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Pedagogical Strategies and Resource Utilization during Mathematics Instruction in Rural Schools. A Case Study on Schools in Sogbini Chiefdom-Bonthe District - Sierra Leone

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Abstract: ***This study investigates the challenges and opportunities of mathematics education in rural schools, focusing on pedagogical strategies, resource utilization, and teacher qualifications. Despite the critical role of mathematics in developing essential skills for societal participation, rural students often underperform due to limited access to qualified teachers, instructional resources, and infrastructural support. The research employs a mixed-methods approach across 20 rural schools, involving 40 teachers and 200 pupils. Findings reveal a predominantly male teaching workforce (75%) with most teachers having 5 to 7 years of experience, yet only 32.5% hold the Higher Teacher Certificate primary and 30% are untrained or unqualified, with no female teachers holding degrees. Student achievement improved significantly, with an average increase of 6.9 points from pre- to post-test scores ($p<0.001$), and attendance rates remained high at 92% for boys and 94% for girls. Classroom observations indicate many teachers need improvement in lesson planning, instructional skills, and classroom management, largely relying on traditional methods and underutilizing active pedagogies like inquiry-based learning and manipulatives. Resource shortages such as insufficient technological tools, online resources, and printed materials, further impede effective instruction. The findings highlight the urgent need for targeted professional development, resource investment, and contextually relevant pedagogical strategies to bridge educational disparities and improve mathematics learning outcomes in rural settings.***

Keywords: Rural schools, Pedagogical, Resource Utilization, Mathematics Instruction.

I. INTRODUCTION

Mathematics education is a fundamental component of the broader educational framework, serving as a critical skill set for students to participate effectively in a rapidly evolving, knowledge-based society (NRC, 2013). It promotes essential skills such as critical thinking, problem-solving, and analytical reasoning, which are vital for both individual development and societal advancement (Gordon et al., 2016). However, disparities in the quality of mathematics instruction between urban and rural schools remain a persistent challenge worldwide (OECD, 2019). Rural schools often face unique obstacles, including limited access to qualified teachers, inadequate instructional resources, and infrastructural deficits, all of which collectively hinder student achievement in

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mathematics (Adams et al., 2020; Bowers & Moyer, 2017; Lloyd & Milner, 2018; Holden & Swinney, 2017). Despite the recognized importance of mathematics education, rural schools frequently lag behind their urban counterparts in student performance. Addressing these disparities necessitates the identification and implementation of pedagogical approaches and resource strategies that are both effective and adaptable to the specific contexts of rural settings. Studies had indicated that effective pedagogical strategies tailored to the context of rural education can significantly enhance learning outcomes (Gordon & Choi, 2018). Pedagogical approaches such as inquiry-based learning, collaborative problem-solving, and the use of manipulatives have demonstrated efficacy in engaging students and deepening conceptual understanding (Hiebert & Grouws, 2007; Boaler, 2016). Moreover, integrating culturally relevant resources and locally contextualized examples can foster meaningful learning experiences that resonate with rural students' lived realities (Ladson-Billings, 1994; Ginsberg, 2019).

The availability and utilization of appropriate instructional resources are also pivotal in improving mathematics teaching quality. Digital technologies, including mobile learning applications and online repositories, have expanded access to high-quality instructional materials even in geographically isolated areas (Kozma, 2015; Warschauer, 2011). Teacher professional development programs focusing on pedagogical content knowledge and innovative instructional practices have shown promise in equipping rural teachers with the skills necessary to deliver effective mathematics instruction (Desimone & Garet, 2015; Darling-Hammond et al., 2017) Despite these insights, the implementation of effective pedagogical approaches in rural contexts often encounters barriers such as limited infrastructure, insufficient training opportunities, and socio-cultural factors (Kirkland et al., 2018; Sosa et al., 2020). Addressing these challenges requires a multifaceted strategy that combines contextually relevant pedagogical methods with resource enhancements and ongoing professional development.

This study aims to explore and synthesize evidence-based pedagogical strategies and resource utilization approaches that can enhance mathematics instruction in rural schools. By identifying effective practices and addressing contextual barriers, this work seeks to contribute to the ongoing efforts to bridge educational disparities and foster equitable mathematics learning opportunities for rural students.

