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CONFIRMATORY FACTOR ANALYSIS OF STUDENT MATHEMATICS ENGAGEMENT SCALE AMONG SENIOR SECONDARY SCHOOL STUDENTS IN EKITI STATE, NIGERIA

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ABSTRACT

This study validated student mathematics engagement scale (SMES) among secondary school 2 students in Ekiti State, Nigeria. The study adopted a survey design. Multi-stage sampling procedure was used to select a sample of 1600 SS2 students from 32 schools in Ekiti State, Nigeria. Confirmatory Factor Analysis (CFA) was used in the validation of a robust student mathematics engagement scale to measure students' engagement in mathematics.

Six factors, comprising 45 student mathematics engagement items (SMEI) were reduced to 37 items through CFA. Dimensionality analysis of CFA showed that the 37 items distinctly loaded on six factors and denoted sub-scales. These factors were: Personal Agency Engagement, Positive Affective Engagement, Negative Affective Engagement, Positive Behavioural Engagement, Negative Behavioural Engagement and Cognitive Engagement. The composite reliabilities of each of the sub-scales of the SMES ranged from 0.66 to 0.90. A robust 6-dimensional Students Mathematics Engagement scale was validated. Mathematics teachers should be encouraged to use this scale for measuring secondary school students' level of engagement in the subject.

KEYWORDS: ***Student mathematics engagement scale, Confirmatory factor analysis, Dimensionality of scales, Composite reliabilities.***

INTRODUCTION

Over the years, it has been observed that one of the learner's characteristic which has a high probability of affecting learning outcomes and achievement in Mathematics is students' engagement. This denotes students' vigorous obsession in learning activities (Reschly, Wylie & Christenson, 2012). In learning Mathematics, engagement happens when students are systematically busy with the teacher inside the classroom, partake in solving problems, do the Mathematics, and grasp the opinion that having mathematical knowledge is meaningful and suitable, in the classroom and outside the classroom. Basically, the conception of engaging students is grounded on the trust that their knowledge increases when they are snooping, fascinated, or encouraged. But their knowledge decrease when they are uninterested, calm, dissatisfied, or otherwise disengaged in learning activities (Attard, 2011).

Academically engaged students are dedicated, tenacious, and captivated in their academic quest (Adegbuyi, 2019). Seeley (2004) noted that students' engagement brings about success and that commitment could have the utmost influence on fairness during Mathematics class. Seeley also noted that students' engagement makes students to study. To corroborate Seeley's view, Akpan & Umobong (2013) carried out a research work on students' achievement, students' Inspiration and students' level of engagement during teaching and learning process in Nigeria. Their results showed that students' success, students' performance, and students' achievement have a positive correlation with engagement. These researchers said that before a child can achieve success in his or her academics, he or she must affianced maximally in academic work, as

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academic commitment is essential for a child to be successful in the classroom.

However, despite the significance of engagement of students to their success in the classroom, the level of students' engagement in some of their subjects is low, most especially in Mathematics. However, in order to increase the level of engagement in mathematics, teachers and school administrators need to identify these set of disengaged students and occupy them in meaningful teaching and learning process, for high level performance in their classrooms. Basically, assessment of students' level of engagement is highly necessary in their subject areas, most especially in Mathematics with valid and reliable student mathematics engagement questionnaire, that researchers and teachers can use to investigate the feelings, views, and beliefs which students have about Mathematics and how an adjustment can be made to improve students' level of comprehension during the teaching of Mathematics, among secondary school students in Nigeria and outside Nigeria.

However, among psychometricians and mathematics' researchers, the dimensionality of student engagement construct has constituted a problem. Most of the instruments currently available to assess students' level of engagement, most especially in Mathematics in Nigeria and outside Nigeria, are validated by not very effective psychometric procedures. For researchers to assess the extent of students' involvement in Mathematics, so as to improve students' learning outcome and achievement, there is a need to validate a multidimensional student mathematics engagement scale with sophisticated statistical tool, that is, Confirmatory Factor Analysis (CFA). With the use of this statistical tool, valid, reliable and robust multidimensional student mathematics engagement instrument in Nigeria can be validated. On the bases of the reason mentioned above, this work validated the six sub-scales of student Mathematics engagement scale constructed with the use of Exploratory and parallel analysis by Adegbuyi & Adegoke in (2017). This work use Confirmatory Factor Analysis for more rigorous validation of the six sub-scales.

The need for CFA in this study is borne out of the fact that CFA is a multivariate statistical technique which is basically for hypothesis testing. The hypothesis deals with a latent pattern of factors behind the items. The CFA tested the extent to which a group of items represent the number of factors that have been generated through EFA. In CFA, the extracted factors must be identified by the researcher prior the analyses of data. Confirmatory factor analysis examined how well the measure of construct is reliable with the assessment of researchers concerning the pattern of the latent variable.

