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RESEARCH ARTICLE

STUDENTS AFFECTIVE FACTORS INFLUENCING MATHEMATICS ACHIEVEMENT IN SENIOR HIGH SCHOOL IN GHANA

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Abstract

The study investigated how senior high school students' affective factors (attitudes toward mathematics, mathematics anxiety, classroom climate, and parental involvement) influence their mathematics achievement. A One hundred and eighteen (118) second-year students (64 males and 54 males) and 4 teachers were randomly sampled from four public senior high schools in two municipalities in the then Brong Ahafo region. The explanatory sequential mixed method approach was employed using an achievement test, questionnaire, and semi-structured interview guide to collect both quantitative and qualitative data from the participants. Descriptive, inferential and logistic regression technique were used to analyze the study data. The study found that attitude towards mathematics was the most significantly associated with mathematics achievement of the students. It is recommended that mathematics teachers make their students see the relevance of mathematics in order to boost students' interest in the study of the subject. This will help the students discard the negative perceptions about the study of mathematics. Also, mathematics teachers in senior high schools must devise some interesting and easy ways to make mathematics more attractive and engaging to their students. Students are also advised to respond positively to the learning process.

Introduction: -

The worth of education of any nation is seen in the quality of its human resource capital. Cognizant of this, the Ministry of Education (MOE) designed programmes aimed at empowering the Ghanaian learner with the necessary skills, attitudes, values, and competencies needed to enable the dream Ghanaian child to fit in the dynamic world (MOE, 2019). The MOE recognizes that education is a powerful whirl that drives the social, economic, scientific, technological, and cultural transformational needs of any nation (MOE, 2019). A successful implementation of the MOE's aim, is therefore a key indicator for the achievement of the Sustainable Development Goals (SDGs) Agenda 2030. The IMF has however disclosed that Ghana spends close to 4% of its GDP on education with good results in terms of enrollment but poor learning outcomes (Myjoyonline.com, May, 2023)

Mathematics as a school subject permeates all aspects of life and applies to all areas of learning. Thus, there is a high valuation being placed on the teaching and learning of mathematics globally. Although it is taught across grades owing to its utility in other subjects, mathematical proficiency in Ghana is below average (Fletcher, 2018).

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Despite the relative importance of mathematics, it is very disappointing to note that Ghanaian students' performance in the subject, both internal and external examinations such as the National Education Assessment (NEA), Trends in International Mathematics and Science Study (TIMSS), West African Secondary Schools Certificate Examinations (WASSCE have remained consistently poor.

The National Education Assessment (NEA) administered tests in 2016 and 2018 consisting of pupils in primary 4 and 6. Begue-Aguado (2021) cited (MOE, 2018), stating that the 2018 NEA report shows that '35-48' percent of pupils scored below minimum competency and '19-25' percent of pupils met the NEA criterion for proficiency across grades (P4 and P6) and subject areas (Mathematics and English language). In 2016 at P4, 45.2%, 32.8%, and 22.0% scored below minimum competency and proficiency levels respectively with a marginal improvement in the 2018 minimum competence (33%) and a three-percentage point drop in the proficiency level (19%). Also, the 2016 NEA showed that 29.2% of pupils in P6 fell below minimum competence, 45.9% attained minimum competency, and 24.9% attained proficiency. In 2018, 35% of the pupils were below minimum competency while 44% attained minimum competency with only 22% attaining proficiency level (Begue-Aguado, 2021).

The underachievement in the performance of students in mathematics has been of great concern to mathematics educators, parents, stakeholders, and the government.

Trend analysis of students' mathematics achievement at the Senior High school level reveals an abysmal performance in the acquisition of a qualifying grade in mathematics for entry into tertiary institutions in Ghana (Fletcher, 2018; Abreh, Owusu &Amedahe, 2018). The percentage of students obtaining WASSCE grades A1 to C6 and D7 to F9 in the WASSCE examination from 2007 to 2018 is shown in Table1.1.

Table 1.1: Percentage of students obtaining WASSCE grades A1 to C6 (the qualifying grade for tertiary education in Ghana) and disqualifying grades from 2007 to 2017.

