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Determinants of Quality of Mathematics Education Using Multiple Regression Model

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Abstract:- This paper examines the determinants of the quality of mathematics education. A multi-stage random stratified sampling method was used to select students and schools. To identify determinants of quality of general secondary school mathematics education and to explore the relationship between students' mathematics performance and independent variables a multiple linear regression model was developed. The results indicated that family supports, students' mathematics background, interest and motivation of students and teachers, the participation of students and cooperation between students and teachers were the most significant predictor of students' mathematics achievement. To change the image of students and society at a large have in mathematics the school should work with different stakeholders to create awareness about the importance of mathematics for society as a whole. The school should also exert more effort to develop teacher's pedagogical skills on how to motivate and participate in all students equally in the classroom were recommended.

Keywords:- *General Secondary School; Mathematics Education; Multiple Regression Analysis; Student Performance; Teaching And Learning.*

I. INTRODUCTION

Teaching and teacher quality have innumerable definitions and are sometimes linked together or used in isolation. According to Fenstermacher and Richardson (2005), quality of teaching can be expressed as teaching that makes learning. Furthermore, Fives (2005) stated that teacher performance is typically considered to be related to student learning achievements, including student motivation. It recommends that teaching quality in reality represents a set of actions and activities that develop student results.

Similarly, Abebe and Woldehanna (2003) identified that the learning and teaching practice would be more successful if teachers were dedicated and motivated for his profession; students' committed towards their study. They were also stated that school management and other stakeholders support to fulfill adequate facilities and infrastructure; parents and community members' support for teachers' work; and students study determines the quality of education.

Mathematics is a core subject, which taught all over the world. It plays a key role in shaping how individuals deal with the various spheres of private, social, and civil life (Anthony & Walshaw, 2009). Due to this, the Education Sector Development Strategies of Ethiopia put mathematics as one of the most essential subject (MoE, 1994). Effective teachers model the procedure of exploring and justifying, directing learners into mathematical principles (Anthony & Walshaw, 2009). To motivate and encourage students in learning mathematics and improve their performance in Nigerian Secondary School Dauda, Jambo & Umar (2016) found that, mathematics teachers should understand the perceptions of their students and try to adopt instructional strategies that turn out to be easy and properly addressed their difficulties. They also suggested to enhance the quality of mathematics teachers as the government should provide in-service training to equip them with skills for teaching mathematics in secondary schools. Mensah, Okyere, and Kuranchie (2013) further highlighted that teachers' positive attitudes towards the teaching and learning of mathematics play a vital role to increase student's confidence and to develop a positive mind-set towards mathematics. This was due to ability of teachers, method of instruction, and instructional resources were greatly perceived by learners as important predictors of their success in learning and their attitude towards mathematics learning was an important cause in the performance of students (Dauda, Jambo & Umar, 2016)

A. Description of the Problem

Atnafu (2014) indicated that Ethiopian general secondary school (GSS) student's mean score in mathematics was the second from the least and only 14.7% of them scored pass mark. This shows that most of the students failed in mathematics. Their mathematics background was also weak (Author, 2017). Learner-centered way of instruction is not implemented properly in the GSS mathematics class of Ethiopia (Hunde & Tegegn, 2010). Their teachers' attitude in teaching the course is also low (Atnafu, 2014). Thus, studies exploring factors affecting the quality of general secondary education in general and mathematics, in particular are important. Thus, this study is different from earlier studies, especially those conducted in Ethiopia in such a way that it focuses specifically on determinants of quality of mathematics teaching and learning.

Hence, the purpose of this study is to apply a multiple linear regression model to examine the students, teachers, school administrators and parents of students' related factors that determine the quality of mathematics education of GSS in Ethiopia. By examining the determinants of quality of learning

and teaching mathematics, this paper contributes to bridges the gap that has existed about research evidence on determinants of quality of learning and teaching mathematics education in Ethiopia.

II. LITERATURE REVIEW

Dossett and Munoz (2003) categorized the factors that influence student achievement into three types: school, student, and teacher-related factors. In line with this recent study categorize four causes to attribute for the students' failure in mathematics: causes originating from students, teaching and learning methods, due to the nature of mathematics itself and physical causes (Baştürk, 2016). Causes originated from itself was also affected their characteristics; such as achievement, motivation, attitude towards study and effort (Veenstra & Kuyper, 2004). For instance, children who perceive their teachers to be fair and caring are more likely to have a positive attitude towards school and increased motivation to achieve (Babad, 1996). Student's self-efficacy beliefs about themselves exert a direct effect on their mathematics achievement (Klassen, 2004). Study results revealed that students' prior achievement has also the strongest direct effect on their mathematics achievement (Bandura, 1977).

