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A Systematic Review of Pedagogical Challenges in Mathematics Instruction in Geographically Isolated and Disadvantaged Areas (GIDA) Schools

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ABSTRACT

Research on mathematics instruction in Geographically Isolated and Disadvantaged Areas (GIDA) remains fragmented, as studies tend to examine single barriers, treat rural education generally, or focus on primary-level and multigrade settings. This systematic review offers an integrated, mathematics-specific synthesis of pedagogical challenges at the secondary level in GIDA, rural, remote, and disadvantaged schools. Following PRISMA 2020, we searched Google Scholar for peer-reviewed, English-language empirical studies; after screening and eligibility checks ([n] records identified, [n] screened, [n] excluded), eleven studies published between 2021 and 2025 were analysed using content analysis. Seven were from South Africa, and one each from the Philippines, Zambia, Ghana, and an international sample; seven were qualitative, three mixed-methods, and one quantitative. Four themes emerged. Resource scarcity and chronic underfunding narrowed teachers' pedagogical repertoires to procedural, teacher-centred instruction and weakened curriculum implementation and assessment. Teacher underqualification, professional isolation, and deficit beliefs about rural learners reinforced these limits, while poverty and digital exclusion widened learning gaps; for instance, over 56% of Zambian secondary students lacked adequate ICT, electricity, or internet access during COVID-19 school closures. Despite these constraints, teachers sustained learning through contextualised instruction, cooperative learning, and peer consultation. The review shows that these challenges are strikingly similar across countries and that material deprivation and narrowed pedagogical thinking reinforce each other, so resource investment alone is unlikely to suffice; the evidence points to sustained investment in infrastructure, teacher preparation, and technology access, alongside community-responsive professional support. These conclusions are tempered by limitations: the corpus is small and drawn from a single database, dominated by South African and largely qualitative studies, with only one Philippine study, and learning outcomes were rarely measured, so claims about intervention effectiveness remain tentative.

INTRODUCTION

Quality mathematics education is widely recognized as foundational to individual academic success, national economic development, and the cultivation of critical reasoning skills across all levels of schooling (Naidoo, 2025). However, the equitable provision of mathematics instruction remains one of the most persistent and unresolved challenges in education systems globally, particularly in communities that are geographically remote, economically marginalized, and structurally underserved. In the Philippine context, these communities are formally designated as Geographically Isolated and Disadvantaged Areas (GIDA), localities physically and socioeconomically separated from the mainstream society due to distance, difficult terrain, limited transportation, high poverty incidence, and the presence of vulnerable population groups (Department of Health, 2020). Within these settings, the delivery of effective mathematics instruction is severely constrained by a convergence of pedagogical, infrastructural, and contextual barriers that collectively undermine both teaching quality and student learning outcomes.

Pedagogical challenges in mathematics instruction are

inherently complex, encompassing not only the content demands of the discipline but also the instructional strategies, classroom management approaches, and assessment practices that teachers must navigate in resource-limited environments. Structural challenges in isolated and rural educational contexts persistently limit the full pedagogical potential of mathematics teaching: the scarcity of human and material resources, limited subject-specific teacher training, and the workload involved in simultaneously serving students with different levels of curricular competence remain critical issues across many countries. In the Philippine setting, these challenges are further compounded by the prevalence of multigrade teaching arrangements, classrooms in which a single teacher simultaneously instructs students across two or more grade levels, a common feature of GIDA schools where student enrollment is too low to justify grade-level sectioning. Research involving multigrade teachers in rural Philippine schools has found that educators experience challenges to a moderate to significant extent, particularly in managing diverse learners, handling increased workloads, and coping with limited instructional materials.

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The consequences of these pedagogical challenges are measurable in student learning outcomes. Across international contexts, rural and geographically isolated students consistently underperform in mathematics relative to their urban counterparts, a disparity attributable not only to socioeconomic disadvantage but to differential access to qualified teachers, advanced course offerings, and adequate instructional resources (Naidoo, 2025; Recla & Potane, 2023). Teachers in rural contexts encounter unique challenges when integrating effective pedagogy, including difficulties arising from inadequate and unstable internet connectivity, outdated or nonexistent infrastructure, and budget constraints that affect the procurement and maintenance of educational tools, all of which widen the gap in instructional quality between urban and rural schools. For mathematics teachers specifically, these barriers restrict the adoption of innovative, inquiry-based, and technology-enhanced pedagogical approaches that are increasingly recognized as essential for fostering deep conceptual understanding and numeracy proficiency. Despite growing awareness of these challenges, the existing body of literature on mathematics instruction in GIDA and comparably isolated school contexts remains fragmented. Studies have tended to address specific barriers in isolation, such as teacher preparation deficits, resource shortages, or multigrade class management, without providing an integrated synthesis of the pedagogical challenges as a unified phenomenon. Furthermore, much of the available literature focuses on general rural education concerns without sufficiently centering the discipline-specific difficulties of mathematics instruction, or on primary rather than secondary education levels. A systematic review that consolidates existing empirical evidence and maps the full landscape of pedagogical challenges in mathematics instruction in GIDA schools is therefore both timely and necessary.

