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MODELING FACTORS INFLUENCING MATHEMATICS LEARNING AND PERFORMANCE IN TANZANIAN SECONDARY SCHOOLS

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Abstract: The purpose of this study is to develop a factor model describing factors affecting mathematics performance in Tanzania's secondary schools. The factors were first identified by first administering structured questionnaires to 520 secondary school students with designed variables therein. Factor analysis/principal component method was used to identify the underlying factors affecting students' performance in mathematics. It was revealed that lack of interest while studying mathematics, triviality and lack of practice by students, lack of drive and enthusiasm for teachers and students, perception and attitude towards the subject terming it to be difficult and lack of qualified mathematics teachers are the main contributors towards mathematics performance. Principal component analysis revealed that, lack of interest and triviality in studying mathematics were the most significant factors to the performance of students in mathematics. The factor model explained 50.5% of the total variation of the students' mathematics performance. Furthermore, multiple linear regression and correlation analysis were conducted on the factors identified. Multiple linear regression revealed that lack of interest while studying mathematics and triviality and lack of practice by students are the main contributors towards the students' performance in mathematics. Correlation analysis revealed that lack of interest while studying mathematics and lack of qualified mathematics teachers correlated with all other factors.

1. Introduction

Tanzania's education system provides mathematics at all levels of education. It is compulsory in kindergarten, primary and secondary education. Mathematics lays a foundation to both social and science subjects through derivation of concepts. Mathematics is widely applicable in business, economics, engineering and agriculture. Mathematics is also used in thinking and organizing logical proofs. Thus to a society, mathematical

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knowledge will always remain an important tool (Baroody, 1987; Köğce, Yıldız, Aydın, & Altındağ, 2009).

A report by NECTA (2013) on Basic Mathematics performance in the Tanzania national examination shows that performance in the subject has been deteriorating. A similar trend was exhibited in the 2014 Form Four National Examination where Basic mathematics faired poorly in comparison to other subjects (NECTA, 2014). A score below 30% in an examination in Tanzania secondary schools is regarded as a fail (Mtulya, 2014). According to Zaya (2014), only 17.8% of the students who sat for the National Form Four Examinations in 2013 passed mathematics. A pass rate of only 19.58% in mathematics was recorded for candidates who sat for the 2014 National Form Four Examinations (Kilonge, 2015). This is due to the fact that the students think that, mathematics is a difficult subject to understand (Veloo, Ali, & Krishnasamy, 2014). This had led students not understanding mathematical concepts which are being taught. Thus this paper seeks to examine factors contributing towards mathematics performance and subsequently model the identified factors to performance in Tanzania National secondary school mathematics examinations.

2. Methodology

2.1 Study area and data collection

The study was conducted in Arusha and Kilimanjaro regions of Tanzania. The study used primary data gathered using a structured student questionnaire. The questionnaire was divided into two sections. The first part had 4 items while the second section had 22 variables, with each variable being a statement in a 5-point Likert scale ranging from 1 representing strongly disagree to 5 for strongly agree. A mathematics test was conducted and scores were used in formulating a multiple linear regression model. Simple random sampling procedure was used to select secondary schools and students that participated in the study. Ten secondary schools were chosen randomly with a sample (N) of 520 secondary school students (257 boys and 263 girls). Students were chosen randomly from the following classes, Form Two, to Form Six. The questionnaires were distributed to the 520 secondary school students and all questionnaires were completed and returned.

2.2 Data Analysis

Statistical Package for Social Scientists (SPSS) version 21.0, Stata 09 and R-software were used to analyse data gathered. The analysis focused on the second section of the questionnaire. The reliability of the instrument (questionnaire) was checked using Cronbach Alpha Coefficient which was found to be 0.71. According to Cooper and Schindler

(2008) cited in Mutodi and Ngirande (2014), an instrument is reliable if it has the Cronbach Alpha Coefficient of above 0.70. Hence, the instrument and the variables therein were reliable and acceptable.

