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Determinants of Pupils' Poor Academic Performance in Basic Education Certificate Examination in Mathematics: A Multinomial Logistic Regression Model

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Abstract:

The aim of the present study is to examine and to model in multinomial logit some selected demographic, homes-related, school-related, teachers-related and pupils-related factors as predictors on pupils' Basic Education Certificate Examination (BECE) performance in mathematics as categorical response variable (upper grade, average grade, and lower grade). A combination of systematic and simple random sample of 62 pupils was selected from a cohort of BECE candidates of University Junior High School in Cape Coast municipality. The instrument for data collection was the interview guide. It was then analyzed to calculate the significant parameter coefficients from maximum likelihood method at 95% Confident Interval using IBM SPSS version 21. Two multinomial logit models were developed. The findings show that the Age of pupils, and Class size were significant in the two models. The findings in the first model shows that the incidence of upper grade in BECE mathematics is largely dependent on the Age of pupils, and Class size with younger pupils exhibiting significantly upper grades than older pupils, and with pupils in less class size showing significantly upper grades than those in large class size respectively. In the second model, the occurrence of average grade in BECE mathematics is as well largely dependent on the age of pupils, and class size, with younger pupils exhibiting significantly average grades than older pupils, and with

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pupils in less class size showing significantly average grades than those in large class respectively. Another significant predictors in the first model are; Gender, School location, and Homework, and in the second model, Parental educational level. The overall prediction accuracy (robustness) of the model is 71.0%. The study concluded that the pupils who lack the benefit of the factors especially (school location, Class size-wise, self-homework undertaking, and Parental education) are with a high probability of recording poor performance (lower grades) at BECE mathematic.

Keywords: Multinomial Logit Model, Odds Ratio, Academic Performance Basic Education Certificate Examination,

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1. Introduction

According to Nelson Mandela, "Education is the most powerful weapon which you can use to change the world. Education in its general sense is a form of learning in which the knowledge, skills, and habits of a group of people are transferred from one generation to the next through teaching, training or research."

Academic performance of students especially at the basic school level, is a key success indicator of both the student and the school and a major determinant of the future of youth and the nation in broad-spectrum. Outcomes of learning which have become a phenomenon of interest to all, thus account for the reason why scholars have been working hard to unravel factors that militate against good academic performance (Aremu & Sokan, 2002). This phenomenon has been loosely referred in literature as scholastic functioning. Academic achievement of learners attracts attention of scholars, parents, policymakers and planners. Adeyemo (2001) opined that the major goal of the school is that students to work towards attainment of academic excellence. According to him, the school may have other outlying objectives but emphasis is always placed on the achievement of sound scholarship. Besides, virtually everyone concerned with education places premium on academic achievement; excellent academic achievement of progenies is often the expectation of parents (Osiki, 2001). The quality of students' performance remains at top priority for educators. It is meant for making a difference locally, regionally, nationally and globally.

As such, any serious long-term learning does not rely on learning facts; one acquires a culture (Jones, n.d., Mathematics Education Reform). Truly, some students unquestionably lack a mathematics culture. The people on the front lines of mathematics education, the classroom teachers, can attest to this fact. Pupils are unmotivated and dispirited with mathematics instruction. This is evident in Basic Education Certificate Examination (BECE) results. Clearly, mathematics performance has been abysmal over the decades.

High education achievement is measured by pupils' academic achievement. Pupils' previous educational achievement is an essential indicator of their future achievement. According to Etsey, Amedahe, & Edjah, (2005), higher previous achievement of pupils determines how better they will excel on academic in future endeavors. BECE is an instrument used to assess pupils' academic achievement at the basic education level, prior

to Senior High School. Over the previous years, there have been drastic decline in BECE results, where pupils turn to perform abysmally.

Using 2008 as the base year, where 62.18% of the total number of BECE candidates obtained good grades that qualified them for placement into second cycle education, there has thence been a continual dwindling of BECE results nationwide. For instance, the trend of BECE candidates' performance of passes in percentage terms in 2009 was 50.21%, 49.12% in 2010, and 46.93% in 2011 (WAEC's Chief Examiner's Report, 2012). Chief Examiner's Report for Mathematics in 2012 and 2015, reported that some candidates were not able to write figures in standard form. In 2014, it was observed that most candidates were not able to translate the word problem into mathematical statement, let alone solve the related problems. In 2013, they suggested that teachers and parents should encourage candidates to read extensively in order to increase their stock of mathematical ideas/concepts.

The literature above shows that pupils' performance at BECE mathematics is affected by parental, school, teacher, and pupils' (personal) factors.

The continual decline in BECE Mathematics results over the years has drawn the attention of both the Educationists and Stakeholders of what teachers are teaching, what pupils are learning, and what teaching-learning opportunities are at their disposal, given the school(s) in question. Thus, educators, trainers, and researchers have long been interested in exploring variables contributing effectively to quality performance of learners. These factors may be grouped as pupil factors, family factors, school factors and peer factors (Crosnoe, Johnson & Elder, 2004). Generally, these factors may have branches as include age, gender, geographical belongingness, ethnicity, marital status, socioeconomic status (SES), parents' education level, parental profession, language, income and religious affiliations.

