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Teachers' characteristics and students degree of errors in different content areas in senior secondary certificate examination in mathematics

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Abstract:
The study objective was to determine the influence mathematic teachers' characteristics on errors made by students in different content areas. Ex-post facto design was used to study a sample of 400 students' scripts drawn from scripts of 18,000 SS3 (senior secondary three) students that participated in the West African Examination Council (WAEC) examination; and 100 of their mathematics teachers in two Nigerian States. The sources of data were the students' answer scripts with a redesigned marking scheme and questionnaire administered on their mathematics teachers. Students' errors and content areas were respectively categorized into four areas for analysis. Chi-square test, ANOVA, and multiple regression analyses were used to analyze the data. The findings revealed that students taught by teachers with WAEC marking experience committed fewer errors than their counterparts taught by teachers without WAEC marking experience. The mean achievement scores of students taught by WAEC examiners significantly differed from that of those taught by non-WAEC examiners. Teachers' qualifications and competence affected the type and degree of students' errors. It is recommended were that mathematics teachers should be encouraged to attend WAEC script-marking workshop (tagged "coordination"), even if they may not participatee the actual marking, and regular workshops and seminars be organized for mathematics teachers.
Keywords: Teacher Characteristics, Student Errors, Content Areas, Error Types, Mathematics

I. INTRODUCTION

Mathematics with its abstract symbolism, its logical structures, and its wide application has unique teaching/learning problems. A mathematics teacher must therefore know 'when and what concepts to teach', 'when and why' students are having difficulty, how to make concepts meaningful, 'when' and how to practice skills and 'how' to stimulate productive thinking. Teacher effectiveness is a major indicator of students' achievement.[1] Teacher effectiveness depends upon the student's understanding of the mathematical concept and ideas which are confirmed by as an essential aspect of mathematics [2]. Teachers' lack of knowledge about mathematical concepts has remained a very serious issue that needs attention. It is believed that one can not give what he / she does not have, and so a teacher cannot teach what he does not know.

Teaching and learning cannot be separated and so it is generally assumed that teaching improves performance since the essential function of teaching is to facilitate learning. Ale [3], observed that a teacher's method of presenting mathematical content to students is one part of the problem affecting their mathematics achievement. Most teachers tend to content areas they know and can easily teach while avoiding those they do not understand and cannot easily teach. This leads to students encountering unfamiliar questions in external examinations. This implies that some teachers tend to view content areas in secondary school in terms of their ability or capability to teach, which invariably leads to poor student performance on external examinations.

Some teachers do not take interest in WAEC marking and in some areas, team leaders do not encourage new markers by giving them practice scripts to mark so that they can be better prepared for questions asked in National examination. Some researchers have attributed poor student performance to a lack of qualified mathematics teachers [4], poor teaching of the subject because of the teachers "quest for the right answer syndrome" and rote memorization [5.6]

It is the intention of this study to investigate the impact of these teacher characteristics on their students' academic achievements in the different content areas and to investigate errors committed in those areas. It should be noted that the total achievement score of a student depends not on the degree of errors alone but the type of error committed. Some error might not affect the achievement score as much as other errors.

II. RESEARCH QUESTION AND HYPOTHESES

Research question: What is the frequency of errors that secondary school students taught mathematics by West African Examination Certificate (WAEC) Examiners and non-WAEC examiners commit in solving mathematics problems in Senior \secondary Certificate Examination (SSCE)?

Hypotheses: The following hypotheses were also tested:

1. Mean achievement in mathematics scores of students taught mathematics by teachers who mark West African School Certificate Examination (WASCE) will not differ significantly from those of their counterparts taught mathematics by teachers who do not mark WASCE.
2. There is no significant influence of the mathematics teachers' qualification on the frequency of each type of error committed by their students.
3. There is no significant relationship between students' achievement in each of the content areas used for SSCE and errors committed in those areas.

III. Subjects and methods

The population of this study was 18,000 SS3 mathematics students that took mathematics in May/ June 2002 and their 451 mathematics teachers that taught them mathematics in Enugu and Cross River States of Nigeria. From the 218 schools in the two states, 47 schools were randomly selected using a proportionate stratified random sampling. 400 students were randomly selected and their 47 mathematics teachers from the 47 schools. The students' scripts were removed from the scripts of other students that took the examination for the analysis. The scripts were categorized into two groups, those taught by examiner and those taught by non-examiners with two hundred (200) scripts in each group. The teachers considered have taught for three years and above.

The two sources of data collection for this study were:

1. The students answer scripts and redesigned marking scheme for their scores.
2. The questionnaire for the mathematics teachers were drawn from the question paper for their students.