SUBJECT	2007	2008	2009	2011	2012	2013	2014	2015	2016	2017
English	27.9	49.4	43.9	75.9	45.2	65.7	45.2	50.1	53.19	54.06
Int. Science	23.8	26.7	34.5	42	56.8	49.7	28.7	23.3	48.48	43.73
Soc. Studies	75.1	60.1	77.5	82.2	87.1	57.4	57.4	51.6	47	52.2
Mathematics	**25.3**	**26.2**	**28.6**	**43.8**	**49.4**	**36.6**	**32.4**	**24**	**35**	**43**
D7-F9	74.7	73.8	71.4	56.2	50.6	63.4	67.6	76	65	57

Source: (Fletcher, 2018; Abreh et al, 2018)

Although the Ghanaian students' performance improved in 2019 with 65.3%passed, 65.71% (in 2020), 54.11% (in 2021) and 61.39% candidates passed mathematics (Knust Notice Board, 2022), the table above shows a consistent and persistent underachievement in mathematics among Senior High School students. This underachievement Ghanaian SHS students in mathematics in contrast to the other core subjects can be traced to the lower basic school.

Following the trend analysis of students' performance in the NEA, TIMSS, BECE, and WASSCE in Ghana over the years, one can infer that more than half the population of Ghanaian students who sit for a standardised mathematics test underperform.

The available statistics however, gives credence to the IMF assertion that Ghana spends close to 4% of its GDP on education with good results in terms of enrollment but poor learning outcomes.

The alarming situation of the performance of students in mathematics has called for the study of the various factors that affect the performance of students in the study of mathematics in Ghana. Some researches have been conducted in the area of factors affecting students' performance as well as their achievements in the study of mathematics in Ghana. Ansah, Quansah &Nguba (2020) looked at the teacher knowledge and experience on mathematics achievement, the home environment factor was also looked at by Butakor& Nyarko (2017) and Poku (2019) looked at the effect of students' attitude towards mathematics on academic achievement. Yet this canker still hangs on.

In achievement contexts, success and failure typically are ascribed to some ability factor that includes both aptitude and acquired skills, an exertion factor such as temporary or sustained effort, the difficulty (ease) of a task, personality, mood, and help or hindrance from others. Among these causal ascriptions, in this culture at least, ability and effort appear to be the most dominantly perceived causes of success and failure. When explaining achievement

outcomes, individuals attach importance to their perceived competencies and how hard they try. Hence this study investigates factors (attitude towards mathematics, mathematics anxiety, classroom climate, and parental involvement) influencing students' mathematics achievement in senior high schools in Ghana.

The objectives for the study are;
1. To determine students' overall performance in mathematics in the region
2. To examine the most affective influential factor(s) affecting mathematics achievement among students in the Senior High School

These research questions are designed to help achieve the stated objectives.
1. What is the students' overall performance in mathematics in the region?
2. What is/are the most influential factors that affect the mathematics achievement of students in Senior High School?

This study advances the understanding of the perceived affective factors affecting the academic performance of senior high school students in mathematics by applying Weiner's (1986) and Edward et al, (1998) theories as the theoretical underpinning of the study. The behaviours and attitudes of individuals in relation to academic achievements are caused by either one, or multiple experiences with factors such as the environment, peer interactions, teacher input, and their personal experiences. The interactions of all these variables affect student behaviour as well as self-efficacy in a specific topic/subject in a classroom situation (mathematics). This research is therefore focused on the theoretical frames of the Attribution Theory paradigm (Weiner, 1986) and the Individual Environment fit theory Edward et al, (1998) to examine the causal influence of mathematics achievement.

The conceptual model for the study is however built on the interaction of the research variables (attitude towards mathematics, mathematics anxiety, classroom climate, and parental involvement) of this study. The conceptual model is conceived from the Ethington path model. Ethington (1992) [9] expanded the levels of learning and modelled the causal effect on mathematics achievement. These variables, attitude towards mathematics, mathematics anxiety, classroom climate, and parental involvement were modeled using Ethington conceptual path model. These variables were then hypothesized to influence mathematics achievement among Senior High School students. The paths drawn indicate the causal effects hypothesized by the theoretical model (Ethington,1992, Weiner, 1986). If no path is drawn to a variable from a prior variable, then the effect of the prior variable is expected to be zero (Ethington, 1992).

