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Pass or Failure of Students in The "WASSCE" Mathematics Mock Examination: The Binary Logistic Regression Model

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ABSTRACT: *This study predicts students' pass or failure in the WASSCE mathematics mock examination. Three hundred (300) Senior High School (SHS) students, comprising one hundred and fifty-nine (159) males and one hundred and forty-one (141) females from selected Senior High Schools in the Cape Coast Municipal District of the Central Region, participated in the study. The binary logistic regression model comprising continuous and categorical predictor variables was adopted. The results indicated that the raw score coefficients for Math self-concept, Math attitude, Instructional strategies and methods, Teacher competency in math, and Gender, were positive and significant (P < .05), while that of High Socio-Economic Status (SES) was negative and significant (P < .05). The adjusted odds ratio for gender was 2.24, with a C. I of .45 -11.02. The adjusted odds ratio for mathematics self-concept was 7.40, with a C. I of 2.32 - 23.60, while, the adjusted odds ratio for Instructional strategies and methods was 31.67, with a C.I of .97 -15.40. An implication of this study is that mathematics teachers should not downplay the role these significant predictors play in the teaching and learning of the subject. Mathematics teachers must create a conducive atmosphere in the classroom to support active learning among students. The study concludes that to increase the probability of students passing the examination, the value of the exponential term in the computation of the probability must reduce considerably. This can be realised through an effective combination of the predictor variables.*

KEYWORDS: WASSCE, Cape Coast municipal district, Math self-concept, binary logistic regression model, mock examination.

INTRODUCTION

Students' mathematical skills and proficiency are essential for academic success and for solving everyday problems (Carey, Hill, Devine, & Sz ̋ucs, 2017). Through mathematics, students attain accuracy in their judgement, consistency in their goals and ambitions, and mental discipline, which are essential skills they need to be effective and responsible citizens. Knowledge of mathematics is crucial in several disciplines including technical, engineering, economics, finance, agriculture, pharmaceuticals, and health sciences (Joyce, Hine, & Anderton, 2017; Gradwohl & Eichler, 2018). Mathematics is a fundamental subject because arithmetic and logical reasoning, which form major components of the subject, are the basis of science and technology. For this reason, policymakers the world over, emphasize students' proficiency in computational skills and problem-solving in

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their students' learning outcomes (Yehi et al., 2019). In Ghana, the government recognises that student mathematics achievement could improve if students consciously take a keen interest in STEM-related disciplines. As a consequence of this ambition, the government is putting up STEM senior high schools across the country, to equip students with the skills they need to be successful in the careers they may pursue.

LITERATURE REVIEW

Several psychological, social, and biological factors greatly influence students' pass or failure in mathematics (Kushwaha, 2014). The psychological factors include their attitude towards mathematics (e.g., Enu,Agyeman, & Nkum, 2015; Kargar, Tarmizi, & Bayat, 2010). mathematics anxiety (e.g., Wahid, Yusof & Razak, 2014; Awaludin, Ab Razak, Azliana Aridi, & Selamat, 2015; Núñez-Peña, Suarez Pellicioni, & Bono, 2013; Bjälkebring, 2019), intelligence, self-concept, study habits, mathematical aptitude, numerical ability, cognitive style, self-esteem, interest in mathematics, reading ability, problem-solving ability, mathematical creativity, educational and occupational aspiration, personal adjustment, locus of control, emotional stability, and confidence in mathematics. The social factors include socioeconomic status, school environment, home environment, parents' education, parental involvement, parents' occupation, parents' income, social status, social relations, type of school, teacher's expectation, and social maturity. Whilst, the biological factors include gender, locality, methods of instruction, birth order, teacher effectiveness, and home tutoring (Kushwaha, 2014).

Other factors that play an important role in student mathematics achievement include students' mathematical self-efficacy and engagement (Warwick, 2008), academic self-beliefs (Hailikari, Nevgi, & Komulainen, 2008), learning motivation (see, e.g., Enu, Agyman, & Nkum, 2015; Gradwohl & Eichler, 2018), learning strategies and/or availability of teaching resources (see, e.g., Enu, Agyeman, & Nkum, 2015; Gradwohl & Eichler, 2018), teaching style (e. g., Kazemi & Ghoraishi, 2012), parent's profile (e.g., Dagaylo-AN &Tancinco, 2016), class size (see, e.g., Eng, Li, & Julaihi, 2010), gender (see, e.g., Eng, Li, & Julaihi, 2010; Mohd, Tengku Mahmood, Mahmood, & Ismail, 2011), and age (Josiah, Olubunmi, & Adejoke, 2014).

The student factors influencing mathematical achievement are demographics, gender, attitude, knowledge, and student engagement (Maamin, Maat, & Ikhsan, 2021). Student engagement is discussed extensively in this literature review because of its importance in the teaching and learning process. It is a multidimensional construct, often associated with academic achievement predictors (Lee, 2013; Baroody, Rimm-Kaufman, Larsen, & Curby, 2016; Christenson, Wylie, & Reschly, 2012), and defined as "a student's psychological investment in an effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote" (Finn,1989). It is composed of three dimensions, namely cognitive, behavioural, and affective engagements. Student engagement and academic achievement are constructs that help teachers understand and improve students' mathematics achievement (Furlong, & Christenson, 2008). Further, student engagement and school activities are important to improve mathematics achievement (Wang, Fredricks, Ye, Hofkens, & Linn, 2016), because student engagement is a predictor of academic achievement (Deveci & Karademir, 2019; Finn & Zimmer, 2012; Finn & Voelkl,1993).

