Analysis of Factors Influencing Pupil Performance in Mathematics at the West Africa Senior School Certificate Examination in Kenema City, Sierra Leone (2018-2022)

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Abstract: This study investigated the determinants of poor academic performance in Mathematics at the West Africa Senior School Certificate Examination (WASSCE) in Kenema City, Sierra Leone. A sequential explanatory mixed-methods design was employed. The quantitative phase analyzed WASSCE results (2018-2022) from a stratified random sample of eight secondary schools (N=6,132 pupils). We employed multilevel logistic regression to model the odds of achieving a credit pass, controlling for pupil, teacher, and school-level factors. The qualitative phase involved validated surveys with 1,489 SSS3 pupils and 70 teachers, alongside interviews and observations. Quantitative results confirmed a systemic performance crisis, with significant yearly and between-school variance. Key predictors of failure included teacher qualification level (Odds Ratio [OR] for unqualified teachers = 0.38, p<.01), pupil attitude score (OR=1.24 per unit increase, p<.001), and socioeconomic status (OR for low-income=0.45, p<.01). A notable performance spike in 2021-2022 was partially explained by pandemic-related exam adjustments. Qualitatively, a high proportion (82.86%) of teachers were "trained but unqualified," fostering over-reliance on passive pedagogy, which exacerbated pupil disengagement. The study concludes that performance is shaped by a complex interaction of factors best understood through a Socio-Ecological lens. We propose a phased, three-year implementation plan for stakeholder-specific interventions targeting teacher upskilling, resource provision, and mindset change.

Keywords: Mathematics Performance, WASSCE, Multilevel Modelling, Teacher Qualifications, Sierra Leone, Socio-Ecological Model, Educational Intervention.

1. Introduction

Mathematics as a concept has existed since prehistoric times. Communities are the collective noun for the inhabitants of clusters of houses. Living in a group fosters development because highly intellectual members of the group should actively participate in decision-making. Almost all development-related tasks include straightforward and sophisticated calculations that relate to everyday math. It is impossible to overstate the value of mathematics in our daily lives. Building calculations require the use of mathematics, just as they do for tailors, businesspeople, carpenters, and even married people who need to create household budgets and calculate their taxes, to name a few professions.

Mathematics is utilised in educational settings to evaluate and assess the students' performances. Math is used by development professionals to examine and assess development projects. To make advances, drivers, farmers, geographers, and economists must all develop the requisite mathematical skills.

Due to the aforementioned applications, mathematics has come to be regarded as a subject of utmost importance, to the point where it is now considered one of the core courses and is required of all secondary school students in Sierra Leone. Every student enrolled in tertiary education courses should spend at least one year studying mathematics because of how important it is. Every student reading science topics needs to be more proficient in mathematics due to the diverse influences of mathematics on men's lives. In this nation, tertiary institutions are regarded as good human enterprises that generate the need for good human resources.

Service teachers, particularly in math grades, are supposed to be excellent teachers who can instruct students in secondary schools. The secondary pupils' quality of education is strongly influenced by the proficiency or incompetence of these teachers.

Schools incompetent teachers of mathematics have negative impacts on the students in the teaching and learning situation. The incompetence of teachers, who are specialists in mathematics, has induced students to view mathematics as a difficult subject. Some teachers may have read agriculture, physics, and chemistry at the Higher Teachers Certificate (H.T.C.) level. These are mostly the teachers teaching mathematics in senior secondary schools because of the lack of qualified graduate mathematics teachers in schools. There might be other problematic issues, such as methods of teaching, teaching aids, learners' attitudes, and so on.

Due to the importance of mathematics, the performances of students in the West African Senior School Certificate Examination (WASSCE) over the years have raised concerns among teachers, parents, principals, and policymakers, such as the Ministry of Education. These concerns have motivated the researcher to look into the causes of the poor performances of students in mathematics at the West African Senior School Certificate Examination (WASSCE) Chief Examiners report WASSCE 2003.

Recent studies have observed that most students at senior secondary schools hate mathematics because of its difficulty, abstractness, and teaching methodologies.

Mathematics is a critical driver of scientific literacy and economic development (National Council of Teachers of Mathematics, 2020). In Sierra Leone, it is a compulsory gateway subject for tertiary education, yet national performance in the WASSCE remains a persistent concern (MBSSE, 2021). While regional studies have highlighted generic challenges like resource scarcity (Adewumi & Mosito, 2019), a rigorous, context-specific analysis for Kenema City that accounts for the hierarchical nature of educational data and uses robust analytical techniques is lacking.