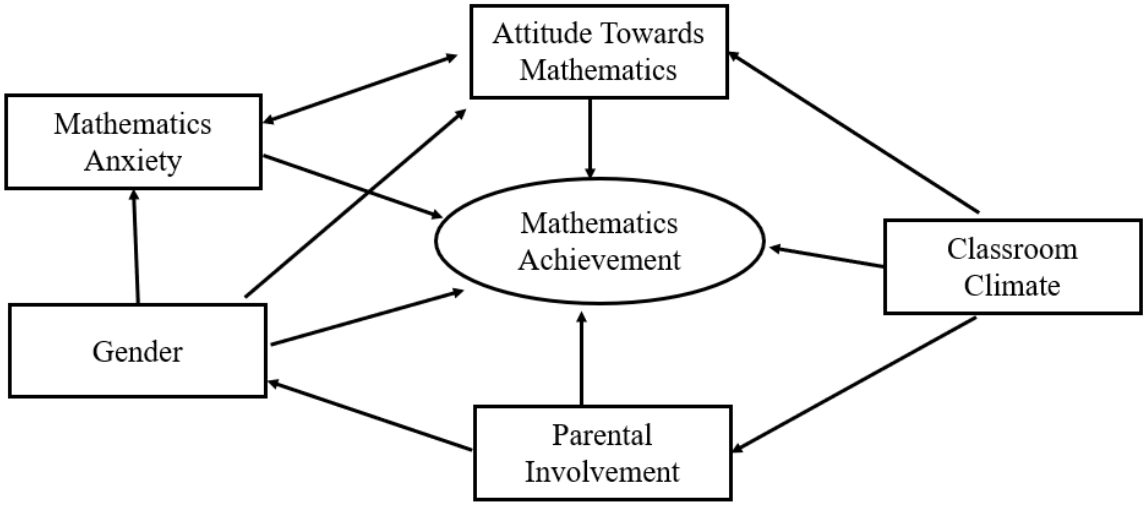

Figure 1.1: **Conceptual Model.**

Review of Related Literature:

Attitude is surely a forceful determinant of learning outcomes. Every student with similar abilities differs in school attainment due to his/her attitude towards the subject. According to Aiken (1970), an attitude is an individual's learned predisposition to respond positively or negatively to an object, concept, situation, or another individual.

Several efforts have been made from time to time to satisfy the query of finding out the effect of attitude toward mathematics on learning outcomes in mathematics (Mazana, et al, 2019). A strong relationship has been established between students' positive attitude towards mathematics and achievement in the subject (Ma & Kishor, 1997; Nicolaidou& Philippou, 2003). In a study of the trend in research on mathematics achievement, Kushwaha, concluded that students with a positive attitude toward mathematics get more marks in comparison with those students who have a negative attitude toward mathematics (Kushwaha, 2014).

The American Psychological Association (APA) defined anxiety as an emotion characterized by feelings of tension, worried thoughts, and physical changes like increased blood pressure (APA, 2014). Maloney &Beilock, (2012) mathematics anxiety has an effect on learning outcomes, and it may inhibit mathematics learning than supposed deficiencies in school curricula and teacher preparation programs. Ramirez, et al (2012) low mathematics achievement could be the result of math-anxious teachers being charged with the responsibility to teach mathematics at the basic level of education.

Classroom climate is the kind of or the nature of rapport established by the classroom teacher and learners. According to Freiberg [(1998), a healthy classroom climate could positively influence the health of the learning environment, or it could significantly impede learning.

Amponsah et al (2018) in a studyonthe relationship between parental involvement and academic performance of Senior High School Students in Ghana have concluded that there is a significant positive relationship between parental involvement and students' academic performance. This suggests that parents' involvement through homework, creating a conducive home environment for studying, motivating, and setting realistic and high expectations for children enhances academic performance. Students whose parents are actively involved in their academics display better behaviours and academic outcomes (Hanif & Alwi, 2019).

A mixed method approach using sequential explanatory design was employed in this study.

The diagrammatic representation of explanatory sequential design is as presented in Fig. 1.2

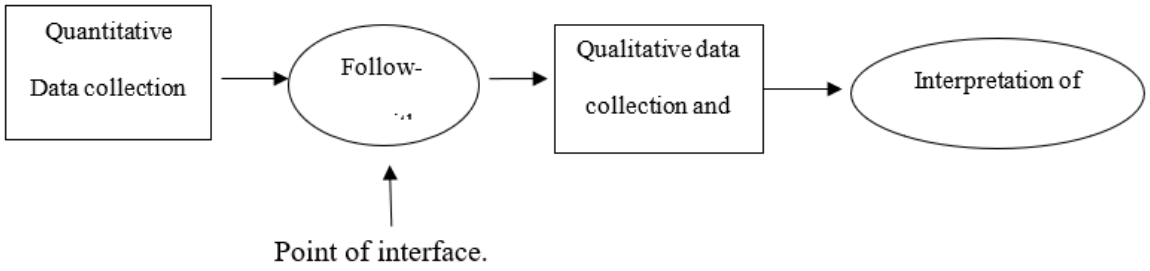

Figure 1.2: Explanatory Sequential Design.

