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Teacher-Student Variables as Predictor of Students' Interest in Mathematics: The Use of Stepwise Multiple Linear Regression Analysis

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Authors' contributions

This work was produced through collaboration between all authors. Author YDA gathered all literature materials and designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors SAA and CA initiated the study design and supervised the statistical analysis as well as given valuable inputs into analysis. All authors read and approved the final manuscript.

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Abstract

The study investigated the effect of teacher and student variables on student interest in Mathematics. The study used quantitative approach to research to explore and explain the effect of teacher and students variable on students' interest in Mathematics. The study used probability sampling technique to select and administer questionnaires to the participating schools and students. A sample of One Thousand Two Hundred and Sixty Three (1,263) was selected from Ten (10) schools in the Ashanti region of Ghana using the random sampling technique. The study revealed that six (6) out of eight (8) predictor variables are statistically significant in predicting students' interest in Mathematics. The teacher's ability to connect Mathematics to real life problems and school leadership contributed 37.8% and 2% approximately to the

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variance in the student interest. The study further concluded that, students' perception, students' background, Mathematics facility as well as instructor quality and availability were statistically significant in predicting the student interest in Mathematics. However, the contribution of these predictor variables in explaining the variance in students' interest was less than 1%. The study recommends that in order for students to be interested in Mathematics, Mathematics teachers should connect Mathematics to real life scenarios to help build student interest.

Keywords: Mathematics; mathematics connection; student's background; student's interest, student's perception.

1 Introduction

Mathematics permeates all fields of human endeavor and its importance cannot be underestimated. Mathematics is useful in today's technological advancement, educational research, economic integration and business. The development of strong mathematical concepts at all levels of higher education demands solid foundation in Mathematics education for students to effectively apply mathematical concepts. In most West African countries, including Ghana, Mathematics is a compulsory subject at the basic, junior and high school levels. This means that every student has to pass with at least acredit before admitted intoto any tertiary institution. Thus, without at least credit in mathematics, the educational progress of a student is more likely to be truncated. Since Mathematics is very important in student learning, students' interest in learning mathematics and teachers' involvement in teaching the subject could be very paramount. It against this background that student-teacher variables are used in the present study to assess their effects on student interest in mathematics, since without interest: students' achievement would not be a reality. The problem of students' failure in Mathematics and factors that constitute this failure are of great concern to educators and parents.

1.1 Research objective

The study examined critically teacher-student variables as predictor of student interest in Mathematics in senior high schools.

The study specifically sought to achieve the following

i. To determine the extent to which teacher motivation (TM), school leadership (SL), instructor quality and availability (IQA) affect students' interest in Mathematics.
ii. To examine the impact of Mathematics connections (MC), Mathematics facility (MF) and Teachers' Teaching methods (MTT) on students interest in Mathematics.
iii. To determine the effects of Student Perception (SP), Student Background (SB) and Student Motivation (SM) on the students' interest in Mathematics.

1.2 Research questions

The research questions for the study are as follows:

1. Do students' perception, students' and teacher motivation, students' background, Mathematics connection, teachers teaching methods, Mathematics facility availability instructor quality and availability and school leadership when taken together, predict student interest in Mathematics among senior high school student?
2. To what extent does each predictor variable relatively contribute to the prediction of the student interest in Mathematics?

1.3 Research hypothesis

The present study however tests the hypothesis that, the predictor variables do not predict significantly students' interest in Mathematics against the alternative that at least one of the predictor variables statistically predicts significantly students' interest.

1.4 Review of relevant literature

In the delivery of high standard Mathematics education, technology integration is highly indispensable makes Mathematics a central intellectual discipline [1]. Although mathematics has been seen as a language of science [2,3] shares a contrary view and argues that the language of Mathematics must not be seen as just as language of science but rather a fuel that serves as nutrient for thought and intellectual development. The subject, Mathematics, remains the basis of all science and technology and despite its relevance in application, many students fail in the West Africa Senior Secondary certificate examination (WASSCE).

1.5 Instructor quality and availability (IQA)

The continuous failure of students in Mathematics calls for investigation with several authors taking the lead into the investigation of factors that contribute to poor performance in Mathematics [4–7]. In all these investigations, they identified instructor quality where schools use unqualified Mathematics teachers to instruct students. They also identified poor Mathematics facilities, equipment as well as instructional materials as contributing to students' poor mathematics achievement. These studies have considered students' academic achievement and performance, but the fact still remains that if students are not interested in Mathematics, their performance; to larger extent becomes a mirage.