Motivation has been considered as one of the most important concern in mathematics education (Walker & Guzdial, 1999; Zhu & Leung, 2010). Ryan and Deci, (2000) stated that interest was also a key point for the high quality of education. Thus, according to ANIGBO there are seven factors affecting Senior Secondary School Students' Mathematics interest such as: student factor, teacher factor, government factor, infrastructural problem, instructional strategy, class size and mathematics anxiety (ANIGBO, 2016). Interrelated to gender gaps, boys performs more than girls in both mathematics (Skryabin, Zhang, Liu & Zhang, 2015; Veenstra & Kuyper, 2004). According to Henderson & Mapp, (2002), parents' involvement is also associated with children's higher achievements in language and mathematics. In line with this Muhammad et al., (2013), confirmed that parental involvement has a significant effect to enhance their children's academic achievements.

Teachers play a great role in involving all students in classroom teaching activities and in developing their mathematical identities (Cobb & Hodge, 2002; Anthony & Walshaw, 2009). Although teacher quality is very hard to measure, observable core teacher quality types are verbal ability, subject-matter knowledge, knowledge of teaching and learning and ability to use a different range of strategies adapted to student needs (Darling-Hammond & Sykes, 2003). They influence how students imagine of themselves in the classroom (Walshaw, 2004). This gives them confidence in their mathematics learning. Giving feedback after a homework or assessment helps students to know their mistakes and correct them for the future. Due to this, researchers (Good & Brophy, 2000; Struyven, Dochy, Janssens, Schelfhout, & Gielen, 2006) remarks as teachers should give feedback to students after assessments.

Instructional time spent on subjects, homework, feedback and actively involving students in the classroom are major cause of educational quality (Fuller, 1987). Research studies show that the advancement of teacher knowledge is greatly enhanced by the efforts of school community to improve teacherstheir understandings of mathematics teaching and learning (e.g. Cobb, & McClain, 2001; Sherin, 2002). Mathematics teachers should be supported by everyone involved in mathematics education including policymakers, as well as students themselves to enhance students' mathematical proficiency (Anthony & Walshaw, 2009). Similarly, Dalin (1994) `suggested; in-service teacher training, adapting curriculum and teaching materials to local practices, community support and supervision, sufficient resources, and motivated school leadership were required for school success.

III. DESIGN OF THE STUDY

The research design of this study was quantitative methods. A multi-stage random stratified sampling method was used to select schools. Initially, schools in Urban and Rural areas of the Ilu Ababor zone were identified. Then three schools from each area were selected randomly.

A. Participants

The data of this study were taken from a total of 405 randomly selected GSS students (209 from urban schools and 196 from rural schools) from the sampled schools based on proportional stratified sampling and all 32 sampled GSS mathematics teachers of the Zone where purposely participated in the study.

B. Instruments of Data Collection

Questionnaires, for students and teachers, and document analysis (students' mathematics score) were used to collect data. The student's questionnaires consisted their background and their mathematics teachers' characteristics while, teachers questionnaires were consisted the students and their school characteristics.

Validity and reliability of the instruments. The instruments were reviewed based on the comments collected from professionals and the result of the pilot study for the face and content validity. To ensure the reliability of the measures, 40 GSS students and five mathematics teachers were chosen randomly using simple random sampling from Guder GSS in Toke Kutaye district in the West Showa Zone, which was not included in the sample schools for the main study. To assess the reliability and internal consistency of the instruments alpha coefficient of Cronbach was used and yielded 0.78 for teachers and 0.81 for students, which is considered acceptable for research purposes (Muijs, 2004). Therefore, all the independent variables were correlated with the quality of mathematics teaching and the correlations were significant at 0.05 level of significance.