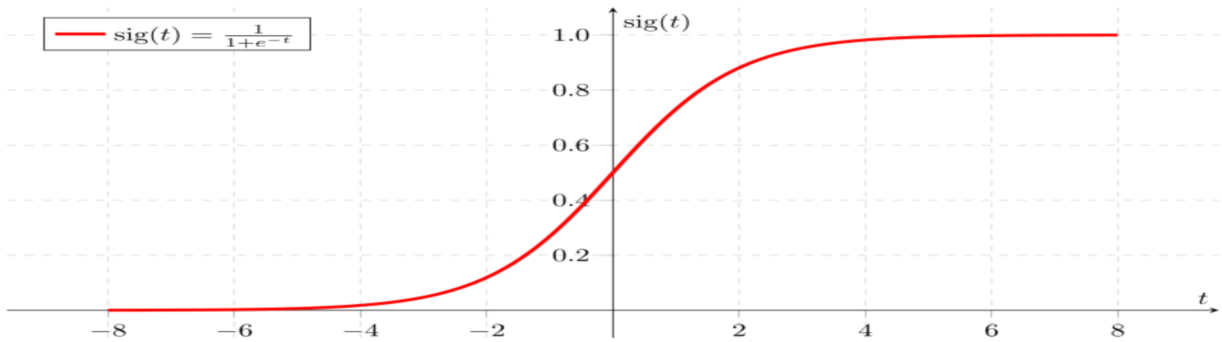
The relationship between student engagement and mathematics achievement has been studied by some researchers, where a significant relationship between cognitive engagement and student achievement, has been identified (Carini, Kuh & Klein, 2006; Delfino, 2019). It needs emphasising that student learning strategies that measure cognitive engagement also relate significantly to mathematics achievement (Park, 2005). Furthermore, a significant relationship exists between behavioural engagement and mathematics achievement (Asif, Thomas, Awan, & Din, 2020; Wong, Lam, & Kong, 2003). For example, diligence, a measure of behavioral engagement, has a bearing on mathematics achievement (Aguanta Jr, & Tan, 2018). Diligent students achieve success in mathematics because they practice well and submit assignments on time (Gasevic, Jovanovic, Pardo, & Dawson, 2017). Student affective engagement occurs when students feel they belong to the school whose environment, positively influences their experiences (Asif, Thomas, Awan, & Din, 2020).

For this to occur in the schools, mathematics teachers should endeavour to build confidence among students, by assigning them authentic tasks that increase their drive to engage with meaningful mathematics requiring creativity and problem solving. These teachers should encourage questioning and make space for critical thinking and curiosity. They should emphasise conceptual understanding over procedural learning, and endeavour to share positive attitudes about mathematics with their students. The purpose of this study was to determine the variables (i.e., Math self-concept, Math attitude, Arithmetic ability, Motivation, Instructional strategies and methods, Teacher competency in math, Gender, and Ethnicity), which predicted SHS students' pass or failure in WASSCE mathematics mock examination. This study was guided by the following research questions:

(a) Which predictor variables contributed significantly to the binary logistic regression model?
(b) Which predictor variables did not contribute significantly to the binary logistic regression model?
(c) What was the nature of odds ratios associated with a unit increase in each predictor variable?
(d) What was the probability of a student passing in the examination, given a set of applicable predictor
variables?

METHOD

Fig 1: Sigmoid function



Mathematical Model

The binary logistic regression model is a statistical method that describes and tests hypotheses about relationships between a categorical response variable with two possible outcomes and at least one explanatory variable, which can either be categorical, continuous, or a mixture of the two. The response variable might be a student receiving or denying funding, a patient living or dying during emergency surgery, or a student passing or failing the WASCCE mathematics mock examination. Generally, the two outcomes of the response variable, often denoted by "pass" and "fail" are represented by 1 (for pass) and 0 (for fail). The mean is the proportion of 1s, p = p (pass). The two possible outcomes in binary regression represent two different groups of cases. The results of the analysis are framed in terms of the likelihood of a case being (coded in the data file as one of the groups), as opposed to the other. In building the data, one can formulate the group (categorical) coding schema for the outcome variable. The two groups (outcomes) and category codes are as follows:

The response or target group represents the desired or expected outcome (e.g., pass). It is this category to which prediction is directed. This category is often given a code of 1 for the outcome variable. The reference or control group represents the alternative outcome (e.g., fail). This category is given a code of 0 for the outcome variable. Categorical variables can be used as predictors in binary logistic regression and the results of the analysis can be framed in terms of one of the categories being more or less likely to achieve the target outcome. The analysis describes the likelihood of achieving the target outcome for the focus category concerning the other category, which is the reference category. For example, if the predictor variable is gender and a researcher wishes to describe the results in terms of males being more (or less) likely to achieve the target outcome, the male would be the focus category and female would be the reference category and the vice versa. The statistical outcome of one would be the inverse of the other.

Figure 1 denotes a sigmoidal or S-shaped curve. It is difficult to describe this with a linear equation for two reasons. First, the extremes do not follow a linear trend. Second, the errors are neither normally distributed nor constant across the entire range of data (Peng, Manz, Keck, 2001). It has a property that maps the entire number line into a small range such as between 0 and 1. One use of a sigmoid function is to convert a real value into an interpretable probability. This function also serves as a basis for discovering other functions that lead to efficient and good solutions for supervised learning in deep learning architectures. The sigmoid function is a special form of the logistic function and is usually denoted by $\sigma(x)$ or $sig(x)$, and given by $\sigma(x) = \frac{1}{(1+\exp(-x))}$. There are a number of common sigmoid functions, such as the logistic function, the hyperbolic tangent, and the arctangent.