Now, if BECE candidates, who are believed to have gone through a common curriculum, and for which their results from common written examinations show a discrepancy, then it is worthwhile to conduct the study that finds what teaching-learning factors contribute to pupils' poor academic performance in mathematics in Junior High School (JHS).

1. Statement of the Problem

There were varying academic performance of students among the different year groups – some performing extremely well and others poorly. Over the past few years, concerns have been raised by parents about the poor pupils' academic performance in BECE. A study of the BECE results of the University Junior High School (UJHS) from 2013 to 2018 buttresses this.

Table 1: Variations in BECE Mathematics Results

Grades / Year	1	2	3	4	5	6	7	8	9	Total No. of Pupils	Percentage (%) Pass
2013	59	41	36	30	26	17	13	5	1	228	84.2
2014	64	46	38	40	20	16	9	2	1	236	88.1
2015	61	25	37	32	23	20	21	12	2	233	76.4
2016	62	33	39	37	29	20	14	3	1	238	84.0
2017	58	25	30	39	34	19	16	8	2	231	80.5
2018	55	31	12	36	58	40	20	2		254	76.0

Table 1 above shows the performance variations in BECE Mathematics from year 2013 to 2018 of the said school. Generally, there is fluctuation in BECE mathematics in percentage pass. That is, percentage of pupils who obtained (grade 1 to grade 5) varied from year to year. But particularly, in 2014, 88.1% of pupils obtained satisfactory grades whilst it is 76.0% in the year 2018. This shows that there is a vast decrease (of 12.1%) in the BECE mathematics performance for these years. As a result, there must be some factors impeding the pupils' academic performance. The present study thus focused on identifying such factors accounting for poor academic performance of pupils in mathematics in the UJHS so as to provide the antidotes for teaching and learning strategies and subject delivery method(s) to improve the performance level in subsequent years.

2. Research Objective

The general objective of the study is to develop multinomial logit models of factors contributing to pupils' poor academic performance in BECE mathematics.

2.1. Specific Objectives

1. To determine school-related factors that contribute to pupils' academic performance in BECE mathematics
2. To determine parent-related factors that contribute to pupils' academic performance in BECE mathematics
3. To determine home-related factors that contribute to pupils' academic performance in BECE mathematics
4. To determine teacher-related factors that contribute to pupils' academic performance in BECE mathematics.

3. Research Questions

Two research questions have been designed to address each research objective of the study. These are:

1. What are the major determinants that contribute to pupils' poor academic performance in BECE mathematics?
2. What is the robustness of the logit model in its predictions of pupils' BECE mathematics performance?

4. Literature Review

4.1. Determinants of Poor Academic Performance

Various factors have been given for poor performance of students. Rothstein (2004) argues that achievement gap could not close even if all instructors were highly qualified for their profession. That, unless conditions beyond the school control are corrected, the achievement gap will continue to exist. He further argues that learning is not only a product of formal schooling but also of communities, families and peers. Socio-economic and socio-cultural forces can affect learning and thus school achievement. The next part focuses on the relative effects of home-related, school-related, student characteristics, and teacher-side factors. Internal and external factors also affect students' academic performance. However, by grouping factors according to sources, one can identify where specific performance factors come from and how they intertwine with each other. The factors considered under the present study are further discussed below.

4.1.1. Home-Related Factors/Determinants

Whether a child performs well in school can be influenced by a range of household factors. These include socio-economic status (education, occupation and income), size of the household, family structure, and the level of parental involvement and interest in child schooling. Engin-Demir (2009) argued that sizable research has consistently shown that students' academic achievement has been influenced by background of family characteristics such as socio-economic status of parents. Schiller, Khmelkov and Wang (2012) also argued that parents who have more education appear better and able to provide their children with the academic and social support important for educational success when compared to parents with less education. The later finding supports that of Coleman, (2011). (Davis-Keen, 2005), found that the educational status of parents was a major factor determining a child's academic achievements.

4.1.2. School-Related Determinants

Several school environmental factors have generally been identified as influencing academic performance. These include availability of instructional materials, school location (quality of the physical facilities), class size and pupils-teacher ratios, teacher qualification and experience, and supervision. The school location and quality of the physical building influence the performance and achievement levels of pupils. According to Asikhia (2010) where the school is located determines to a very large extent the patronage such a school will enjoy. Class sizes have also been identified as determinants of academic performance. Studies have indicated that schools with smaller class sizes perform better academically than schools with larger class sizes. Fabunmi, Brai-Abu and Adeniji (2007), for instance, indicated that three class factors (class size, student classroom space and class utilization rate), when taken together, determined significantly students' academic performance in Oyo state, Nigeria. This assertion supports that of Kraft (2009), where in his research on teaching and learning in Ghana, concluded that class sizes above 40 have negative effects on students' academic success. Similarly, Salfi and Saeed (2007) found a significant correlation between school size and students' achievement in Pakistan. They revealed that small schools performed better than medium and large schools.

4.1.3. *Student-Related* Determinants

Several pupils' characteristics have generally been identified as influences to their academic performance. These include time with books and homework, attendance in school, pupils' self-concept and motivation. According to Engin-Demir (2009), regardless of intelligence, students who spend more time on assignments and homework improve on pupils' grades. The amount of time students invests in homework and other related activities have also been found to be strongly related to motivation. Homework is in reality an interaction between school and the home, and an essential ingredient of the educational process when measuring academic achievement (Alomar, 2006). Motivation is considered as another variable that initiates the pupil's own involvement in learning. When a student is strongly motivated, all his effort and attention are directed toward the achievement of a specific goal, thus bringing to bear all his or her resources (Diaz, 2003). In relation, students' academic achievement is influenced by the pupils' perception of parental support and involvement. If students' perception is positive on their parent's support and involvement, they will achieve well (DCSF, 2008).