II. LITERATURE REVIEW

This literature review explores recent research on pedagogical practices and instructional resources that have demonstrated success in improving mathematics instruction in rural schools. The review synthesizes findings across empirical studies, theoretical frameworks, and policy reports to identify common themes and promising strategies.

A. Challenges in Rural Mathematics Education

Research consistently highlights the multifaceted challenges faced by rural schools. These include insufficient instructional materials, limited access to technology, high teacher attrition, and professional development gaps (Gordon et al., 2016; Liu & Hwang, 2020). Such factors contribute to lower student achievement levels, particularly in foundational topics like fractions, algebra, and geometry (Huang & Wang, 2019). Moreover, students in rural settings often lack exposure to engaging, contextualized mathematics experiences, which are critical for fostering interest and deep understanding (Ladson-Billings, 1994; Sutherland & Brown, 2017).

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B. Effective Pedagogical Approaches

Embedding mathematics instruction within local cultural and community contexts enhances relevance and motivation (Ladson-Billings, 1994; Kirkland & Jackson, 2020). For instance, incorporating local stories, practices, or artifacts into lessons helps students see the practical application of mathematical concepts (Sutherland & Brown, 2017). Such approaches foster a sense of ownership and validate students' cultural identities. Inquiry-based learning (IBL) shifts the focus from passive reception to active exploration (Furtak et al., 2012; NRC, 2013). In rural classrooms, IBL has been associated with increased engagement, deeper understanding, and improved problem-solving skills (Miller et al., 2018). Teachers facilitating student-led investigations create more meaningful learning experiences, especially when guided by well-designed prompts and scaffolding. Use of manipulatives such as tile, rod and blocks, fraction bars, or locally available materials supports concrete understanding of abstract concepts (Carbonneau et al., 2013). Rural teachers employing low-cost manipulatives report higher student comprehension, particularly in topics like fractions, ratios, and geometry (Bakker et al., 2014). Visual aids further reinforce understanding and cater to diverse learning styles. Differentiated instruction adapts teaching to meet students' varying abilities, interests, and learning paces (Tomlinson, 2014). In rural contexts, where classroom sizes may be small but student needs diverse, differentiation enhances motivation and achievement (O'Connor & Fernandez, 2018). Strategies include flexible grouping, varied assessment methods, and personalized tasks.

C. Technological Resources and Innovations

Technological interventions tailored for infrastructural limitations such as offline-enabled tablets or preloaded content have expanded access to quality mathematics resources in remote areas (Bishop, 2019; Chigona & Chigona, 2020). These tools enable interactive learning experiences without requiring continuous internet connectivity. Blended learning models, combining traditional teaching with digital resources, have shown promise in rural settings by providing flexible, self-paced learning opportunities (Garrison & Kanuka, 2004; Graham et al., 2013). Open education resources (OER), adaptable learning materials, offer cost-effective solutions to resource scarcity (Wiley & Hilton, 2018). Rural teachers utilizing open education resources (OER), report increased instructional variety and student engagement, especially when materials are tailored to local contexts (Hilton, 2016).

D. Professional Development and Community Engagement

Ongoing professional development (PD) enhances teachers' pedagogical skills, content knowledge, and confidence (Desimone, 2009; Ingersoll & Strong, 2011). Mentorship programs, collaborative peer learning, and context-specific professional development sessions have demonstrated positive effects on instructional quality in rural schools (Garet et al., 2001). Engaging families and community stakeholders creates a supportive environment conducive to teach (Epstein, 2011). Community-based mathematics projects, family math nights, and local mentorship initiatives foster positive attitudes towards mathematics and increase student motivation (Mapp & Kuttner, 2013).

III. METHODOLOGY

A. Design, sample size and sampling

This study will adopt a mixed-methods research design, integrating both quantitative and qualitative approaches. The quantitative component will assess the impact of pedagogical approaches on student achievement, while the qualitative component will explore teachers' experiences, perceptions, and challenges.

This comprehensive approach allows for a nuanced understanding of effective practices in rural schools. The sample size comprises 20 rural schools, 40 mathematics teachers, and 200 pupils enrolled in these schools. A stratified random sampling method was used to select the 200 pupils, ensuring representation across different grades, genders, and achievement levels.

