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A Confirmatory Factor Analysis of Pseudo-Dyscalculia Scale among Undergraduates in Ibadan, Nigeria

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Abstract. This study was designed to examine confirmatory factor analysis of pseudo-dyscalculia among undergraduates in Ibadan, Nigeria using a survey design of correlational type. While 150 participants were randomly selected for the trial testing and exploratory factor analysis, a total of 800 consenting participants were randomly selected for confirmatory factor analysis. The result of the findings was analyzed using SPSS 25 and AMOS 18. The exploratory factor analysis on the scale yielded strong construct validity with a fair eight-factor structure. The results from the confirmatory factor analysis indicated a good fit for the bi-dimensional model (of Positive and Negative Affect Reactions) (X^2 = 1560.009, df = 188, NFI =.910, CFI = .923, RMSEA =.059), while it indicated an excellent model-fit for the 3 model factor-structure of mathematics evaluation anxiety, learning mathematics anxiety and numerical anxiety (X^2 = 4604.932, df = 699, NFI =.932, CFI = .920, RMSEA =.052). Also, observed in the result is a high rate of internal consistency among the dimensions of the scale and this ranges from 0.75 for worry to 0.97 for learning mathematics anxiety; while the entire scale garnered an overall reliability value of 0.97. Education stakeholders should take cognizance of these identified indices in order to alleviate the fear of mathematics related courses in students.

Keywords: Math Anxiety, Structural Equation Modelling, Factor Analysis

Background

It is no news that "mathematics", like no other, is a major contributor to the transformations we have witnessed from the 20th century through the 21st century and apparently, will remain a strong force to reckon with when it comes to efficiency and effectiveness of human dealings in the years to come. Hence, there is no gainsaying that for a nation to attain that milestone wherein her people perform optimally and cope with the technologically inclined 21st century, there must be an unflinching likeliness for and engagement in mathematics and its related fields of study. Its robust, dynamic, and ubiquitous nature has directly and indirectly, shaped the world we live in. Thus, its relevance to all facets of human endeavors cannot be exhausted nor overemphasized. The relevance of mathematics is evident in our mundane life through menial activities such as attaching figure to a phenomenon, calculating change in the market, counting dose of drugs as well as the provision of logical explanations to phenomenal encountered by the human race.

Despite the significance of mathematics as a subject and in our daily lives, it is pertinent to note that a lot freshmen in Humanities in our various universities in Nigeria have fear for the subject and all its related courses. This point of note is really peculiar to a very large number of students in the selected faculties (Education, Arts and Social Sciences) in the University of Ibadan. Students experiencing Mathematics anxiety often feel they are not capable of engaging in activities and participating effectively in classes that related to Mathematics such as, statistics, which is essential in behavioral sciences. It is a fact to state that some of these students experience emotional blockings, a situation that gives rise to the term "*pseudo-dyscalculia"* (unrealistic fear of figure, Taiwo, 2014; Aremu & Taiwo, 2014; Taiwo & Rasaq,

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2018). It is so perturbing and mind-boggling that unfortunately, a large chunk of students have *pseudo-dyscalculia* for mathematics, and therefore, cannot even withstand hearing about it, not to talk of actually engaging in it. Pseudo-dyscalculia can be termed as a false belief in Mathematics disability that emanates from the absence of, inconsistent, poor, or inappropriate systematic Mathematics instruction; inattention, apprehension, anxiety, or emotional blocking (Taiwo, 2014; Aremu & Taiwo, 2014).

This unrealistic fear in mathematics has been regarded as “Mathematics Anxiety” in the United Kingdom (UK) and “Math Phobia” in the United States of America (USA) (Murray, 2019), and Pseudo-dyscalculia in Nigeria (Taiwo, 2014; Aremu & Taiwo, 2014). Anxiety implies the normal feelings people experience when confronted with stressful or strenuous life circumstances. Mathematics phobia is seen as the feelings of tension that affects number manipulation and solving of mathematical related problems in mundane life and academic situations (Skagerlund et al., 2019). This fear of mathematics is said to affect a lot of people at various levels of education and different facets of life. It confronts both students and teachers (Smith, 2004), without failing to manifest itself on others outside the walls of the classroom.

From global perspectives, Statistical reports on *pseudo-dyscalculia* show that around 20% of the population suffers from a varying level of psychological symptoms that relates to a feeling of anxiety when poised with situations or tasks that demand the manipulation of numerical information (Eden, Heine, & Jacobs, 2013; Aremu & Taiwo, 2014). Also, reports from the University of Cambridge (2019) stated that the United Kingdom (UK) is being confronted with a mathematics crisis which was made evident from the report of National Numeracy that said four out of every five adults demonstrated low functional mathematics skills. Thus, Eden et.al (2013) concluded that one out of five individuals belongs to the group of high-math anxious individuals. Jones 2001 (cited in Marshall, Mann & Wilson, 2016) opined that 26% out of the 9000 American students engaged in their study had a moderate to high levels of mathematics anxiety. Additionally, Perry 2004 (cited in Marshall et. al. 2016) found that 85% of students in introductory mathematics classes said they experience at least mild mathematics anxiety. Luttenberger, Wimmer, and Paechter, (2018) said about 93% of Adults in USA agreed they experience some level of mathematics anxiety. It was reported that about 17% of the American population has high levels of math anxiety, while a sample, comprising adolescent apprentices in United Kingdom also had 30% of the participants reporting high level of math anxiety, with 18% of the participants being at least somewhat affected by it.

In Africa, Edzai (2015) submitted that over 60% of the global population experiences mathematics anxiety. Additionally, in Nigeria, a study carried out by Mutiu et al. (2018) on students of the Moshood Abiola Polytechnic, revealed that the mathematics anxiety factors (Physical and Emotional factor, Assessment factor, and social factor) all have joint significant influence on student academic performance. Also, a study carried out by Bamidele (2005) (cited in Aremu & Taiwo, 2014) revealed that in most Nigerian school, students perceived mathematics a horrible subject.