Additionally, teachers with professional and academic knowledge in the relevant subject area intuitively have huge strategies and teaching techniques to match the content and professional knowledge. Teachers with requisite academic and professional knowledge prepare their lessons by reflecting, conceptualizing and using classroom experiences. This means that, Mathematics teachers need to reflect and decide on the lesson preparation and delivery [8,9]. It is therefore a matter of personal characteristics and professional responsibility for a Mathematics teacher to evaluate their instructional effectiveness as well as accepting academic responsibility for student learning and behaviors since the very essence of teaching is a matter of human interaction.

1.6 Motivation and attitude

The argument exists that students enter the school certainly ready and willing to study and learn something new and the onus greatly lies on the Mathematics teachers to make sure that these disposition is strengthened to motivate the students to realize them. Although teachers are charged with the responsibility of ensuring the achievement and delivering of results but the student has a role to play in terms of attitude and perception toward the subject Mathematics. [10] argue that, the attitude and the perception of learners direct how they will respond to situations and events in new environment. This brings in the theory of motivation and self-determination as a tool for active participation. The theory of motivation establishes that, relationships exist among motivation, cognitive engagement and conceptual change. The realization of this is mostly made possible by the effective teacher who is able to use the wide variety of teaching methods available to enhance the learner's interest in the subject.

1.7 Teachers' teaching methods

For the purposes of investigating into the predictors of student interest in Mathematics, teachers are not professionally sound in the area of Mathematics then they have the tendencies of imparting negatively on the student academic achievement [11–13]. The contrary to this report is the fact that the professionally and

academically incompetent teacher will not improve on the student interest and as a result, the lack of interest will lead to less academic achievement and failure. The studies in [14–16] has shown that teaching of science related subject like Biology should be connected to real life situation or scenarios of the learners. This calls for the need to integrate real life situation to the teaching of Mathematics to aid student understanding and interest as well as swift application the acquired knowledge.

The teachers' teaching method or approach that is learner centered has great tendency of motivating learners to learn meaningfully compared to methods that see learners as passive participants [17–19].

1.8 Teachers' self-efficacy and certification

The less academic achievement, according to the studies [20–22] can be mastered if quality of teaching is practiced by teachers. In this case the teachers teaching methods should be examined to maximized learning for all students. When such activities are done then the teachers will engage learners with activities which will in turn induce comprehensive and positive change in what they know and the new skill developed. If teachers develop methods that are able to build on students' interest it will further improve on the performance [23–25].

In the light of performance and student academic achievement, policy makers around the globe have intensified their interest in research into teacher qualifications and student academic performances [7,12,26]. The series of research in this area has been able to associate student academic performance with the teachers' qualification, with most teachers of Mathematics not professionally trained to teach Mathematics [27–29]. This is technically, to some extent, the case in Ghana where many people go into teaching of Mathematics not because they have the requisite Mathematics teacher training for teaching Mathematics but as a means of survival. This is not adequate enough to assure student of proper understanding of mathematical concepts need to progress to higher Mathematics interest and achievement.

Studies in Mathematics education have examine the relationship between students' academic performance and their teacher's academic qualification, and in most case the teachers academic qualification and students' performance are positively correlated [27]. The study by [4,22,30] also had slightly similar results of positive correlation between student academic performance and teachers' qualification although extremely greater percentage of the student had viewed teacher's qualification to have negatively correlated with the student academic performance.

Teachers' academic qualification is required to ensure teachers self-efficacy which predicts teachers ability to perform. Teachers' self-efficacy is believed to be an outward express of inward competence of teachers' capability and ability of delivering in the subject Mathematics. The concept of self-efficacy is very crucial in the delivery of the core responsibility of Mathematics teachers since it makes the teacher satisfied in the job, demonstrates commitment to the job, persists when there is failure and above all motivates students to greater achievements and performance [31–33].

2 Research Methodology

2.1 Design

The study adopted the quantitative research paradigm in the investigation process to obtain the set objectives. The research used relational survey research approach in attempt to obtain the needed information from the participant. This method was chosen because according [34], it presents participants with investigators that seek answers about people's opinions, characteristics and behavior.

The study used general research operational procedures which strictly followed ethics and code of conduct of the data collection. Participants were assured of their confidentiality and they gave approval to participate in the study.

2.2 Population, sampling procedure and sample

The study targeted all senior high schools students in the Ashanti region. The students' population is eighty thousand (80,000) as annual students' average population. The study used a two-stage cluster sampling technique by first randomly selecting 10 schools. The second stage involved selection of the program of study and consequently the students from these programs to be part of the study. On average 150 questionnaires were administered to the 10 selected schools. Students at all class levels were considered in the study with third year student years given the greater proportion of the sample since they have gone through the course for almost three years and second years were the second highest followed by the first years since at the time of the study there were only less than one year in the school. The study participants were assured of anonymity and further gave their consent to be included. The schools were also ensured of anonymity as far as their participation is concerned.