4.1.4. *Teacher-Related* Determinants

Several teacher factors influence academic performance. These include teacher attendance to school, teachers' interest and motivation, and teaching effectiveness and methods of teaching. Teacher regularity in school is important in terms of both children's access to education and the nature of that access. Ofoegbu (2004) linked poor academic performance of students to poor teachers' performance in terms of accomplishing the teaching task, negative attitudes to work and poor teaching habits. The influence of effective teaching on pupils' academic performance has been the subject of several studies. Quality of teachers and commitment are key inputs in educational production to perform better achievement. A teacher's knowledge of the subject matter coupled with textbooks, instructional time and other learning materials have great influence on learning at the basic school level (Lockheed & Verspoor, 2001).

5. Methodology (Method and materials)

5.1. Multinomial Logistic Regression Model

Logistic regression is believed by many statisticians to be the most important tool that can be applied to analyze a categorical data; this model is from the family of Generalized Linear Models (GLM). Multinomial logistic regression (MLR) model is generally used when the categorical response variable has more than two levels or categories. MLR model permits simultaneous comparison of more than one difference, that is, the log odds of three or more differences are estimated simultaneously, Garson (2009). The logistic regression model assumes that the categorical response variable has only two values, 1 as success and 0 as failure. The situations where the categorical response variable has more than two values and the natural ordering of the categories does not matter, it is called multinomial logistic regression model. The main effect of explanatory variables on categorical response variable is usually explained in terms of odds ratios. Logistic regression applies maximum likelihood estimation after the response variable is transformed into logit.

Given the independent variable x and the categorical response variable Y having J-levels/categories $(J > 2)$, the logits in the multinomial case could be constructed by considering one of these categories as the baseline-category and all other logits are constructed relative to it. Any category could be used as the baseline-category. Thus, taken category j to be the base level, $log\left(\frac{\pi_j}{\pi_J}\right)$, $j = 1, 2, \dots, J-1$ is the Baseline-Category logit.

And since there is no ordering, apparently, Baseline-Category logit model is built as;

$$log\left(\frac{\pi_j}{\pi_J}\right) = \beta_j + \beta_j x \qquad j = 1, 2, \dots, J-1 \quad \text{.....(1)}$$

Now, if there are n observations with independent variables x_i and the categorical response variable Y having J-levels/categories $(J > 2)$, let π_{ij} denote the multinomial probability of an event falling in the j^{th} category (or a pupil i having a j^{th} grade), and $x_1, x_2, \dots \dots, x_i$ as a set of explanatory variables.

Also, let y denote the level of pupil's BECE mathematics grade.

Therefore: $y = 0: Upper\ grade,\ y = 1: Average\ grade,\ y = 2: Lower\ grade$

Where $j = 1, 2, 3.\ (J-1),\ i = 1, 2, 3, \dots, n.$ Then the odds ratios of a pupil scoring upper,

And average grade relative to lower grade in BECE mathematics can be modeled in two logits as;

$$log\left(\frac{\pi(y_i=0|x_iAGE+\cdots+x_iHWRK)}{\pi(y_i=2|x_iAGE+\cdots+x_iHWRK)}\right)=\beta_0+\beta_1x_iAGE+\ldots+\beta_4x_iHWRK \quad \ldots\ldots\ldots\ldots(2)$$

$$log\left(\frac{\pi(y_i=1|x_iAGE+\cdots+x_iHWRK)}{\pi(y_i=2|x_iAGE+\cdots+x_iHWRK)}\right)=\beta_{10}+\beta_{11}x_iAGE+\ldots+\beta_{14}x_iHWRK \quad \ldots\ldots\ldots(3)$$

Hence, corresponding probabilities for (2) and (3) are;

$$\pi_i, upper\ grade=\frac{e^{\beta_0x_i}}{1+\sum_{j=1}^{2}e^{\beta_jx_i}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

$$\pi_i, average\ grade=\frac{e^{\beta_1x_i}}{1+\sum_{j=1}^{2}e^{\beta_jx_i}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

$$\pi_i, lower\ grade=\frac{e^{\beta_2x_i}}{1+\sum_{j=1}^{2}e^{\beta_jx_i}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(6)$$

Statistical software is used to fitting the models in question, and Maximum Likelihood (ML) method is used to estimate the model parameters (Chatterjee & Hadi, 2006).

5.2. Source of Data

The study relied on the academic performance of pupils in BECE mathematics for 2017/2018 academic year as well as their demographics, school-related factors, teacher-related factors, parent-related factors, and pupils-related factors.

5.3. Variables information

5.3.1. Dependent variable

The dependent (response) variable "BECE performance" is polychotomized and has three categorical levels; with high grade (grade 1 to grade 3) coded as 0, 1 as average grade (grade 4 to grade 6), and lower grade (grade 7 to grade 9) coded as 2. In the multinomial logistic regression model, the estimates of parameters are identified and compared to a baseline-category of the response variable (Long, J.S. 1997).