Pseudo-dyscalculia has been attributed to failure in mathematics, negative attitude of the teachers or due to cognitive factors that hamper resources needed to pay attention and working memory (WM) which in turn affects mathematical operations (Smith, 2004).While Ashcraft and Kirk (2001) also pointed out that those with high mathematics anxiety shows smaller/lesser working memory spans compared to those with less mathematics anxiety. Unrealistic fear for Mathematics can make students doubt their competence in solving a mathematical problem prior to tryout or perhaps before the teacher even explains the problem.

Mathematics anxiety begets other forms of anxiety; like test and social anxiety (Shishigu, 2018; Taiwo, 2016; Taiwo, 2018) and it has led to depletion in functional numeracy skills in the people (Skagerlund et al., 2019), which consequently had prompted people to make ill-informed decisions since numeracy according to Skagerlund et al (2019) is linked to ability to assess risk in medical terrain, capacity to more normative decision- making and reduction in cognitive biases such as framing effect.

However, a lot about its measures remain elusive, due to differences in definition and opinions on the nature of mathematics anxiety and its constituent parts (Kazelskis, 1998). Numerous scales that measures mathematics anxiety have been developed among which are Number Anxiety Scale (NAS) (Dreger & Aiken, 1957), Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972), Revised Mathematics Anxiety Rating Scale (R-MARS) (Plake & Parker, 1982), Abbreviated Mathematics Anxiety Rating Scale by Hopko (2003), 4-factor mathematic anxiety scale (Taiwo & Razak, 2018) and a host of others. A lot of factors have been identified through factor analysis and it is blatant to all that the indices of *pseudo-dyscalculia* have not been satisfactorily delineated by one specific tool. However, the fact that there is no single instrument that integrates all identified measures of mathematics anxiety together, such as pseudo-dyscalculia scale has received little attention from previous researches, indicates paucity in literature. Hence, there arises the need for a study on the indices or combination of indices that best address the menace "*pseudo-dyscalculia*" as a measure of mathematics anxiety. It is on this note that the researchers deem it fit to conduct a factor analyses of *pseudo-dyscalculia* indices.

Method

Design

The study made use of survey research design of correlational type. This type of design was used because the phenomenon under study is presumed to have been in existence and there is no need for any manipulation and also, it afforded the researcher an opportunity to elicit information from a large sample.

Population

The study's population is made up of freshmen in the faculties of education and arts, University of Ibadan, Ibadan, Nigeria. The faculty of education has 12 department while the Faculty of arts has 14 department. The choice of population was chosen because students in education and arts have been said to have higher likelihood of mathematic avoidance.

Sample and Sampling Technique

To ensure originality in facts and figures to be obtained, the study made use of two-stage sampling technique. At the initial stage, 5 departments each were randomly selected from the two faculties. These departments were selected because their students have little or no exposure to math related courses. Of the ten selected department, 80 students each were randomly selected to serve as respondents. In the whole, 200 respondents were selected per faculty thus there was a total of 800 respondents to represent the entire population.

Research Instrument

For data collection, a structured self-administered questionnaire was used. The questionnaire has a demographic section accompanied by the following:

The Mathematics Anxiety Rating Scale (MARS-30-Brief)

The MARS-30-Brief, developed by Suinn and Winston (2003) is a 30 items instrument used in measuring math anxiety. The scale requires respondents to complete the items by rating how much anxious they are in a variety of math activities related scenarios. The scale ranges from 1- Not at all to 5- Very Much. The psychometric property of the scale was established on 150 respondents and a Cronbach's alpha value of .962 was observed.

The Mathematics Self-Efficacy Scale (MSES)

This scale was developed by Diana K. May (2009). It is made up of thirteen (13) items on math self-efficacy and it is part of a larger scale named mathematics self-efficacy and anxiety questionnaire. It is a self-rating questionnaire that requires respondents to rate how frequent they think of themselves in accordance to the stated items. The response format employed is: Never – 1, Seldom – 2, Sometimes – 3, Often – 4, Usually – 5. A pilot study of the scale yielded a Cronbach's alpha of .976.

Multidimensional Pseudo-Dyscalculia Scale (MPS)

Multidimensional Pseudo-Dyscalculia Scale initially consists of 93 items that measure how anxious or how an individual reacts in various mathematics-related situations in relation to the identified dimensions. The scale adopted a 5-point Likert response format, ranging from SA – Strongly Agree to SD – Strongly Disagree and items were worded in ways that aid clarity so that no item has two or more meanings across respondents.

Results

Research Question 1: What are the factors indicative of the Multidimensional Pseudo-Dyscalculia Scale?

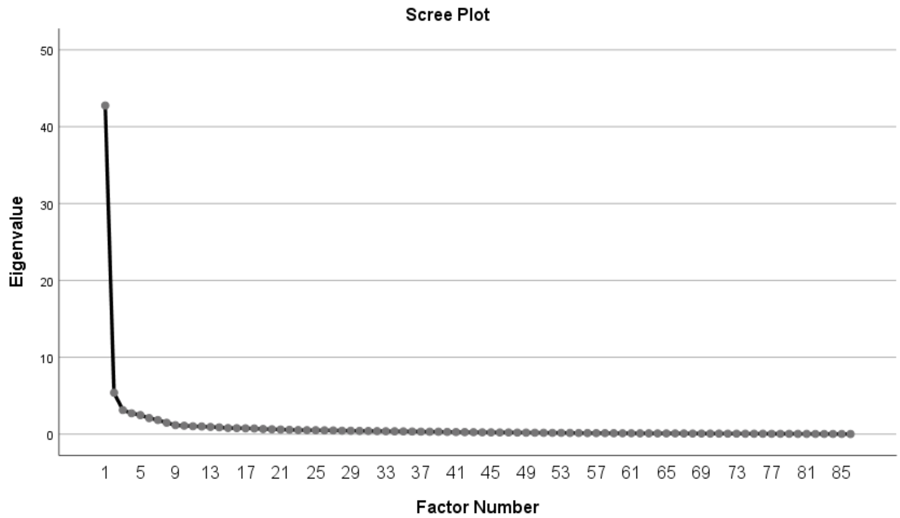

Figure 1. Scree Plot showing the factor extraction

Presented in Figure 1 is a scree plot showing the number of factors retained in the scale; Results of which in addition to that of Table 1 suggested that 8-factor models were the most appropriate fit.