In all, the study randomly administered one thousand five hundred questionnaires to the participants included in study. The study finally had one thousand two hundred and sixty three (1,263) participants whose questionnaires were fit for purpose. This represented 84.2% response rate.

The study used an instrument used a researcher-designed instrument that reflects the problems associated with teaching and learning Mathematics. The instrument was divided into two main part where the first part having constructs such as Mathematics interest (Cronbach's Alpha=0.71), Mathematics connections (Cronbach's Alpha=0.692), teachers teaching methods (Cronbach's Alpha=0.59), student background (Cronbach's Alpha=0.765), school leadership (Cronbach's Alpha=0.599), instructor quality and availability (Cronbach Alpha =0.699), Mathematics facility Motivation (Cronbach 's Alpha =0.701) and student perception (Cronbach's Alpha=0.823). The overall conbach's Alpha value of 0.939 was reported for 84 items in the first part of the instrument as indicated in Table 1a. The second part of the instrument contained the demographic information and personal believes about Mathematics.

Table 1a. Test of reliability statistics

Constructs	Cronbach's Alpha	Number of items
Mathematics interest variables	0.815	11
Students interest	0.741	4
Mathematics connections	0.692	6
Teachers teaching methods	0.59	10
Students background	0.765	8
School leadership	0.599	8
Instructor quality and availlability	0.699	8
Mathematics facilities	0.701	6
Student and teacher motivation	0.676	13
Students perception	0.823	10
Total constructs reliability	0.939	84

2.3 Data collection instruments

The study collected data across gender with 44% males and 56% females. The instrument used for the first part of the questionnaires was closed ended Likert scale response questions where students indicated their level of agreement or disagreement to the items constructed to obtain information about the construct in question. In the early stages of the data collection, the participants were given instructions on how the instrument should be filled in with the help of the teachers of the participating schools.

3 Data Analysis, Results and Discussion

The study used multiple linear regression analysis to evaluate the effect of Mathematics connection, Teachers' teaching methods, students' background, school leadership, instructor quality and availability, facility availability in teaching Mathematics, students' and teachers motivation as well as students' perception on the student interest in Mathematics.

The result from the correlation analysis in Table 1 indicates that, the predictor variables significantly relate with the dependent variable which is the student interest in Mathematics. The study of the correlation analysis reveals that some of the independent variables relate positively and significantly with each other. The study further built a regression model for the student interest to ascertain how well the independent variables predict the student interest.

Table 1. Inter-correlation analysis among predictor variables and student interest in mathematics

	MC	TTM	SB	SL	IQA	FM	STM	SP
Interest	.795**	.320**	.446**	.458**	.258**	.115**	.329**	.362**
MC		.431**	.502**	.663**	.281**	.179**	.379**	.365**
TTM			.480**	.579**	.362**	.246**	.400**	.314**
SB				.550**	.459**	.212**	.470**	.532**
SL					.461**	.344**	.473**	.432**
IQA						.440**	.494**	.476**
FM							.391**	.290**
STM								.511**
SP								

***. Correlation is significant at the 0.01 level (2-tailed)*

3.1 Test of reliability and internal consistency

Table 2, the model summary provides us with overview of the results generated from the analysis. The results present include the R Square and Adjusted R Square values of 0.657 and 0.655 respectively. These results suggest that the weighted combination of the predictor variables can predict 65.5% of the student interest in Mathematics.

Table 2. Summary of standard regression analysis between predictor variables and mathematics interest

R	R square	Adjusted R square	Std. error of the estimate	R square change	F change
.811	0.657	0.655	0.55493	0.657	300.436

Table 3. Analysis of variance for standard regression model adequacy

	Sum of squares	Df	Mean square	F	Sig.
Regression	740.135	8	92.517	300.436	0.000
Residual	386.159	1254	0.308		
Total	1126.294	1262			