Dependent and independent variables. The Dependent variable was out of 100% students' mathematics scores, which is obtained from school records to measure their achievement at the end of the academic year. In Ethiopia schools scores (below 50 = Failure; [50, 59] = Average; [60, 79] =

Satisfactory; [80, 89] = Very Good; [90, 100] = Excellent) [7]. Based on theoretical and empirical considerations, three sets of independent variables (IVs) were identified for this research. The first IV was students' characteristics which consisted: gender, family support, interest, and motivation towards learning mathematics, students' self-efficacy about the subject. The second IV was teachers' characteristics which consisted of their interest and motivation to teach, collect, correct return and give reaction on homework to the whole class and level of participating students equally in the classroom. The final IV was school characteristics: location of the school, school resources, school implementing work in small groups with assistance from the teacher and cooperation between students and teachers in the school.

C. Mathematical Model used for Data analysis

In this study quantitative statistical analysis procedures were employed. Accordingly, multiple regression model analysis (using IBM SPSS 20) was employed. A multiple linear regression analyzes the effects of two or more DV on a dependent variable (Freedman, 2009). A linear model relating the response y to several predictors has the form:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k + \varepsilon, \quad (1)$$

where: y = dependent variable;

$x_1, x_2, \cdots, x_k$ = independent variables;

$\beta_0, \beta_1, \beta_2, \cdots, \beta_k$ = regression parameters and;

ε = random error. The model for the i^{th} observation is:

$$y_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + ... + \beta_k x_{ki} + \varepsilon_i, \ i = 1, 2, ..., n \ (2)$$

The subscript i refers to the i^{th} individual in the population. In the notation for the x-variables, the subscript following i simply denotes which x-variable it is. The close-ended questionnaire items were rated on a Likert scale having five degrees of agreements ranging from 1= strongly disagree to 5 = strongly agree. Note that, mean (M) and standard deviation (SD).

IV. RESULTS

The mean score of students was 58.75% which is average according to Ethiopia context and the majority of students' (71.11%) mathematics achievement was also average, 10.37% failure and only 2.47% of students score excellent results. A multiple regression analysis was used to predict the relationship between independent variables and the dependent variable. The dependent variable, students' mathematics performance, was estimated by k independent variables (Ramachandran & Tsokos, 2009). The hypothesized model to be studied is of the form in equation 6, when $k = 14$. Where x_{ik} is the k^{th} independent variable for the i^{th} observation, $i = 1, 2, 3, \cdots, n$ and $\beta_k, (k = 1, 2, \cdots, 14)$ is the constant weight by which each value of the variable x_k is to be multiplied in the multiple regression equation that includes all k independent variables.

Thus, β_0 is the intercept of the regression model and β_i is the average or expected change in y for each unit increase in x_k, when the values of each of the $k-1$ other independent variables are held constant.

TABLE I. ANOVA SUMMARY

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	30568.6	5	6113.72	325.386	0
	Residual	7440.5	396	18.789		
	Total	38009.1	401			
2	Regression	33408	10	3340.8	283.898	0
	Residual	4601.13	391	11.768		
	Total	38009.1	401			
3	Regression	34011.3	14	2429.38	235.167	0
	Residual	3997.88	387	10.33		
	Total	38009.1	401			

Before multiple regressions analysis, first correlations between each independent variable with dependent variable were examined. Variables with insignificant correlation were excluded from multiple regressions analysis. Secondly, correlations between study variables were examined to assess the extent of multicollinearity (Ramachandran & Tsokos, 2009).

Similarly, the variance inflation factors (VIF) values changed between 1.019 and 2.332, which is less than 3 and all tolerance statistics were greater than .3, which indicates that the final model did not exhibit multicollinearity (Tabachnick & Fidell, 2013). The Durbin-Watson statistic of 1.902 was also between one and three, implying that errors in the regression were independent. Standardized residuals were examined to detect the presence of outliers. In three cases, standardized residuals were greater than 3 and Mahalanobis distance greater than 23.685 and Cook's distance greater than one considered as outliers and removed from the final regression analysis.

Furthermore, the assumptions of linear regression such as normality, linearity, and homoscedasticity were checked by

looking standardized residuals scatterplots to examine whether residuals are normally distributed about the predicted students' scores, the residuals have straight-line relationship with predicted students' scores and the variance of the errors is a constant and independent for all predicted score. It was found that all the assumptions were met (Tabachnick & Fidell, 2013).

The first prediction model, students' characteristics, was (F (5, 396) = 325.386) (table 1) which was a good model and accounted for 80.2% of the variation in students' mathematics performance (table 2). The correlation coefficient for the set of students' characteristics was 0.897. Model I, indicated that except gender all variables of students' characteristics were significantly related to students' mathematics performance.

