

Using Hierarchical Linear modeling to examine attitudinal and instructional variables that predict students' achievement in mathematics

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Outline



Introduction

TIMSS

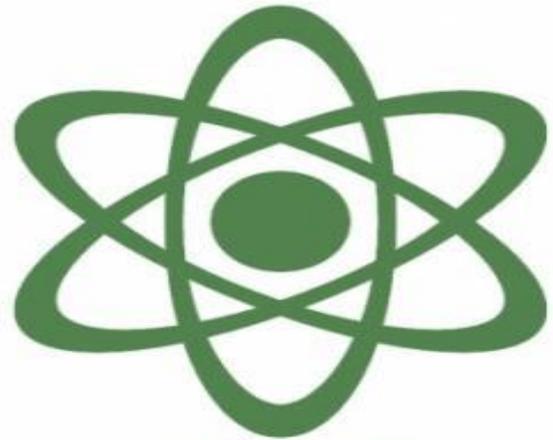
Performance of Ghanaian students
in maths

Methods

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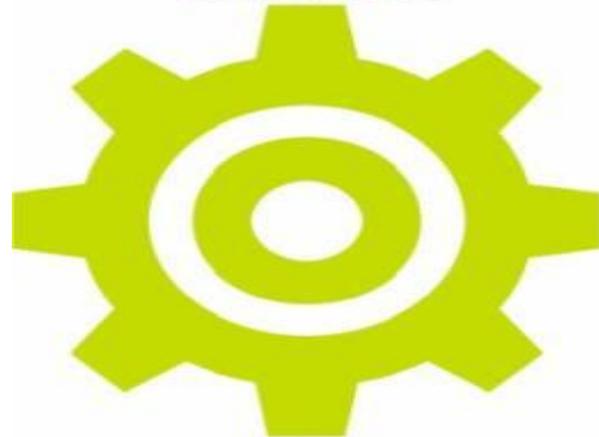
Relevance of Mathematics



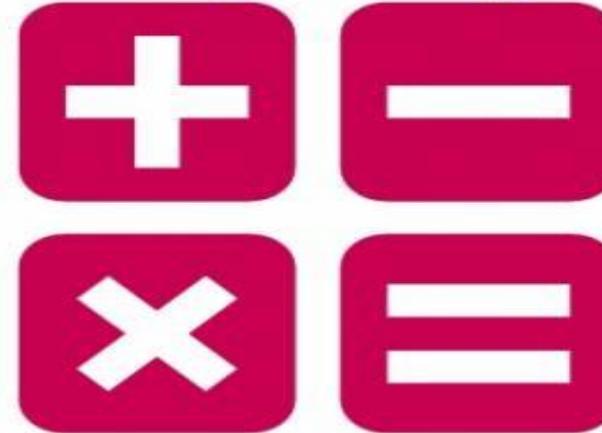
science



engineering

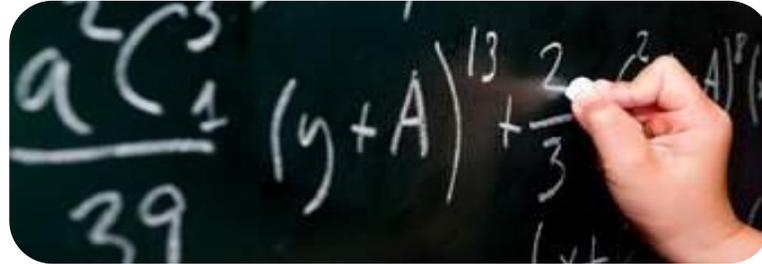


technology



mathematics

Relevance of Mathematics



Mathematics is important for success in many aspects of life

Effective teacher training and student preparation has become driving force behind most educational policies in several countries.

For common standards and easy comparisons, countries participate in national and international large-scale assessments.

- Trends in International Mathematics and Science Study (TIMSS)
- Programme for International Student Assessment (PISA; OECD)
- National Assessment of Educational Progress (NAEP)
- National Education Assessment (NEA)

About TIMSS



TIMSS (Trends in International Mathematics and Science Study)

International Association for the Evaluation of Educational Achievement (IEA)

TIMSS seeks to monitor trends in mathematics and science at two levels: the fourth grade (Primary 4) and eighth grade (JHS2)

The goal was to provide comparative information about educational achievement across countries

Performance of Ghanaian students in maths



- Ghana first participated in the TIMSS in 2003 at the 8th grade and ranked 45th out of 46 countries with an average score of 276 (500, 100)
- *Government initiated new policies such as the introduction of new mathematics and science curriculum and re-structuring of teacher education*
- In TIMSS 2007, Ghana still ranked 2nd from bottom with an average score of 309
- In TIMSS 2011, with an average score of 331, Ghana ranked last when the participating countries were rank-ordered