Binary logistic regression deals with this problem by applying logit transformation to the dependent variable. The model predicts the logit of Y from X_s. The logit is the natural logarithm of odds of Y, and odds are ratios of probabilities (P) of Y happening (i.e., a student passes the WASSCE mathematics mock examination) to probabilities (1-P) of Y not happening (i.e., a student fails the WASSCE mathematics mock examination). The statistical model is indicated as:

$$logit[Y] = \text{natural log}[odds] = \ln\left[\frac{p}{1-p}\right] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n, \ldots (1)$$

Where, β_0 is the intercept on the logit (Y) axis, and $\beta_1, \beta_2 \ldots, \beta_n$ are the regression coefficients.

For a dichotomous variable X_1 such as gender, $x_1 = 1$ for male and $x_1 = 0$ for female, we have

$$\text{In}\left[\frac{p_{Male}}{1-p_{Male}}\right] = \beta_0 + \beta_1(1) = \beta_0 + \beta_1 \ldots (2)$$

$$In\left[\frac{p_{Female}}{1-p_{Female}}\right] = \beta_0 \ldots (3)$$

Substituting equation (2) into equation (1) gives,

$$ln\left[\frac{p_{Male}}{1-p_{Male}}\right] - ln\left[\frac{p_{Female}}{1-p_{Female}}\right] = \beta_1 \ldots (4)$$

$$ln\left[\frac{\frac{p_{Male}}{1-p_{Male}}}{\frac{p_{Female}}{1-p_{Female}}}\right] = \beta_1 \ldots \ (5)$$

i.e., $$\frac{\frac{p_{Male}}{1-p_{Male}}}{\frac{p_{Female}}{1-p_{Female}}} = e^{\beta_1} \ldots \ (6)$$

The left-hand side of Equation (5) is known as the Odds ratio of males to females passing the WASSCE mathematics mock examination. That is, the odds of males passing the examination is $e^{\beta 1}$ times the odds of females passing the examination.

Participants and Setting

Three hundred (300) Senior High School (SHS) students, made up of one hundred and fifty-nine (159) males and one hundred and forty-one (141) females, selected from Senior High Schools in the Cape Coast Municipal District of the Central Region of Ghana, participated in the study. The district has eight (8) public SHSs, four (4) technical schools, and two (2) commercial schools. Thirty-seven (37) SHS3 students were randomly selected from each of the first seven (7) SHSs, whilst, forty-one students were randomly selected from the eighth SHS. The students' ethnicity was (Asanti = 69; Fanti = 60; Ga = 50; Ewe = 54; and other ethnicity = 67), and their socio-economic status was (High = 64; Middle = 113; Low = 123). Additionally, their responses to the Math self-concept, Math attitude, Arithmetic ability, Motivation constructs, Instructional strategies and methods, and Teacher competency in math constructs were collected, by using a questionnaire. The average age of the students was 18 years, 2 months. Table 3 indicates the students' demographics.

Table 3 Students' Demographics

Demographics	Category	Number of teachers	Percentage
Gender	Male	159	53.0
	Female	141	47.0
	Total	300	100.0
Ethnicity	Asanti	69	23.0
	Fanti	60	20.0
	Ga	50	16.7
	Ewe	54	18.0
	Others	67	22.3
	Total	300	100.0
SES	High	64	21.3
	Middle	113	37.7
	Low	123	41.0
	Total	300	100.0

Instrumentation and Data Collection Procedure

This study analysed questionnaire responses of SHS students, to determine the predictor variables contributing to the probabilities of students falling into each of the two categories (Pass or Fail). The questionnaire consisted of seven (7) subscales that measured these constructs (Math self-concept, Math attitude, Arithmetic ability, Motivation, Curriculum, Instructional strategies and methods, and Teacher competency in Math). The students' results on the WASCCE Mock examination were obtained from their student records, upon permission by the district director of education and their Headmaster. Initially, the questionnaire was explained to the students, who were assured of anonymity and confidentiality. They were administered to the students and collected in an envelope, without their names written on them. Each student was given a code traceable to that student. On average, each student spent between 8 and 10 minutes to complete the questionnaire, and each SHS was visited once.

Validity and Reliability

Validity is the extent to which researchers really measure a concept in a quantitative study (Field, 2005). A type of validity, known as content validity, looks at the extent to which a research instrument accurately measures all aspects of a construct. Content validity is assessed by checking

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how well the results correspond to established theories and other measures of the same concept. Therefore, a survey designed to measure depression but actually measures anxiety is not valid.

Reliability is the extent to which a measurement of a phenomenon provides a stable and consistent result (Carmines & Zeller, 1979). A scale or test is said to be reliable if repeated measurement under constant conditions gives the same result (Moser & Kalton, 1989). Testing for reliability is important since it refers to the consistency across the parts of a measuring instrument (Huck, 2007). A scale is said to have high internal consistency if the items of a scale "hang together" and measure the same construct (Huck, 2007). The most commonly used internal consistency measure is the Cronbach's Alpha coefficient. Cronbach's alpha is calculated using the formula $\alpha = \frac{nc}{[v+(n-1)]c}$, where n = number of test items; c = average inter-item covariance among items; and v = average variance. It is viewed as the most appropriate measure of reliability when making use of Likert scales (Whitley, 2002). No absolute rules exist for internal consistencies, however most agree on a minimum internal consistency coefficient of .70 (Whitley, 2002). Hinton et al. (2004) have suggested four cut-off points for reliability, which include excellent reliability (0.90 and above), high reliability (0.70 - 0.90), moderate reliability (0.50 - 0.70) and low reliability (0.50 and below). For a test or scale to be reliable, it should first be valid (Wilson, 2010). If a questionnaire or test has a strong internal consistency, most measurements should show only moderate correlation among items (.70 to 0.90).