B. Data Collection Methods

Pre- and post-intervention assessments was administered to measure students' learning gains. These tests were aligned with the curriculum and validated for reliability and validity. Structured questionnaire was used to gather data on teachers' pedagogical practices, resource utilization, and perceptions of instructional effectiveness. Observation checklists will document instructional strategies, resource use, and student engagement during mathematics lessons. Semi-structured interviews with teachers explored their experiences, challenges, and perceptions regarding pedagogical approaches and resources. Focus Group Discussions (FGDs) with pupils was conducted to understand their perceptions of mathematics instruction and their level of engagement.

C. Data Analysis

The data analysis involved using descriptive statistics, such as means and frequencies, to summarize demographic data. Inferential statistics, including paired t-tests, were employed to compare pre- and post-test scores in order to assess the effectiveness of the pedagogical interventions. Correlation analysis was conducted to examine the relationships between resource utilization and student achievement. To gain deeper insights, thematic analysis was performed to identify patterns, themes, and insights related to pedagogical practices and resource challenges. Observation notes were also used to triangulate data and validate the finding

IV. RESULT

Table 1. Gender of teachers

Gender	Frequency	%
Male	30	75
Female	10	25
Total	40	100

Majority of teachers are male (75%), with only 25% being female.

Table 2. Teacher teaching years of experience by gender

Years of Experience	Male	Female	Total	%
>2	2	3	5	12.5
2-- 4	7	1	8	20
5-- 7	9	5	14	35
8-- 10	9	-	9	22.5
<10	3	1	4	10
Total	30	10	40	100

Most teachers have between 5 to 7 years of experience (35%), with a notable number having more than 8 years (22.5%). Females tend to have slightly less experience overall.

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Table 3. Teacher highest qualification by gender

Qualification	Male	Female	Total	%
Untrained and unqualified	10	2	12	30
Teacher Certificate	8	2	10	25
Higher Teacher Certificate primary	8	5	13	32.5
Higher teacher certificate Secondary	3	1	4	10
Degree	1	-	1	2.5
Total	30	10	40	100

The most common qualification is the Higher Teacher Certificate primary (32.5%), followed by untrained and unqualified teachers (30%). Only a small fraction holds degrees (2.5%), and no female teachers have degrees.

Table 4. Pupils age distribution by gender

Age interval (year)	Boys	Girls	Total	Mean	SD
Below 7	10	13	23	6.5	0.5
7 – 9	29	34	63	8	1
10 – 11	26	32	58	10.5	0.5
12 – 14	17	19	36	13	1
Above 14	7	13	20	15	0.5
Total	89	111	200	-	-

The pupils are spread across various age groups, with the majority between 7 and 11 years. The mean ages align with the typical age range for primary and early secondary education.

Table 5. Pupil's attendance Rate by Gender (100 days attendance report)

Gender	Number of Pupils	Mean Attendance rate (%)	Standard Deviation (%)
Boys	89	92	4.5
Girls	111	94	3.8
Total	200	93	4.2

Girls have a slightly higher average attendance (94%) compared to boys (92%), with both groups showing relatively high attendance rates.

Table 6. Pupil's distribution by level and gender

Age Interval	Boys	Girls	Total	%
Below 7 years	12	15	27	13.5%
7 – 9 years	28	35	63	31.5%
10 – 11 years	25	30	55	27.5%
12 – 14 years	18	20	38	19%
14 years and above	6	11	17	8.5%
Total	89	111	200	100%

The largest groups are in the 7–9 years (31.5%) and 10–11 years (27.5%) categories.

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Table 7. Pupil's achievement improvement

Level	Number of pupils per level	Pre-test Mean	Post-test Mean	Mean Improvement
Class 2	30	52.0	58.5	6.5
Class 4	30	54.5	58.8	4.3
Class 5	20	55.2	61.3	6.1
JSS 1	20	53.8	59.0	5.2
JSS 2	24	56.1	62.5	6.4
Total	200	54.3	61.2	6.9

The total mean score increase from 54.3 to 61, indicating an average improvement of 6.9 points across all student reflecting a positive impact of the intervention

Table 8. Test statistics for pupil's achievement improvement

Level	Number of pupils per level	t-value	Degree of freedom	P- value
Class 2	30	16.50	29	<0.001
Class 4	30	16.33	29	<0.001
Class 5	20	12.34	19	<0.001
JSS 1	20	12.51	19	<0.001
JSS 2	24	14.09	23	<0.001
Total	200	-	-	-

The t-values across the levels are all quite high, ranging from approximately 12.34 to 16.50, indicating substantial differences in achievement before and after the intervention or across conditions. The degrees of freedom (df) correspond to the sample sizes minus 1 for each group. All p-values are less than 0.001, suggesting that the observed improvements are statistically highly significant. This strongly implies that the achievement improvements are unlikely due to chance.