TIMSS 2007 Results



Table 1 The overall mean mathematics achievement scale score

	Country	Average Scale Score	S.E.*	Rank
1	Chinese Taipei	598	(4.5)	1
2	Korea, Rep. of	597	(2.7)	2
3	Singapore	593	(3.8)	3
4	Hong Kong SAR	572	(5.8)	4
5	Japan	570	(2.4)	5
6	England	513	(4.8)	7
7	United States	508	(2.8)	9
8	Malaysia	474	(5.0)	20
9	Tunisia	420	(2.4)	32
10	Egypt	391	(3.6)	38
11	Algeria	387	(2.1)	39
12	Botswana	364	(2.3)	43
13	Ghana	309	(4.4)	47
14	Qatar	307	(1.4)	48
	TIMSS Scale Avg.	500	-	13

Purpose of the Study



- Educators, researchers and policy makers in search of changes that can lead to improved students achievement in mathematics and science.
- To use Hierarchical Linear Modeling (HLM) to identify how attitudinal and the frequent use of instructional variables measured by TIMSS influenced mathematics achievement of Ghanaian eighth graders in TIMSS 2007.

Methodology



- **Data**
 - The TIMSS 2007 data from Ghana
 - *Selecting a sample of schools from all eligible JHS schools;*
 - *Randomly selecting a JSS 2 mathematics class(es) from each sampled school, regardless of the ability level of the class; and*
 - *Including all the students in the selected class*
 - 5,294 students nested within 163 schools
 - 2,868 (54.2%) boys
 - 2,422 (45.8%) girls
 - 163 teachers

Attitudes



How much do you agree with these statements about learning mathematics?

Fill in **one** circle for each line

- | | Agree
a lot
↓ | Agree
a little
↓ | Disagree
a little
↓ | Disagree
a lot
↓ |
|---|---------------------|------------------------|---------------------------|------------------------|
| a) I usually do well in mathematics ----- | ① | ② | ③ | ④ |
| b) I would like to take more
mathematics in school ----- | ① | ② | ③ | ④ |
| c) Mathematics is more difficult for me
than for many of my classmates ----- | ① | ② | ③ | ④ |
| d) I enjoy learning mathematics ----- | ① | ② | ③ | ④ |
| e) Mathematics is not one of
my strengths ----- | ① | ② | ③ | ④ |
| f) I learn things quickly in mathematics | ① | ② | ③ | ④ |
| g) Mathematics is boring ----- | ① | ② | ③ | ④ |
| h) I like mathematics ----- | ① | ② | ③ | ④ |

Attitudes



How much do you agree with these statements about mathematics?

Fill in **one** circle for each line

Agree
a lot
↓

Agree
a little
↓

Disagree
a little
↓

Disagree
a lot
↓

- a) I think learning mathematics will help me in my daily life ----- ① ----- ② ----- ③ ----- ④
- b) I need mathematics to learn other school subjects ----- ① ----- ② ----- ③ ----- ④
- c) I need to do well in mathematics to get into the <university> of my choice ----- ① ----- ② ----- ③ ----- ④
- d) I need to do well in mathematics to get the job I want ----- ① ----- ② ----- ③ ----- ④

Instructional variables



How often do you do these things in your mathematics lessons?

*Fill in **one** circle for each line*

	Every or almost every lesson	About half the lessons	Some lessons	Never
	↓	↓	↓	↓
a) We practice adding, subtracting, multiplying, and dividing without using a calculator -----	① -----	② -----	③ -----	④ -----
b) We work on fractions and decimals -----	① -----	② -----	③ -----	④ -----
c) We solve problems about geometric shapes, lines and angles -----	① -----	② -----	③ -----	④ -----
d) We interpret data in tables, charts, or graphs -----	① -----	② -----	③ -----	④ -----
e) We write equations and functions to represent relationships -----	① -----	② -----	③ -----	④ -----
f) We memorize formulas and procedures -----	① -----	② -----	③ -----	④ -----

Instructional variables



- g) We explain our answers ----- ① ----- ② ----- ③ ----- ④
- h) We relate what we are learning in
mathematics to our daily lives ----- ① ----- ② ----- ③ ----- ④
- i) We decide on our own procedures
for solving complex problems ----- ① ----- ② ----- ③ ----- ④
- j) We review our homework ----- ① ----- ② ----- ③ ----- ④
- k) We listen to the teacher give a
lecture-style presentation ----- ① ----- ② ----- ③ ----- ④
- l) We work problems on our own ----- ① ----- ② ----- ③ ----- ④
- m) We work together in small groups ----- ① ----- ② ----- ③ ----- ④
- n) We begin our homework in class ----- ① ----- ② ----- ③ ----- ④
- o) We have a quiz or test ----- ① ----- ② ----- ③ ----- ④
- p) We use calculators ----- ① ----- ② ----- ③ ----- ④
- q) We use computers ----- ① ----- ② ----- ③ ----- ④

Methodology(cont'd)



