Investigating the Psychometric Properties of the Mathematics Self-Efficacy and Anxiety Questionnaire on a Zambian Sample

Victor Chikampa [1*], Alick Rabson Gumbo[2], Raymond Sooli Kawina[2], Cifwala Clement Hikacila[2], Audrey Muyuni[3], Jacqualine Siwale[2] Ireen Moonga[4]
[1]Faculty of Social Sciences– Department of Social development studies-Mulungushi University
[2]Department ofBusiness and Management Studies-Texila American
[3]Faculty of Education- Department of Religious Studies- Mulungushi University
[4]Faculty of Education- Department of English and Literature- Mulungushi University
***Corresponding Author**

DOI: https://dx.doi.org/10.47772/IJRISS.2023.7702

Received: 20 May 2023; Accepted: 16 June 2023; Published: 14 July 2023

ABSTRACT

Mathematics is an important element for national development in that people in society use it for solving life practical problems. The Zambia government has relentless promoted the importance of mathematics and science in schools through certain education programmes such as JETS. However the performance of pupils as well as students in mathematics has not been encouraging. Mathematics achievement to a certain extent is determined by ones self-efficacy and anxiety (May, 2009). Mathematics instructors in Zambian schools lack the instruments as well as the competencies to reliably and validly measure the two concepts. One instrument that can be used to assess mathematics self-efficacy and anxiety is the mathematics self-efficacy and anxiety questionnaire (MSEAQ) developed by May (2009). However the psychometric properties of this instrument has not been established on the Zambian sample. This study aimed at investigating the reliability and construct validity of the mathematics self-efficacy and anxiety questionnaire (MSEAQ) on a Zambian sample. A quantitative research design through structural equation modelling (SEM) was used to achieve the research objectives. The 29 item MSEAQ with two sub scales was administered to a non-probability sample of 132 mathematics, engineering, natural and applied sciences university freshmen from Mulungushi University. The factorial structure models underlying the MSEAQ was investigated using item analysis, exploratory factor analysis (EFA) as well as the confirmatory factor analysis (CFA). Statistical analyses provided acceptable fit of the MSEAQ measurement model with the empirical data. The study has demonstrated evidence of reliability and construct validity for the usage of the MSEAQ in the Zambian context.

Keywords: Mathematics Self-efficacy, Mathematics Anxiety, Structural Equation Modelling,

INTRODUCTION

In our modern day society mathematics is increasingly becoming an essential necessity in that almost all activities of life requires the usage of mathematics in solving life practical problems. For students or pupils success in mathematics determines future career success. To a certain extent success in mathematics is influenced by ones perceived abilities (self-efficacy) and levels of mathematics anxiety. Bandura (1997) defined mathematics self-efficacy as a student belief or perception in terms of his or her abilities in mathematics. May (2009) on the other hand defines mathematics self-efficacy 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,

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue VI June 2023

Britner & Pajares,2008). Mathematics anxiety was coined by Dreger and Aiken (1957) to describe students attitudinal difficulties with mathematics. Tobias and Weissbrod (1980) defined mathematics anxiety as the panic, helplessness, paralysis and mental disorganisation that arises among some people when they are required to solve a mathematical problem.

One instrument that can be used to alleviate Zambian students in mathematics anxiety as well as strengthen their self-efficacy in mathematics is the mathematics self-efficacy and anxiety questionnaire (MSEAQ). To justify the use of the MSEAQ in Zambia, however requires that predictive validity of the criterion-referenced inferences be empirically demonstrated. This requires more than merely demonstrating a correlation relationship between the MSEAQ, self-efficacy and anxiety. To convincingly demonstrate that the derivations of inferences on a specific criterion construct are justifiable the construct validity and the predictor measures as well as the construct validity of the criterion measures have to be demonstrated (Binning & Barrett, 1989). To the researcher's knowledge, there's been no study done to validate the construct referenced inferences derived from the dimension scores obtained on the MSEAQ on a Zambian sample. It was considered important that the validation of the construct referenced inferences derived from the dimension scores obtained on the MSEAQ precedes its use in applied and research settings and precedes the validation of the criterion-referenced inferences derived from the dimension scores obtained on the MSEAQ. The main research question of the study was thus, is the mathematics self-efficacy and anxiety questionnaire (MSEAQ) a reliable and constructs valid measure of the perceived self-efficay/anxiety construct as constitutively defined in Zambia.