This systematic review addresses this gap by synthesizing peer-reviewed empirical studies published between 2020 and 2026 that examine pedagogical challenges in mathematics instruction in GIDA, remote, rural, and underserved school contexts. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Page *et al.*, 2021), this review is guided by five research questions: (1) What pedagogical challenges are encountered in mathematics instruction in GIDA schools? (2) What factors contribute to these pedagogical challenges? (3) How do these challenges affect mathematics teaching and student learning? (4) What strategies or interventions have been implemented to address these challenges? and (5) What themes and trends emerge from the reviewed studies? By providing a comprehensive, evidence-based synthesis, this review aims to equip educators, curriculum developers, and policymakers with the knowledge needed to design targeted, context-responsive interventions that can meaningfully improve the quality and equity of mathematics education in geographically isolated and disadvantaged communities.

LITERATURE REVIEW

Quality mathematics education is broadly recognized as a cornerstone of individual academic development and national economic progress, providing students with the critical reasoning, problem-solving, and quantitative literacy skills essential for participation in contemporary society (Naidoo, 2025). Yet the equitable provision of mathematics instruction remains one of the most persistently unresolved challenges in global education systems, particularly in communities that are geographically remote, economically marginalized, and institutionally underserved. In the Philippine context, such communities are formally classified as Geographically Isolated and Disadvantaged Areas (GIDAs), localities characterized by physical separation due to distance, difficult terrain, and limited transportation, compounded by high poverty incidence and the presence of vulnerable populations (Department of Health, 2020). In these settings, the delivery of effective mathematics instruction is systematically constrained by a convergence of pedagogical, infrastructural, and contextual barriers that compound one another and collectively undermine both teaching quality and student numeracy development.

Constructivist theories of learning, which emphasize the active construction of mathematical knowledge through exploration, problem-solving, dialogue, and meaningful engagement with mathematical concepts, provide the foundational theoretical basis for contemporary mathematics pedagogy (Vygotsky, 1978, as cited in Subramaniam, 2024). However, enacting constructivist mathematics instruction presupposes conditions, qualified teachers, adequate instructional materials, collaborative learning environments, and reliable technological resources — that are precisely those most absent in GIDA and similarly isolated school contexts. This disjunction between aspirational pedagogy and material reality defines the core challenge that this literature addresses.

The pedagogical challenges encountered by mathematics teachers in geographically isolated and disadvantaged schools are multidimensional, spanning content knowledge deficits, instructional strategy limitations, classroom management complexity, and assessment constraints. Naidoo (2025), in a mixed-methods study involving 28 mathematics teachers in rural schools in KwaZulu-Natal, South Africa, found that teachers encountered significant difficulties in integrating digital pedagogy into mathematics instruction, with challenges related to inadequate infrastructure, limited professional training, and negative perceptions of technology adoption. These teachers reported that the structural conditions of their schools, unreliable internet, absence of devices, and lack of technical support, fundamentally constrained their capacity to implement innovative, student-centered mathematics pedagogies, forcing continued reliance on rote-based, teacher-directed approaches that limit conceptual understanding.