Preliminary Data Analysis

Exploratory factor analysis was conducted to reduce the number of predictor variables

22 student-level variables

students' gender, educational aspiration, attitudes (self-confidence, value, perceived difficulty), homework, and 17 instructional activities

7 teacher variables:

teachers' gender, highest level of formal education, teachers' major area of study, teaching license or certificate, years of teaching, amount of homework, and instructional practice

The outcome variable was the overall mathematics achievement

Methodology(cont'd)



Hierarchical Linear Modeling (2-Level)

- *Null model: no predictors*
- *Model with students level predictors (Level 1)*
- *Model with teacher/principal predictors (Level 2)*
- *Full model: model with the full set of student, and teacher/principal variables*
- *Parsimonious model : model consisting of only significant student- and teacher/principal- predictors*

Methodology(cont'd)



Parsimonious Model

$$Y_{ij} = \beta_{0j} + \sum_{q=1}^Q \beta_{qj} X_{qij} + r_{ij}$$

$$\beta_{qj} = \gamma_{q0} + \sum_{s=1}^{s_q} \gamma_{qs} W_{sj} + U_{qj}$$

where Y_{ij} is the mathematics achievement score of student i in school j

β_{0j} is the regression intercept of school j or the mean of school j

γ_{00} is the grand mean or overall average mathematics score for all schools

r_{ij} is the random effect of student i in school j , and

u_{0j} is the random effect of school j , that's the deviation of the school-mean achievement from the grand mean.

β_{qj} are the level-1 intercepts and slopes that indicate how much of influence student level variable X_{qij} has on the mathematics achievement of students within each school j

γ_{qs} denotes the level-2 coefficients; W_{sj} are the school-level variables; and U_{qj} the error term at the school level

Final Results



Significant Predictors of the Parsimonious Model

	<i>B</i>	<i>S.E</i>	<i>t-ratio</i>	<i>p-value</i>
Student Variables				
Students' gender	15.71	2.73	5.76	0.000
Level of aspiration	4.08	0.73	5.59	0.000
Self-confidence in mathematics	13.23	1.59	8.31	0.000
Value of mathematics	7.58	2.18	3.48	0.005
Perceived difficulty of mathematics	-11.89	2.17	-5.48	0.001
Practice adding, subtracting, multiplying, and dividing without using a calculator	5.60	1.27	4.42	0.001
Solve geometric problem	-5.15	1.51	-3.41	0.003
Use calculators	-5.48	1.86	-2.94	0.007
Use computers	-7.43	1.66	-4.45	0.000
Decide procedures for complex problems	-3.46	1.12	-3.01	0.003
Begin homework in class	-8.19	1.60	-5.11	0.000
Classroom/Teacher/School level variables				
Teaching license or certificate	-23.90	8.52	-2.80	0.006
Education- Mathematics	15.45	7.36	2.10	0.037
Amount of homework	9.90	3.90	2.54	0.012
Teachers' instructional practices	2.59	1.09	2.38	0.018

Results



Boys
outperformed
girls

Self-confidence
and value for
maths were
positively related
to maths
performance

Perceived
difficulty
negatively
influenced maths
performance

Six of the 17
instructional
variables were
significantly
related to
performance;

Teaching
license/certificate
negatively related
to maths
performance.

Results



Proportion of Variance Explained at Student and Teacher Levels

Level	Initial Variance	Final Variance	Percent Variance Explained
Student	4782.77	3616.59	24.38%
Teacher	3083.49	1922.65	35.96%

Conclusion



The poor performance of Ghana as a country in the TIMSS 2007 is partially attributable to;

- inconsistent use of homework
- failure to engage students in their learning
- lack of progress of girls
- lack of students' interest and confidence in mathematics
- Lack of teaching for conceptual understanding
- students' lower educational aspiration

Unlike other educational systems, the findings of the current study suggested that the difference in students' achievement in mathematics is largely due to schools.

- although Ghana follows a centralized education system, the schools appear not to be homogenous when it comes to instruction in mathematics.

Way Forward



- GES Inspectorate Division to strengthen its supervisory and monitoring activities
- Ensure teachers frequently give mathematics homework which gets marked and reviewed in class
- Revise Teacher training curriculum to enable trainees learn modern and innovative teaching methods and strategies
- In-service training on how to engage students more actively in their learning, modern and innovative teaching methods and strategies, etc.
- All pre-service teachers to obtain a B.Ed. with specialization in mathematics if they plan to teach mathematics

Limitations and Future Directions



- **Limitation**

- Literature reviewed and guided the selection of variables was mainly from developed countries
- Only variables measured in the TIMSS 2011 were used

- **This Research could be extended by**

- Researchers from other African countries replicating this study using their TIMSS data, or the fourth-grade mathematics data. Similarly, in the future, this study can be extended to the science achievement data as well as other large-scale datasets like PISA, NEA

The End



THANK YOU