Results

Table 1 Case Processing Summary

Unweighted cases		N	Percent
Selected cases	Included in analysis	300	100
	Missing cases	0	0
	Total	300	100
Unselected cases		0	0
Total		300	100

Table 2 Dependent Variable Encoding

Original Value	Internal value
Fail	0
Pass	1

Table 3 Categorical Variables Coding

		Frequency	Parameter coding (1)
Asanti	0	231	.00
	1	69	1.00
Fanti	0	240	.00
	1	60	1.00
Ga	0	250	.00
	1	50	1.00
Ewe	0	246	.00
	1	54	1.00
High	0	236	.00
	1	64	1.00
Middle	0	187	.00
	1	113	1.00
Gender	Female	141	.00
	Male	159	1.00

Tables 1, 2, and 3 indicate the administrative output. The case processing summary in Table 1 displays information on three hundred (300) students. The dependent variable encoding in Table 2 shows the internal recoding of the binary outcome variable. In the recoding process, IBM SPSS assigns a code of 0 to the lower code and a code of 1 to the higher code. The categorical variables coding in Table 3 specifies a code of .00 as a reference group and a code of 1 as a focus group. For example, for the binary variable gender, the females with a of frequency 141 have a code of .00 as the reference group, while the males with a frequency of 159 have a code of 1 as the focus group.

Table 4 Classification Table

			Predicted		
			Outcome		Percentage correct
			Fail	Pass	
Step 0	Outcome	Fail	0	101	0
		Pass	0	199	100
	Overall percentage				66.3

Table 5 Variables in the Equation

		β	SE	Wald	df	Sig.	Exp(β)
Step 0	Constant	.68	.12	30.81	1	.00	1.97

Table 6 Variables not in the Equation

			Score	df	Sig
Step 0	Variables	Gender	48.77	1	.00
		Math self-concept	195.06	1	.00
		Math attitude	56.48	1	.00
		Arithmetic ability	19.65	1	.00
		Motivation	48.02	1	.00
		Curriculum	2.73	1	.10
		Instructional strategies and methods	115.59	1	.00
		Teacher competency in math	141.95	1	.00
		Fanti	.96	1	.33
		Ga	2.51	1	.11
		Ewe	1.48	1	.22
		Asanti	.95	1	.32
		High	131.51	1	.00
		Middle	14.39	1	.00

Tables 4, 5, and 6 show the classification, the variables in the equation and variables not in the equation. Table 4 provides counts of the number of cases in each binary outcome. It is a prediction table, with the observed cases in the rows and the predicted group membership at the columns. With only the intercept in the model, the prediction was based exclusively on the frequencies in the table: 101 students failed the WASSCE mathematics mock examination and 199 passed. Thus, if no additional information was given, a student would have passed more than did not pass the examination. The classification (predictions) would be correct 66.3% of the time. Table 5 shows the variables in the equation. In the intercept-only model, there were no predictor variables. The only factor in the model is the intercept (shown as constant). The odds ratio, shown as Exp (β) has a value of 1.970. This is because 199 is 1.970 times as large as 101. The odds ratio shows that a random student is 1.970 times more likely to have passed than failed. Table 6 indicates the variables yet to be entered into the model.

Table 7 Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	323.36	13	.00
	Block	323.36	13	.00
	Model	323.36	13	.00

Table 8 Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	59.92	.66	.92

Table 9 Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	12.04	8	.19

Table 10 Contingency Table for Hosmer and Lemoshow Test

		Outcome = fail		Outcome = pass		Total
		Observed	Expected	Observed	Expected	
Step 1	1	30	29.99	0	.00	30
	2	29	29.88	1	.12	30
	3	30	28.55	0	1.45	30
	4	10	10.83	20	19.17	30
	5	1	1.09	29	28.91	30
	6	0	.41	31	30.59	31
	7	0	.16	31	30.84	31
	8	1	.06	29	29.94	30
	9	0	.02	30	29.98	30
	10	0	.00	28	27.99	28

Tables 7, 8, 9, and 10 were used to evaluate the model, with the predictor variables included. This is called block 1 or step 1 because the predictor variables were entered together at once. The Omnibus test of model coefficients in Table 7 contains the model chi-square, a statistical test of the null hypothesis that all predictor variables coefficients are zero. It is equivalent to the overall F test in linear regression. The model chi-square value (in the row) is 323.36, and with 14 degrees of freedom (there are 14 predictors in the model). There are statistically significant predictions ($p < .05$). Table 8 provides three indexes of how well the logistic regression model fits the data. With all the variables in the model, the goodness-of-fit -2 log likelihood statistic is 159.54. The Cox and Nell pseudo R^2 is .34, and the Nagelkerke pseudo R^2 is .55. on the basis of Nagelkerke pseudo R^2, it means 55% of the variance associated with students' passing the WASSCE mathematics mock examination was explained by the predictor variables. The Hosmer and Lemeshow test in table 9 shows chi-square statistic of 12.03 and p > .05. This indicates an acceptable match between predicted and observed probabilities.

Table 11 Classification Table

			Predicted Outcome		Percentage correct
	Observed		Fail	Pass	
Step 1	Outcome	Fail	96	5	95.0
		Pass	3	196	98.5
	Overall percentage				97.3

Table 11 shows the overall predictive accuracy of the model, which stands at 97.3. After all the variables were entered into the model, 98.5% of the students passed and 95% failed.