Table 1. Showing the total variance explained by the factors extracted

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	42.749	49.708	49.708	42.388	49.289	49.289
2	5.387	6.264	55.971	5.062	5.886	55.175
3	3.134	3.644	59.616	2.806	3.262	58.437
4	2.712	3.154	62.769	2.406	2.797	61.234
5	2.476	2.879	65.649	1.861	2.164	63.398
6	2.085	2.425	68.073	1.696	1.972	65.370
7	1.835	2.134	70.207	1.579	1.836	67.207
8	1.485	1.726	71.934	1.340	1.558	68.765

Extraction Method: Maximum Likelihood

The table above shows the factor indicative of the MPS. Wherein a factor analysis of the scale produced an eight factors structure for the 79- item scale; the eight factors accounted for some reasonable percentage of variance, with the first factor having loaded more and a close variations observed among the other seven. However, a factor analysis of the eight-factor has a clean factor structure of the 79-item scale; the eight factors all together accounted for 68.765 percent of the variance.

Research Question 2: What is the relationship among all the dimensions of the Multidimensional Pseudo-Dyscalculia Scale (MPS)?

Table 2. Correlation Matrix showing the relationship among the factors of Multidimensional Pseudo-Dyscalculia Scale (MPS)

Factors	Mean	Std.Dev	1	2	3	4	5	6	7	8
Mathematics Evaluation Anxiety	49.25	15.02	1							
Learning Mathematics Anxiety	44.34	16.93	.799**	1						
Positive Affect Reaction	30.44	10.41	-.683**	-.639**	1					
Worry	10.82	3.05	.573**	.533**	-.413**	1				
Negative Affect Reactions	33.33	13.20	.814**	.905**	-.681**	.552**	1			
Abstraction Anxiety	34.71	10.07	.787**	.773**	-.629**	.451**	.800**	1		
Social Responsibility Anxiety	16.45	6.20	.391**	.458**	-.201**	.386**	.458**	.383**	1	
Numerical Anxiety	26.85	10.59	.606**	.672**	-.483**	.448**	.690**	.661**	.651**	1
**. Correlation is significant at the 0.01 level (2-tailed).										

Table 2 above reveals that there exists a significant relationship among the component of the Multidimensional Pseudo-Dyscalculia Scale, it therefore indicates the components converge amongst themselves with the exception of positive affect dimension whose items were positively worded and were not reverse coded during analysis and thus, diverge when compared with other factors.

Research Question 3: What is the relationship among the dimensions of Multidimensional Pseudo-Dyscalculia Scale (MPS) and those of Mathematics Anxiety Rating Scale (MARS-30-Brief)?

Table 3. Correlation Matrix showing the relationship amongst the factors of the MPS and MARS-30-Brief

Factors of Scales	Mean	St.Dv	MARS30EA	MARS 30LMA	MARS 30ENA	MARS 30PA	MARS 30SRA
Mathematics Evaluation Anxiety	52.7277	14.68172	.456**	.579**	.370**	.362**	.336**
Learning Mathematics Anxiety	47.8508	19.45845	.414**	.631**	.539**	.537**	.538**
Positive Affect Reaction	30.8298	11.34567	-.461**	-.477**	-.175**	-.115*	-.159**

Negative Affect Reaction	33.8194	12.85560	.484**	.569**	.541**	.508**	.505**
Abstraction Anxiety	35.9058	15.73806	.419**	.535**	.288**	.280**	.172**
Worry	11.6597	2.56555	.226**	.386**	.328**	.420**	.241**
Social Responsibility Anxiety	17.4895	6.48427	-.034	.100	.306**	.301**	.484**
Numerical Anxiety	26.3639	10.53932	.179**	.476**	.495**	.483**	.502**
Mathematics Anxiety Rating Scale (MARS – 30 – Brief)		**Mean**	32.3168	16.0393	14.3246	20.1335	8.6859
		St.Dv	12.08985	5.61550	5.75706	8.34496	4.08644
Evaluation Anxiety (EA), Learning Mathematics Anxiety (LMA), Everyday Numerical Anxiety (ENA), Performance Anxiety (PA), Social Responsibility Anxiety (SRA).							

As shown in Table 3 above, there is a significant relationship between factors of the Multidimensional Pseudo-Dyscalculia Scale and those of the Mathematics Anxiety Rating Scale. It was revealed that all the dimension that share the same definitions have strong and positive relationship compared to those that share relatively different definitions. Mathematics Evaluation anxiety (MEA) has a positive strong relationship with Evaluation Anxiety (EA); r(379) = .456, P < .05. Also, Both the Learning Mathematics Anxiety factors of the two scales have a strong significant positive relationship; r (379) =.631; P < .05. Additionally, Numerical Anxiety (NA) and Everyday Numerical Anxiety (ENA) have a strong positive relationship; r(379) = .495; P < .05. Furthermore, Both Worry and Negative Affect Reactions (NAR) in comparison to Performance Anxiety (PA) produce an r-value of .420 and .508 respectively, P for both < .05. In the same vein, Social Responsibility Anxiety Factors of both scales produce a strong positive relationship coefficient; r (379) = .484, P < .05. Worthy of note is the negative (-) correlation between the positive affect reactions (PAR) items and all the dimensions of the MARS-30-Brief. However, also evident in the above diagram is the negative but not significant relationship that exist between Social Responsibility Anxiety (SRA) of the Multidimensional Pseudo-Dyscalculia Scale and the Evaluation Anxiety (EA) dimension of the Mathematics Anxiety Rating Scale (MARS-30-Brief) and also the non-significant relationship that exist between the SRA and the Learning Mathematics Anxiety (LMA) dimension of the MARS-30-Brief. In sum, a holistic view of the table indicates that the dimensions of the Multi-dimensional Mathematics Anxiety Scale (MPS) significantly correlated with those of the Mathematics Anxiety Rating Scale (MARS-30-Brief). This, therefore, satisfies \upholds the condition for convergent validity of the two scales with an indication of a high correlation given the size of effects (Cohen, 1998; Fiddle, 2000).