A particularly prominent feature of mathematics

instruction in GIDA and rural schools is the prevalence of multigrade classroom arrangements, in which a single teacher simultaneously instructs students across two or more grade levels. Ares-Ferreirós *et al.* (2025), in a PRISMA-guided systematic review of forty international studies on multigrade teaching, identified that the organizational and pedagogical demands of multigrade classrooms create distinct instructional challenges: teachers must develop differentiated lesson plans, apply flexible grouping strategies, and manage widely varying levels of student competence within a single instructional session. These demands are consistently found to overwhelm teachers who lack specialized training, with teachers reporting that the preparation burden, including multi-level lesson planning and the production of differentiated instructional materials, often from personal funds, significantly impairs the quality of mathematics instruction they can deliver (Bunglay & Cutab, 2025). In the Philippine context specifically, Recla and Potane (2023), synthesizing studies on multigrade teaching through a systematic review, found that teachers experienced challenges to a moderate to significant extent, particularly in managing diverse learner needs, handling increased workloads, and coping with a severe scarcity of instructional materials, conditions that directly constrain the quality of mathematics instruction in GIDA schools. Beyond multigrade complexity, pedagogical challenges in mathematics instruction in isolated settings are also shaped by teachers' own content knowledge and pedagogical preparation. Research consistently shows that mathematics teachers in rural and underserved schools often lack advanced pedagogical skills and subject-matter expertise, limiting their capacity to design engaging lessons, address student misconceptions, and employ differentiated instructional strategies (Narh-Kert *et al.*, 2021, as cited in Owusu-Ansah *et al.*, 2025). Ingersoll and Tran (2023) identify out-of-field teaching, where teachers without mathematics-specific certification are assigned to teach mathematics, as a particular problem in rural schools, driven by persistent teacher shortages that are more acute in geographically isolated communities than in urban counterparts.

Multiple interacting factors contribute to the pedagogical challenges in mathematics instruction in GIDA and rural schools, spanning teacher-related, resource-related, institutional, and socioeconomic dimensions. Subramaniam (2024), using multilevel analysis of TIMSS data from Malaysian secondary schools, found that school-level factors, including the availability of qualified teachers, instructional resources, and school infrastructure, had a stronger relationship with mathematics achievement disparities between rural and urban schools than student-level factors alone, underscoring the systemic character of the problem. This finding resonates with broader comparative evidence: PISA 2022 results indicate that rural students across OECD countries consistently score lower than their urban counterparts in mathematics, with the gap attributable not solely to student background but

significantly to differential school resource conditions (OECD, 2023, as cited in Theron *et al.*, 2025).

Teacher shortages constitute one of the most consequential contributing factors. The scarcity of mathematics-qualified teachers in rural and GIDA schools forces school systems to deploy non-specialist teachers into mathematics classrooms, depressing both pedagogical quality and instructional confidence (Ingersoll & Tran, 2023). Compounding this, limited access to professional development perpetuates existing knowledge deficits. Professional development for mathematics teachers in rural areas is consistently constrained by geographic isolation, logistical barriers, and insufficient institutional funding, leaving teachers unable to update their instructional repertoire or build the knowledge for teaching that research identifies as central to mathematics learning outcomes (Hattie *et al.*, 2022, as cited in Lynch *et al.*, 2025).

Resource limitations represent a second major contributing factor. The inequitable distribution of instructional materials such as textbooks, manipulatives, and technology tools, places GIDA mathematics teachers at a structural disadvantage. Li (2024), surveying 366 mathematics teachers across urban and rural schools in China, found that rural teachers exhibited significantly lower Technological Pedagogical Content Knowledge (TPACK) proficiency and less favorable attitudes toward technology integration than their urban counterparts, a disparity rooted primarily in differential access to devices, connectivity, and professional learning opportunities. This urban-rural TPACK divide has direct consequences for mathematics pedagogy: teachers who lack competence and confidence in technology integration are less able to leverage digital tools, including dynamic mathematics software, virtual manipulatives, and adaptive learning platforms, that have been shown to enhance mathematical conceptual understanding.

Socioeconomic and community factors further shape instructional conditions. Students in GIDA schools frequently arrive at mathematics lessons with weak foundational numeracy skills, a result of prior exposure to low-quality instruction, irregular school attendance, and home environments with limited educational support (Owusu-Ansah *et al.*, 2025). Teachers must therefore navigate the dual challenge of addressing knowledge gaps from previous grade levels while simultaneously advancing grade-level curriculum objectives, a challenge that is intensified in multigrade arrangements where these gaps span multiple years of expected learning.

The cumulative effects of these pedagogical challenges on mathematics teaching quality and student outcomes are well documented across diverse national contexts. Subramaniam (2024) found that eighth-grade rural students in Malaysia consistently underperformed in mathematics relative to urban peers across multiple TIMSS cycles, with the achievement gap widening in recent years, linked to increasing reliance on socioeconomic and attitudinal factors that disadvantage

rural learners. Denton *et al.*(2025), analyzing urban-rural educational disparities in England, found a persistent negative association between attending rural schools and mathematics achievement even after controlling for contextual variables, challenging earlier assumptions that the urban-rural achievement gap had been substantially closed.