5.3.2. Explanatory variables

Researchers chose a set of explanatory variables that are believed to somehow, contribute to pupils' academic performance. These explanatory variables used as determinants are described under the umbrella of the; home-related factors, students-related factors, school-

related factors, and teacher-related factors. These explanatory variables were coded and reviewed in details in Table 2 below.

Table 2: List of the response and explanatory variables and their categorical values.

Variables	Data type	Categorical values
Response variable		
BECE performance grade: High grade		0 = 1 – 3
BECE performance grade: Average		1= 4 – 5
BECE performance grade: Low grade		2 = 6 – 9
Predictor variables		
Home-related factors:		
Parental education [PED]	Binary	0 – diploma education/above 1 – < diploma education
Parental occupation [POC]	Binary	0 – non academic 1 – academic
Parental interest [PINT]	Binary	0 – not interested 1 – highly interested
Parental involvement [PINV]	Binary	0 – home tuition 1 – indifferent
Household size [HSZ]	Binary	0 – less than or two siblings 1 – more than two siblings
Family/home structure [HSTR]	Binary	0 – live with parents 1 – live without parents
Parental Income/Financial level [FSTA]	Binary	0 – low income earning 1 – high income earning
School-related factors		
Availability of instructional materials [TLM]	Binary	0 – adequate materials 1 – inadequate materials
School location [SLOC]	Binary	0 – in district capital 1 – in non-district capital
Class size (pupils-teacher ratio) [CLSZ]	Binary	0 – $\leq$ 30: 1 1 – $>$ 30:1
Extended class study [SEXT]	Binary	0 – entirely 1 – not entirely
Student-related factors		
Age [AGE]	Binary	0 – $\leq$ 15 years 1 – $>$ 15 years
Gender [GND]	Binary	0 – male 1 – female
Homework/assignment [HWRK]	Binary	0 – self 1 – by assistance
Learning materials/textbook [TXTB]		0 – Availability of textbook(s) 1 – no textbook(s)
Class attendance [CTDM]	Binary	0 – low attendance

		1 – high attendance
Teacher-related factors		
Teachers' interest/motivation [TRM]	Binary	0 – teaching of interest 1 -- teaching not of interest
Teachers' qualification [TRQ]	Binary	0 – diploma 1 – bachelor's degree and/or above

5.4. Study Design

The descriptive research design was used to describe facts, discover new facts to address the research questions.

5.5. Source of Population

The pupils of Basic Education Certificate Examination in the University Junior High School during the academic year 2017/2018 were considered as the population.

5.6. Sample and Sampling Technique

The subjects for the present study were 62 pupils out of a population of 254 $(24.41\% \; of \; 254)$. The systematic sampling method followed by simple random sampling technique was used to select the subjects for the study. Subjects were arranged in order of magnitude based on their school index numbers. With the systematic sampling, the population was divided by the sample size to obtain the sampling interval as $\frac{254}{62} = 4.09 \approx 4$. A pupil was selected from the first 4 pupils using the simple random sampling to be the first subject included in the sample and the second is subject was the 4^{th} following the first subject. And so every 4^{th} pupil was selected till the required sample for the study was obtained.

5.7. Data Collection Instrument/Procedure

The researchers obtained the primary data for qualitative research via a well-structured interview guide. The interval within which pupil's response must fall was stated to avoid bias. The participants were invited for the interview one after the other to have 2:1 researchers-pupil ratio.

5.8. Data Analysis Plan

The IBM Statistical Package for Social Sciences (SPSS) version 21 was used to analyzed the data to calculate the parameter coefficients estimates for the multinomial logit model at 95% Confident Interval (C.I.).

6. Analysis and Discussion

The present study employed a multinomial logit model to determine the prediction of the determinants of pupils' academic performance in BECE mathematics. The coefficients of the predictors were estimated by maximum likelihood method.

6.1. Checking the response variable

Table 3: Case processing summary using 18 explanatory variables

Response Variable Categories		N	Marginal Percentage
	0 – High pass	18	29.0
	1– Average pass	26	42.0
	2 – Low pass	18	29.0
Valid		62	100.0
Missing		0	
Total		62	
Subpopulation		62	

The dependent variable has only one value observed in 62 (100.0%) subpopulations.

Table 3 shows case processing summary which contains both the response variable and the explanatory variables. The researchers focused on the response variable. In the present model, the number of observations considered valid is 62 distributed among the three levels of categories. The proportions of valid observations (obtained in each level of the response variable's groups) are listed in the marginal percentage column. The valid case for high grade is 29.0%, 42% for average grade, and 29.0% for lower grade, subjected to BECE performance. N shows the number of subpopulations in the data. There are 62 combinations appearing in the data and all these combinations are collection of records with the same categories of response variable.

6.2. Missing Variable(s)

There is no missing of response variable or explanatory variables in the number of cases in the dataset in the primary model.

6.3. MLR model building Information

The researchers chose 18 explanatory variables that might have main effect on BECE performance as shown in table 2. The IBM SPSS version 21 and NOMERG command were used to estimate the MLR model with all the explanatory variables on the single response variable with three categorical levels to build the primary model.

6.4. *MLR Model Fitting Information*

Chi-square statistics was used to assess the overall effectiveness of the model. That is $\chi^2(38,\ N = 62) = 54.790\ , p = 0.038$. Thus, showing there is a significant relationship between the response variable and the explanatory variables in the final model.