Objectives

The main objective of the study was to ascertain the reliability and construct validity of the mathematics self-efficacy and anxiety scale (MSEAQ) on the Zambian Sample. The specific objectives for this were to confirm the:

1. reliability of the MSEAQ by computing the Cronbach's alpha reliability coefficient;
2. construct validity of the MSEAQ by testing the measurement model goodness of fit using the confirmatory factor analyses;
3. To confirm discriminant validity of the MSEAQ.

The overarching substantive research hypothesis is that the mathematics self-efficacy questionnaire provides a construct valid and reliable measure of mathematics self-efficacy and anxiety as defined by the instrument among Zambian employees. The overarching substantive research hypothesis can be divided into the following specific operational hypotheses:

- The construct referenced inferences derived from the MSEAQ could be considered valid (i.e. permissible) if: The measurement model implied by the scoring key and the design intention on the manner in which the MSEAQ items should reflect the latent dimensions of the self-efficacyand anxiety constructs shows close (or at least reasonable) fit;
- The unstandardized factor loadings λij are statistically significant ($p < .05$);
- The completely standardised factor loadings are large ($\lambda ij \geq .50$);
- The unstandardized measurement error variances $\theta_{\delta} ii$ are statistically significant ($p < .05$);
- The completely standardized measurement error variances are small ($\theta \delta ii \leq .75$);
- The inter- latent measurement dimensions correlate Φkj statistically significantly ($p < .05$) but low with each other.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS |Volume VII Issue VI June 2023

RESEARCH METHODOLOGY

Research Design

A quantitative ex post facto research design through structural equation modelling (SEM) was used to test the substantive research hypotheses.

Research Method

Sample

A sample of conveniently 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-selected 132 engineering and natural sciences Mulungushi university freshmen participated in this study. Of the respondents 51.5% were males while 48.5 % were females.
26. Convenient non-probability sampling method was used due to large numbers of sample sizes required by SEM.

Measuring Instruments

Data was collected using the mathematics self-efficacy and anxiety questionnaire. The MSEAQ has 29 items with five factors. The general mathematics self –efficacy dimension relates to the self-efficay of students with respect to general mathematics abilities (May, 2009). The grade anxiety factor has items from the two main dimensions and relates to self-efficacy and anxiety of grades in the mathematics class (May, 2009). The Future factor is related to self-efficacy and anxiety regarding future courses and careers (May, 2009). According to May (2009) the in class factor items covers students self-efficacy and anxiety related to asking questions in class. The assignment factor has items involving students self-efficacy and anxiety related to completing assignments. In May (2009), the combined two sub scales of anxiety and self-efficacy have a combined cronbach alpha coefficient of .96.

RESULTS AND ANALYSIS

Missing Values

According to Chikampa,Chilala and Moonga (2021) treating missing values is the process of dealing with data sets with incomplete responses. According to Burger (2012) missing values can potentially present a problem that will have to be solved before the data is analyzed. In this study multiple imputation was used as the method to solve the problem of missing values.

Reliability analysis

The mathematics self-efficacy subscale comprised of 14 items while the mathematics anxiety subscale comprised of 15 items. Results obtained for the item analysis that was performed on the two subscales are depicted in Table 1. High internal consistency for the two subscales namely mathematics self-efficacy .875 and mathematics anxiety .919 were obtained. The two subscales meet the benchmark reliability standard of greater than 0.70 (Pallant, 2010).

Exploratory factor analysis

Exploratory factor analysis (EFA) was used to investigate the unidimensionality assumption with regards to each of the two subscales.

All the subscales were found to be uni-dimensional. The items comprising the two sub scales all reflect a

single underlying factor. All factor loadings except one were acceptable (> 0.50) and variance explained in each factor was satisfactory (> 40%) except for the future and in class/assignment sub scale under self-efficacy as well as the in class/assignment anxiety.

Multivariate normality

The default method used to estimate model parameters when fitting a measurement model to continous data is maximum likelihood estimation (Moyo, 2009). This method assumes that the data follows a multivariate normal distribution (Chikampa, 2013). In this study Robust maximum likelihood (RML) estimation method was utilised to normalise the data (Mels, 2003).