For teachers, the compounding burden of pedagogical challenges in isolated settings affects not only instructional quality but also professional morale and retention. Naidoo (2025) found that mathematics teachers in rural South African schools expressed frustration and a sense of professional inadequacy when confronted with the gap between the technology-integrated pedagogical approaches promoted in preservice training and the resource-deprived realities of their classroom contexts. This experience of professional dissonance, being expected to teach in ways that one's school environment does not support, contributes to the documented pattern of higher teacher turnover in rural and isolated schools, creating a cyclical deterioration of mathematics instructional quality (Ingersoll & Tran, 2023).

For students, inadequate mathematics instruction in GIDA settings translates into widened numeracy gaps that constrain future academic and occupational opportunities. Students from rural and geographically isolated communities are less likely to access advanced mathematics courses, less likely to meet minimum proficiency standards in international assessments, and less likely to pursue mathematics-intensive tertiary programs, trajectories that reproduce cycles of socioeconomic disadvantage across generations (Lee & LaHaye, 2024).

Despite the severity and persistence of these challenges, the literature identifies a range of strategies and interventions that have demonstrated potential to improve mathematics instruction in rural and underserved school contexts. Professional development emerges as the most consistently supported lever for improving instructional quality. Lynch *et al.*(2025), in a meta-analysis of experimental evidence on mathematics professional development interventions, found that well-designed programs, characterized by sustained duration, content-specificity, alignment with teaching practice, and opportunities for collaborative reflection, significantly improved teachers' mathematical knowledge for teaching and produced measurable gains in student achievement. Critically, however, such programs must be designed with the contextual realities of rural and isolated teachers in mind: one-size-fits-all, urban-centered programs have been shown to be largely ineffective without adaptation to the specific curricular demands, resource constraints, and professional isolation characteristic of GIDA and rural teaching environments.

Multigrade-specific pedagogical strategies have also been developed and evaluated. Ares-Ferreirós *et al.*(2025) identified that structured differentiated instruction, cooperative learning, peer tutoring, and project-based approaches were among the most effective pedagogical adaptations in multigrade classrooms, enabling teachers

to engage students at different levels of competence simultaneously while maintaining curriculum coverage. In the Philippines, Bunglay and Cutab (2025) found that multigrade teachers in rural settings reported meaningful success with adaptive peer-led activities and community-based problem-solving tasks that leveraged students' local cultural contexts to make mathematics meaningful, a locally grounded form of contextual teaching that aligns with place-based learning approaches documented in international literature.

Technology-mediated interventions, when implemented with adequate infrastructure and training, have further shown promise. Naidoo (2025) found that rural mathematics teachers who received structured support in digital pedagogy integration, framed through the Substitution, Augmentation, Modification, and Redefinition (SAMR) model, were able to meaningfully enhance student engagement and mathematical exploration through the deliberate use of digital tools, even within constrained resource environments. Broader evidence from rural school-university partnership models and contextualized professional development programs reinforces the finding that sustained, pedagogically-grounded support is more effective than isolated training events in producing durable improvements in mathematics instructional quality in isolated school contexts (Lynch *et al.*, 2025; Hattie *et al.*, as cited in Theron *et al.*, 2025).

Synthesizing across the reviewed literature, several dominant themes emerge. First, the pedagogical challenges in mathematics instruction in GIDA and rural schools are systemic rather than individual, reflecting structural inequities in resource distribution, teacher preparation, and institutional support rather than failures of individual teacher effort or capability. Second, multigrade instruction is a defining feature of mathematics education in geographically isolated Philippine schools that amplifies all other pedagogical challenges, warranting dedicated research attention. Third, the urban-rural digital divide in TPACK competency and technology access represents a growing dimension of pedagogical inequality that current policy frameworks have yet to adequately address. Fourth, interventions that are most effective tend to be contextualized, sustained, and grounded in the realities of rural and isolated teaching, rather than transplanted from urban educational contexts.

A critical gap in the existing literature is the relative scarcity of empirical studies that center specifically on mathematics instruction, as distinct from general rural education or STEM-wide concerns, in Philippine GIDA schools at the secondary level. This review addresses that gap and provides a synthesis foundation for future targeted research and intervention design in this underrepresented but educationally critical context.