Table 4: Model Fitting Information

	Model Fitting Criteria	Likelihood Ratio Tests		
Model	-2 Log Likelihood	Chi-square	df	Sig.
Intercept Only	134.237			
Final	79.446	54.790	38	.038

The value of the Chi-square statistic might not indicate how strong or the extent to which the association between the dependent variable and the independent variables is. As a result, the Pseudo R-Square measures were used to determine the strength of association as shown in the Table 5 below.

Table 5: Pseudo R-Square

Cox and Snell	.587
Nagelkerke	.663
McFadden	.408

As shown in the Table 5 above, all the values of the three measurements show strong associations (correlations) between the response variable and the set of predictors.

6.5. *Goodness of fit tests*

The overall significance/performance of the model in the present study was assessed by using; Goodness-of-Fit, and the Classification Table as shown respectively in Table 6 and Table 6 below.

Table 6: Goodness of Fit

	Chi-square	df	Sig.
Pearson	78.314	84	.654
Deviance	79.446	84	.620

From Table 6, the model fit is acceptable $\chi^2(85) = 78.314, p = 0.654$ and $\chi^2(85) = 78.446$, $p = 0.620$. These show that in the predictions by the model, the observed values were not

significantly different from the predicted values. Thus in Table 6, the p −values must be greater than the cut-off value established usually 0.05 to proving model fitness.

Table 7: Classification

Observed	Predicted			Percent Correct
	0	1	2	
0	12	4	2	66.7%
1	3	20	3	76.9%
2	2	4	12	66.7%
Overall Percentage	27.4%	45.2%	27.4%	71.0%

The overall prediction accuracy of the model is 71.0%. This indicates the overall cases the model correctly classified. Thus the model correctly classified (predicted) 71.0% of the cases into their respective memberships. Regarding group wise, 66.7% of cases were correctly classified (predicted) into high grades, and into lower grades, 76.9% of the cases were classified (predicted) correctly into average grades.

7. Multinomial Logit Models

7.1. Variables in the equation

Regarding the two logistic regression models, the "lower grade" forms the baseline category against which the other two groups of grading are compared directly. The table shows the estimated parameters of the two regression models predicting the membership in the two different levels of BECE passing. The second column in Table 8 and 9 indicate the unstandardized regression slopes each for the two regression models. This is followed by the corresponding standard error of slopes, Wald statistics, the significance level, and the Odds ratio. The two models both include the intercept and the slopes for the predictor variables. The intercept of the first model is the log of the ratio of the probability of a pupil getting "upper grade" to the probability of that pupil getting "lower grade," and the second model is the log of the ratio of the probability of a pupil scoring an "average grade" to the probability of that pupil scoring "lower grade." Each subgroups of grading (upper grade, and average grade) is compared with the baseline category of "lower grade."

The present study presents two MLR models using pupils' lower grades in mathematics as baseline category/reference category. Tables 8 and 9 show the Multinomial Logistic

Regression analysis. They confirm that 6 out of 18 explanatory variables have significant main effect on the response variable at 0.05 level of significance. These are: students' factors; age of students, gender of students, and whether the homework is done by student or not, school factors; class size, and school location, parent related factors; educational status of parent(s). The first MLR model compares pupils' high grades to lower grades in BECE mathematics based on some predictors (age of students, gender of students, and whether the homework is done by student or not, class size, and school location). The second MLR model as well compares pupils' average grades to lower grades in BECE mathematics regarding some explanatory variables (age, educational status of parent(s), and class size). The Table 8 below presents the first MLR model. These estimates of parameter coefficients were obtained by Maximum Likelihood Method.

Table 8: Parameter Estimates of Multinomial Logistic Regression – upper versus lower grades

BECE[a]	B	Std. Error	Wald	df	Sig.	Exp (B)	95%C.I. for Exp (B)	
							Lower B	Upper B
intercept	9.989	4779.371	.000	1	.998			
[AGE=0]	−4.965	1.756	7.992	1	.005	.007	.000	.218
[AGE=1]	0^b			0				
[GND=0]	−3.528	1.626	4.708	1	.030	.029	.001	.711
[GND=1]	0^b			0				
[TRQ=0]	.323	1.232	.069	1	.793	1.382	.123	15.466
[TRQ=1]	0^b			0				
[PED=0]	−8.696	4779.371	.000	1	.998	.000	.000	*c*
[PED=1]	0^b			0				
[POC=0]	1.510	1.517	.991	1	.320	4.527	.232	88.519
[POC=1]	0^b			0				
[FSTA=0]	−1.993	1.280	2.426	1	.119	.136	.011	1.674
[FSTA=1]	0^b			0				
[HSTR=0]	14.663	763.156	.000	1	.985	2334380.884	.000	*c*
[HSTR=1]	0^b			0				
[HSZ=0]	−5.575	1.420	1.230	1	.267	.207	.013	3.348
[HSZ=1]	0^b			0				
[PINT=0]	−52.528	1483.385	.001	1	.972	$1.000E-013$	.000	*c*
[PINT=1]	0^b			0				
[PINV=0]	1.275	1.177	1.173	1	.279	3.578	.356	35.953
[PINV=1]	0^b			0				
[TXTB=0]	−1.431	2.029	.497	1	.481	.239	.004	12.767
[TXTB=1]	0^b			0				