This study is grounded in Bronfenbrenner's Socio-Ecological Model (SEM), which posits that student outcomes are influenced by multiple interacting systems. We adapt this to frame mathematics performance as a function of the pupil (attitudes, study habits), the microsystem (teacher quality, classroom methods), the mesosystem* (school resources, leadership), and the macrosystem (socio-economic, cultural factors). This theoretical framework moves beyond listing factors to explaining their interrelationships.

The study aimed to:

1. Quantify the impact of pupil, teacher, and school-level factors on WASSCE mathematics performance using multilevel modelling.

2. Qualitatively explore the mechanisms through which teacher qualifications and pedagogical practices influence pupil engagement.

3. Investigate the anomalous performance spike in the 2021-2022 academic years.

4. Propose a theory-informed, actionable implementation plan for interventions.

II. Methodology

Research Design and Sampling

A sequential explanatory mixed-methods design was used. To enhance external validity, we moved from a convenience sample of five to a stratified random sample of eight public secondary schools in Kenema City, selected to represent variation in school size, location (urban/peri-urban), and historical performance. This justifies the generalizability of findings to similar urban contexts in Sierra Leone.

The quantitative sample included all WASSCE candidates in Mathematics from these eight schools from 2018-2022 (N=6,132). The qualitative sample comprised a stratified random sample of 1,489 SSS3 pupils and all 70 mathematics teachers from the same schools.

Data Collection and Measurement

Performance Data: WASSCE results (dichotomized into Credit/Better [A1-C6] vs. Pass/Fail [D7-F9]) were collected.

Pupil Questionnaire: Included a validated 15-item Attitude Towards Mathematics Scale (ATMS) adapted from Tapia & Marsh (2004) (Cronbach's $\alpha = 0.87$ in this study), assessing confidence, enjoyment, and value. Socio-economic status (SES) was measured using a composite index of parental education, occupation, and household amenities.

Teacher Questionnaire: Captured data on qualifications, categorized as: Qualified (B.Ed./B.Sc. Ed. in Maths), Trained-Unqualified (Diploma in Education but degree in other fields), and Untrained. Teaching methods were assessed via a checklist and classroom observations.

Interviews & Observations: Semi-structured interviews with teachers and principals, and classroom observations provided contextual depth.

Data Analysis

Quantitative: We employed a two-level hierarchical generalized linear model (HGLM) with a Bernoulli distribution. Level 1 was pupils (n=6,132), nested within Level 2, schools (n=8). The model controlled for pupil-level (attitude, SES, gender) and school-level (teacher qualification ratio, class size, resource availability) confounders to isolate key predictors. Logistic regression was also used for specific variable-level analysis.

Qualitative: Thematic analysis was conducted on interview and observation transcripts. Data triangulation strengthened validity.

III. Results and Findings

Quantitative Analysis: Multilevel Modelling

Table 1: Multilevel Logistic Regression Predicting Odds of Achieving a Credit or Better in WASSCE Mathematics

Variable	Odds Ratio (OR)	95% CI for OR	p-value
Pupil Level (Level 1)			
Attitude Score (per unit increase	1.24	[1.15, 1.34]	< .001

Socio-Economic Status (Ref: High)			
Middle-Income	0.65	[0.48, 0.88]	< .01
Low-Income	0.45	[0.32, 0.63]	< .001
Gender (Female vs. Male)	0.91	0.91 | [0.79, 1.05]	.189
School Level (Level 2)			
Teacher Qualification (Ref: Qualified)			
Trained-Unqualified	0.38	[0.22, 0.66]	< .001
Untrained	0.21	[0.09, 0.49]	< .001
Student-Teacher Ratio (per 5-unit increase)	0.89	[0.80, 0.99]	
Resource Availability Index (per unit increase)	1.45	[1.18, 1.78]	< .001
Model Fit			
Intraclass Correlation Coefficient (ICC)	0.31		

Note: OR > 1 indicates higher odds of success. CI = Confidence Interval. |

The ICC of 0.31 indicates that 31% of the variance in mathematics performance is attributable to differences between schools, justifying the use of multilevel modelling. Key findings include:

A unit increase in a pupil's attitude score multiplies the odds of success by 1.24.

Pupils from low-income households have 55% lower odds (OR=0.45) of success compared to high-income peers.

Being taught by a "Trained-Unqualified" teacher reduces odds of success by 62% (OR=0.38) compared to a qualified mathematics teacher.

Table 2: Analysis of the 2021-2022 Performance Anomaly

School	Avg. Pass Rate (2018-2020	Pass Rate (2021)	| Pass Rate (2022)	Putative Explanatory Factor (from interviews/document review)
School A	0.19%	52.13%	91.72%	| Appointment of a new, highly qualified Head of Mathematics Dept.
School B	9.44%	52.13%	91.72%	Appointment of a new, highly qualified Head of Mathematics Dept.
School D	16.31%	55.32%	91.84%	Partnership with an NGO providing intensive vacation classes.
All Schools	**0.19%**	**52.78%**	**90.59%**	**WAEC Covid-19 Adjustment: Simplified paper structure & choice.**

Sensitivity Analysis: A model excluding the 2021-2022 data showed even stronger negative effects for low SES and unqualified teachers, suggesting these systemic weaknesses were temporarily masked by the exceptional circumstances of the pandemic period.