MATERIALS AND METHODS

This study utilized the systematic literature review (SLR) method to synthesize existing literature on the pedagogical challenges encountered in mathematics instruction in Geographically Isolated and Disadvantaged Area (GIDA)

schools, including instructional barriers, teacher-related difficulties, resource limitations, and contextual factors affecting mathematics teaching and learning. The review procedure followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Page, 2021). Article selection was carried out according to the four major phases outlined in the PRISMA flowchart: identification, screening, assessment of eligibility, and final inclusion. In the identification stage, relevant literature was identified from the search engine Google Scholar using the search terms “mathematics teaching,” “math education,” “mathematics pedagogy,” “numeracy instruction,” “instructional barriers,” “teaching difficulties,” “classroom challenges,” “pedagogical issues,” “geographically isolated schools,” “disadvantaged schools,” “remote schools,” “rural schools,” “underserved schools,” “public schools,” “basic education,” “elementary schools,” and “secondary schools.” In the screening stage, the identified relevant literature was screened by selecting journal articles published between 2020 and 2026. In the eligibility stage, the selected journal articles were further screened by excluding studies that focused on non-mathematics subjects such as science-only or unrelated disciplines, were limited to urban school contexts without involvement of disadvantaged areas, were non-empirical sources, such as editorials, opinion papers, or blogs, contained duplicate entries, or focused solely on

curriculum policy or assessment without a pedagogical focus. In the inclusion stage, articles were included in the study if they were published between 2020 and 2026, addressed mathematics instructional or pedagogical challenges, were situated in GIDA, remote, rural, or underserved school contexts, involved mathematics teachers, students, or administrators as participants, were written in English, employed qualitative, quantitative, or mixed-methods designs, were at the secondary education level, and were available in full-text format. Studies that met the inclusion criteria were analyzed using content analysis.

RESULTS AND DISCUSSION

This section presents and analyzes findings synthesized from eleven peer-reviewed empirical studies published between 2021 and 2025, examining the pedagogical and instructional challenges confronting mathematics education in geographically isolated, rural, remote, and disadvantaged school settings. The studies span five geographic contexts, the Philippines, South Africa, Zambia, Ghana, and an international comparative setting, and employ qualitative, quantitative, and mixed-methods designs. Table 1 provides a structured overview of each included study. The discussion that follows is organized according to the five research questions guiding this review.

Table 1: Summary of Included Studies on Mathematics Education Challenges in GIDA and Rural Schools

Author/s (Year)	Country / Location / Setting	Field of Study (Level)	Method	Key Findings
Sionicio & Besmonte (2023)	Philippines (Bicol Region; remote and rural areas; n = 268 teachers)	Mathematics education (secondary)	Mixed methods (descriptive + thematic analysis)	Remote-area mathematics teachers faced challenges in assessing student learning, including poor quality of outputs, scarce materials and resources, weak feedback mechanisms, and logistical barriers to monitoring performance
Tibane, Mafa-Theledi, Masebe, & Peter (2024a)	South Africa (Gauteng; disadvantaged Community Learning Centres; n = 12 teachers)	Mathematics education (Grade 12 / secondary)	Qualitative (multiple case study; structured interviews)	Implementation of the Grade 12 Mathematics curriculum was hampered by resource constraints, inadequate instructional materials, and socioeconomic disparities; systemic underfunding of CLCs was a central barrier
Tibane, Mafa-Theledi, Masebe, & Peter (2024b)	South Africa (Gauteng; disadvantaged Community Learning Centres; n = 6 teachers, 3 CLCs)	Mathematics education (Grade 12 / secondary)	Qualitative (focus group discussions)	Resource inequality directly shaped the quality of mathematics teaching; teachers adapted instruction under materially uneven conditions; learner socioeconomic disadvantage compounded institutional resource scarcity
Mukuka, Shumba, & Mulenga (2021)	Zambia (Kitwe; under-resourced, remote-adjacent districts; n = 367 students)	Mathematics education (Grades 10–11 / secondary)	Mixed methods (descriptive survey)	Over 56% of students lacked adequate ICT, electricity, and internet during COVID-19 school closures; mathematics was perceived as best learned face-to-face; remote learning significantly disrupted mathematical comprehension and engagement