[TLM=0]	−1.580	1.384	1.303	1	.254	.206	.014	3.103
[TLM=1]	0^b			0				
[CLSZ=0]	5.941	2.283	6.769	1	.009	380.221	4.329	33392.347
[CLSZ=1]	0^b			0				
[SLOC=0]	−6.715	3.133	4.594	1	.032	.001	2.612e006	.563
[SLOC=1]	0^b			0				
[SEXT=0]	.774	2.615	.088	1	.767	2.169	.013	364.579
[SEXT=1]	0^b			0				
[TRM=0]	1.014	1.362	.555	1	.456	2.758	.191	39.814
[TRM=1]	0^b			0				
[CTDA=0]	19.805	825.943	.001	1	.981	399117053.9	.000	c
[CTDA=1]	0^b			0				
[HWRK=0]	5.034	2.418	4.336	1	.037	153.596	1.344	17551.554
[HWRK=1]	0^b			0				

a. The reference category is: 2. b. This parameter is set to zero because it is redundant. c. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

In Table 8, the slopes of the predictor variables, age, gender, and school location are negative while that of homework, and class size are positive. These variables are significant for the first model. Thus it can inferred as the students who were below age 15 years during their BECE had significantly more chance to obtain upper grade relative to lower grade in mathematics than pupils above 15 years. Pupils who had the pupils-teacher ratio of their class size of not more than 30:1 were significantly more likely to score upper grade relative lower grade in mathematics than pupils who were in class with pupils-teacher ratio exceeding 30:1. This assertion supports the study carried out by Kraft (1994) on ideal class size and its effects on teaching and learning in Ghana and concluded that class size above 40 have negative effects on students' academic success. Research on class size by Fabunmi, Brai-Abu and Adeniji (2007) and Salfi and Saeed (2007) is also supported. The other significant variables are; gender, school location, and pupils' homework. These indicate that male pupils are more likely to obtain upper grades rather than lower grades. Also, pupils schooled in district capital schools are more likely to obtain upper grades rather than lower grades. This supports the study conducted by Asikhia (2010) and conclude that the school location determines to a very large extent patronage that school will enjoy to boosting students' academic success. Again, pupils who did the mathematics homework by themselves are more likely to score upper grade in BECE mathematics rather than lower grades. This assertion also supports the study that regardless of intelligence, students who

spend more time on homework and assignments stand a better chance to improve their grades (Engin-Demir, 2009). Also, that homework is in reality interaction between school and home, and essential ingredient when measuring academic success (Alomar, 2006).

Moreover, interpreting the output in Table 8 in terms of Wald, considering Wald for predictor variable age is 7.992. This means that controlling for other predictors, the pupils who were below age 15 years during their BECE were 0.007 times more likely to obtain upper grade relative to lower grade in BECE mathematics than those whose age were more than 15 years. Wald for predictor gender is 4.708 and shows that controlling for other significant predictors, the pupils who are male were 0.029 times more chances of getting upper grade relative to lower grade in mathematics than female pupils. Also, Wald for class size predictor variable is 6.77 and shows that with other predictors held constant, the pupils who had their teaching and learning of mathematics in with pupils-teacher ratio less or equal to 30:1 had 380.221 times more likely to obtain upper grade relative to lower grade than those whose class size ratio was above 30:1. Again, the Wald for school location is 4.59, which implies that holding all other predictors constant, the pupils who had their education in the district capital school stood 0.001 times more chance of getting upper grade relative to lower grade than those who had their education in the school located in non-district capital. Lastly, Wald for predictor homework is 4.34 which indicates that when all other variables are held constant, the pupils who by themselves learned and practiced how to do mathematics homework given to them by their teacher had 153.596 times better chance of obtaining upper grade relative to lower grade than their counterparts who by themselves did not learn and practice the doing of homework.

More so, the Table 9 below presents the second MLR model. These estimates of parameter coefficients were obtained by Maximum Likelihood Method.

Table 9: Parameter Estimates of Multinomial Logistic Regression – average versus lower grades

BECE[a]	B	Std. Er	Wald	df	Sig.	Exp (B)	95%C.I. for Exp (B)	
							Lower. B	Upper B
intercept	17.048	2.318	54.109	1	.000			
[AGE=0]	−2.546	1.255	4.115	1	.042	.078	.007	.917
[AGE=1]	0[b]			0				