Research Question 4: What is the relationship between the Multidimensional Pseudo-Dyscalculia Scale and the Mathematics Self-Efficacy Scale?

Table 4. Correlation summary showing the relationship between the Multidimensional Pseudo-Dyscalculia Scale and the Mathematics Self-Efficacy Scale

Scales	N	Mean	Std. Dev	Df	r	Sig	P
Multidimensional Pseudo-Dyscalculia Scale	781	256.5669	65.45934	779	-.851	.000	P< .05
Mathematics Self-efficacy Scale	781	39.1444	15.37403				

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

Table 4 above reveals that there is a significant negative correlation between the Multidimensional Pseudo-Dyscalculia Scale and the validated Mathematics Self-efficacy Scale; r(779)= -.851, P <. 05. The table further reveals that both scales are inversely related. The coefficient of determination ($r^2 = 0.724$) shows that an increase in math anxiety will lead to 72.4% decrease in mathematics self-efficacy.

Model Fitness

Research Question 5: Which of the models would significantly gain a better fitness?

Table 5. Confirmatory Factor Analysis (CFA) showing goodness of fit indexes of the 5 models tested

Model	X^2	Df	P	NFI	CFI	RMSEA
Bi-dimensional (Pos & Neg Afft)	1560.009	688	<.05	.910	.923	.059
Bi-dimensional (MEA & LMA)	2795.190	776	<.05	.899	.894	.073
Bidimensional MEA Vs NA	11728.705	798	<.05	.558	.593	.129
Newly Proposed Model	15135.694	776	<.05	.628	.676	.104
3-Dimensional Model	4604.932	699	<.05	.932	.920	.052

Table 5 shows result of a confirmatory factor analysis of the five models tested using different fit indexes. The confirmatory factor analysis was conducted using maximum likelihood Estimates. From the above table, the Bi-dimensional (Positive and Negative Affect Reactions) model shows a model fit of X^2 (688) = 1560.009, p < .05. But base on the assumption that says chi-square goodness of fit is easily influenced by a large sample size (Bentler and Bonnet, 1980; Jöreskog and Sörbom, 1993 cited in Hooper, Coughlan, & Mullen, 2008), there comes the need to use other fit indexes NFI, CFI and RMSEA; NFI = .910 <.0.95 and CFI = .923 > .90, RMSEA = 0.67. This reveals a fairly good model. The second bi-dimensional (MEA and LMA) model tested revealed a X^2 (776) = 2795.190, p < .05. While other indexes such as NFI =.899 CFI = .894, RMSEA = .073; all these revealed a relative bad model based on available cut-off points. Additionally, revealed in the table is another bi-dimensional mode (MEA Vs NA) and this revealed X^2 (798) =11728.705, NFI = .558. CFI = .593, RMSEA =.129 which all depicts a very poor fit model by virtue of agreed upon benchmarks. Further shown in the table is the initially proposed model that was gotten from the scale used for data collection. The model consists of 8-factors, and it produces X^2 (798) = 15135.694, p <.05, NFI = .558, CFI =.593, RMSEA = .129. This is another poor model fit. However, finally revealed in the table is the modified model which was arrived at after a thorough modification was carried out following the procedures laid down by Hatcher (1994). The fit indexes were X^2 (699) = 4604.932, p <.05, NFI = .932, CFI = .920, RMSEA = .052 and this has the best model fit indices.

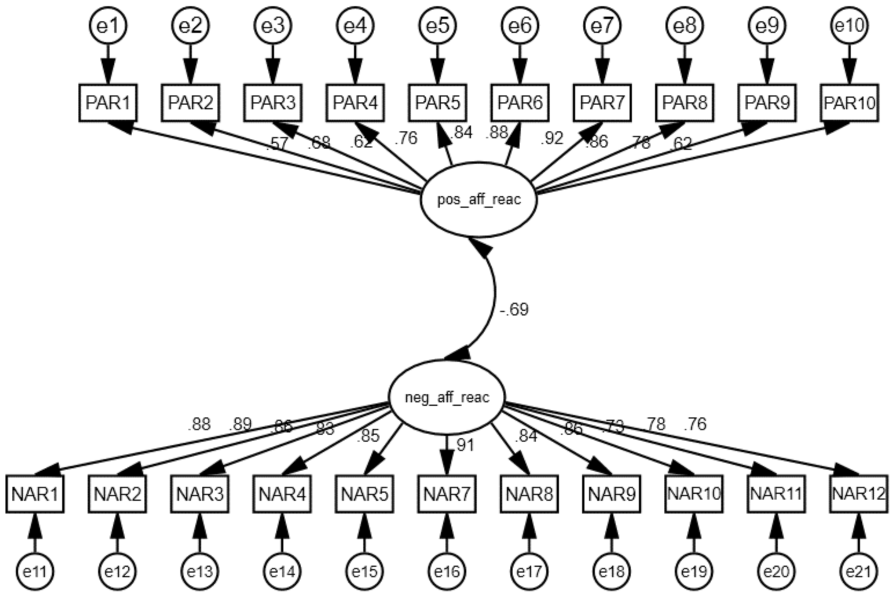

Figure 2. Bi-dimensional measurement model of pseudo-dyscalculia (Positive and Negative Affect Reactions)