In the second model II, the set of teachers characteristics was added to the set of students' characteristic variables, and the regression analysis found (F (10, 391) = 283.90) which was a good model at p <0.001 (table 1) and accounted for 87.6% of

TABLE II. REGRESSION ANALYSIS FOR DEPENDENT VARIABLE AND IVS

Variables	Students Achievement					
	Model I		Model II		Model III	
	B	***t***	***B***	***t***	***B***	***t***
Gender	0.854	1.953	0.272	0.769	0.451	1.335
Family support their child's	4.656	12.545***	3.161	10.183***	3.061	10.396***
Students interest in learning mathematics	3.396	10.864***	2.12	7.817***	1.904	7.277***
Students motivation to learn Mathematics	4.608	11.991***	2.824	8.509***	2.604	8.315***
Mathematics is primarily an abstract subject	-2.425	-7.775***	-1.752	-6.508***	-1.3	-5.003***
Teachers interest in teaching			2.145	8.185***	1.457	5.406***
Teacher motivation to teach			2.048	6.517***	1.646	5.481***
Collect, correct and return homework			1.112	3.329**	0.78	2.441*
Give feedback on homework to a whole class			0.394	1.806	0.279	1.34
Participating all students equally in the class			1.909	6.038***	1.606	5.281***
Location of schools					0.584	1.731
School resources					0.56	3.500**
Work in small groups with assistance from the teacher					0.506	2.669**
Cooperation between students and teachers					1.412	4.963***
Multiple R	0.897		0.938		0.946	
R2	0.804		0.879		0.895	
Adjusted R2	0.802		0.876		0.891	
Variance (R2 change)	0.804		0.075		0.016	

*p<.050 **p<.010 ***p<.001

The variation in students' mathematics performance, with a correlation coefficient of 0.94 (table 2). Model II indicated that students' mathematics performance was significantly related to teachers' interests and motivation to teach, teachers' activity to collect, correct and return homework and participating all students equally in the class but give advice on homework to the whole class was not (table 2).

The inclusive model (third model), that combined school characteristics with students' and teachers' characteristics, because of adjusted R2 = 0.891 is the largest of all models and p <0.001 (table 2) was F (14, 387) = 235.17 (table 1). It was the best predictor model from the candidate models of students' mathematics performance and accounted for 89.1% of the variation in student's mathematics performance (table 1). The multiple regressions correlation coefficient for model III was 0.95. School resources, work in small groups with assistance from the teacher and cooperation between students and teachers were significantly related to students' mathematics performance whereas the location of schools was not.

Student's characteristics. Multiple regression analysis of student's responses showed that student's characteristics

were highly associated with student mathematics (Veenstra & Kuyper, 2004).

From the analysis, the coefficients of gender on their mathematics achievement showed that statistically non-significant gender difference in mathematics performance. The coefficients of family support on their achievement show that having family support was likely to better their counterparts and increases of a unit in family support is associated with a children's score increase by 4.66, holding other IVs as constant. This coefficient is significant at a 5% of significance and the result was consistent with the findings of Abebe & Woldehanna (2013); Henderson & Mapp (2002) on the importance of parents' support on quality of education and better mathematics performance of their children's.

The coefficient of students' interest to learn mathematics, which is an important issue for high quality teaching Ryan and Deci (2000), revealed that a unit increase in their interest cause an increase in their mathematics performance by 3.396, keeping other IVs as it is. This coefficient is significant at 5%. The coefficient of the motivation of students to learn mathematics signified that a one standard deviation increase in students' motivation cause an increase in students' mathematics performance by 4.61, holding other IVs as constant. This coefficient is significant at 5% of significance. This finding was consistent with Walker and Guzdial, (1999); Zhu and Leung, (2010) findings.

Whereas from the analysis the coefficients of students considering mathematics is an abstract subject that indicated a unit increases in it related with a decrease of students' mathematics performance by 2.43, holding other IVs as constant. This coefficient is significant at 5% level of significance. This study has consistency with the result of Klassen (2004) which confirmed that an individual belief about themselves exerts a direct effect on students' achievement.

