The Effect of Mathematics Anxiety on Mathematics Self Efficacy and Perceived Mathemathics Achievement

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ABSTRACT

This study examined the relationship between mathematics anxiety, mathematics self-efficacy and perceived mathematics success among 131 freshmen Zambian engineering and natural and applied science students. A quantitative ex post facto survey design was used to achieve the research objectives. Negative but statistically significant relationships between mathematics anxiety and self-efficacy as well as perceived mathematics achievement were established. A positive empirical relationship between mathematics self-efficacy and perceived mathematics achievement was supported.

Keywords: Mathematics anxiety, Self-efficacy, Perceived achievement

INTRODUCTION

As society becomes more complex and technology dependant, mathematics is seen as an essential necessity in that almost all activities of life requires the usage of mathematics in solving life practical problems. This importance is reflected in the curriculum for university students studying engineering, natural and applied sciences. For university students, perceived mathematics accomplishment determines actual mathematics success in terms of grades, progression and eventually career success later on in life (Alves, Rodrigues, Rocha & Coutinho,2016). According to Flegg, Mallet & Lupton (2012) one factor in higher education that influences student motivation to learn mathematics is their perception about the role of mathematics in their course and in their future career. Given the importance attached to perceived mathematics achievement it is important for educational psychologist, mathematics educators and policy makers to possess an understanding on factors that influences engineering and natural sciences students in exhibiting perceived mathematics success. Research has established that there are several variables that acts as antecedents of perceived mathematics success such as Mathematics self-efficacy (Hannula, 2006; Pape & Smith, 2002; Pajares & Miller, 1994), personality traits (Clearly, Breen & O Shea, 2010), mathematics anxiety (Olango, 2016), socio-cognitive factors (Homayouni, 2011) as well as teaching methods and teachers personality (Sirmaci, 2010). For practical, theoretical as well as limiting the scope of the study to a governable and meaningful level this study will investigate two latent variables namely mathematics anxiety and mathematics self-efficacy.

Using the Eysenck and Calvo (1992) model of general anxiety effect called the processing efficiency theory the relationship between mathematics anxiety and performance can be established. It can be argued that anxiety disrupts ongoing working memory processes in that mathematics students will devote their attention to intrusive thoughts such as dislike or fear of mathematics as well as low self-confidence thereby lowering mathematics performance (Olango, 2016).

Objectives

The general objective was to examine the relationship between mathematics anxiety, mathematics self-efficacy and perceived mathematics performance. From this general research objective, more specific operational research objectives were derived for this study.

1. To evaluate the influence of mathematics anxiety on mathematics self-efficacy.
2. To evaluate the link between mathematics anxiety and perceived mathematics performance.
3. To evaluate the influence of mathematics self-efficacy on perceived mathematics performance

LITERATURE REVIEW

Conceptualising Mathematics Anxiety

Mathematics anxiety was coined by Dreger and Aiken (1957) to describe student's attitudinal difficulties with mathematics. Tobias and Weissbrod (1980) defined mathematics anxiety as the panic, helplessness, paralysis and mental disorganisational that arises among some people when they are required to solve a mathematical problem. Mathematics anxiety is related to students feeling tense or anxious when working with numbers or solving mathematical problems (Richardson & Suinn, 1972). Mathematics anxiety was conceptualised as having one general factor but also measured with items found in the other four factors namely future, grade, assignment and in class.

Conceptualising Mathematics Self-efficacy

Mathematics self-efficacy is defined as a student belief or perception in terms of his or her abilities in mathematics (Bandura, 1997). May (2009) defines it as a student confidence in completing a variety of mathematics tasks, understanding mathematics concepts to solving mathematics problems. Students with higher levels of mathematics self-efficacy tend to be more motivated to learn than their peers and are more likely to persist when presented with mathematical challenges (May 2009; Zeldin, Britner & Pajares,2008). May (2009) for example conceptualised mathematics self-efficacy as having one general factor which was interpreted as students belief regarding their abilities in mathematics in general. Mathematics self-efficacy was also measured partly in four more factors namely the future, grade, in class and assignment dimensions. The future factor is about the students' confidence in using mathematics in their future careers while the grade factor is about the students' confidence in their grades (May, 2009). The in-class factor involved students confidence about asking questions in class while the assignment factor is about students mathematics self-efficacy regarding completion of assignments in mathematics (May, 2009).