Table 12

Predictor	β	SE	Wald	df	Sig	Exp(β)	95 C.I. for EXP(β) Lower	Upper
Constant	-23.57	6.12	14.84	1	.00	.00		
Math Self Concept	2.00	.59	11.43	1	.00	7.40	2.32	23.60
Math Attitude	.67	.76	.77	1	.04	1.96	.44	8.73
Arithmetic Ability	.23	.78	.09	1	.76	1.26	.28	5.81
Motivation	-.96	.79	1.47	1	.23	.38	.08	1.81
Curriculum	-.69	.72	.91	1	.34	.50	.12	2.07
Instructional Strategies and Methods	1.35	.71	3.66	1	.04	3.86	.97	15.40
Teacher Competency in Math	3.46	1.13	9.35	1	.00	31.67	3.46	290.20
Gender	.81	.81	.98	1	.03	2.24	.45	11.01
Fanti	-.87	.96	.82	1	.37	.42	.06	2.77
Ga	-.96	1.20	.65	1	.42	.38	.04	3.97
Ewe	1.34	1.19	1.27	1	.26	3.83	.37	39.63
Asanti	1.30	1.21	1.24	1	.24	3.65	.35	12.30
High	-3.38	1.10	9.42	1	.00	1.34	.00	.30
Middle	-1.68	.96	3.03	1	.08	.19	.03	1.24

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Table 11 presents for each predictor the raw score partial coefficient (β), and its standard error (SE). These coefficients represent the amount of change in the log odds when there is a unit change in the predictor variable, with all the other variables in the model held constant. A coefficient close to zero suggests that there is no change in the outcome variable associated with the predictor variable. The sig. column represents the *p-value* for testing whether a predictor is significantly associated with a student passing the examination controlling for the other predictor(s). Thus, the raw score coefficients for Math self-concept, Math attitude, Instructional strategies and methods, Teacher competency in math, and Gender, were positive and significant ($P < .05$), while that of High SES was negative and significant ($P < .05$). For each predictor with a positive raw score coefficient, a unit increase in the predictor, increased the log odds, while for High SES, a unit increase in the predictor, decreased the log odds.

The Exp (β) provides the odds ratio associated with each predictor (adjusting for the other predictors), with a 95 % C. I provided in the final two columns. The adjusted odds ratio for gender is 2.24, with a C. I of .45-11.02. The odds ratio indicates that in this sample, the odds of males (because they are the focus group) passing the WASSCE mathematics mock examination are 2.24 times the odds of females passing the examination controlling for the other variables. The odds of students whose parents have high SES (the focus group) passing the WASSCE mathematics mock examination are 1.34 times the odds of students whose parents have low SES (the reference group). The adjusted odds ratio for mathematics self-concept is 7.40, with a C.I 2.32-23.60. This is a quantitative measure, so the odds ratio of 7.40 is interpreted to mean that an increase of one unit in the math self-concept measure increased the odds of passing the WASCCE mathematics mock examination over the odds for failing the WASCCE mathematics mock examination by 7.40 times, controlling for the other variables. Again, the adjusted odds ratio for Instructional strategies and methods is 31.67, with a C.I .97- 15.40. The odds odds ratio of 31.67 is interpreted to mean that an increase of one unit in the Instructional strategies and methods measure increased the odds of students passing the WASCCE mathematics mock examination over the odds of students failing the WASCCE mathematics mock examination by 31.67 times, controlling for the other variables.

The odds ratio can be applied to any two scores on the quantitative measure. For the math self-concept variable, the odds of a student passing the WASCCE mathematics mock examination with a math self-concept score of 5 are 7.40 times greater than the odds of passing the examination for a student whose mathematics self-concept score was 4, controlling for the other variables, while 2 * 7.40 times greater than the odds of passing the examination for a student whose mathematics self-concept score was 3.
Applying the model equation:

$$logit(Y) = \text{natural log(odds)} = \ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n.$$

$$\ln(odds) = -23.57 + 2.00X_1 + .67X_2 + .23X_3 - .96X_4 - .69X_5 + 1.35X_6 + 3.46X_7 + .81X_8 - .87X_9 - .96X_{10} + 1.34X_{11} + 1.30X_{12} - 3.38X_{13} - 1.68X_{14}$$

Suppose that $X_1 = Math\ self - concept = 4$; $X_2 = Math\ attitude = 3$; $X_3 = Arithmetic\ ability = 4$; $X_4 = Motivation = 5$; $X_5 = Curiculum = 5$; $X_6 = Instructional\ strategies\ and\ methods = 4$; $X_7 = Teacher\ competency\ in\ math = 4$; $X_8 = Gender = 1$; $X_9 = Fanti = 1$; $X_{10} = Ga = 0$; $X_{11} = Ewe = 0$; $X_{12} = Asanti = 0$; $X_{13} = High = 1$; $X_{14} = Middle = 0$, for a given student. Then;

$$logit(Y) = -23.57 + 2.00(4) + .67(3) + .23(4) - .96(5) - .69(5) + 1.35(4) + 3.46(4) + .81(1) + .87(1) - 3.38(1)$$
$$= -23.57 + 8.00 + 2.01 + .92 - 4.80 - 3.45 + 5.4 + 13.84 + .81 + .87 - 3.38$$
$= -3.35$. Thus,
$$logit(Y) = In\left(\frac{p}{1-p}\right) = -3.35$$
$$\left(\frac{p}{1-p}\right) = e^{-3.35}$$
$$p = \frac{e^{-3.35}}{1 + e^{-3.35}} = \frac{1}{e^{3.35} + 1} = \frac{1}{28.5027 + 1} = .034$$

DISCUSSION

In this study, Math self-concept, Math attitude, Instructional strategies and methods, Teacher competency in math, and Gender, were positive and significant, while that of High SES was negative and significant. This implies that for each predictor variable with a positive raw score coefficient, a unit increase in the predictor variable increased the log odds, while a unit increase in High SES decreased the log odds. Ultimately, these significant predictor variables increased the probability of students' passing the mathematics examination. Mathematics self-concept, which has been shown in some studies to significantly predict student mathematics achievement, predicted students' pass in the examination. Thus, a positive mathematics self-concept, a mediating factor, facilitated student pass in the examination (Marsh et al., 2005; Skaalvik & Valås, 1999). There exists a consistent positive relationship between student self-concept and their academic achievement (Kung, 2009; Ercikan et al., 2005; Marsh et al., 2005; Ross, Scott, & Bruce, 2012; Sarouphim & Chartouny, 2017).