A correlation matrix was computed and the determinant was found to be 0.003. The determinant is above 0.00001 which indicates an absence of multicollinearity (Yong & Pearce, 2013). The Kaiser–Meyer–Olkin Measure of Sampling Adequacy (KMO) and Bartlett's test of sphericity values were checked to determine if the data were suitable for factor analysis. The KMO value should be at least 0.5 for factor analysis to be conducted (Field, 2009). The Bartlett's test of sphericity should be significant, that is, the probability, p, should be less than 0.005. The KMO value was found to be 0.801 which is above the acceptable limit. The Bartlett's test of sphericity was found to be, $\chi^2(231) = 2912.125$, $p = 0.000$ and it is highly significant. Child, (2006) cited in Yong and Pearce (2013) argues that the KMO statistics for an individual variable should be checked by observing the diagonal of the Anti-Image Matrix. All the values of the Anti-Image Matrix were above 0.5 which allowed the inclusion of each variable in the factor analysis. This enabled extraction of distinct and reliable factors.

Factor analysis was conducted using Principal Component Method (Hamilton, 2008; Rencher, 2003). The aim of using the principal component method was to identify the underlying factors that affect the students' mathematics performance. An oblique rotation (direct oblimin) was used to extract factors so as to allow the correlation between factors. An orthogonal rotation (varimax) was not appropriate because it did not produce a symmetrical component transformation matrix. The oblique rotation produced pattern matrix which contains factors (see Table 1). The pattern matrix was rotated to produce structure matrix which shows the correlations between variables and factors (see Table 2). The aim of factor rotation was to improve the interpretation of the factor model after getting a solution i

n which each variable has only a small number of large loadings (Montanari & Viroli, 2010). Field (2009) points out that, factors with eigenvalues greater than one should be retained. Using Kaiser's criterion seven components/factors with an eigenvalue greater than one were extracted. However, Yong and Pearce (2013) recommend that a factor should have at least three variables with a significant loading of a critical value 0.3. Rencher (2003) supports this by suggesting that the significant loading value of 0.5 be used to avoid the complexity of variables (Rencher, 2002). A variable with factor loading value at least 0.5 was identified as a significant variable and it was used in naming a factor. Thus, in this

paper, we have used at least three variables with the factor loading at least 0.5 to denote a factor. Hence, five factors were extracted and named accordingly. The five factors explained 50.5% of the total variation of the students' mathematics performance. The factors were (where x_i *for* $i = 1, 2, 3, \ldots, 18$ notate variables used in naming factors and writing the factor model see Table 2)

- Factor 1 (F_1), include the variables x_1, x_2, x_3 *and* x_4 and is named as lack of interest while studying mathematics.
- Factor 2 (F_2), include the variables x_5, x_6, x_7, x_8 *and* x_9 and is named as triviality and lack of practice by students.
- Factor 3 (F_3), include the variables x_{10}, x_{11} *and* x_{12} and is named as lack of drive and enthusiasm for teachers and students.
- Factor 4 (F_4), include the variables x_{13}, x_{14} *and* x_{15} and is named as perception and attitude towards the subject terming it to be difficult.
- Factor 5(F_5), include variables x_{16}, x_{17} *and* x_{18} and is named as lack of qualified mathematics teachers.

These five factors were used to build the factor model. However, the four variables named **a**, **b, c** and **d** (see Table 2) were excluded in the factor model because they did not have any significant correlations between these variables and the factors. Further analysis was done on the five factors, that is, multiple linear regression model and Pearson correlation model. The aim was to determine strengths and relationships among factors extracted.

3. Model development

3.1 Factor model

The following is the factor model that describes the factors that affect students' performance in Mathematics in Arusha and Kilimanjaro regions.