Data collection and analysis: Students' errors were classified into four categories: Arbitrary (inability to write the answer in an acceptable form and sequentially too), structural (lack of understanding of the basic concept), executive (inability to select an appropriate mathematical process towards solving the problem and forming necessary equations) and clerical (inability to perform mathematical operations due to carelessness or distraction) errors. Also the content areas for the question paper used were categorized into four areas: N.N (Number and numeration) A.P. (Algebraic processes), S.P (Statistics and probability), T.G. (trigonometric and geometric construction) [7].

The questionnaire was in three parts (qualification, personal data and WAEC marking experience) were given only to mathematics teachers that taught the students in SS3 and their responses were collected. Also collected were the error scores and actual score of each student in each of the content areas.

These were analyzed using simple frequency, Chi-square, ANOVA and multiple regression analysis.

IV. RESULTS

The findings are presented to respond directly to the research question and address the hypotheses.

Research Question 1: What is the frequency of errors that secondary school students taught mathematics by WAEC examiners and non-WAEC examiners commit while solving mathematics problems?

To respond to this research question, the total errors committed in arbitrary, structural, executive and clerical errors by categories made by students taught mathematics by teachers that mark WAEC and those that do not mark WAEC were computed. The results are shown in Table 1.

Table 1: Frequency of the errors committed by secondary school students taught mathematics by WAEC and Non-WAEC Markers.

Type of error	Type of Teacher	Frequency of error committed by student
Arbitrary	WAEC Examiner	1339
	Non-WAEC Examiner	1682
Structural	WAEC Examiner	983
	Non—WAEC Examiner	1160
Executive	WAEC Examiner	1535
	Non- WAEC Examiner	1835
Clerical	WAEC Examiner	1446
	Non- WAEC Examiner	1644
Total	WAEC Examiner	5303
	Non-WAEC Examiner	6321

Table 1 shows that errors committed by students taught by WAEC Examiners were far less than those committed by students taught by non-WAEC examiners in all error categories. The structural errors committed by students taught by WAEC examiners were far less than the structural errors committed by students taught by non-WAEC Examiners. This shows that the frequency of errors committed by students taught by non-WAEC examiners were far more than the identified errors committed by students taught by WAEC examiners.

HYPOTHESIS 1: Mean achievement in scores of students taught mathematics in WASCE will not differ significantly from those of their counterparts taught mathematics by teachers who do not mark WASCE.
The result of this analysis is shown in Table 2.

Table 2: A One–way Analysis of Variance (ANOVA) of Mathematics Mean Achievement Scores of Students by WASCE Marking Experience of their Mathematics Teachers.

Source of Variance	Sum of Squares (ss)	Df	Mean Square MS	F-cal	P-value	Sign	Decision
Between Groups	669.7283	1	669.7283	4.8450*	.0283	S	Reject Ho
Within Groups	55016.3492	398	138.2320				
Total	55686.0775	399					

Critical f = 2.60; .05 level of significance df = 1, and 398

From Table 2, the critical value of F for 1 and 398 degrees of freedom at .05 level of significance is 4. 8450. Since the computed value of 4.8450 is greater than the critical values of 2.60, the null hypothesis of no significant difference is rejected. This shows that the mean achievement mathematics scores of students taught by teachers who mark mathematics in WASCE significantly differ from those of their counterparts taught mathematics by teachers who do not mark mathematics in WASCE.

HYPOTHESIS 2: There is no significant influence of the mathematics teachers' qualification on the frequency of each type of errors committed by their students.
The result is as shown in table 3:

Table 3: A Chi-square Table Showing Teachers' Qualification and the Different Errors Committed by their Students.

Type of Error	Teacher Qualification	Obs X^2	Expected X^2	Calculated Value	Critical Value at .05	Interference
Arbitrary	Qualified	1468	1510.50			
	Non-Qualified	1553	1510.50	2.39	3.84	NS
Structural	Qualified	2064	2225.50			
	Non-Qualified	2387	2225.50	23.44*	3.84	S
Executive	Qualified	1634	1685.00			
	Non-Qualified	1736	1685.00	3.09	3.84	NS
Clerical	Qualified	1492	1530.00			
	Non-Qualified	1568	1530.00	1.89	3.84	NS
Total	Qualified	6658	6551			
	Non-Qualified	7244	6551	24.7*	3.84	S

Table 3 shows the calculated chi-square values. The critical chi-square value at a .05 level of significance with 1 degree of freedom was 3.84. The calculated values of 2.39 for the arbitrary error of 3.09 for executive and 1.89 for clerical errors are less than the critical value of 3.84. For these, the null hypothesis of no significant difference was upheld. The calculated chi-square value of 23.44 for structural error far exceeded the critical value of 3.84. The null hypothesis of no significant difference was rejected for this. This shows that the qualification of the mathematics teachers had no significant influence on the frequency of the arbitrary, executive and clerical errors committed by students, but qualification significantly influenced the frequency of structural errors committed by their students. With all the errors put together, qualification had the most significant influence on the frequency of all the errors (24.7).

