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Multiple Regression of Mathematics Achievement Based on Mathematics Anxiety, Student Attitudes and Home Educational Resources

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Abstract

Mathematics anxiety, students' attitudes, and home educational resources are among the factors that are often associated with students' achievement. There are still few studies examining the relationship of these three variables to students' achievement. Therefore, this study was conducted to examine the relationship between mathematics anxiety, students' attitudes, and home educational resources on mathematics achievement among primary students. The Modified Abbreviated Math Anxiety Scale (mAMAS) and Short Version of Attitudes toward Mathematics Inventory (Short ATMI) and home educational resources (HER) from TIMSS questionnaire were used in this study. The questionnaires were adapted using forward-back translation and two experts were invited to validate the translated questionnaires. A total of 214 year 5 students from three rural schools in Semporna Sabah became the respondents in this study. The results from the study showed the reliability of the questionnaire is acceptable. Cronbach alpha value of mAMAS is 0.882, Short ATMI (0.922) and HER (0.639). The data with no violation assumption then were analyses with multiple regression. The R^2 for mathematics anxiety, student attitudes, and home educational resources towards mathematics achievement was found to be 0.226 using ordinary least square as a parameter estimator. Mathematics anxiety, student attitudes, and home educational resources explain 22.6% of the variation in mathematics achievement. The results of the multiple regression analysis were found to be significant ($F=20.483$, $df=3$, $p<0.001$). The achievement in mathematics is only significantly explained by two of the three independent variables ($p<0.05$). More specifically, home educational resources ($\beta=0.303$) and mathematics anxiety ($\beta=-0.188$). While student attitudes variable is not significant in explaining Mathematics achievement ($p=0.054$).

Keywords: Multiple regression; mathematics achievement; mathematics anxiety; student attitudes; home educational resources

INTRODUCTION

The world has undergone rapid changes. Society and the economy have become increasingly complex. The culture and environment experienced by students today is far different compared to previous societies. The field of science, technology, engineering, and mathematics (STEM) continues to grow, demanding more high-quality, highly skilled workforce but these demands at the same time bring complex challenges.

LITERATURE REVIEW

One of the challenges that must be faced in the education system at the global level is the decline in mathematics performance for most countries in the international assessment organized by the Organization for Economic Co-operation and Development (OECD) and the International Association for the Evaluation of Educational Achievement (IEA) [1]–[3] whereas mathematics is said to be a subject that has such great influence in various fields [4], [5]. For example, mathematics is also applied in the fields of economics, politics, geography, science, and technology because mathematics focuses on the use of numbers which are an important component in every aspect of knowledge.

Through past studies, there are several constructs that have been identified that consistently influence mathematics achievement. Among those constructs are cognitive ability [6]–[8], individual personality [9]–[11], students' attitudes towards mathematics [12], [13], family background factors such as socioeconomic status, family size, parents' background [14]–[16] and other factors. [17] argues that the factors that influence academic achievement are different according to the cultural context. Therefore, the factors that have been previously studied need to be tested in other cultural contexts so that the findings from the study can be enriched and contribute to the field of education in more detail.

Malaysia is also increasingly conducting quantitative studies looking at the relationship between mathematics achievement and recommended factors. Among those studies is a study by [18] that examines the relationship between math anxiety and additional mathematics achievement. A study by [19] also focuses on the relationship between math anxiety and Additional Math achievement. [20] also studied the relationship between mathematics anxiety and mathematics achievement among first grade students. While [21] conducted a study of the relationship between motivation and mathematics achievement among secondary school students.

Most of the studies done in Malaysia focus on students in secondary schools and students in higher education. However, there is still a lack of research on the factors that affect mathematics achievement at the primary school level in Malaysia, especially in the state of Sabah. Therefore, the purpose of this study is to look at the factors that affect the mathematics achievement of students in primary schools in Semporna, Sabah.

METHODOLOGY

This study is a quantitative study in the form of a questionnaire survey to identify the relationship between math anxiety factors, student attitudes and socioeconomic status on students' mathematics achievement in primary schools.

A total of 214 students from three school in Sabah are involved in this study. The students are 11 years old and consist of various family backgrounds in accordance with the characteristics of the desired study population.

Instruments

This study tests two variables, the dependent variable, and the independent variables. The Modified Abbreviated Math Anxiety Scale (mAMAS) and Short Version of Attitudes toward Mathematics Inventory (Short ATMI) and home educational resources (HER) from TIMSS questionnaire were used in this study. The questionnaires were adapted using forward-back translation and two experts were invited to validate the translated questionnaires.