Confirmatory factor analysis (CFA) results

Goodness-of-fit: The measurement model

The goodness of fit statistics for the measurement model are presented in Table 3 while a visual representation of the fitted measurement model is provided in Figure 1 below. The RMSEA value of 0.0725 reflect reasonable fit. The CFI (0.961),NFI (0.903), NNFI (0.957),IFI(0.961), exceed .90 which represent good fit(Diamantopoulos & Siguaw, 2000; Kelloway, 1998) while the values for RFI (0.895) and the GFI (0.705) values missed the 0.90 cut off. In considering the whole array of goodness of fit indices it can generally be said that the MSEAQ measurement model has achieved acceptable fit.

Table 1:Reliability of the measurement scales

Scale	No. items	α
Math Anxiety	15	0.919
Math self-efficacy	14	0.875

Table 2: Exploratory factor analysis output

Dimension	No. items	Factor loadings	% variance
Grade Anxiety	6	0.557-0.800	53.089
Future Anxiety	5	0.471-0.793	43.843
Class/Assign anxiety	3	0.508-0.740	36.825
General self-efficacy	7	0.571-0.689	40.961
Self-efficacy(Grade)	2	0.701-0.701	49.106
Self-efficacy(Future)	2	0.462-0.462	21.373
Self-efficacy (Class/Asg)	2	0.566-0.566	31.991

Table 3: Goodness-of-fit indices for the measurement model

Model	RMSEA	P/Fit	SRMR	GFI	NFI	NNFI	CFI	IFI	RFI
Meas	0.0725	0.000519	0.0796	0.903	0	.957	0.961	0.961	0.985

Measurement model factor loadings

The completely standardised factor loading for the MSEAQ items in the overall measurement model as

shown in table 4 are generally satisfactorily large >.50 (Hair, Black, Babin, & Anderson, 2010) except for three items namely MAT2(0.498), MAT15 (0.428), MSE8(0.477) AND MSE11 (0.214).

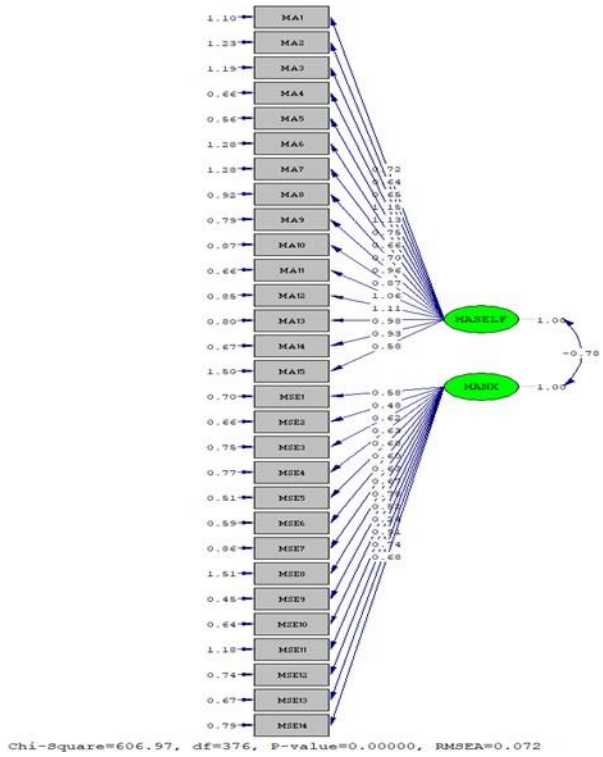

Figure 1. Path diagram of the fitted bifactor DBQ measurement model (completely standardised solution)

Table 4:Completely standardised lambda-X factor loading matrix of the MSEAQ measurement model.

MSEAQ	
MAT 1	0.566
MAT 2	0.498
MAT 3	0.514
MAT4	0.817
MAT 5	0.834
MAT 6	0.553
MAT7	0.506
MAT 8	0.589
MAT 9	0.735
MAT10	0.681
MAT11	0.796
MAT12	0.77
MAT13	0.737
MAT14	0.749
MAT15	0.428
MSE1	0.571
MSE2	0.508
MSE3	0.581

MSE4	0.584
MSE5	0.692
MSE6	0.616
MSE7	0.565
MSE8	0.477
MSE9	0.758
MSE10	0.543
MSE11	0.214
MSE12	0.725
MSE13	0.669
MSE14	0.606

Note: MAT refers to mathematics anxiety, MSE refers to mathematics self-efficacy

The completely standardised measurement error variances are shown in table 5. All the measurement error variances are satisfactorily small (??ii? .75) except for item MA15 (0.817), MSE8 and MSE11(0.954).