HYPOTHESIS 3: There is no significant relationship between students' achievement in each of the content area and errors committed in those areas.
To test this hypothesis, multiple regression analysis was computed and the result shown in Table 4:

Table 4: Multiple Regression Analysis of the Prediction of Students' Academic Achievement in Different Content Areas and Errors in those Areas.

Variable	Multiple R	Standard Error	B	Beta	Obs T	Critical t at .05	Interpretation
Academic Achievement Vs Error in NN	.33743	5.89216	-.517078	-.337431	-7.151*	3.84	S
Academic Achievement Vs Error in AP	.58501	3.22813	-.491971	-.585015	-14.390*	3.84	S
Academic Achievement Vs Error in SP	.28752	2.21980	-.148739	-.287517	-5.989*	3.84	S
Academic Achievement Vs Error in TG	.15196	3.41989	-.103724	-.151959	-3.067	3.84	NS

Critical t= 3.84 at .05 alpha level, df= 1; 398

The calculated t-values for academic achievement and the four content areas were as computed in the table above. From table 4 the critical t-value at 0.5 level of significance with 1 and 398 degrees of freedom is 3.84. Since the critical value of 3.84 is less than the calculated values of -7.151, -14.390 and -5.989 for academic achievement and error in NN, AP and SP respectively, the null hypothesis of no significant relationship is rejected. This means that there is significant relationship between academic achievement and error committed in three of the content areas under study (NN, AP and SP). The negative values showed that the academic achievements were negatively affected by errors in those content areas.

For T.G., since the calculated value is less than the critical value, the null hypothesis that stated that there is no significant relationship between students' achievement in each of the content areas and errors committed in those areas was upheld. This means that there is no significant relationship between academic achievement in trigonometric and geometric constructions and errors committed in them.

V. DISCUSSION

One of the findings of this study is that the number of errors committed among students taught mathematics by non-WAEC Examiners were higher than those taught by WAEC Examiners. The fact that the structural errors committed by students taught by WAEC markers were far less than those of their counterparts taught by non-WAEC markers goes a long way to tell us that WAEC marking exposes the teacher to mathematics concepts and ways of solving it. Recall that structural errors deal with failure to appreciate the relationship involved in a problem or lack of understanding of the basic concept. During WAEC, markers/ examiners are advised on how best to tackle some of these mathematics concepts that pose problems to students.

It was also discovered from the students' scripts and teachers' responses to the questionnaire that about 60 percent of mathematics teachers in Enugu State that did not have WAEC marking experience have attended the marking orientation against 29 percent found in Cross River State, and their students performed better than those in Cross River State. This could contribute immensely to their students' frequency of errors and level of understanding of concepts since these teachers prepare them for WASCE. This suggest that though they have not been given the opportunity to participate in the actual marking, but the encouragement from their schools to attend the marking orientation went a long way to help their students to best respond to WASCE questions in mathematics. This is due to the fact that examiners discuss such issues during the marking training.

We also observed from the results on errors by students and qualification of their teachers that a significant difference existed in the frequency of structural errors of students taught by mathematics qualified

teachers and non-mathematics qualified teachers. This shows that the qualifications of their mathematics teachers significantly influence the structural errors being the most serious error. This error deals with the understanding of the basic concept in mathematics and bears itself out since you can never have a smooth solution in mathematics without a proper understanding of the concepts.

The evidence obtained with regard to the relationship between students' achievement in each of the content areas and errors committed in those areas shows that a very high and significant negative relationship exists between them. This shows that the indication of low scores on those content areas were a result of the high degree of errors on those areas.

VI. CONCLUSION

The study revealed significant influence of the qualifications of mathematics teachers and his/her involvement in WAEC marking on students' achievement in mathematics. Error scores were also seen to have negative effect on the actual scores in the content areas used. Considering the results of this study, it is therefore recommended that:

- Regular workshops and seminars should be organized for mathematics teachers on difficult topics.
- All mathematics teachers should be encouraged to attend WAEC training even if they are not going to participate in the actual marking.
- Mathematics qualified teachers should be employed to teach examination classes of Junior Secondary Three (JSS 3) and Senior Secondary Three (SS3).

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