Table 9. Classroom Observation result

Main Observations	Number of teachers			
	Excellent	Good	Satisfactory	Need Improvement
Lesson Planning & Preparation	2	3	5	30
Teaching & Instructional Skills	1	5	7	27
Classroom Management & Student Engagement	2	5	8	25
Assessment & Evaluation	-	3	9	28
Reflective & Adaptive Teaching	1	5	5	29

The table reveals a concerning trend of a large number of teachers needing improvement in various categories, with the most striking pattern being the high number of teachers (30) requiring improvement in Lesson Planning & Preparation. Across all categories, a significant proportion of teachers (average of 26-29) need improvement, suggesting a systemic issue or lack of support. Only 5-8 teachers are rated as "Excellent" or "Good" in each category, indicating that there may be a gap in teacher development and support, particularly in areas such as Lesson Planning, Teaching & Instructional Skills, and Assessment & Evaluation.

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Table 10. Pedagogical strategies used by teachers during mathematics instruction in rural schools

Pedagogical Strategies	Yes	No
Inquiry-Based Learning	-	x
Collaborative Learning	X	-
Differentiated Instruction	-	X
Use of Manipulatives	X	-
Real-World Contexts	X	-
Formative Assessment	X	-
Explicit Instruction	-	X
Metacognitive Strategies	-	X
Visual Aids and Representations	X	-
Technology Integration	-	x

Teachers predominantly do not use inquiry-based learning, collaborative learning, or differentiated instruction. Most strategies like manipulatives and real-world contexts are underutilized.

Table 11. Resource Utilization Approaches availability during mathematics instruction in rural school

Resource Approaches	Sufficient	Insufficient	Not available
Mathematics Software and Apps	-	-	x
Online Resources and Tutorials	-	-	x
Manipulatives and Tactile Resources	-	x	-
Printed Materials	-	x	-
Educational Games	-	-	X
Community and External Resources	-	X	-
Data and Analytics Tools	-	-	x
Professional Development Resources	-	-	x

Resources such as software, online tutorials, and educational games are largely unavailable. Manipulatives are insufficient, and printed materials are lacking.

V. DISCUSSION

The teaching workforce in these rural schools is predominantly male, making up 75%, with females at 25%. Most teachers have 5 to 7 years of experience, with some exceeding 8 years. However, only 32.5% hold the Higher Teacher Certificate primary, and 30% are untrained or unqualified. No female teachers have degrees, highlighting gender gaps in qualifications. Students are mainly aged 7 to 11, reflecting typical primary school demographics, with some starting late or repeating grades. Attendance is high, averaging 92% for boys and 94% for girls, indicating strong engagement. Pupil's Academic achievement improved significantly, with an average increase of 6.9 points from pre- to post-test scores across levels, from Class 2 to JSS 2. The statistical significance ($p<0.001$) confirms that these gains are unlikely due to chance, demonstrating the effectiveness of current interventions.

Classroom observations reveal many teachers need improvement in lesson planning, instructional skills, classroom management, and assessment. Only a few are rated as "Excellent" or "Good," pointing to systemic issues like limited professional development and resources. Enhancing teacher support is crucial for improving classroom quality and student outcomes. Most teachers rely on traditional, teacher-centered methods, with minimal use of active, student-centered strategies such as inquiry-based learning, collaborative activities, or differentiated instruction. Strategies like manipulatives and formative assessments are underused, limiting student engagement and understanding. Promoting diverse pedagogies could foster better critical thinking and academic results.

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Resource shortages also impede effective teaching. Many technological tools, online resources, manipulatives, and printed materials are unavailable or insufficient. This hampers the implementation of innovative teaching methods. Investing in resources and establishing partnerships are essential to create an environment conducive to quality education and improved student motivation.