The Logistic regression analysis was also employed to identify the most predictive factor among the four variables which influence students' achievement in mathematics. To validate the results from a logistic analysis, the assumptions and limitations of the logistics regression must be met.
The logistic model predicts the$logit$of Y from$X$. As stated earlier, the$logit$is the natural logarithm (ln) of odds of Y, and odds are ratios of probabilities (π) of Y happening (a student who passed the course) to probabilities $(1-\pi)$ of Y not happening (a student who failed the course).
Let Y be a binary response variable, which is coded as 0 or 1, referred to as fail or pass, respectively. Then the logistic regression model is given as follows:

$$\pi(x) = \frac{e^{\beta_0 + \beta x}}{1 - e^{\beta_0 + \beta x}} \qquad (1)$$

$\pi(x)$represent the conditional mean of Y given x, thus, $E(Y/x)$. The value of the response variable given$x$ can be expressed as $y = \pi(x) + \varepsilon,$ $\varepsilon$is the error term. If y =1, then$\varepsilon = 1 - \pi(x)$ with probability $\pi(x)$, and if y = 0,

$\varepsilon = -\pi(x)$ with probability $1 - \pi(x)$. Therefore, εfollows a binomial distribution with mean 0 and variance $\pi(x)[1 - \pi(x)]$. A transformation of $\pi(x)$ which is called $logit$ function is required:

$$g(x) = In\left[\frac{\pi(x)}{1-\pi(x)}\right] = \beta_0 + \beta_{x_i} \quad (2)$$

Where
β_0 : The model constant.
β_i : The parameter estimates for the independent variables.
x_i: The set of independent variables (I =1, 2… n)
π: Probability ranges from 0 to 1
$\frac{\pi(x)}{1-\pi(x)}$: The natural logarithm ranges from negative infinity to positive infinity.

It is important to note that; the unknown parameters are estimated by the method of maximum likelihood estimation with given likelihood function for $\beta = (\beta_0, \beta_1)$given as

$$L(\beta) = \prod_{i=1}^{n} \pi(x)^{y_i}[1 - \pi(x_i)]^{1-y_i} \quad (3)$$

According to Lee (2003), two important reasons make logistic regression popular;

1. The range of the logistic function is between 0 and 1; which makes it suitable for use as a probability model, representing individual risk.
2. The logistic regression curve has an increasing s-shape with a threshold; that makes it suitable for use as a statistical model, representing risk due to exposure.

A simple transformation of equation (1) yields

$$\frac{\pi(x)}{1-\pi(x)} = e^{\beta_0+\beta_{x_i}} = e^{\beta_0} \cdot e^{\beta_{x_i}} \quad (4)$$

Results:

Research Question 1:
What is the students' overall performance in mathematics in the region?

The first research question sought to determine the overall mathematics performance of students in the region. To answer this question, a 10-item mathematics test was developed and administered to the 118 students in the selected schools in the Sunyani and Techiman municipalities. The scripts were marked and scored out of a total of 100 using a marking rubrics/scheme. The descriptive statistics of the performance of students in the sampleare as presented in Table 4.3.

Table 4.1: Descriptive statistics of performance of students in the sample.

	Participants	Mean	St. Dev	Min	Max	Range	Skewness	Kurtosis
Score	118	67	18	29	100	71	-0.158	-0.980

From Table 4.1, the least score was 29 while the highest score was 100 with a range of 71. The overall mean score was 66.86 with a standard deviation of 18.027. The mean score of 66.86 is above the expected minimum pass mark of 50%. This indicates that the performance of the students was above average. The skewness, -0.158, of the distribution indicates that the scores are slightly skewed to the left and the kurtosis -0.980 of the scores indicates that the distribution is not heavily skewed as indicated in the histogram.