The study used student perception, student and teacher motivation, Mathematics facility availability, Mathematics connections, student background, instructor quality and availability and school leadership in as standard regression analysis to predict student interest in Mathematics. The prediction model was found to be statistically significant $F(8,1254)=300.44$, P-value <0.00001 which accounts for approximately 65% of variance of student interest in Mathematics(R Square =0.657, Adjusted R-Square =0.655). The student interest in Mathematics was predicted primarily by student perception, student background, school

leadership, Mathematics connection and to lower extent Mathematics facility availability. The study however found student and teacher motivation as well as the teachers' teaching methods to have no significant effect on the student interest. The unstandardized and the standardized regression coefficient of the predictors together with their correlation with the student interest in Mathematics, their squared semi partial correlation as well as their structural coefficient are shown in Table 4. Mathematic connection received the strongest weight in the model followed by school leadership and student perception but Mathematics facilities availability was the lowest. Further examination of correlation proved strong existence of correlation between the predictor variable but the unique variance explained by the predictor variables which is indexed by the squared semi partial correlation was relatively low with the exception of Mathematics connection to real life problem. Mathematics connection and school leadership accounted for 37.5% and approximately 1.4% of the variance student interest with each of the remaining predictor variables accounting for less than 1% of the variance of student interest in Mathematics. The data set was further analyzed to using the backward multiple linear regression analysis approach to build a model that would be able to exclude the non-statistically significant predictor variables from the final model. The results of the backward regression analysis are shown in Tables 5 to 7.

Table 4. Standards multiple linear regression analysis coefficient results

Model	B	SE-b	Beta	T-statistics	P-values	Pearson r	sr^2	structure coefficient
(Constant)	0.565	0.107		5.295	0.000			
MC	0.916	0.025	0.848	37.017	0.000	0.795	0.375	0.98027127
TTM	-0.013	0.032	-0.009	-0.416	0.677	0.362	0.00005	0.446362515
SB	0.07	0.027	0.060	2.627	0.009	0.446	0.002	0.549938348
SL	-0.246	0.035	-0.187	-7.067	0.000	0.458	0.014	0.564734895
IQA	0.048	0.021	0.049	2.253	0.024	0.115	0.0014	0.141800247
FM	-0.043	0.022	-0.037	-1.918	0.055	0.258	0.001	0.318125771
STM	0.029	0.03	0.021	0.963	0.336	0.32	0.0003	0.394574599
SP	0.099	0.026	0.080	3.753	0.000	0.329	0.004	0.40567201

Table 5. Summary of backward regression analysis between predictor variables and mathematics interest

Model	R	R-square	Adjusted R square	STD. error	R square change
1	.811a	0.657	0.655	0.55493	0.657
2	.811b	0.657	0.655	0.55474	0.000
3	.810c	0.657	0.655	0.55471	0.000

Table 6. Analysis of variance for stepwise multiple linear regression model adequacy

Model	Source of variation	Sum of squares	Df	Mean square	F	Sig.
1	Regression	740.135	8	92.517	300.436	.000a
	Residual	386.159	1254	0.308		
	Total	1126.294	1262			
2	Regression	740.081	7	105.726	343.557	.000b
	Residual	386.213	1255	0.308		
	Total	1126.294	1262			
3	Regression	739.818	6	123.303	400.719	.000c
	Residual	386.476	1256	0.308		
	Total	1126.294	1262			

The study further used stepwise multiple regression analysis using student perception, Mathematics connection, student's background, Mathematics facility, instructor quality and availability, teachers teaching methods, student and teacher motivation, and student and teacher motivation to predict student interest in

Mathematics. The correlation analysis of the predictor variable with respect to students' interest in Mathematics was statistically significant as shown in Table 7.

Table 7. Summary of stepwise regression output

Model	B	Std. error	Beta	T-statistics	P-value	Pearson r	sr^2	structure coefficient
(Constant)	0.565	0.107		5.295	0.000			
MC	0.916	0.025	0.848	37.017	0.000	0.795	0.374544	0.98
TTM	-0.013	0.032	-0.009	-0.416	0.677	0.32	0.000049	0.39
SB	0.070	0.027	0.06	2.627	0.009	0.446	0.001849	0.55
SL	-0.246	0.035	-0.187	-7.067	0.000	0.458	0.013689	0.56
IQA	0.048	0.021	0.049	2.253	0.024	0.258	0.001369	0.32
FM	-0.043	0.022	-0.037	-1.918	0.055	0.115	0.001024	0.14
STM	0.029	0.03	0.021	0.963	0.336	0.329	0.000256	0.41
SP	0.099	0.026	0.08	3.753	0.000	0.362	0.003844	0.45
(Constant)	0.548	0.099		5.558	0.000			
MC	0.916	0.025	0.848	37.033	0.000	0.795	0.374544	0.98
SB	0.068	0.026	0.058	2.595	0.010	0.446	0.001849	0.55
SL	-0.250	0.033	-0.19	-7.584	0.000	0.458	0.015625	0.56
IQA	0.047	0.021	0.048	2.237	0.025	0.258	0.001369	0.32
FM	-0.043	0.022	-0.037	-1.927	0.054	0.115	0.001024	0.14
STM	0.028	0.03	0.02	0.926	0.355	0.329	0.000225	0.41
SP	0.100	0.026	0.081	3.783	0.000	0.362	0.003969	0.45
(Constant)	0.572	0.095		6.004	0.000			
MC	0.917	0.025	0.849	37.19	0.000	0.795	0.378225	0.98
SB	0.071	0.026	0.061	2.732	0.006	0.446	0.002025	0.55
SL	-0.247	0.033	-0.188	-7.531	0.000	0.458	0.015376	0.57
IQA	0.051	0.021	0.052	2.44	0.015	0.258	0.0016	0.32
FM	-0.039	0.022	-0.034	-1.786	0.074	0.115	0.0009	0.14
SP	0.105	0.026	0.086	4.118	0.000	0.362	0.004624	0.45