VI. CONCLUSION

The analysis shows that the teaching staff in these rural schools are predominantly male (75%), with most having 5 to 7 years of experience, though many lack advanced qualifications, as only 32.5% hold the Higher Teacher Certificate and 30% are untrained. No female teachers have degrees, highlighting gender disparities. Pupils aged 7-11 demonstrate high attendance rates (92-94%) and have shown significant academic improvement through targeted interventions. However, classroom quality is hindered by many teachers needing improvement in lesson planning, instructional skills, and classroom management, partly due to limited professional development and resources. Teaching methods remain largely traditional, with little use of active, student-centered approaches, and resource shortages; such as technological tools and teaching materials further restrict effective instruction. Addressing these issues through professional training, resource investment, and promoting diverse pedagogies could enhance teaching quality and student learning outcomes.

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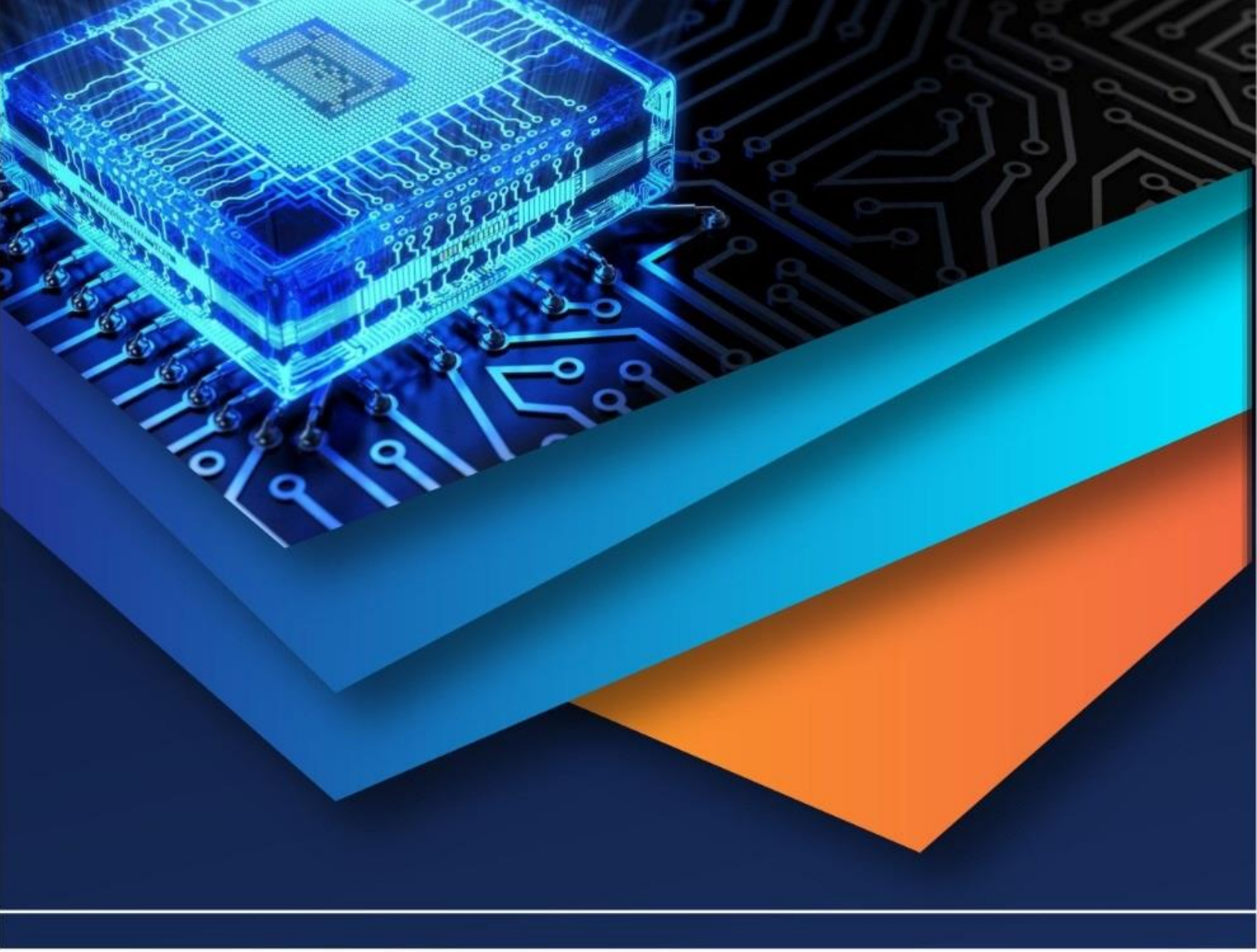
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