Teacher's characteristics. The second model incorporated student's characteristics. Study results have shown that teachers are the most important resource for developing students' mathematical identities (Cobb & Hodge, 2002). Students taught by interested mathematics teachers, motivated to teach and those who were collecting, correcting homework/assignments and participated in all students equally in the classroom were significantly performed more than counterparts. Because teachers' positive attitudes towards mathematics play a vital role to develop student's mathematics learning (Mensah, Okyere and Kuranchie, 2013). The finding of this study indicated that the increase of one standard deviation in mathematics teacher's interest, motivation to teach mathematics was associated with an increase of student's mathematics performance by 2.15 and 2.05 respectively, holding other IVs as constant. These coefficients are significant at 5% level.

Study results also revealed that the increase of one standard deviation in mathematics teacher's collecting, correcting homework/ assignments connected with a raise of student's mathematics performance by 1.11. A unit increase of participating all students equally in the class, which promote students positive attitude towards school and increase motivation to achieve Babad (1996) and which develop students mathematical and culture identities Anthony and Walshaw (2009), was also associated with an increase on student's mathematics performance by 1.91 ($p < .001$), keeping other IVs as constant.

Even though, giving feedback on homework/assignments to a student and students' mathematics performance was positively correlated it was not significant to students' mathematics performance in the case of Ethiopia specifically in Ilu Ababor. This contradicted the results found by Good & Brophy (2000); Struyven, et al., (2006) that indicated feedback should be given to students after assessments.

School characteristics. Research investigations found that the development of teacher's knowledge and improvement of mathematics teaching and learning is enhanced by the efforts of the school community (Cobb, & McClain, 2001; Sherin, 2002).

The analysis found that an increase in one standard deviation in school resources associated with enhancement of students' mathematics performance by 0.56, holding other IVs as constant. This coefficient is significant at 5% level of significance. This result is consistent with study result of Dalin (1994) which shows sufficient resources is one of the requirements for school success. The coefficient of students work in small groups with assistance from the teacher, which is one of the major factors related to educational quality Fuller (1987), showed that a one standard deviation increase in students work in small groups with assistance from the teacher was associated with an increase of student's mathematics performance by 0.51, holding other IVs as constant. This coefficient is significant at 5% level of significance.

The coefficient of cooperation between students and teachers indicated that a unit increase of cooperation between students and teachers was associated with an increase of student's mathematics performance by 1.41. This coefficient is significant at 5%. This result is consistent with (Muhammad et al., 2013). The location of schools was also positively correlated (favoring urban) with students' mathematics performance, it is not statistically significant to students' mathematics performance in the case of Ethiopia.

V. CONCLUSIONS AND RECOMMENDATIONS

This study was aimed to identify determinants of quality of mathematics education by determining the effects of students' characteristics, teachers' characteristics and school characteristics on students' mathematics performance in Ethiopia. From the results of multiple regression analysis, one can concluded that family supports on their children mathematics performance, interest, and motivation of students to learn mathematics were statistically significant and positively related to student's performance. Parents should

support, encourage and give time to study for their children's on their mathematics education.

Interest and motivation of teachers to teach mathematics were statistically significant and positively related to student's performance. Community and students should give value, respect and encourage teachers on his/her work. Teachers practice to collect, correct homework and return to students and participating all students uniformly in the classroom, appropriate teaching, and learning resources were also statistically significant and positively related to students performance. The school administrators should support and provide a continuous professional development opportunity for teachers to improve their teaching skills and follow up and support them on its implementation. They should also fulfill facilities, resources, and laboratory of geometry for effective mathematics teaching and learning processes in collaboration with governmental and non-governmental organizations.

Similarly, work in small groups with assistance from the teacher and cooperation between students and teachers were statistically significant and positively related to students performance. Thus, the school should promote academic cooperation between students and teachers and its impact on the quality of education through awareness creation programs. Students considering mathematics as an abstract subject were statistically significant and negatively related to their performance. To solve such problem the school should work with different stakeholders (students, teachers and parents) to create awareness about the importance of mathematics for the society as a whole. The government should also play a vital role to change the image of students and society at large on mathematics. While, gender, giving feedback on homework/ assignments to all students and the location of schools were not significant factors in the case of Ethiopia.

Further research should be done to explore how the Ethiopia government works to improve the first cycle primary school mathematics curriculum that might affect quality of general secondary school mathematics education. And also to improve the status of the quality of mathematics teaching in general and to develop a school-based curriculum on students' characteristics, school resource and school environment in particular further research should be done.

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