The squared multiple correlations (R2) of the indicators depict the extent to which the measurement model is adequately represented by the observed variables (Byrne, 1998). According to Diamantopoulos and Siguaw (2000) a high R2 value would indicate that variance in the indicator under discussion reflects variance in the latent variable to which it has been linked to a large degree. An examination of the R2 values shown in table 6 reveals below average correlations except for variables MA9, MA11, MA12, MA13, MA14, MSE9 AND MSE12 which were falling slightly above (> .50).

Table 5: Completely standardized measurement error variances

MA1	MA2	MA3	MA4	MA5	MA6	MA7	MA8	MA9
0.68	0.752	0.736	0.333	0.305	0.694	0.744	0.653	0.46
MA10	MA11	MA12	MA13	MA14	MA15	MSE1	MSE2	
0,536	0.367	0.407	0.457	0.438	0.817	0.674	0.742	
MSE3	MSE4	MSE5	MSE6	MSE7	MSE8	MSE9	MSE10	
0.662	0.659	0.521	0.621	0.681	0.773	0.426	0.705	
MSE11	MSE12	MSE13	MSE14					
0.954	0.475	0.553	0.633					

Table 6 –Squared multiple correlations for the items of the MSEAQ

MA1	MA2	MA3	MA4	MA5	MA6	MA7	MA8	MA9
0.32	0.248	0.264	0.66	0.695	0.306	0.256	0.347	0.54
MA10	MA11	MA12	MA13	MA14	MA15	MSE1	MSE2	
0.464	0.633	0.593	0.543	0.562	0.183	0.326	0.258	
MSE3	MSE4	MSE5	MSE6	MSE7	MSE8	MSE9	MSE10	
0.338	0.341	0.479	0.379	0.319	0.227	0.574	0.295	
MSE11	MSE12	MSE13	MSE14					
0.046	0.525	0.447	0.367					

In terms of the dissected overarching substantive research hypothesis, the MSEAQ did in a limited way met

this evidentiary burden. No measurement error variances θδii were statistically significant ($p < .05$) while the unstandardized factor loadings were all in siginificant ($p > .05$)

Discriminant Validity

The Phi matrix of the MSEAQ model as seen in table 7 revealed a moderate correlations between the two dimensions of the MSEAQ. Discriminant validity therefore did not present a problem. Evidence for lack of discriminant validity occurs when there are excessive high correlations between the latent variables in the phi matrix (Chikampa, 2013). More sophisticated analyses of the discriminant validity with which the MSEAQ measures the two latent dimensions of the mathematics self-efficacy and mathematics anxiety (MSEAQ) construct (i.e., calculating the 95% confidence intervals for Φkj and calculating the average variance extracted (AVE) for each latent dimension of the MSEAQ construct and comparing AVEk and AVEj with Φ^2kj) was not considered necessary.

Table 7: Inter latent mathematics self-efficacy and anxiety dimension correlations

MASELF	MANX	
MASELF	1.000	
MANX	-0.777	1.000
	(0.039)	
	-19.812	

DISCUSSION

This study aimed at assessing the psychometric properties of the MSEAQ on the Zambian Sample. Internal consistency was established for the two subscales. Results under exploratory factor analysis were generally satisfactory except for three low factor loading and low variance under two dimensions sub scale (anxiety-future and anxiety-in class and assignment). Acceptable fit with the data was attained for the measurement model. These results are in line with those of May (2009). Theoretically the study makes a significant contribution to education psychology by providing empirical support for the usage of the instrument in Zambia. Practically educational practitioners can therefore make use of the MSEAQ for assessing ones anxiety in mathematics and enhancing mathematics self-efficacy.

CONCLUSION

Results of the MSEAQ on the Zambian sample have provided limited empirical evidence of good psychometric properties. Educational practitioners should use this measure with caution due to some limitations noted above which could have been perpetuated by the small sample size. Structural Equation Modelling (SEM) requires huge sample sizes if good results are to be obtained. Future studies should replicate the study using bigger and culturally diverse samples. Since validation studies are important in the area of education assessment, future studies should validate measuring tools for other perceived difficulty subjects like sciences

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