Logistic regression was performed to assess the impact of a number of factorson the likelihood that respondents would report that they had a mathematics achievement. The model contained four independent variables (attitude towards mathematics, classroom climate, mathematics anxiety, and parental involvement). The fullmodel containing all predictors was statistically significant, $X^2(4, N = 118) = 10.905$, $P < .001$. The model as a whole explainedbetween 8.8 % (Cox and Snell R square) and 11.8% (Nagelkerke R squared) ofthe variance in mathematics achievement, and correctly classified 74.6 % of cases. As shown in Table 4.2, only one of the independent variables made a unique statisticallysignificant contribution to the model (attitude towards mathematics). The strongest

predictor of reporting attitude towards mathematics influencing mathematics achievement, recording an odds ratio of 3.277.

Table 4.2: Logistic Regression Predicting Likelihood of Reporting mathematics achievement.

		B	S.E.	Wald	Df	Sig	Exp(B)
Step 1	**AM**	1.187	.546	4.719	1	.030	3.277
	CC	.420	.526	.636	1	.425	1.521
	MA	.576	.565	1.039	1	.308	1.779
	PI	.229	.447	.263	1	.608	1.258
	Constant	-5.479	2.014	7.404	1	.007	.004

Variable(s) entered on step 1: AM, CC, MA, PI

From Table 4.2, among the four variables in equation, only students' attitude towards mathematics (AM: $p = .030 < .05$) was found to be statistically significant predictor of students' mathematics achievement.

A positive or negative B value indicates the direction of the relationship. The only significant categorical variable (Attitude towards Mathematics), has a positive B value (1.187). This suggests that students with a poor attitude toward mathematics are more likely to fail the achievement test.

Another useful piece of information in Table 4.2, is the values of odds ratios (OR) as seen in the column Exp (B) for each of the independent variables. According to Tabachnick and Fidell as cited in Pallant (2016), the odds ratio represents 'the change in odds of being in one of the categories of the outcome when the value of a predictor increases by one unit (p. 461). Hence, the odds of a student with positive passing a mathematics achievement test is 3.277 times higher than a student with a poor attitude toward mathematics failing an achievement test, all other factors being equal. Thisindicated that respondents who had an attitude toward mathematics is over 3 timesmore likely to influence mathematics achievement, controlling for all other factors in the model.

Again, for each of the odd's ratios EXP (B) shown in the Variables in the Equation table 4.13, there is a 95 percent confidence interval (95.0% **CI** for EXP(B)) displayed, giving a lower value and an upper value. Thus, the confidence interval for the variable 'attitude towards mathematics' (AM; OR = 3.277) ranges from 1.123 to 9.562. So, although we quote the calculated OR as 3.277, we can be 95 percent confident that the actual value of OR in the population lies somewhere between 1.123 and 9.562, quite a wide range of values. The confidence interval, in this case, does not contain the value of 1; therefore, this result is statistically significant at $p < .05$.

Finding and Conclusion:

Students' overall performance in mathematics in the region.

The SHS students' performance in the region is above average with the mean score of 67 representing grade B3 in the WAEC grading system. This finding is consistent with Lee & Kung (2018) who examined gender variation and reciprocal relations among Junior High School students in Taiwan. They found mathematics achievement among Taiwanese Junior High School students to be high. The finding disagrees with the findings of Fletcher, (2018) and Abreh, et al, (2018) who in separate studies analyzed trends in the performance of WASSCE candidates in Science and Mathematics in Ghana and found their performance in core mathematics characterized by a high percentage of candidates with Grade F9. In general, the students' overall performance is above average.

Most influential factor(s) that affect mathematics achievement of students in Senior High School.

The present study investigatedthese variables: mathematics anxiety, attitude towards mathematics, classroom climate, and parental involvement which most influence students' mathematics achievement in single research. The findings revealed a significant positive relation between mathematics achievement and attitude towards mathematics. The finding is consistent with Anuonye et al (2014), Maria et al (2012), and Arhin &Offoe (2015) who in a separate study on the effect of multiple factors determining mathematics achievement, found attitude toward mathematics the most influential variable affecting students' academic achievement in schools.
This finding is inconsistent with Chaman (2014) who also studied the effect of multiple factors on mathematics achievement in single research. Chaman's study found that mathematics anxiety, attitude towards mathematics, and parental involvement have statistically insignificant influences on students' mathematics achievement.

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