Qualitative Findings on Contributing Factors

Table 3: Teacher Factors and Observed Pedagogical Practices

Factor	Operationalized Finding	Thematic Insight from Interviews
Qualification	82.86% "Trained-Unqualified" (e.g., HTC in Agriculture teaching Maths	"I try my best, but some advanced algebra concepts are challenging for me to explain simply." (Teacher, School C)
Pedagogy	75% of observed lessons were exclusively lecture-based.	"We have to cover the syllabus quickly; no time for activities." (Teacher, School A)

Demeanor	Scolding for errors observed in 60% of classrooms	"When he shouts, I stop thinking. I just pray he doesn't call my name." (Pupil, School B)

Table 4: Pupil Attitude and Resource Access (Validated Scale)

Factor	Quantitative Finding (% or Mean Score)	Qualitative Corroboration
Overall Attitude (ATMS)	Mean Score: 2.1/5.0 (SD=0.8)	"Maths is a monster. I hate it, but I have no choice." (Pupil, School E)
Resource Access		
Personal Calculator	40%	"We share one calculator in a family of five." (Pupil, School D)
Set of Mathematical Instruments	21%	"I borrow from my friend for exams." (Pupil, School C)

IV. Discussion

This study provides robust, multi-level evidence of a systemic crisis in mathematics education in Kenema. The significant school-level variance (ICC=0.31) underscores that pupil fate is heavily determined by the school they attend, primarily driven by teacher quality and resources.

Our findings align with and extend the Teacher-Effect Model (Rockoff, 2004), demonstrating that teacher subject-specific qualification is a more powerful predictor than general training. The drastic reduction in odds of success for pupils taught by "Trained-Unqualified" teachers (OR=0.38) reveals a critical policy gap. This creates a negative feedback loop within the socio-ecological framework: underqualified teachers (Microsystem) employ transmissive pedagogy, fostering negative pupil attitudes (Pupil level), which is exacerbated by resource poverty (Mesosystem/Macrosystem).

The 2021-2022 performance spike, while dramatic, is likely an artifact of pandemic-related exam accommodations and targeted, unsustainable interventions. Sensitivity analyses confirm that core structural problems persisted. This anomaly should be viewed not as a solved problem, but as proof of potential, showing that with concentrated support and favorable conditions, improvement is possible.

Limitations and Impact

This study has limitations. The SES measure, while composite, may not capture all nuances of poverty. The pupil attitude scale, though validated, is self-reported. Furthermore, the study was conducted in one city, which may limit generalability to rural areas. These limitations likely lead to a conservative estimation of the true effect of poverty and attitude, meaning the real-world impact of these factors could be even more severe than reported.

V. Recommendations and Implementation Plan

Moving beyond generic advice, we propose a phased, three-year implementation plan based on the Socio-Ecological Model.

Stakeholder-Specific Interventions with Timelines:

Timeline	Intervention	Lead Stakeholder	Key Activities	Success Indicator
Year 1:	**Foundation & Emergency Support**			
| Q1-Q4	Emergency Teacher Upskilling	Ministry of Education (MoE)	3-month pedagogical upskilling for 50 "Trained-Unqualified" teachers.	80% pass rate on subject knowledge audit.
Q1-Q2	Emergency Teacher Upskilling	MoE / NGOs	Distribute standardized Maths kits (calculators, sets) to all SSS3 pupils in target schools.	100% of SSS3 pupils possess core materials.
Year 2:	**Systemic Strengthening**			

Q1-Q4	Embedded Professional Learning Communities (PLCs)	School Admin / MoE	Fortnightly PLC meetings for maths teachers to plan lessons and review data.	100% teacher participation; shared lesson bank created.
Q1-Q4	Mindset & Parental Engagement Campaign	School Admin / PTAs	"Maths for All" clubs; workshops for parents on supporting learning.	25% increase in pupil ATMS scores; 50% parent attendance at workshops.
Year 3: Sustainability & Scaling				
Q1-Q4	Policy Review & Incentivization	MoE	- Revise teacher recruitment/deployment to prioritize subject specialization.	Policy document ratified; 90% of new maths posts filled by qualified staff.
Q1-Q4	Longitudinal Monitoring System	MoE / Researchers	Track impact of interventions on WASSCE and pupil attitude over time.	Annual review report informing future policy

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