Mathematics attitude, which significantly predicts student mathematics achievement in some studies, predicted students' pass in the examination. This finding corroborates earlier studies that indicated that mathematics attitude, a key predictor variable of mathematics achievement, also affects the probability of students' passing (Mohamed & Waheed, 2011; Mata, Monteiro & Peixoto, 2012; Ngussa & Mbuti, 2017). Attitudes can change and develop over time and once a positive attitude is formed, it could improve student mathematics achievement and probability of passing (Syyeda, 2016; Mutai, 2011). On the flip side, a negative attitude could hinder effective learning and consequently affects achievement outcome and the probability of passing (Joseph, 2013). This finding of Gender being a significant predictor variable, is in contrast to studies by Campbell (1995), and Kimball (1989), which did not predict significant results in student mathematics achievement and, hence the probability of passing. Earlier findings by Beaton et al., (1996) and Mullis et al., (1997), have indicated the same levels of mathematics achievement between males and females.

Similar to the Eamon (2005), Jeynes (2002), Hochschild (2003), and McNeal (2001) studies, socioeconomic status was a significant predictor variable of students' probability of passing the examination. Parents with high socioeconomic status can provide their children with the needed resources for them to excel academically. Instructional strategies and methods predicted, which predicted student mathematics achievement, also predicted students' probability of passing the examination. However, these strategies and methods ought to be selected and implemented in ways that enable students to apply higher-order thinking and problem solving (Wilson, 1996).

Teacher competency which predicts student mathematics achievement also predicted students' probability of passing the examination. Teachers who have a good understanding of the subject matter, improves student mathematics achievement with their instruction, thereby increasing the probability of passing their examination (Ball, 1993; Grossman, et. al., 1989; Rosebery et. al., 1992). Ethnicity, which predicted student mathematics achievement in some studies, also significantly predicted the probability of students' passing in the examination. However, the gap has shrunk over the past three decades, making it an almost negligible factor in recent times (McGraw, Lubienski, & Strutchens, 2006).

Computational ability significantly predicted the students' probability of passing the mock examination. It includes skills such as manipulating mathematical knowledge and concepts in ways that transform their meaning and implications. It allows students to interpret, analyze, synthesize, generalize, or hypothesize the facts and ideas of mathematics.

Implications for the study

Undoubtedly, teachers with a positive attitude towards mathematics improve student mathematics achievement. These teachers are highly motivated and have confidence in their thoughts and expressions. They are innovative and enthusiastic about teaching and willing to take risks, tolerate ambiguity, and act decisively. They create an exciting learning atmosphere and develop students' critical thinking. On the other hand, teachers with negative attitudes towards mathematics hinder effective learning, thus affecting student achievement outcomes. These teachers find it difficult to implement innovative teaching strategies. They consider integrating creative ideas into their teaching a difficult task. They are less concerned with teaching creatively. Therefore, students feel bored and are not attentive in the classroom. Among students, this somehow creates a perception that mathematics is difficult to understand, abstract and uninteresting.

Teacher competency is necessary for student development to ensure quality mathematics learning. It affects students' academic achievement and helps teachers improve their teaching techniques. Four classes of competencies that yield effective results and improve student learning outcomes are instructional delivery, classroom management, formative assessment, and personal competencies.

Instructional strategies and methods enable students to become independent and strategic learners. They assist them to complete tasks or meet specific goals. They also motivate students and help them focus attention, organize information, and monitor and assess learning. To realise this, teachers could use a variety of instructional approaches and learning materials, meaningful connections between skills and ideas, real-life situations, and encouragement to self-monitor and self-correct.

CONCLUSIONS

To increase the probability of students passing the examination, the value of the exponential term in the computation of the probability should reduce considerably. In spite of the known factors that improve student mathematics achievement, this study offers additional predictor variables that could play significant roles in student mathematics achievement. The study has demonstrated that teachers, students and other stakeholders have a role to play in ensuring that students are assisted with appropriate teaching methods and support to improve their mathematics achievement.

References

Aguanta Jr, E.R. & Tan, D.A. (2018). Effects of cooperative learning strategy on students' academic performance and attitude towards mathematics. *International Journal of English Education*, 7, 303–313.

Asif, M., Thomas, G., Awan, M.U. & Din, A.M. (2020). Enhancing student engagement through heterogeneous pedagogical approaches: Action research in a university-level course in Saudi Arabia. *International Journal of Education in Management*, 35, 1–28.

Awaludin, I.S., Ab Razak, R., Azliana Aridi, N. & Selamat, Z. (2015). Causes of low mathematics achievements in a private university. *Journal of Computer Science & Computational Mathematics*, 21–26.

Ball, D.L. (1993). With an eye on the mathematical horizon: Dilemmas of teaching elementary school mathematics. *Elementary School Journal 9*, 373-397.

Baroody, A.E., Rimm-Kaufman, S., Larsen, R.A. & Curby, T.W. (2016). A multi-method approach for describing the contributions of student engagement on fifth-grade students' social competence and achievement in mathematics. *Learning and Individual Differences*, 48, 54–60.

Beaton, A. E., & O'Dwyer, L., M. (2002). Separating school, classroom, and student variances and their relationship to socioeconomic status. In D. F. Robitaille & A. E. Beaton (Eds.), *Secondary analysis of the TIMSS data* (pp. 211-231). Kluwer Academic Publishers.