Conceptualising Perceived Mathematics Achievement

Perceived Mathematics achievement can be conceptualised as an attitude or students expectations in understanding and solving mathematics problems successfully. It's a student's hope in obtaining reasoning skills and knowledge in mathematics to help in scoring high mathematical grades Attitude towards mathematics determines achievement (Yaser,2014). This comes about because attitudes are formed by beliefs, emotional reactions and behaviours intended for attitude objects and as such determine what one

will think, feel and how to behave towards mathemathics (Yasar,2014).

Relationship between Mathematics Self-efficacy and Perceived Mathematics achievement

Belief has an influence on action, motivation and cognitive process (Bandura, Caprara, Fida, Vecchione, Delbove, Vecchio & Barbaranelli (2008). It is therefore argued that self-efficacy is linked to students' perceived achievement in mathematics. Students self-belief in their abilities will compel them to think, feel and behave positively towards mathematics hence improved performance. A study by Chen (2003), examined students belief of self-efficacy in 107 seventh grade math students and its relation to math achievement. Results showed that expectations have a powerful direct positive effect on the prediction of student performance in mathematics.

Relationship between Mathematics Anxiety and Self-Efficacy

Negative thoughts and feelings about mathematics culminates into reduced self-belief and phobia in mathematics. According to Hodges and Kim (2013) anxiety interferes with future self-esteem. Ikegulu (2003) found that students with high levels of mathematics anxiety were much less interested in mathematics related activities.

Relationship between Mathematics Anxiety and Perceived Mathematics Achievement

Mathematics anxiety results into fear of failure and avoidance of mathematics classes and subjects involving maths skills (Pizzie & Kraemer, 2017). Negative thoughts and actions eventually leads to poor performance. Cates and Rhymer (2003) examined the relationship between mathematics anxiety, fluency and the number of errors made by students in basic maths operations. Results of the study showed that the group with the highest math anxiety achieved low levels of fluency in all of the basic math operation test.

The structural model involving the three variables as argued above is depicted in figure 1 below.

Statistical Hypotheses

Hypothesis 1: The overarching research hypothesis was interpreted to indicate that the structural model depicted in Figure 1 provides a perfect explanation of the manner in which mathematics anxiety influences mathematics self-efficacy and perceived mathematics performance. The research hypothesis was translated into the following exact fit null hypothesis:

H01: RMSEA=0

Ha1: RMSEA>0

Where RMSEA is the root mean square error of approximation.

Hypothesis 2: The overarching research hypothesis for the close fit null hypothesis is:

H01: RMSEA<0.05

Ha1: RMSEA > 0.05

Where, RMSEA is the root mean square error of approximation.

In order to test the validity of the proposed relationships in the structural model, the following specific research hypotheses were tested:

Hypothesis 3: mathematics self-efficacy (β_1) is positively related to perceived mathematics performance (β_2) (H03: $\beta_{21} = 0$; Ha3: $\beta_{21} > 0$).

Hypothesis 4: mathematics anxiety (β_1) is negatively related to perceived mathematics performance (β_2) (H04: $\beta_{21} = 0$; Ha4: $\beta_{21} > 0$).

Hypothesis 5: mathematics anxiety (β_1) is negatively related to mathematics self-efficacy (β_1) (H05: $\beta_{11} = 0$; Ha5: $\beta_{11} > 0$).

RESEARCH METHODOLOGY

Research design

Research approach

A quantitative research design through structural equation modelling (SEM) was used to achieve the research objectives.

Research Method

Sample

In this study the sample (n=132) was composed of conveniently selected engineering and natural sciences university freshmen. In terms of the demographic profile 51.5% of the participants were males while 48.5% of these were females. 75.8% of the respondents were aged between 18-20, 14.8% between 15-17,8.6% between 21-23 while 0.8% between 24-26.

