundamental to achieving this goal. Supporting teacher leadership, fostering interdisciplinary collaboration, and promoting digital equity are key priorities. Ongoing research and policy efforts must continue to address these complex challenges. Doing so will enhance the quality and equity of mathematics education for vocational learners in border-region schools.

Implication

The outcomes of this study offer valuable insights for improving mathematics instruction in vocational schools, particularly those located in border regions. The evident disconnect between curriculum reform aspirations and classroom realities suggests an urgent need for more operational and context-sensitive support for teachers. Developing and disseminating practical models of contextualized instruction, aligned with vocational competencies, can aid in bridging this gap. Strengthening institutional mechanisms to foster regular collaboration between academic and vocational subject teachers is equally important, enabling mathematics instruction to be more integrated and relevant to students' vocational pathways. Additionally, ensuring equitable access to digital tools and infrastructure is essential to enhance the quality and inclusiveness of mathematics learning experiences. Investments in both technological infrastructure and teacher capacity-building are required to fully realize the potential of digital learning. Finally, promoting teacher leadership and cultivating professional learning communities can drive sustainable instructional innovation. Such efforts are critical to advancing equity and quality in mathematics education for vocational learners in marginalized and under-resourced educational contexts.

Limitations

While this study provides important insights into mathematics instructional management in a border-region vocational school, certain limitations should be acknowledged. The study was conducted in a single institutional setting, which may constrain the generalizability of its findings across diverse vocational schools in other regions or countries. Moreover, the qualitative case study approach adopted, while enabling deep contextual understanding, does not allow for the establishment of causal relationships. The reliance on qualitative data sources, particularly interviews and observations, may also be subject to biases, including social desirability and researcher interpretation. Additionally, the study did not directly measure student learning outcomes, focusing instead on instructional practices and management. Finally, the perspectives of broader stakeholders, such as policymakers, industry partners, and parents, were not incorporated, which could provide valuable complementary insights. Addressing these limitations in future research would further enrich understanding of effective instructional management in vocational mathematics education.

Suggestions

Based on the findings of this research, several avenues for future inquiry and practice enhancement are recommended. Expanding research to encompass a larger and more diverse sample of vocational schools across multiple border regions would offer a more comprehensive understanding of instructional management dynamics. Longitudinal studies examining the impact of

targeted professional development programs on instructional practices and student outcomes in vocational mathematics would provide valuable evidence for guiding teacher training efforts. Furthermore, exploring effective models of cross-disciplinary collaboration between mathematics and vocational subject teachers could inform institutional strategies to enhance instructional integration. Research into the adoption and effective utilization of adaptive technologies and AI-driven instructional supports in vocational contexts is also warranted, particularly in under-resourced settings. Finally, further investigation into students' experiences—especially regarding language diversity, gender dynamics, and perceptions of instructional relevance—can inform the design of more inclusive and responsive mathematics teaching practices. Advancing research in these areas is essential to support equitable and effective mathematics education for vocational learners in border-region schools.

CONCLUSION

This study offers meaningful insights into the instructional management of mathematics within the context of a vocational school situated in a border region. The findings highlight persistent challenges, including the predominance of teacher-centered instruction, limited cross-disciplinary collaboration, and insufficient integration of adaptive technologies, all of which hinder efforts to deliver mathematics instruction that is both contextually relevant and vocationally meaningful. Furthermore, systemic and institutional barriers continue to constrain teachers' ability to fully implement curriculum reforms and foster inclusive and engaging learning environments. Addressing these challenges requires targeted support at multiple levels, including the development of practical instructional models, investment in digital infrastructure, and the promotion of teacher leadership and professional learning communities. Equally important is the need for fostering collaborative institutional cultures that enable mathematics instruction to be better integrated with vocational learning pathways. By advancing equity-driven and contextually responsive approaches, stakeholders can significantly enhance mathematics learning opportunities for vocational students in marginalized and under-resourced educational settings. Continued research and policy engagement are essential to sustain progress toward this goal and ensure that mathematics education contributes meaningfully to the aspirations and futures of vocational learners in border-region schools.

AUTHOR CONTRIBUTIONS STATEMENT

Mohamad Rif'at led the conceptualization of the study, designed the research framework, and coordinated the overall research process and manuscript preparation.
Sudiansyah contributed to the development of the research questions, conducted thematic data analysis, and provided critical input on the interpretation of findings.
Soleh Khalimi designed the methodological approach, developed the data collection instruments, and conducted field observations.
Anugrah Kurniawati contributed to the qualitative data analysis, participated in the validation of findings, and assisted in drafting the manuscript.
Dwita Roma) prepared the research instruments, contributed to data collection, and assisted in refining the final version of the manuscript.

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