Bjälkebring, P. (2019). Math anxiety at the university: What forms of teaching and learning statistics in higher education can help students with math anxiety? *Frontiers in Education*, 4, 2 - 10

Campbell, J. R., Hombo, C. M., & Mazzeo, J. (2000). *NAEP 1999 trends in academic progress: Three decades of student performance.* National Center for Education Statistics.

Carini, R.M., Kuh, G.D. & Klein, S.P. (2006). Student engagement and student learning: Testing the linkages. *Research in Higher Education*, 47, 1–32.

Carey, E.; Hill, F.; Devine, A.; Sz ˝ucs, D. (2017). The modified abbreviated math anxiety scale: A valid and reliable instrument for use with children. *Frontiers in Psychology*, 8, 3-10.

Carmines, E. G., & Zeller, R. A. (1979). *Reliability and validity assessment*. Sage.

Christenson, S.L., Wylie, C. & Reschly, A.L. (2012). *Handbook of research on student engagement*. Springer.

Dagaylo-AN, M.B. & Tancinco, N.P. (2016). Mathematics anxiety and the academic performance of the freshmen college students of the naval state university. *International Journal of Engineering Science & Research Technology*, 5, 1125–1136.

Delfino, A.P. (2019). Student engagement and academic performance of students of a Partido State University. *Asian Journal of University Education*, 15, 42–55.

Deveci, O. & Karademir, C.A. (2019). Investigation of the 5th grade students' engagements in mathematics course towards student opinions. *European Journal of Educational Research*, 8, 337–348.

Eamon, M. K. (2005). Social-Demographic, School, Neighborhood, and Parenting Influences on Academic Achievement of Latino Young Adolescents. *Journal of Youth and Adolescence*, 34, 163-175. http://dx.doi.org/10.1007/s10964-005-3214-x

Ercikan, L., McCreith, T., & Lapointe, V. (2005). Factors associated with mathematics achievement and participation in advanced mathematics courses: An examination of gender differences from an international perspective. *School Science and Mathematics*, *105*(1), 5-14. doi:10.1111/j.1949-8594. 2005.tb18031.x

Eng, T.H., Li, V.L. & Julaihi, N.H. (2010) The Relationships between students' underachievement in mathematics courses and influencing factors. *Procedia Social and Behavioral Sciences*, 8, 134–141.

Enu, J., Agyeman, O. & Nkum, D. (2015). Factors influencing students' mathematics performance in
some selected colleges of education in Ghana. *International Journal Education, Learning and Development*, 3, 68–74.

Field, A. (2005) Reliability analysis. *Discovering statistics using spss* (2nd ed). Sage.

Finn, J.D. (1989). Withdrawing from school. *Review of Educational Research*, 59, 117–142.

Finn, J.D. &Voelkl, K.E. (1993). School characteristics related to student engagement. *Journal of Negro Education*, 62, 249.

Finn, J.D. & Zimmer, K.S. (2012). *Student engagement: What is it? Why does it matter*? In Handbook of research on student engagement. Springer.

Furlong, M.J. & Christenson, S.L. (2008). Engaging students at school and with learning: A relevant construct for all students. *Psychology in the Schools*, 45, 365–368.

Gasevic, D., Jovanovic, J., Pardo, A. & Dawson, S. (2017). Detecting learning strategies with analytics: Links with self-reported measures and academic performance. *Journal of Learning Analy*tics, 4, 113–128.

Gradwohl, J. & Eichler, A. (2018). *Predictors of performance in engineering mathematics*: INDRUM Network. University of Agder.

Grossman, P.L., Wilson, S.M., & Shulman, L.S., (1989). Teachers of substance: Subject matter for teaching. In M.C. Reynolds (ed.). *Knowledge base for the beginning teacher*. Pergamon Press.

Hailikari, T., Nevgi, A. & Komulainen, E. (2008). Academic self-beliefs and prior knowledge as predictors of student achievement in Mathematics: A structural model. *Educational Psychology*, 28, 59–71.

Hinton, P., Brownlow, C., McMurray, I., & Cozens, B. (2004). *SPSS explained*. Routledge Inc.

Hochschild, A. R. (2003): *The commercialization of intimate life. Notes from home and work*. University of California Press.

Huck, S. W. (2007). *Reading statistics and research, United States of America*: Allyn & Bacon.

Jeynes, W. H. (2002). Examining the Effects of Parental Absence on the Academic Achievement of Adolescents: The Challenge of Controlling for Family Income. *Journal of Family and Economic Issues, 23* (2), 189-210.

Josiah, O. & Olubunmi Adejoke, E. (2014). Effect of gender, age, and mathematics anxiety on college students' achievement in algebra. *American Education Research Journal*, 2, 474–476.

Joseph, G. (2013). A Study on school factors influencing students' attitude towards learning mathematics in the community secondary schools in Tanzania: The case of Bukoba municipal council in Kagera Region. (Masters dissertation). Retrieved on 20th October, 2020, from http://repository.out.ac.tz/919/

Anderton, R., Hine, G., & Joyce, C. (2017). Secondary school mathematics and science matters: Academic performance for secondary students transitioning into university allied health and science courses. *International Journal of Innovation in Science and Mathematics Education, 25* (1), 34-47.

Kargar, M., Tarmizi, R. A. & Bayat, S. (2010). Relationship between mathematical thinking, mathematics anxiety and mathematics attitudes among university students. *Procedia-Social and Behavioral Sciences*, 8, 537- 542.

Kazemi, F. & Ghoraishi, M. (2012). Comparison of problem-based learning approach and traditional teaching on attitude, misconceptions and mathematics performance of university students. *Procedia Social and Behavioral Sciences*, 46, 3852–3856.

Kimball, M. M. (1989). A New Perspective on Women's Math Achievement. *Psychological Bulletin 105*, 198-214.