Method

Multiple regression is a method used to identify changes in two or more predictor variables that contribute to changes in the response variable [22]–[25]. In general, the formula that is often used to obtain the multiple regression equation is as follows;

$$y = b_0 + b_1 x_1 + b_2 x_2 + \cdots + b_k x_k \quad (1)$$

Where;
y is the predicted variable.
x_1, x_2 and x_k are k known variables.
b_0 is the intercept of a straight line. Intercept is the value of y when $x = 0$.
b_1, b_2, ..., and b_k is a numerical constant that must be determined from the observed data.
The criteria for a good regression line is to minimize the sum of the squared errors of the predicted value ε^2 using the following formula.

$$S_\varepsilon = \sqrt{\frac{\sum \varepsilon^2}{n-2}} \tag{2}$$

RESULT

The results from the study showed the reliability of the questionnaire is acceptable. Cronbach alpha value of mAMAS is 0.882, Short ATMI (0.922) and HER (0.639) as shown in Table 1.

Table 1 Cronbach's Alpha Values

	α	Number of Items
Home educational resources	0.639	6
Mathematics anxiety	0.882	9
Attitudes toward mathematics	0.922	19

Meeting the assumptions in multiple regression is very important to ensure that the findings are truly representative of the sample. The assumptions in multiple regression analysis are linearity, homogeneity of variance and normality which are respectively tested against the independent variable and the dependent variable (Copeland, 1997; Field, 2018; Warner, 2013). From the scatterplot matrix as shown in Figure 1, we can conclude that the data of this study met all the assumptions.

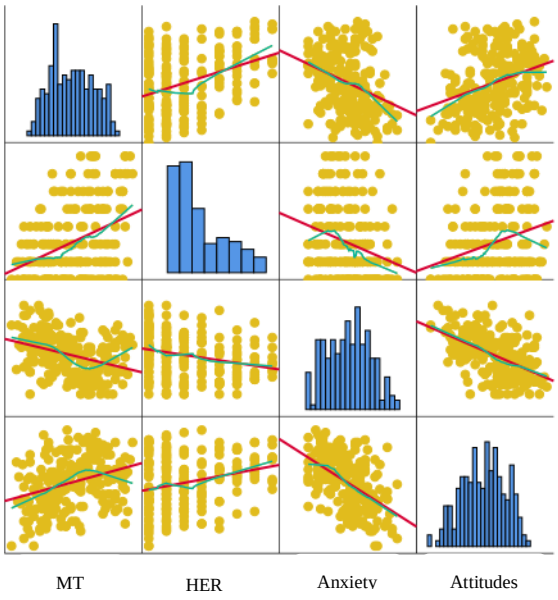

Figure 1 Scatterplot Matrix

The data with no violation assumption then were analysed with multiple regression analysis. **Table 2** below shows the predictor variables involved in this study. There are three predictor variables in this study.

Table 1 Variables and Descriptions

Variables	Descriptions
Y	Mathematics Achievement
X_1	Mathematics anxiety
X_2	Attitudes
X_3	Home Educational Resources

The statistical model for multiple regression involving three independent variables is written as follows:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon_i \quad (3)$$

Standard multiple regression analysis [26] using ordinary least-squares estimation was performed through SPSS 28.0. All independent variables are entered when the analysis is performed (enter method).

Output of the correlations test provides information on the relationship between variables, which in this study involves the relationship between mathematics anxiety, student attitudes and home educational resources toward mathematics achievement. Correlation values <0.7 between independent variables do not cause multicollinearity problems [26]. Table 3 shows that there is no multicollinearity problem between independent variables. All the independent variables are correlated to mathematics achievement (p<0.001).

Table 2 Correlations

		MT	Anxiety	Attitudes	HER
Pearson Correlation	Mathematics achievement	1.000	-0.341	0.319	0.388
	Mathematics anxiety	-0.341	1.000	-0.528	-0.259
	Attitudes	0.319	-0.528	1.000	0.263
	HER	0.388	-0.259	0.263	1.000
Sig. (1-tailed)	Mathematics achievement	.	<0.001	<0.001	<0.001
	Mathematics anxiety	0.00	.	0.00	0.000
	Attitudes	0.00	0.00	.	0.00
	HER	0.00	0.00	0.00	.