Mbhiza (2021)	South Africa (Acornhoek, Mpumalanga; rural secondary schools)	Mathematics education (Grade 10 / secondary)	Qualitative (case study; semi-structured interviews + classroom observations)	Rural mathematics teachers relied on limited pedagogical repertoires shaped by restricted access to digital tools and professional resources; commognitive analysis revealed discourses constrained by technological and material isolation
Mutsakisi <i>et al.</i> (2025)	South Africa (rural secondary schools)	Mathematics education (secondary)	Qualitative (interpretive)	Teachers' deficit perceptions of rural learners reinforced teacher-centred pedagogical approaches; rurality was framed as a limiting condition that constrained adoption of inquiry-based and culturally responsive mathematics instruction
Nkambule & Mbhiza (2022)	South Africa (North-West Province; rural secondary schools)	Mathematics education (secondary)	Quantitative (survey)	Effective mathematics teaching in rural schools was shaped by specific teacher attributes; barriers included lack of parental involvement, insufficient funding, resource shortages, and teacher underqualification
Dlamini & Rafiki (2022)	South Africa (rural schools)	Mathematics education (primary / foundational secondary-adjacent)	Qualitative (reflective practice + case study)	Rural mathematics teachers demonstrated evolving TPACK but were constrained by infrastructure limitations and technological knowledge gaps; sustained professional reflection enabled gradual technology integration
Yilmaz, Dede, Sears, & Nielsen (2021)	International (disadvantaged/underserved student populations; remote instruction; n = 9 teachers)	Mathematics education (secondary)	Qualitative (semi-structured interviews)	Equitable mathematics instruction during remote learning was undermined by disparities in resource access, student socioeconomic status, language barriers, and teachers' differing beliefs about reaching marginalized learners
Mdodana-Zide (2023)	South Africa (under-resourced rural schools)	Mathematics education (secondary)	Qualitative (interpretive)	Teachers employed background-based knowledge instruction and cooperative learning as adaptive strategies; these approaches sustained instructional engagement despite severe resource deficits
Gyan <i>et al.</i> (2025)	Ghana (rural and urban schools; comparative)	Mathematics education (primary–secondary)	Mixed methods (comparative)	Rural mathematics teachers faced acute professional isolation, language barriers, inadequate pedagogical resources, and poor infrastructure compared to urban counterparts; rural-urban disparities in teacher support were structurally embedded

Pedagogical Challenges Encountered in Mathematics Instruction in GIDA Schools?

The reviewed studies reveal a convergent and interrelated set of pedagogical challenges confronting mathematics instruction in geographically isolated and disadvantaged school contexts. These challenges operate at three primary levels: instructional delivery, assessment, and pedagogical orientation.

At the instructional delivery level, resource scarcity consistently constrained the pedagogical options available to mathematics teachers. Tibane *et al.*(2024a) found that mathematics teachers in Gauteng's Community Learning Centres were unable to implement the Grade 12 Mathematics curriculum as intended, due to shortages

of instructional materials and inadequate physical infrastructure. Mbhiza (2021) found that rural mathematics teachers in Acornhoek, Mpumalanga, operated within narrow pedagogical repertoires shaped by the absence of digital tools and professional resources — relying on chalk-and-talk and procedural demonstration rather than the interactive, inquiry-based approaches increasingly recommended in mathematics education reform. Gyan *et al.*(2025) confirmed this pattern comparatively, documenting that rural mathematics teachers across their Ghanaian sample were significantly more constrained in pedagogical variety than their urban counterparts. At the assessment level, Sionicio and Besmonte (2023) found that remote-area mathematics teachers in Bicol

Region, Philippines, reported specific difficulties with generating quality student outputs, providing timely and meaningful feedback, and monitoring individual student progress, challenges directly traceable to resource scarcity and logistical constraints that compromise the formative assessment cycle on which effective mathematics instruction depends.

At the level of pedagogical orientation, Mutsakisi *et al.*(2025) identified a particularly consequential challenge: the prevalence of deficit-framed teacher beliefs about rural learners. Teachers in their South African rural school sample characterized rural students as inherently limited by their socioeconomic and geographic circumstances, and these beliefs reinforced teacher-centred, transmission-based instructional approaches that limited learners' opportunities for mathematical reasoning, problem-solving, and inquiry. Nkambule and Mbhiza (2022) similarly found that teacher underqualification in rural North-West Province schools produced instruction that was pedagogically thin and poorly responsive to learners' needs.

Factors Contributing to Pedagogical Challenges in Mathematics Instruction

The pedagogical challenges identified in RQ1 are generated and sustained by interconnected structural, institutional, and socio-cultural factors operating at multiple levels.

Systemic underfunding is identified across multiple studies as the primary structural driver. Tibane *et al.*(2024a; 2024b) traced the material deprivation of disadvantaged South African CLCs directly to chronic institutional underfunding, noting that resource inequality between schools was not incidental but policy-embedded. Nkambule and Mbhiza (2022) identified insufficient government and school funding as a top-ranked barrier to effective rural mathematics teaching in North-West Province, a finding consistent with UNESCO and Teacher Task Force (2023) evidence that rural and remote schools in low- and middle-income countries are systematically underfunded relative to urban schools, generating the instructional material deficits documented across this review.

Geographic isolation compounds the effects of underfunding by generating professional isolation. Gyan *et al.*(2025) found that rural mathematics teachers in Ghana lacked access to collegial professional networks, collaborative planning opportunities, and the informal pedagogical exchanges that sustain teacher development in better-connected schools. This isolation was not merely social but epistemological: teachers in geographically peripheral settings were effectively cut off from the evolving discourses of mathematics education reform, limiting their exposure to inquiry-based and culturally responsive pedagogical approaches.