$$x_1 = 0.83F_1 + 0.05F_2 + 0.06F_3 + 0.32F_4 + 0.22F_5 + 0.30$$

$$x_2 = 0.81F_1 + 0.04F_2 + 0.12F_3 + 0.26F_4 + 0.33F_5 + 0.32$$

$$x_3 = 0.80F_1 + 0.12F_2 + 0.10F_3 + 0.24F_4 + 0.12F_5 + 0.34$$

$$x_4 = 0.78F_1 + 0.16F_2 + 0.08F_3 + 0.37F_4 + 0.21F_5 + 0.37$$

$$x_5 = 0.11F_1 + 0.74F_2 + 0.04F_3 - 0.11F_4 - 0.01F_5 + 0.38$$

$$x_6 = 0.13F_1 + 0.62F_2 - 0.05F_3 + 0.04F_4 + 0.24F_5 + 0.52$$

$$x_7 = -0.10F_1 + 0.53F_2 - 0.06F_3 + 0.08F_4 - 0.13F_5 + 0.67$$

$$x_8 = 0.13F_1 + 0.52F_2 + 0.20F_3 + 0.27F_4 + 0.03F_5 + 0.68$$

$$x_9 = 0.18F_1 + 0.51F_2 + 0.21F_3 + 0.28F_4 + 0.18F_5 + 0.67$$

$$x_{10} = 0.08F_1 + 0.02F_2 + 0.73F_3 - 0.06F_4 + 0.11F_5 + 0.44$$

$$x_{11} = 0.08F_1 + 0.11F_2 + 0.70F_3 + 0.13F_4 + 0.11F_5 + 0.50$$

$$x_{12} = 0.05F_1 + 0.02F_2 + 0.58F_3 - 0.11F_4 + 0.22F_5 + 0.61$$

$$x_{13} = 0.43F_1 + 0.12F_2 - 0.02F_3 + 0.89F_4 + 0.23F_5 + 0.15$$

$$x_{14} = 0.26F_1 + 0.10F_2 + 0.03F_3 + 0.86F_4 + 0.15F_5 + 0.26$$

$$x_{15} = -0.36F_1 - 0.14F_2 + 0.06F_3 - 0.80F_4 - 0.17F_5 + 0.32$$

$$x_{16} = 0.30F_1 + 0.11F_2 - 0.04F_3 + 0.13F_4 + 0.75F_5 + 0.39$$

$$x_{17} = 0.39F_1 - 0.07F_2 + 0.13F_3 + 0.21F_4 + 0.72F_5 + 0.41$$

$$x_{18} = 0.18F_1 + 0.36F_2 + 0.34F_3 + 0.23F_4 + 0.56F_5 + 0.51$$

The factor model above explains 50.5% of the total variation in students' performance in mathematics. The first factor, lack of interest while studying mathematics was explained by 20.6% of the total variation in students' performance in mathematics and the second factor, triviality and lack of practice by the students was explained by 10.3% of the total variation in students' performance in mathematics. The third factor, lack of drive and enthusiasm for teachers and students was explained by 8.3% of the total variation in students' performance in mathematics. The fourth factor, perception and attitude towards the subject terming it to be difficult was explained by 6% of the total variation in students' performance in mathematics and the last factor, lack of qualified mathematics teachers was explained by 5.3% of the total variation in students' performance in mathematics. Thus, lack of interest while studying mathematics and triviality and lack of practice by the students are the most important factors in determining the performance of the students in mathematics.

3.2 Regression model

A multiple linear regression model was constructed using five factors extracted and it was used to determine the statistical significance of the effect of each factor to student performance in mathematics. The performance in the test administered (scores) was used as a dependent variable. Table 3 shows the variable names of factors and their description used in the regression and correlation models.

Table 3: Variable names and their descriptions

Variable name	Description
LACKINT	Lack of interest while studying mathematics.
TRILACK	Triviality and lack of practice by students.
LACKDRIV	Lack of drive and enthusiasm for teachers and students.
PERCATT	Perception and attitude towards the subject terming it to be difficult.
LACKQUAL	Lack of qualified mathematics teachers.

Two factors among the five were identified to have a significant effect on the mathematics performance. These factors were lack of interest while studying mathematics and triviality and lack of practice by students. Similar results were obtained by studies conducted by (Gitaari, Nyaga, Muthaa, & Reche, 2013; Mbugua, Kibet, Muthaa, & Nkonke, 2012). The model was significant at a significance level 0.05.

The multiple linear regression model formulated was

$$Performance = 20.18 - 1.31LACKINT + 2.13TRILACK + 0.37LACKDRIV + 0.97PERCATT - 1.07LACKQUAL$$

3.3 Correlation model

Correlation analysis was conducted to check the relationship between the factors extracted. Table 4 below shows the correlations between the factors.