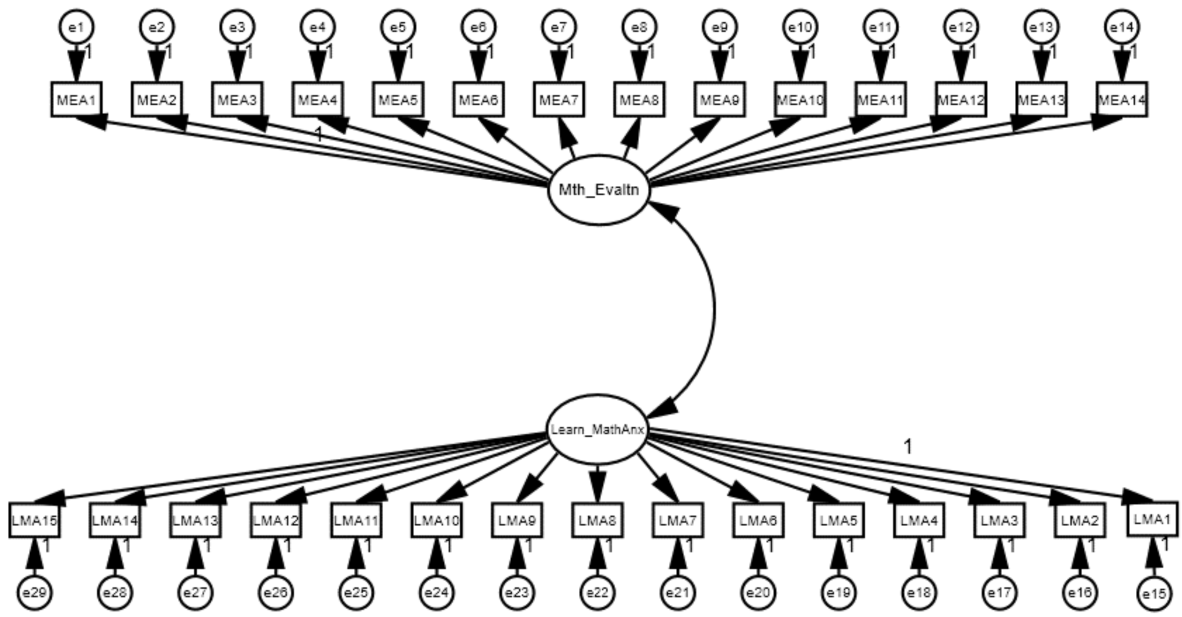

Figure 3. Bi-dimensional measurement model of pseudo-dyscalculia (Math Evaluation Anxiety and Learning Mathematics Anxiety)

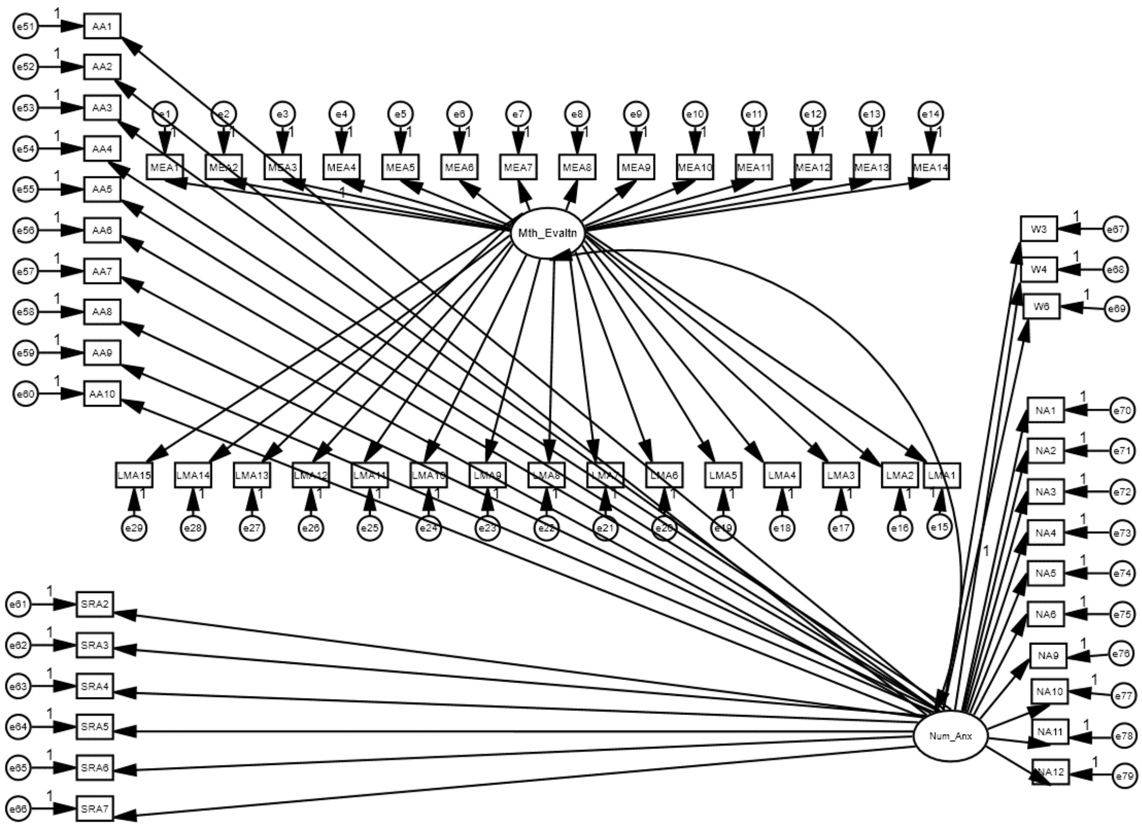

Figure 4. Bi-dimensional measurement model of pseudo-dyscalculia (Mathematics Evaluation Anxiety and Numerical Anxiety)