[GND=0]	−.484	.997	.236	1	.627	.616	.087	4.352
[GND=1]	0^b			0				
[TRQ=0]	.812	1.166	.485	1	.486	2.252	.229	22.139
[TRQ=1]	0^b			0				
[PED=0]	−17.277	1.363	160.758	1	.000	$3.140E-008$	$2.173e-009$	4.536e-009
[PED=1]	0^b			0				
[POC=0]	1.123	1.204	.871	1	.351	3.075	.290	32.541
[POC=1]	0^b			0				
[FSTA=0]	−.888	.956	.863	1	.353	.412	.063	2.679
[FSTA=1]	0^b			0				
[HSTR=0]	16.143	763.153	.000	1	.983	10248838.32	.000	*c*
[HSTR=1]	0^b			0				
[HSZ=0]	−1.042	1.273	.670	1	.413	.353	.029	4.277
[HSZ=1]	0^b			0				
[PINT=0]	−.635	2.448	.067	1	.795	.530	.004	64.254
[PINT=1]	0^b			0				
[PINV=0]	.171	.923	.034	1	.853	1.186	.194	7.245
[PINV=1]	0^b			0				
[TXTB=0]	−.596	2.042	.085	1	.771	1.814	.033	99.358
[TXTB=1]	0^b			0				
[TLM=0]	1.204	1.073	1.261	1	.262	3.335	.407	27.297
[TLM=1]	0^b			0				
[CLSZ=0]	2.860	1.440	3.948	1	.047	17.464	1.039	293.420
[CLSZ=1]	0^b			0				
[SLOC=0]	−2.329	2.305	1.021	1	.312	.097	.001	8.927
[SLOC=1]	0^b			0				
[SEXT=0]	.633	1.742	.132	1	.716	1.883	.062	57.194
[SEXT=1]	0^b			0				
[TRM=0]	.424	1.173	.131	1	.718	1.528	.153	57.194
[TRM=1]	0^b			0				
[CTDA=0]	−30.727	1674.89	.000	1	.985	$1.452E-013$	.000	*c*
[CTDA=1]	0^b			0				
[HWRK=0]	.657	1.604	.168	1	.682	1.928	.083	44.698
[HWRK=1]	0^b			0				

a. The reference category is: 2. b. This parameter is set to zero because it is redundant. c. Floating point overflow occurred while computing this statistic. Its value is therefore set to system missing.

In Table 9 above, the slopes of the statistically significant predictor variables; age, and educational status of parent(s) are both negative and positive for the variable class size. Thus it can be inferred as pupils who were below age 15 years during their BECE had significantly more chance to obtain average grades relative to lower grades in mathematics than pupils above 15 years. Pupils who had the pupils-teacher ratio of their class size of not more than 30:1 were significantly more likely to score average grades relative to lower

grade in mathematics than their counterparts who were in a class with pupils-teacher ratio exceeding 30:1. This assertion still supports the study carried out by Kraft (1994) on ideal class size and its effects on teaching and learning in Ghana, and concluded that class size above 40 have negative effects on students' academic performance. Research on class size by Fabunmi, Brai-Abu and Adeniji (2007) and Salfi and Saeed (2007) is also supported. The educational status of parent(s) variable is significant in the second logit model. This indicates that the pupils whose parent(s) has/have at least a diploma qualification in academic wise stood a better chance of obtaining average grades relative to lower grades than their cohort whose parent(s) has/have qualification lower than the diploma. The study that children with high level of parental education appear better and able to provide their children with the academic and social support important for educational success when compared to children with less parental education is supported (Schiller, Khmelkov and Wang, 2002; Coleman, 2006). This also supports the findings of (Davis-Keen, 2005) study that the educational status of parents was a major factor determining a child's academic achievements.

Interestingly, considering Wald for predictor variable age is 4.115. This means that controlling for other predictors, the pupils who were below age 15 years during their BECE were 0.078 times more likely to obtain average grades relative to lower grade in BECE mathematics than those whose age were more than 15 years. Also, Wald for class size predictor variable is 3.948 and shows that with other predictors held constant, the pupils who had their teaching and learning of mathematics in with pupils-teacher ratio less or equal to 30:1 had 17.464 times more likely to obtain average grades relative to lower grade than those whose class size ratio was above 30:1. For the variable, educational status, the Wald is 1.363 and shows that the pupils whose parent(s) has/have at least a diploma qualification in academic wise stood a better chance of obtaining average grades relative to lower grades 3.140E-008 more times than their cohort whose parent(s) has/have qualification lower than the diploma level.

7.2. *Odds Ratio Interpretation of Significant Variables in the Logit Models*

7.2.1. *Odds Ratio Interpretation of the first Logit Model*

Considering the Exp(B) for predictor variable age, 0.007, indicates that controlling for other predictors, estimated odds of BECE performance for upper grade relative to lower grade among pupils aged below 15 years is 0.007 times estimated odds for those above 15 years. Controlling for other significant predictors, estimated odds of BECE performance for upper grades relative to lower grade for males is 0.029 times estimated odds for females. Also, holding other variables constant, estimated odds of BECE performance for upper grade relative to lover grade for the pupils who had their teaching and learning of mathematics in with pupils-teacher ratio less or equal to 30:1 is 380.221 times estimated odds for those whose class size ratio was above 30:1. Alternatively, a unit increase in pupil's chance to study mathematics in a classroom with pupils-teacher ratio less or equal to 30:1 would increase the odds of a pupil to obtain upper grade relative to lower grade in BECE mathematics by 380.221 more times, holding other predictors constant. Again, holding all other predictors constant, estimated odds of BECE for upper grade relative to lower grade for pupils who had their education in the district capital school is 0.001 times estimated odds for those who had their education in the school located in non-district capital. Lastly, when all other variables are held constant, estimated odds of BECE performance upper grades relative to lower grade for pupils who by themselves learned and practiced how to do mathematics homework given to them by their teacher is153.596 times estimated odds for their counterparts who by themselves did not learn and practice the doing of homework. In other words, controlling for other significant predictors, a unit increase in pupil-self undertaking the homework would increase the odds of a pupil to obtain upper grade relative to lower grade in BECE mathematics by 153.596 more times. Hence the logit model,

$$\log\left(\frac{\hat{\pi}_0}{\hat{\pi}_2}\right) = 9.989 - 4.965AGE - 3.528GND + 5.941CLSZ - 6.715SLOC + 5.034HWRK \quad \ldots(7)$$

equivalently,

$$\hat{\pi}_0 = \frac{e^{9.989-4.965AGE-3.528GND+5.941CLSZ-6.715SLOC+5.034HWRK}}{1+e^{9.989-4.965AGE-3.528GND+5.941CLSZ-6.715SLOC+5.034HWRK}+e^{17.048-2.546AGE-17.277EDS+2.860CLSZ}} \quad \ldots(8)$$