Referring to model summary table (**Table 4**), it was found that the value of R^2 is 0.226 (adjusted R square = 0.215). This means that the variables of math anxiety, student attitudes and learning resources at home explain 22.6% of the variance in mathematics achievement.

Table 3 Model Summary

Model	R	*R Square*	*Adjusted R Square*	*Std. Error of the Estimate*
1	0.476[a]	0.226	0.215	21.431

Based on the ANOVA table (**Table 5**), it was found that the results of the multiple regression analysis were significant (F=20.483, df=3, p<0.001).

Table 4 ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28222.508	3	9407.503	20.483	<0.001[b]
	Residual	96448.931	210	459.281		
	Total	124671.439	213			

Next, variables that are significant contributors to mathematics achievement are determined. The

coefficients output in multiple regression analysis using SPSS 28.0 are referred. Based on the **Table 6**, it was found that the highest beta value was 0.303. This means that home educational resources make the greatest contribution in explaining mathematics achievement when the variance of other variables is controlled. Student attitudes make the smallest contribution to explaining mathematics achievement (0.140) followed by mathematics anxiety (-0.188) when other variables are controlled. If we refer to the rule of thumb in [24], beta <0.05 considered as a small effect, beta>0.10 considered as a moderate effect and beta>0.25 considered as having a large effect. In this study, home educational resources can be concluded to have large impact on mathematics achievement. While mathematics anxiety and students' attitudes have a moderate effect on mathematics achievement.

Table 5 Coefficients

	Unstandardized Coefficients		*Standardized Coefficients*			*Collinearity Statistics*	
Model 1	B	*Std. Error*	*Beta*	*t*	*Sig.*	*Tolerance*	VIF
(Constant)	38.468	11.591		3.319	0.001		
Mathematics anxiety	-0.526	0.202	-0.188	-2.607	0.010	.706	1.417
Attitudes	0.323	0.167	0.140	1.937	0.054	.704	1.421
HER	3.565	0.749	0.303	4.758	<0.001	.911	1.098

RESULTS AND DISCUSSION

From three independent variables, only two independent variables significantly contribute to explain mathematics achievement ($p<0.05$) which are mathematics anxiety and home educational resources. While the student attitude variable is not significant in explaining mathematics achievement ($p=0.054$). The significance impact of mathematics anxiety and home educational resources were also confirmed by 95% confidence interval value excluding zero as the true value.

This finding is supported by [14] who used home learning resources to measure SSE and concluded that SSE has a positive relationship with Mathematics achievement in TIMSS assessment. However, other studies show that home educational resources have a negative relationship with Mathematics achievement [27].

Several studies proved that Chinese and Asian students show high mathematics anxiety compared to the lowest achieving countries including England in TIMSS [28]–[30]. Students in Malaysia are also reported to have high mathematics anxiety [18], [19], [31].

It can be concluded that home educational resources and mathematics anxiety are significant contributors to explain the variance of mathematics achievement. Although the correlation analysis showed there are a relationship between student attitude and mathematics achievement ($r=0.140$) but this variable did not significantly contribute to the regression model ($P>0.05$). The study of the relationship between attitudes and achievement of primary school students has shown diverse results in terms of both the level of attitudes that predict achievement and attitudes that are the strongest predictors of achievement [28]. A study by [32] was found that attitudes towards mathematics showed a stronger predictive in predicting the mathematics achievement of fourth grade students in South Korea, Turkey and the United States.

CONCLUSION

This study revealed that the mathematics achievement model was built to explain as much as 22.6% of the mathematics achievement variance. The home educational resources (HER) is the biggest contributor in explaining the variation of mathematics achievement. Mathematics anxiety is the second largest contributor in the mathematics achievement regression model followed by student attitudes. Overall, it was found that students with low mathematics anxiety tend to obtain better mathematics achievement than students with high mathematics anxiety. On the other hand, the more positive the students' attitude towards mathematics, the better their achievement in mathematics.

Therefore, efforts to reduce the mathematics anxiety and increase students' attitudes need to be intensified to ensure that the mathematics achievement of primary school students can be improved. If this continuous effort is carried out starting from primary school, it is highly likely that the problem of critical mathematics achievement can be curbed.

In conclusion, the findings from this study support the findings from other studies. For example, the strength of the influence of the home educational resources is different compared to some other studies. Findings about the strength of the contribution of student attitude and mathematics anxiety are also an additional value in this study.

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