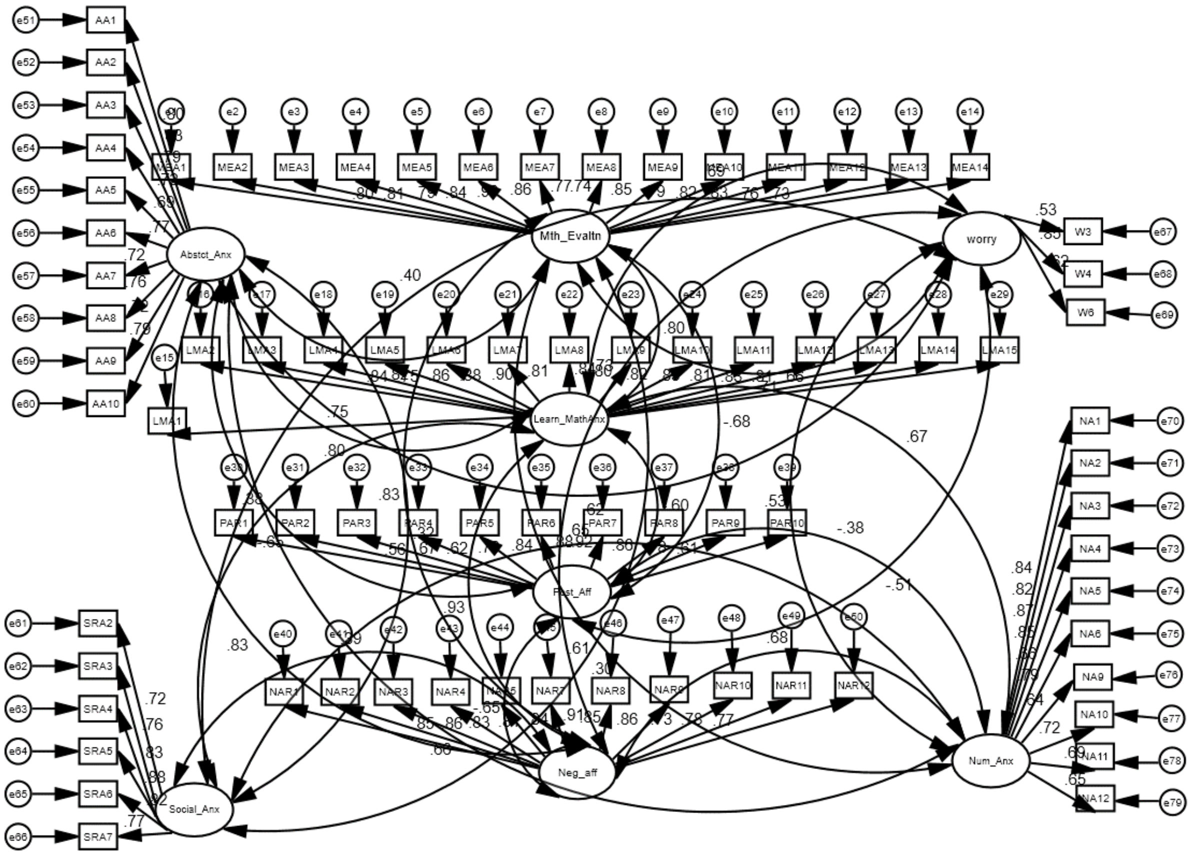

Figure 5. Proposed 8 factor pseudo-dyscalculia model

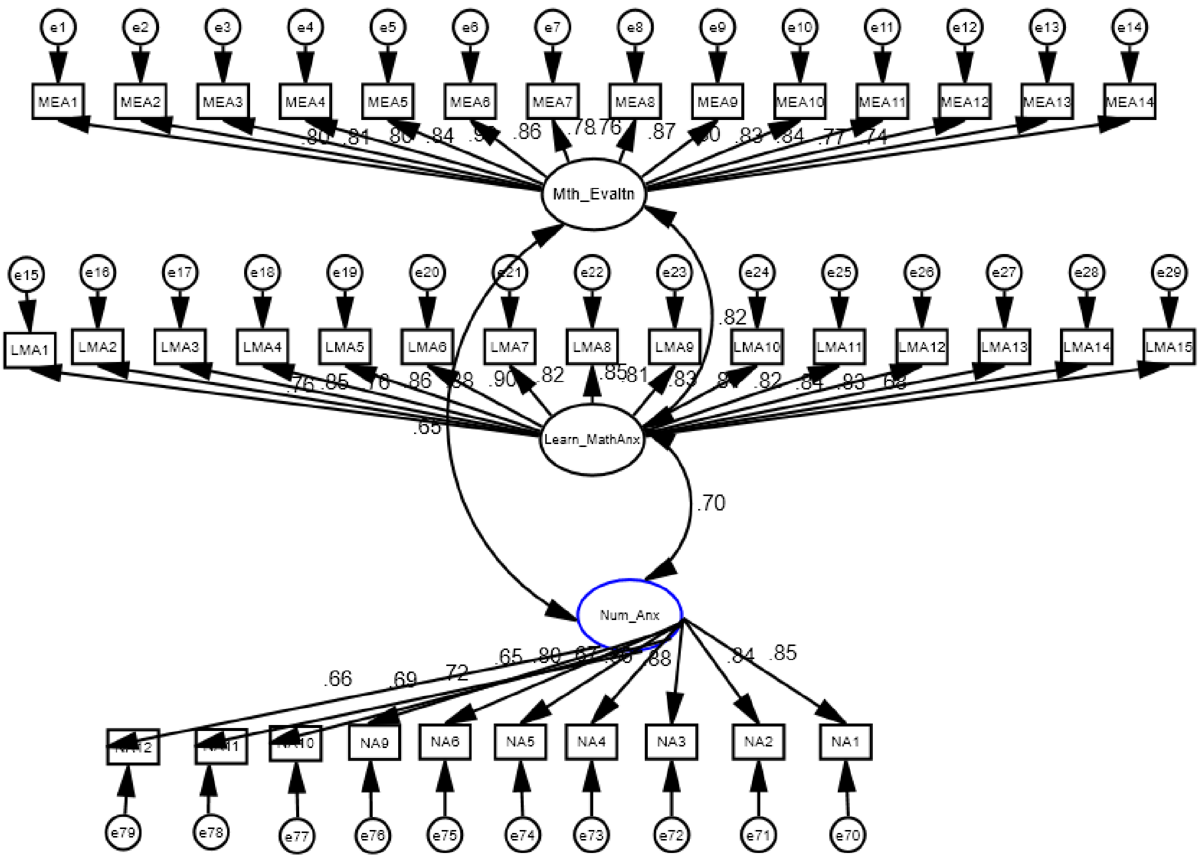

Figure 6. Modified Proposed pseudo-dyscalculia Model

Research Question 6: To what extent will each of the components of Multidimensional Pseudo-Dyscalculia Scale display significant satisfactory reliability coefficient?

Table 6. The reliability coefficients of the Multidimensional Pseudo-Dyscalculia Scale

S/N	Components of the Scale	Cronbach's Alpha
1.	Mathematics Evaluation Anxiety (MEA)	.965
2.	Learning Mathematics Anxiety (LMA)	.969
3.	Positive Affect Reactions (PAR)	.931
4.	Negative Affect Reactions (NAR)	.962
5.	Abstraction Anxiety (AA)	.935
6.	Worry	.752
7.	Social Responsibility Anxiety (SRA)	.911
8.	Numerical Anxiety (NA)	.935
Total	General Reliability of the Multidimensional Pseudo-Dyscalculia Scale.	.971
	Reliability Coefficient rho	.912

Note. *Significant ≥ .7

Table 6 reveals good reliability coefficients that satisfies the criteria specified by Cohen (1988) and Field (2000) that stated "a good reliability coefficient should be 0.7 and above". These therefore indicate that the Multidimensional Pseudo-Dyscalculia Scale developed for the study is reliable enough for use.

Discussion

The aim of this study was to carry out a factor analyses of pseudo-dyscalculia indices among freshmen. In the bid to get this done, all major previously identified dimensions (Mathematics Evaluation Anxiety, Learning Mathematics Anxiety, Positive Affect Reactions, Negative Affect Reactions, Abstraction Anxiety, Worry, Social Responsibility Anxiety, and Numerical Anxiety) were integrated into one bigger and multidimensional scale named the Multidimensional Pseudo-Dyscalculia Scale (MPS). The following were examined; the factor structure of the Multidimensional Pseudo-Dyscalculia Scale, internal convergence for the scale, external convergence validity for the scale, divergent/discriminant validity of the scale, assessment of measurement models with best fit indices and finding out the reliability of the scale. In whole, the study raised six (6) research questions to provide answers to the underpinning specific objectives.

Research question one examines the factors indicative of the Multidimensional Pseudo-Dyscalculia Scale. The Exploratory Factor Analysis (EFA) reported in table 1 depicted the factors indicative of MPS. Wherein a factor analysis of 89 items using Maximum Likelihood and Oblimin rotation produced an 8-factor structure for the 79-items that survived this stage. The eight-factor together accounted for 68.765 percent of the variance. The factors indicative of the scale are Mathematics Evaluation Anxiety (MEA), Learning Mathematics Anxiety (LMA), Positive Affect Reactions (PAR), Worry, Negative Affect Reactions (NAR), Abstraction