Table 4: Correlations between factors (N = 520)

Factors		LACKINT	TRILACK	LACKDRIV	PERCATT	LACKQUAL
LACKINT	Pearson Correlation	1	.161**	.135**	.308**	.429**
	Sig. (2-tailed)		.000	.002	.000	.000
TRILACK	Pearson Correlation	.161**	1	.074	.094*	.216**
	Sig. (2-tailed)	.000		.091	.031	.000
LACKDRIV	Pearson Correlation	.135**	.074	1	.011	.225**
	Sig. (2-tailed)	.002	.091		.798	.000
PERCATT	Pearson Correlation	.308**	.094*	.011	1	.210**
	Sig. (2-tailed)	.000	.031	.798		.000
LACKQUAL	Pearson Correlation	.429**	.216**	.225**	.210**	1
	Sig. (2-tailed)	.000	.000	.000	.000	

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

*. Correlation is significant at the 0.05 level (2-tailed).

There are significant correlations between the first and all other factors, and the fifth and all other factors. There is a moderate relationship between lack of interest while studying mathematics and lack of qualified mathematics teachers. There is also a weak relationship between lack of interest while studying mathematics and the perception and attitude towards the subject terming it to be difficult (Al-Agili, Mamat, Abdullah, & Maad, 2012).

4. Conclusion and recommendations

4.1 Conclusion

Factor analysis modeling was used to describe factors affecting students' performance in mathematics for secondary school students in Tanzania. The formulated model comprises of five factors with eighteen (18) equations. These factors are, lack of interest while studying mathematics, triviality and lack of practice by students, lack of drive and enthusiasm for teachers and students, perception and attitude towards the subject terming it to be difficult and lack of qualified mathematics teachers.

The factor model explained 50.5% of the total variation of the students' mathematics performance. A correlation analysis was conducted on the five factors to check the relationship between the factors. There was a moderate relationship between lack of interest while studying mathematics and lack of qualified mathematics teachers. A multiple linear regression model was used to represent the five factors and identify the most significant factors affecting students performance in mathematics. The factor model appropriately fitted analysis of factors that affect the students' mathematics performance in Tanzania secondary schools.

4.2 Recommendations

The following recommendations are proposed to help with improving performance in mathematics for secondary school students in Tanzania. Teachers should use diverse teaching methods, including the use of teaching aids to create interest and better understanding while at the same time having fun with mathematics. Guidance and counseling need to be introduced in schools with an intention of creating positivity towards mathematics. The government and private sector should train many mathematics teachers to ease shortage of mathematics teachers nationwide. Stakeholders in the education sector should motivate teachers by rewarding them; this will motivate teachers and enhance quality education in secondary schools.

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Appendices

Table 1: A pattern matrix with component/factors before rotation (N = 520)

Variable	Component				
	1	2	3	4	5
I do not do Mathematics homework.	.812	.044	.077	.008	-.075
Mathematics lessons are boring.	.798	-.030	.033	.098	.021
I do not understand my Mathematics teacher when he/she is teaching.	.767	-.043	.084	.028	.139
I do not like Mathematics.	.724	.068	.037	.147	.023
Students do not practice to solve Mathematics questions thus they perform poorly in Mathematics.	.130	.784	-.064	-.270	-.004
The students are not serious in studying Mathematics hence they perform poorly in Mathematics.	.054	.654	-.178	-.108	.254
Students are misbehaving in Mathematics class and thus they do not understand fully the Mathematics concepts which are being taught leading to poor performance in Mathematics.	-.130	.555	-.132	.048	-.098
Poor background of students in Mathematics is the most important factor of poor performance in Mathematics.	.055	.474	.112	.173	-.038
The Mathematics language (for example, estimate, reminder) is not understood by the students, hence causes the students to perform poorly in Mathematics	.074	.453	.109	.154	.116
The language of instruction (English) is not understood by the students leading to poor understanding of Mathematics concepts and poor performance in Mathematics.	-.003	.443	.172	.165	.009
The tendency of students to escape Mathematics class (truancy) causes them to have partial knowledge, hence resulting in poor performance in Mathematics.	-.100	.359	.322	-.038	-.240
Lack of motivation to Mathematics teachers discourages teachers' commitment to work.	.098	-.078	.746	-.135	.009
Lack of motivation to students performing well in Mathematics discourages students' commitment to study Mathematics.	.048	-.012	.697	.062	-.001
The teaching method or style (the teacher is demonstrating without allowing students to participate due to a large number of students in a class).	.055	-.046	.577	-.193	.159
Lack of teaching and learning of Mathematics material at your school lead to poor performance in Mathematics.	.023	.133	.246	.165	-.039
Sometimes I do not attend Mathematics lessons.	.019	-.043	-.042	.860	.026
Mathematics is a difficult subject.	.185	-.024	-.111	.846	.078
Mathematics is a simple subject.	-.146	-.020	.143	-.763	-.043
Lack of qualified Mathematics teachers in your region to teach the subject lead to poor performance in Mathematics.	.136	.110	-.156	-.015	.736
Negative attitude towards Mathematics causes students to perform poorly in Mathematics.	.229	-.119	.043	.065	.659
Poor performance in Mathematics could be explained by poor background in elementary Mathematics.	.012	.303	.211	.087	.506
Poor parents/guardians economic status causes students to perform poorly in Mathematics.	-.220	-.034	.207	.080	.363