The prediction model contained six of the eight predictors and these were reached in three steps with two variables removed. The model was statistically significant (6, 1256) =400.719, p<0.000).The final model accounted for approximately 66% of the student interest in Mathematics $\left(R^2 = 0.657, Adjusted\ R^2 = 0.655\right)$.

The student interest in Mathematics is primarily predicted by the teachers ability to connect or link Mathematics to real life situation rather than abstractly teaching Mathematics without any linkage or case studies and to lower extent predicted by Mathematics facility availability. The unstandardized and the standardized regression coefficient of the predictors together with their correlation with the student interest in Mathematics, their squared semi partial correlation as well as their structural coefficient are shown in Table 5. Mathematics connection received the strongest weight in the model followed by school leadership and student perception but Mathematics facility availability was the lowest. Although sizeable correlation existed between the predictor variables, the unique variance explained by each of the predictor variables indexed by the squared semi partial correlation was relatively low with the exception of Mathematics connection to real life problem. Mathematics connection and school leadership accounted for 37.8% and approximately 2% of the variance student interest with each of the remaining predictor variables accounting for less than 1% of the variance of student interest in Mathematics.

4 Conclusions and Recommendation

The results of the first stated hypothesis sought to investigate whether the teacher-student variables significantly predict students' interest in Mathematics were upheld by the study. The study has further revealed that although student perception, student background, Mathematics facility and instructor quality and availability were statistically significant in predicting the students' interest in Mathematics. The

contribution of these predictor variable in explaining the variance in students' interest is less than 1%. This results is confirmed by [11], which says that student interest is influenced by the student perception of the student about the course intellectual challenge but contrary to interest being predicted by instructor characteristics like instructors teaching method.

The study further showed that Mathematics connection and school leadership were statistically significant in predicting students' interest in Mathematics. Mathematics connection which also refers to the ability of the teacher to connect mathematical concepts to real life problem as well as how the student feels about how Mathematics is taught by their teachers contributes 37.8% of the variance in the student interest in Mathematics; This results is in consonant with the study by [11] that pedagogical affect, influence student interest in Mathematics directly and significantly. School leadership on the other hand contributed approximately 2% of the total variance in students' interest in Mathematics.

The study finally concludes based on the data available to the study that student interest in Mathematics can best be predicted by Mathematics connection, school leadership, student background, instructor quality and availability, Mathematics facility and student perception. This results though seem strange but it may however be attributed to the fact that student with low motivation might not see the significance effects motivation have on achievement and interest. Thefindings further confirm the study by [35] the teaching method of the teacher and the ability of the teacher to impart good knowledge couple with student interest and positive attitude will produce greater achievement. The study by [35] also confirms that without interest, achievement is difficult to reach but the study however contradicts the findings by [35] that instructor quality which encompassed teachers qualification does not correlates with Mathematics achievement.

This study showed statistically significant correlation between the student interest and the predictor variables. The teacher teaching method was found to significantly correlate with student interest; however, this study did not find teachers teaching method and motivation to significantly predicting student interest in Mathematics. The issue of instructor quality and availability as predictor of students' interest was also found to be significant implying that as qualified teachers are employed to teach mathematics the more interested the students will be in mathematics. The instructors' ability to connect mathematical concept to real life problems which predict significantly the student interest in Mathematics might really be the case since teacher of Mathematics will naturally gravitate towards tasks they can comfortably perform and shy away from the task they feel less competent about. Thus when a teacher is competent in a specific area, the competency will generate interest in the students.

Competing Interests

Authors have declared that no competing interests exist.

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