Measuring Instruments

Mathematics anxiety and mathematics self efficacy were measured using the mathematics self efficacy and anxiety scale developed by May (2009). The two sub scales have a combined cronbach alpha coefficient of .96. Perceived mathematics achievement was measured using four items from the perceived mathematics achievement subscale of the short form mathematics attitude scale developed by Yasar (2014). The subscale has a coefficient alpha of .82.

Ethical consideration/procedure

Researchers obtained permission to conduct the study from the ethical clearance committee of Mulungush University. The objectives of the study were explained to the participants. They were also informed that their participation was voluntary and that they were free to withdraw at any time. Anonymity and confidentiality was emphasized. The research participants were then asked to fill in three sections of the questionnaire on a five likert scale once consent was obtained.

RESULTS AND ANALYSIS

Missing Values

Multiple imputation was used as the method of addressing the problem of missing values. According to Dutoit and Dutoit (2001) multiple imputation performs several imputations for each missing value. After treating for missing values a sample size of 131 was retained.

Reliability Analysis

The three measuring instruments for this study informed the researchers of the respondents standing on the three latent variables. The items in each scale functioned as stimuli for eliciting the respondent behaviour (Kriek, 2019). Based on this assumption, it is important to evaluate the psychometric integrity of the three scales so as to determine whether the items accurately represent the constitutive definition of the latent variables (Kriek, 2019; Murphy & Davidshofer, 2014).

Reliability Coefficient analysis for the three scales was performed. Poor items were deleted. An integration of statistical evidence was used as rule for determining whether an item ought to be deleted. Poor items are items that fail to reflect the focal underlying common latent variable or that fail to discriminate between relatively small differences in the level of the focal latent variable (Kriek, 2019).

Five items in the mathematics anxiety scale were deleted, six in the mathematics self, self-efficacy scale and one in the perceived mathematics achievement scale. All the three scales had cronbach alpha coefficients exceeding a critical value of .70 (Nunnally & Berstein,1994). The mathematics anxiety scale obtained a cronbach alpha of .92, while the mathematics self-efficacy and the perceived mathematics achievement sub scale of the mathematics attitude scale obtained .85 and .74

Exploratory Factor Analysis

Unidimensionality for all the three scales was achieved through exploratory factor analysis (EFA). Factor loadings in all the scales were acceptable (> 0.50) with satisfactory explained variance for each factor (> 40%). Adequate Kaiser– Meyer–Olkin (KMO) scores (0.68–0.92) were achieved (>0.60) (Pallant, 2013). loadings were acceptable (> 0.50) and variance explained in each factor was satisfactory (> 40%).

Multivariate Normality

Robust maximum likelihood (RML) estimation method was performed to normalise the data.

Goodness-of-fit: the Measurement Model

The fit Indices indicate that the measurement model attained reasonable fit with the data. The 90 percent confidence interval for RMSEA (0.0428 – 0.0739) also indicate reasonable fit. A positive picture is further expressed by incremental statistics indices all exceeding the critical value of 0.9.

Goodness-of-fit indices for the Structural Model

The RMSEA value of this model 0.0590 presents reasonable fit.. The incremental fit indices, namely the NFI 0.948, CFI; 0.983, IFI; 0.983 and RFI; 0.941 are above 0.90, which indicate good comparative fit.

Other key findings

Relationship between Mathematics Self-Efficacy and Perceived Mathematics Achievement

The SEM path between mathematics self-efficacy and perceived mathematics achievement was statistically significant ($t = 1.970$; $p < 0.05$) as shown in table 1 thus hypothesis 3 was confirmed.