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 10 iterations.

Table 2:A structure matrix showing correlations between variables and component/factors after rotation (N = 520)

Variable		Component				
		1	2	3	4	5
x_1	Mathematics lessons are boring.	**.829**	.054	.062	.319	.220
x_2	I do not understand my Mathematics teacher when he/she is teaching.	**.805**	.036	.120	.260	.327
x_3	I do not do Mathematics homework.	**.803**	.118	.096	.236	.121
x_4	I do not like Mathematics.	**.776**	.155	.083	.365	.214
x_5	Students do not practice to solve Mathematics questions thus they perform poorly in Mathematics.	.112	**.738**	.038	-.107	-.006
x_6	The students are not serious in studying Mathematics hence they perform poorly in Mathematics.	.127	**.618**	-.049	.039	.240
x_7	Students are misbehaving in Mathematics class and thus they do not understand fully the Mathematics concepts which are being taught leading to poor performance in Mathematics.	-.100	**.531**	-.058	.081	-.126
x_8	Poor background of students in Mathematics is the most important factor of poor performance in Mathematics.	.133	**.524**	.197	.273	.025
x_9	The Mathematics language (for example, estimate, reminder) is not understood by the students, hence causes the students to perform poorly in Mathematics.	.181	**.505**	.211	.278	.180
a	The language of instruction (English) is not understood by the students leading to poor understanding of Mathematics concepts and poor performance in Mathematics.	.083	.497	.256	.255	.065
b	The tendency of students to escape Mathematics class (truancy) causes them to have partial knowledge, hence resulting in poor performance in Mathematics.	-.129	.390	.339	-.011	-.216
x_{10}	Lack of motivation to Mathematics teachers discourages teachers' commitment to work.	.077	.023	**.726**	-.055	.113
x_{11}	Lack of motivation to students performing well in Mathematics discourages students' commitment to study Mathematics.	.083	.111	**.701**	.134	.114
x_{12}	The teaching method or style (the teacher is demonstrating without allowing students to participate due to a large number of students in a class).	.050	.018	**.576**	-.112	.222
c	Lack of teaching and learning of Mathematics material at your school lead to poor performance in Mathematics.	.077	.201	.276	.210	.027
x_{13}	Mathematics is a difficult subject.	.432	.119	-.024	**.894**	.226
x_{14}	Sometimes I do not attend Mathematics lessons.	.258	.099	.031	**.858**	.148
x_{15}	Mathematics is a simple subject.	-.364	-.139	.063	**-.800**	-.167
x_{16}	Lack of qualified Mathematics teachers in your region to teach the subject lead to poor performance in Mathematics.	.302	.109	-.035	.134	**.745**
x_{17}	Negative attitude towards Mathematics causes students to perform poorly in Mathematics.	.388	-.069	.127	.207	**.724**
x_{18}	Poor performance in Mathematics could be explained by poor background in elementary Mathematics.	.180	.363	.336	.234	**.557**
d	Poor parents/guardians economic status causes students to perform poorly in Mathematics.	-.113	.003	.252	.084	.352

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Note: Factor loading over 0.5 appears in bold has been used in writing the factor model.