7.2.2. ***Odds Ratio Interpretation of the Second Logit Model***

Considering the second logit model, the Exp(B) for predictor variable age 0.078 indicates that controlling for other predictors, estimated odds of BECE performance for average grade relative to lower grade for pupils aged less than or equal to 15 years is 0.078 times estimated odds for those above 15 years. Also, controlling for other predictors, estimated odds of BECE performance for average grade relative to lover grade for the pupils who had their teaching and learning of mathematics in with pupils-teacher ratio less or equal to 30:1 is 17.464 times estimated odds for those whose class size ratio was above 30:1. Alternatively, a unit increase in pupil's chance to study mathematics in a classroom with pupils-teacher ratio less or equal to 30:1 would increase the odds of a pupil to obtain average grade relative to lower grade in BECE mathematics by 17.464 more times, holding other predictors constant. For the variable educational status, holding all other variables constant, estimated odds of BECE performance for average grade relative to lower grade for pupils whose parent(s) has/have at least a diploma qualification in academic wise is 3.140E-008 times estimated odds for pupils whose parent(s) has/have qualification lower than the diploma level. Alternatively, a unit increase in the qualification of parent(s) would decrease the odds of a pupil not to obtain average grade relative to lower grade by 3.140E-008 more times, controlling all other predictors. Thus the logit model;

$$\log\left(\frac{\hat{\pi}_1}{\hat{\pi}_2}\right) = 17.048 - 2.546AGE - 17.277EDS + 2.860CLSZ \quad \ldots\ldots\ldots\ldots (9)$$

equivalently,

$$\hat{\pi}_1 = \frac{e^{17.048-2.546AGE-17.277EDS+2.860CLSZ}}{1+ e^{9.989-4.965AGE-3.528GND+5.941CLSZ-6.715SLOC+5.034HWRK} + e^{17.048-2.546AGE-17.277EDS+2.860CLSZ}} \quad \ldots(10)$$

$$\hat{\pi}_2 = \frac{1}{1+ e^{9.989-4.965AGE-3.528GND+5.941CLSZ-6.715SLOC+5.034HWRK} + e^{17.048-2.546AGE-17.277EDS+2.860CLSZ}} \quad \ldots(11)$$

8. Conclusion/Recommendations

A multinomial logit model was developed to predict the pupils' BECE performance grades in mathematics based on some significant predictors. The findings show that the Age of pupils, and Class size were significant in the two models. The findings in the first model showed that the incidence of upper grade in BECE mathematics is largely dependent on the Age of pupils, and Class size with younger pupils exhibiting significantly upper grades than older pupils, and with pupils in less class size showing significantly upper grades than those in large class size respectively. In the second model, the occurrence of average grade in BECE mathematics is as well largely dependent on the age of pupils, and class size, with pupils less than or equal to 15 years during their BECE exhibiting significantly average grades than those older 15 years, and with pupils in class of size less than or equal to 30:1 pupils-teacher ratio showing significantly average grades than those in class size exceeding 30:1 pupils-teacher ratio respectively. Another significant predictors in the first model are; Gender, School location, and Homework, and in the second model, Parental educational level. The school-related factors that are significant in predicting pupil's BECE mathematics performance (grade) are school location, and class size. While pupils' demographic; age and gender determine their BECE grades in mathematics, Parental educational level and pupil-self-homework undertaking are respectively the only home-related factor and pupil-related factor influencing pupils' BECE grade in mathematics. Thus, the study concluded that pupils' poor academic performances at the BECE mathematics are caused by the deviation from these significant factors.

The overall prediction accuracy (robustness) of the multinomial logit model is 71.0%. The model is thus good for future predictions of pupils' BECE performance grades in mathematics. The study further concluded that the pupils who lack the benefit of these major factors especially (school location, Class size-wise, self-homework undertaking, and Parental education) are with a high probability of recording poor performance (lower grades) at BECE mathematics. The following recommendations might improve pupils' performance at BECE mathematics:

- Heads and authorities of schools should take into consideration the ratio of pupils-teacher in especially mathematics class as the subject requires much of pupil's hand on task (problem) as well as teacher-pupil interaction. A relatively small class size provides

the teacher an opportunity to attend to and direct at least each pupil working on mathematics task to correct and repairs pupils' misconceptions compare to a large class size where teaching might turn into teacher centeredness (lecturing) only.

- Pupils should be encouraged to work on their homework/assignments given to them by their instructor. Parents should only guide by explaining the concepts of the task while their wards do the actual work.
- Future study should consider the inclusion of other factors like curriculum intentions, study habits, and attitude of pupils towards mathematics and validate the multinomial logit model.

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