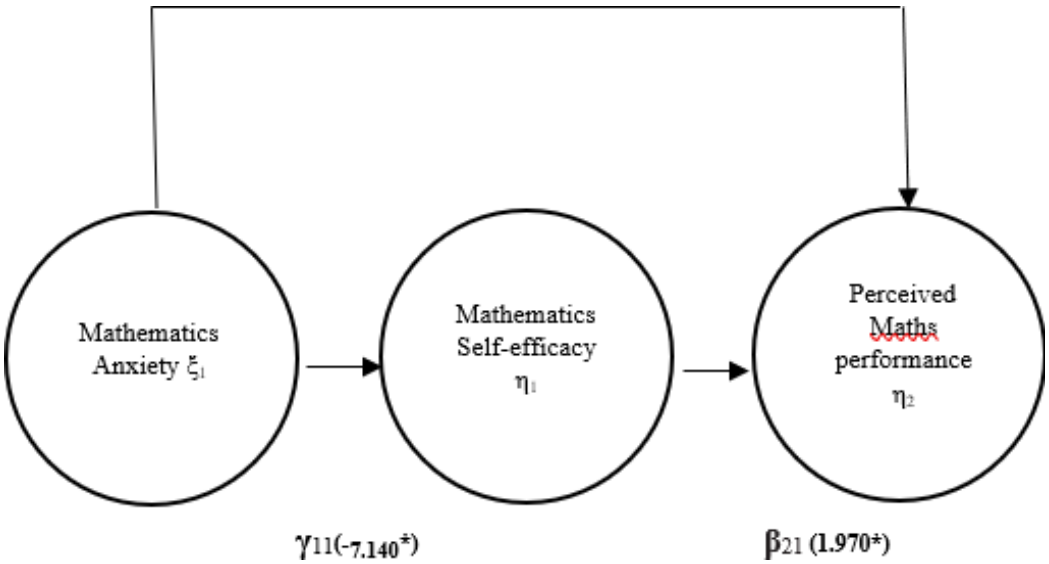
Relationship between Mathematics Anxiety and Perceived Mathematics Achievement

A negative but statistically significant relationship between mathematics anxiety and perceived mathematics achievement was found ($t = -2.625$; $p < 0.05$) hence hypothesis 4 was supported.

Relationship between Mathematics Anxiety and Mathematics Self-Efficacy

The hypothesized relationship between mathematics anxiety and mathematics self-efficacy was confirmed in this study ($t = -7.140$; $p < 0.05$) resulting in the rejection of the null hypothesis (H05: $\gamma 11 = 0$).

Figure 1: Structural model representing the relationship between Math anxiety, self-efficacy and perceived math achievement



*, *t*-values ≥ |1.96| indicate significant path coefficients ($p < 0.05$

Table 1: The gamma and beta matrix of path coefficients for the structural model

Latent variable	Math Anxiety	Math Self-efficacy
Maths self-efficacy	–**0.791**	
	(0.111)	
	– 7.140 *	
Perceived Math Ach	– **0.483**	**0.394**
	(0.184)	(0.200)
	– 2.625*	1.970

Completely standardised path coefficients in bold. Standard error estimates in brackets *t*-values ≥ | 1.96| indicate significant parameter estimates. *, $p < 0.05$

DISCUSSION

The study aimed at investigating the empirical relationship between mathematics anxiety, mathematics self-efficacy and perceived mathematics achievement as well as validate the proposed theoretical model. It was therefore hypothesized that mathematics self-efficacy is positively related to perceived mathematics performance, mathematics anxiety is negatively related to perceived mathematics performance and that mathematics anxiety is negatively related to mathematics self-efficacy. Reliability coefficients for all the three scales were above the .70 threshold. Factor loadings under exploratory factor analysis were adequate

with acceptable variance. Goodness fit indices for the measurement and structural model indicate reasonable fit. A statistically significant positive path coefficient between mathematics self-efficacy and perceived mathematics achievement was obtained. These results are in line with those of Chen (2003). Just like Ikegulu (2003) as well as Cates and Ryhmer (2003) statistically significant but negative path coefficients between mathematics anxiety and self-efficacy as well as perceived mathematics achievement was found.

The obtained result in this study indicates that the proposed theoretical model underlying the relationships between the three variables is supported and that the indicator variables measured the dimensions as proposed. Theoretically the study makes a significant contribution to mathematics education literature by providing empirical evidence to the proposition that anxiety has an influence on mathematics self-efficacy and perceived performance.

CONCLUSION

Results for this study have confirmed that one's self efficacy in mathematics positively influences perceived mathematics achievement, while anxiety negatively affects students self- efficacy towards mathematics and perceived mathematics achievement which eventually affects one's success in mathematics. It is recommended that mathematics instructors should find ways of minimizing mathematics test anxiety when administering tests and when teaching. When mathematics self-efficacy is enhanced, students' motivation to learn and confidence will lead to success in mathematics.

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