Kung, H.Y. (2009). Perception or confidence? Self-concept, self-efficacy and achievement in mathematics: A longitudinal study. *Policy Futures in Education*, 7(4), 387-398. doi:10.2304/pfie.2009.7.4.387

Kushwaha, S.S. (2014). The trend in research on mathematics achievement. *IOSR Journal of Research & Method in Education (IOSRJRME)* 4, 53–62.

Lee, J.S. (2013). The Relationship between student engagement and academic performance: Is it a myth or reality? *Journal of Education*, 107, 177–185.

Maamin, M., Maat, S.M. & Ikhsan, Z. (2021). Analysis of the factors that influence mathematics achievement in the ASEAN countries. *Cypriot Journal of Educational Sciences*, 16, 371–388.

Marsh, H. W., Trautwein, U., Lüdtke, O., Köller, O., & Baumert, J. (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development, 76*(2), 397- 416. doi:10.1111/j.1467-8624.2005. 00853.x.

Mata, M. D., Monteiro, V., & Peixoto, F. (2012). Attitudes towards mathematics: Effects of individual, motivational, and social support factors. *Child Development*, *75*(2), 400-416. https://doi.org/10.1155/2012/876028.

McGraw, R., Lubienski, S. T., & Strutchens, M. E. (2006). A closer look at gender in NAEP mathematics achievement and affect data: Intersections with achievement, race/ethnicity, and socioeconomic status. *Journal for Research in Mathematics Education*, 129–150.

McNeal, R. B. Jr. (2001). Differential effects of parental involvement on cognitive and behavioural outcomes by socioeconomic status. *The Journal of Socio-Economics*, 30(2), 171-180.

Mohamed, L., & Waheed, H. (2011). Secondary students' attitude towards mathematics in a selected school of Maldives. *International Journal of Humanities and Social Science*, 1(15), 277-281.

Mohd, N., Tengku Mahmood, T.F.P., Mahmood, T. & Ismail, M.N. (2011). Factors that influence students in mathematics achievement. *International Journal of Academic Research*, 3, 49–54.

Moser, C. A. & Kalton, G. (1989). *Survey methods in social investigation*. Gower.

Mullis, I. V. S., Martin, M. O., Fierros, E. G., Goldberg, A. L., & Stemler, S. E. (2000). *Gender differences in achievement: IEA's third international Mathematics and Science Study*. Boston College.

Mutai, K. J. (2011). Attitudes towards learning and performance in mathematics among students in selected secondary schools in Bureti district, Kenya (Masters Dissertation). Retrieved on 13th November, 2020, from http://ir-library.ku.ac.ke/bitstream/handle/123456789/609/JACKSON%20KIPRONOH.pdf.

Ngussa, B. M., & Mbuti, E. E. (2017). The Influence of Humour on Learners' Attitude and Mathematics Achievement: A Case of Secondary Schools in Arusha City, Tanzania. *Journal of Educational Research, 2*(3), 170 -181.

Núñez-Peña, M., Suarez Pellicioni, M. & Bono, R. (2013). Math anxiety affects student success in higher education. *International Journal of Education Research*, 58, 36–42.

Park, S.Y. (2005). Student engagement and classroom variables in improving mathematics achievement. *Asia Pacific Education Review*, 6, 87–97.

Peng, C. Y. J., Manz, B. D., & Keck, J. (2001). Modeling categorical variables by logistic regression. *American Journal of Health Behavior*, 25(3), 278-284.

Rosebery, A.S., Warren, B., & Conant, F.R. (1992). Appropriating scientific discourse: Findings from language minority classrooms. *The Journal of the Learning Sciences* 2(1), 61-94.

Ross, J. A., Scott, G., & Bruce, C. D. (2012). The gender confidence gap in fractions knowledge: Gender differences in student belief-achievement relationships. *School Science and Mathematics, 112*(5), 278-288. doi:10.1111/j.1949-8594.2012. 00144.x.

Sarouphim, K. M., & Chartouny, M. (2017). Mathematics education in Lebanon: Gender differences in attitudes and achievement. *Education Studies in Mathematics*, *94*(1), 55-68. doi:10.1007/s10649-016-9712-9.

Skaalvik, E. M., & Valås, H. (1999). Relations among achievement, self-concept, and motivation in mathematics and language arts: A longitudinal study. *The Journal of Experimental Education*, 67(2), 135-149. doi:10.1080/00220979909598349.

Syyeda, F. (2016). Understanding Attitudes Towards Mathematics (ATM) using a Multimodal modal Model: An Exploratory Case Study with Secondary School Children in England. *Cambridge Open-Review Educational Research e-Journal*, 3, 32-62.

Wahid, S.N.S., Yusof, Y. & Razak, M.R. (2014). Math anxiety among students in higher education level. *Procedia Social Behavioral and Sciences*, 123, 232-237.

Wang, M.T., Fredricks, J.A., Ye, F., Hofkens, T.L. & Linn, J.S. (2016). The Math and Science Engagement Scales: Scale development, validation, and psychometric properties. *Learning and Instruction*, 43, 16–26.

Warwick, J. (2008). Mathematical self-efficacy and student engagement in the mathematics classroom. *MSOR Connections*, 8, 31–37.

Whitley, B. E. (2002). *Principals of research and behavioral science*. McGraw-Hill.

Wilson, J. (2010). *Essentials of business research: A guide to doing your research project*. SAGE Publications.

Wong, N.Y., Lam, C.C. & Kong, Q.P. (2003). The Relationship between Student Engagement and Learning Outcome in Mathematics. *Curriculum and Teaching*, 18, 81–95.

Yehi, C.Y.C, Cheng, H.N. H, Chen, Z., Liao, C. C. Y, Chan, T. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning*, 14 (5), 3-19.

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