Anxiety (AA), Social Responsibility Anxiety (SRA), and Numerical Anxiety (NA). These factors have proven themselves to be valid measures of mathematics anxiety. The validity of six of the factors had been supported by researchers such as Kazelskis (1998), while the validity of Positive and Negative Affect Reactions as measures of pseudo-dyscalculia have been strengthened (Taiwo, 2014; Aremu & Taiwo, 2014; Bai et al., 2009; Mahmood & Khatoon, 2011). Also Pletzer, et al., (2016) had also recently identified factors such as social responsibility anxiety, evaluation anxiety, learning mathematic anxiety, everyday numerical anxiety and performance anxiety which are all closely related to those identified in this study.

Research question two was an attempt to establish the internal convergence validity among all the identified components of the Multidimensional Pseudo-Dyscalculia Scale (MPS). Observed in table 2 was a significant relationship among the components of MPS. This indicates that the components converge within themselves with the exception of the relationship observed between positive affect reactions and other dimensions measured. This is because all other items were negatively worded. The negative relationship between positive and negative affect was strengthened by various studies (Bai 2010; Ganley & McGraw, 2016; Kazelskis, 1998; Mahmood & Khatoon, 2011).

The third research question raised intended to establish the external convergence of the Multidimensional Pseudo-Dyscalculia Scale (MPS) with the Mathematics Anxiety Rating Scale (MARS-30-Brief). Hence, the dimensions of the MPS were subjected to a test of relationship with the dimensions identified from the MARS-30-Brief by Pletzer et al., (2016). Findings of the studies as shown in table 3 revealed that holistically, there exists a significant relationship between the components of the newly developed scale and those of the MARS-30-Brief. Nearly all components correlated significantly with the exception of the Social Responsibility Anxiety (SRA) dimension of the MPS that had a negative but non-significant relationship and also a non-significant relationship with both the Evaluation Anxiety (EA) and Learning Mathematics Anxiety (LMA) dimensions of the MARS-30-Brief respectively. This lack of nonsignificant correlations to some regards is desirable and expected because the newly developed MPS was not designed to imitate the MARS-30-Brief or any other scale. If all correlations were unduly high and significant, then the MPS would be a redundant measure of mathematics anxiety, not improving on preexisting measures. The fact that correlations were not extremely and unduly high across dimensions is a proof that MPS has the promise of having high validity, without duplicating on existing scales.