Inadequate teacher preparation constitutes a contributing factor at the institutional level. Dlamini and Rafiki (2022) found that rural mathematics teachers' technological

pedagogical knowledge was underdeveloped relative to the demands of contemporary mathematics instruction, reflecting pre-service and in-service preparation programs that failed to adequately address the technological and contextual realities of rural school placements. Mbhiza (2021) further identified that the professional discourses available to rural mathematics teachers were themselves constrained by the communicational norms of resource-limited environments, a self-reinforcing cycle in which underprepared teachers in under-resourced schools develop pedagogical habits that further entrench the very limitations they face.

Socioeconomic factors among learners add a further layer of challenge. Tibane *et al.*(2024b) and Yilmaz *et al.*(2021) both found that learner poverty, manifested in the absence of home study resources, household labor demands, inadequate nutrition, and limited parental educational support, compounded the effects of classroom-level deficits, creating a compounding disadvantage in which the most resource-deprived students were also the least able to compensate for institutional failures through private means. The COVID-19 pandemic amplified these dynamics acutely: Mukuka *et al.*(2021) found that over 56% of secondary students in under-resourced Zambian districts lacked the ICT infrastructure necessary for remote mathematics learning, and Yilmaz *et al.*(2021) documented teachers' awareness that pandemic-era remote instruction was deepening existing equity gaps for their most marginalized students.

Effects of Pedagogical Challenges in Mathematics Teaching and Student Learning

The challenges identified in the preceding sections carry documented and measurable consequences for both the quality of mathematics instruction and student learning outcomes.

At the instructional level, resource scarcity and pedagogical constraint force mathematics teachers into predominantly procedural, teacher-centred modes of delivery that are poorly aligned with contemporary mathematics education's emphasis on conceptual understanding, mathematical reasoning, and problem-solving. Mbhiza (2021) found that the pedagogical discourses of rural mathematics teachers were routinized and procedural, limiting learners' opportunities for mathematical inquiry. Mutsakisi *et al.*(2025) found that deficit teacher beliefs compounded this instructional narrowing by discouraging teachers from setting ambitious learning goals or employing exploratory approaches, effectively reducing the mathematical ceiling of what was taught and expected. Tibane *et al.*(2024a) documented that curriculum implementation fidelity in disadvantaged CLCs was significantly impaired, meaning that students were not receiving the full scope of the nationally intended Grade 12 Mathematics curriculum.

At the learner level, Mukuka *et al.*(2021) found that the combination of ICT deficits and the loss of face-to-face instruction during COVID-19 produced measurable

disruption to secondary students' mathematical comprehension, with learners unable to access the teacher-guided problem-solving and immediate feedback that are central to mathematics achievement. Sioncio and Besmonte (2023) found that remote-area students in Bicol Region demonstrated significantly poorer assessment performance and output quality than would be expected of learners receiving adequately resourced mathematics instruction, reflecting the cumulative effects of resource scarcity on learning outcomes over time.

Yilmaz *et al.* (2021) found that mathematics teachers serving disadvantaged populations during remote instruction observed widening performance gaps between their most and least resourced students, with learners from low-income, language-minority households experiencing the most severe disruption to their mathematical learning trajectories. These findings collectively evidence a pattern of compound educational disadvantage in which geographic isolation, poverty, resource scarcity, and pedagogical constraint interact to produce mathematics learning outcomes significantly below those of students in better-resourced settings.

Strategies or Interventions that Have Been Implemented to Address Pedagogical Challenges in Mathematics Instruction

Despite the breadth of the documented challenges, the reviewed literature reveals a consistent thread of teacher-level adaptive strategies that have partially mitigated the effects of structural deficits on mathematics instruction. Background-based and contextually grounded instruction is among the most documented adaptive approaches. Mdodana-Zide (2023) found that rural South African mathematics teachers employed background-based knowledge instruction, grounding mathematical content in learners lived community contexts and familiar cultural referents, as a strategy for making abstract mathematical concepts accessible without requiring costly manipulatives or technological support. This approach aligns with the principles of culturally relevant mathematics pedagogy, which positions community knowledge as a legitimate and rich resource for mathematical meaning-making.