Research question four was raised in a bid to establish the divergent or discriminant validity of the newly developed Multidimensional Pseudo-Dyscalculia Scale. As a result, the scale was subject to a test of relationship with a standardized Mathematics Self-efficacy Scale. The result depicted in table 4 reveals a significant and very strong negative relationship which implies that both scales are measuring two different constructs that are not in any significant way related. Although, the negative relationship observed was in contrast with the findings of May (2009) because the part of the overall scale that measures anxiety were reversed scored during analysis in her own study (May, 2009). However, the negative correlation obtained is strengthened by the position held by Jameson (2013) who reported that high math anxious individuals suffer from low self-efficacy in math. while, Ganley and McGraw (2016) on the contrary reported a positive relationship between math anxiety and math confidence because the math confidence part was reverse coded.

Research question five examines which of the model will gain a better fitness than the other. A Confirmatory factor analysis as shown in table 5 was conducted using Maximum Likelihood Estimates. A total of five models were tested. Three of them were to validate existing proposed models via the newly gathered data; while the last two are newly proposed in this study. From our findings, the first bi-dimensional model that used positive and negative affect reactions to some extents fits well and this is in support of Bai (2011) who also reported a very good fit index for the bidimensional scale used in his study. The second bi-dimensional model tested made use of the mathematics evaluation anxiety domain and the learning mathematics anxiety domain. The result revealed a fairly bad model contrary to what was reported by (Hopko, 2003) that this bi-dimensional model gave the best model-fit indexes. This likely has to do with fact that Hopko (2003) eventually modified the initial 24-items scale and this led to the development of a new scale with limited items. Additionally, a model that features two global dimensions which combine all the measures such as (worry, abstraction anxiety, social responsibility anxiety, and numerical anxiety) into one big dimension called numerical anxiety and compared it with another dimension that combines math evaluation anxiety with learning math anxiety into a global dimension called math evaluation anxiety. This was done to test the submission of Rounds and Hendel 1980 (cited in Pletzer, 2016). This model revealed a set of poor fit indexes which has also been proven by Pletzer et al (2016), though not as worse as what was gotten in this study. This may be as a result of the length of the scale used. Also, a newly proposed model that attempted to test the entire dimensions of the MPS gave a very poor fit index. This for sure will be due to the diversity and similarity inherent in the dimensions used. Finally, shown in the table is a three-factor model that gave the best fit-indexes. It has in it, a combination of learning math anxiety, math evaluation anxiety and numerical anxiety; Meaning, all three indices used for the last model are good representative of the model.

The sixth research question provides the reliability of part and whole of the entire scale. It was revealed that the mathematics evaluation anxiety (MEA) domain has a Cronbach's alpha of .965 compared to the one obtained by Hopko (2003) where for MEA, $\alpha = .85$. For the learning mathematics anxiety (LMA), Cronbach's alpha = .969 compared to that of Hopko (2003) wherein Cronbach's alpha = .87. The large difference in the Cronbach's alpha value obtained may be due to difference in study locale or wide difference in the number of items used. The positive affect reaction has .931 compared to the one reported by Bai (2011) where Cronbach alpha for the positive affect subscale was .84. While that of Negative affect reactions of the new scale has .962 compared to that of Bai (2011) which has a Cronbach Alpha of .84 also. The difference observed might be due to number of items since the higher the number of items, determines the higher the Cronbach's Alpha. Abstraction anxiety has an internal consistency value of .935, its internal consistency has not been reported in previous literatures and even Ferguson (1983) who was one of the leading authors on abstraction anxiety used test-retest reliability and its value was not reported. Additionally, Worry has an internal consistency value of .752 compared to the one reported by Wigfield and Meece (as cited in Kazelskis, 1998) where $\alpha = .76$; Both scores are within a range. Social responsibility anxiety has .911, and no other Cronbach's alpha has been reported for this factor in early works. The numerical anxiety dimension has .935 compared to the .86 reported by Feldt and Brennan (Cited in Kazelskis, 1998). The overall scale has a Cronbach's alpha of .971 compared to the MARS 30-Brief which has .96 (Suinn & Winston, 2003). The reliability coefficient rho of .912 justifies a good reliability coefficient that satisfies the criteria specified by Cohen (1998) and Field (2000) that stated "a good reliability coefficient should be 0.7 and above".

Conclusion

An insightful look into all said and done shows that all identified dimensions are valid measures or indices of pseudo-dyscalculia. However, evidence from this research shows that not all identified dimensions are meant for a single scale. Thus, we have the bi-dimensional scales that make use of positive affect and negative affect. While a bi-dimensional scale that comprises math evaluation anxiety and learning math anxiety can also diagnose math anxiety in limited time. However, Ferguson (1988) proposed that while trying to reduce items for whatever reasons, efforts should be made to ensure that all dimensions are represented. Also, Kazelskis (1998) had pointed out that researchers need to carefully and strategically choose the instruments they use in an attempt to measure mathematics anxiety, as instruments to a large extent do not work interchangeably, rather, they measure varying aspects of a complex construct (MA). Thus, mathematics anxiety scale developers are advised to provide in their norms information on the aspect(s) of mathematics anxiety their scales tap into. The scale developed in this study has been validated and can be used for clinical diagnosis, however, users are, to sum up by dimensions as a total score of all may not reveal the actual level of math anxiety nor tell specifically which domain of math anxiety the test takers belong.

Recommendation

There comes the need to highlight certain measure to be put in place in other to address the issues discussed so far.

Prospective and future math anxiety scale developers should ensure that the basics if not all of the domains of mathematics anxiety are represented in any mathematics anxiety scale to be developed.

As the measure would be used for diagnostic purposes. Hence, the need for the accommodation of more indexes; since scales/inventories/batteries are to clinicians and counselling psychologists, like the thermometer, stethoscope, etc. are to physicians.

All identified dimensions should be given adequate consideration by pupils, teachers, clinician, psychologist, counsellors, parents, and other stake holders.

Psychometricians and Clinical Psychologists should adopt this scale as diagnostic tool for identifying mathematics related problems.

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