Cooperative learning structures were similarly documented as effective adaptive strategies. Mdodana-Zide (2023) found that peer-mediated cooperative learning allowed rural mathematics teachers to sustain conceptual engagement and mathematical dialogue even in overcrowded, under-resourced classrooms, reducing dependence on teacher transmission and fostering the collaborative problem-solving central to mathematical proficiency. Gyan *et al.* (2025) documented analogous peer learning approaches among Ghanaian rural mathematics teachers, alongside cross-teacher professional collaboration as a partial compensatory response to professional isolation.

In the domain of technology integration, Dlamini and Rafiki (2022) found that rural mathematics teachers who engaged in sustained professional reflection developed

innovative approaches to TPACK-informed instruction using available — if limited — technological tools, demonstrating that pedagogical growth is possible under constrained conditions when teachers have structured support for professional learning. Sioncio and Besmonte (2023) documented that Filipino remote-area mathematics teachers developed peer consultation networks and shared improvised assessment tools to maintain feedback quality despite logistical and material constraints, reflecting a community-of-practice orientation in which collegial knowledge-sharing substitutes for formal professional development access.

Emerging Themes and Trends from the Reviewed Studies

Several overarching themes and trends emerge from the synthesis that have broader significance for mathematics education research and policy.

The first and most prominent theme is the global convergence of rural mathematics education challenges. Across five countries — the Philippines, South Africa, Zambia, Ghana, and beyond — the reviewed studies document a strikingly consistent set of pedagogical challenges: resource scarcity, teacher qualification deficits, professional isolation, technological exclusion, and socioeconomic vulnerability. This convergence confirms that the challenges of mathematics education in geographically isolated and disadvantaged schools are structurally embedded features of global educational inequality rather than nationally specific anomalies, and demands policy responses that recognize their systemic rather than incidental character.

A second theme concerns the alignment of material deprivation and epistemological deprivation. The reviewed studies, particularly Mutsakisi *et al.* (2025), Mbhiza (2021), and Mdodana-Zide (2023), reveal that material resource scarcity and narrowed pedagogical discourse are not merely parallel problems but mutually reinforcing ones. Teachers who work for extended periods in under-resourced environments develop professional habits, beliefs, and discourses that reflect and reproduce those constraints. Addressing rural mathematics education inequity therefore requires simultaneous attention to resource investment and to the professional beliefs, identities, and epistemological horizons of rural mathematics teachers.

A third trend concerns the digital divide and its amplification by COVID-19. While resource scarcity and teacher deficits have long been documented in rural education research, Mukuka *et al.* (2021) and Yilmaz *et al.* (2021) demonstrate that the pandemic brought into sharp relief the structural exclusion of GIDA-like schools from the digital infrastructure upon which contemporary mathematics education increasingly depends. Digital exclusion in mathematics education is consequential in ways that go beyond other subjects: mathematics relies on immediate feedback, iterative problem-solving, and visual representation, pedagogical processes that

low-connectivity remote learning environments are particularly ill-equipped to support.

A fourth trend is the gradual emergence of contextually grounded, community-responsive approaches to rural mathematics pedagogy, visible in the strategies documented by Mmodana-Zide (2023) and Gyan *et al.* (2025). These practitioner-driven innovations suggest a slow reorientation away from the failed model of delivering urban mathematics curricula unchanged into materially and culturally different rural settings, toward locally anchored approaches that position community contexts and learner knowledge as legitimate starting points for mathematical inquiry. This trend has significant implications for curriculum policy and mathematics teacher preparation in GIDA and remote school contexts.

CONCLUSION

This systematic review examined the pedagogical challenges affecting mathematics instruction in geographically isolated, rural, remote, and disadvantaged (GIDA) school settings across international contexts. Findings revealed that inadequate instructional resources, shortages of qualified mathematics teachers, limited technological infrastructure, insufficient professional development, and professional isolation are major barriers to effective mathematics instruction. These challenges restrict teachers' capacity to implement student-centered, inquiry-based, and technology-integrated approaches that promote conceptual understanding and mathematical reasoning. The review further found that multigrade classrooms, learner poverty, weak institutional support, and digital exclusion intensify instructional difficulties and contribute to disparities between rural and urban learners. The COVID-19 pandemic further exposed inequalities in access to internet connectivity, digital devices, and remote learning support. Despite these challenges, teachers demonstrated resilience through localized teaching strategies, cooperative learning, peer collaboration, and context-responsive practices. Overall, improving mathematics education in GIDA schools requires sustained and comprehensive interventions, including investment in infrastructure, teacher recruitment and retention, contextualized professional development, technological access, and curriculum support. Such measures are essential to strengthen instructional quality, improve learner outcomes, and promote greater educational equity in underserved communities.

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