Besides, CFA gives a more reasonable approach to a researcher during the evaluation of construct validity (Çokluk, & Koçak, 2016). In Confirmatory Factor Analysis, "goodness of fit'' measures are employed to assess the degree to which the predicted latent variable by the researcher apprehended the correlation between all the items in the construct.

RESEARCH QUESTIONS

1) Do the retained factors of students Mathematics Engagement scale show good model fit indices?
2) Do the students Mathematics Engagement items show convergent validity?
3) Are items of each of the dimensions of Students Mathematics Engagement scale unidimensional?

OBJECTIVE OF THE STUDY

This study constructed a valid and reliable multidimensional student mathematics Engagement scale to measure the level of secondary school students' engagement in mathematics in Ekiti State, Nigeria for the purpose of improving learning outcome and achievement in Mathematics.

METHODOLOGY

RESEARCH DESIGN

This study adopted a survey design under Instrumentation research type. This type of research verifies large and small population by choosing small samples from the population to ascertain the relative occurrence, sharing, and relationship between the latent variables and its corresponding measured variables. It involves validation of Instrument.

SAMPLE AND SAMPLING TECHNIQUE

The sample size in this work was 1600 Senior Secondary School 2 students using multi-stage sampling procedure selected from 32 schools in Ekiti State, Nigeria. First, one Senatorial District was randomly selected from the existing three Senatorial Districts in Ekiti State. From the selected Senatorial District, there are six Local government areas out of which four LGAs were randomly selected. From each of the selected Local government areas, simple random sampling was used to select four public senior secondary schools and four private senior secondary schools. Thus, the number of schools in this work was 16 public senior secondary schools and 16 private senior secondary schools respectively. Finally, 50 SS2 students were randomly selected from each of the 32 schools (32x50=1600 students).

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INSTRUMENT: STUDENTS MATHEMATICS ENGAGEMENT SCALE

The instrument comprised six sub-scales with 45 items of students mathematics engagement scale namely (Personal Agency Engagement, Positive Affective Engagement, Negative Affective Engagement, Positive Behavioural Engagement, Negative Behavioural Engagement and Cognitive Engagement). The scale was first constructed by Adegbuyi and adegoke in (2017) through Exploratory Factor Analysis and Parallel Analysis.

Table 1: Method of Data Analysis

Research Question	Statistical software package
1. Do the retained factors of student's Mathematics Engagement scale show good model fit indices?	Confirmatory factor analysis, using LISREL package
2. Do the students Mathematics Engagement items show convergent validity?	Confirmatory factor analysis, using AMOS package
3. Are items of each of the dimensions of Students Mathematics engagement scale unidimensional?	Confirmatory factor analysis, using AMOS package

RESULTS AND DISCUSSION

Research question 1: Do the retained six factors of students Mathematics Engagement scale show good model fit indices?

The following model fits were tested for this research question:

i. Root *Mean* Square Error of Approximation (RMSEA) should be ≤ 0.06, which signify suitable model fit (*Tabachnick B, Fidell* (2007).
ii. Root mean square residual (RMR) and standardized root mean square residual (SRMR) should be ≤ 0.08, which signify suitable model fit (*Tabachnick B, Fidell* (2007).
iv. Values for either non-normed fit index (NNFI) or normed fit index (NFI) should have a limit of 0.95 or larger, which specify a good fit to the model.
v. A comparative fit index (CFI) of 0.90 or larger indicates acceptable model fit. (*Tabachnick B, Fidell* (2007).
vi. Incremental fit index (IFI) of 0.95 or larger indicates acceptable model fit. (James B. Schreiber,; Frances K Stage,; Jamie King,; Amaury Nora and Elizabeth A. Barlow (2006).
vii. An acceptable value of Chi-square probability should be ≥ 0.05 (Suhr, 2006)

Table 2: Model fit indices of students Mathematics Engagement sub-scale

Model fit	ACCEPTED MODEL FIT	DIM1	DIM2	DIM3	DIM4	DIM5	DIM6
RMSEA	≤.06	0.12	0.076	0.073	0.072	0.046	0.044
RMR	≤.08	0.070	0.066	0.055	0.056	0.041	0.046
NFI	≥.95	0.89	0.93	0.94	0.93	0.96	0.96
NNFI	≥.95	0.89	0.93	0.94	0.94	0.97	0.97
IFI	≥.95	0.90	0.94	0.95	0.94	0.97	0.97
CFI	≥.95	0.90	0.94	0.95	0.94	0.97	0.97
RMSEA 90% CI	< 0.06; < 0.08	0.12; 0.12	0.075; 0.078	0.072; 0.075	0.071; 0.073	0.045; 0.048	0.042; 0.045
$\chi 2$	> 0.05	10089.46	6607.04	5007.38	6038.65	3028.80	3367.89
COMMENT		Not Fit	Not Fit	Not Fit	Not Fit	Fit	Fit

DIM = Dimension

To answer this research question, the Confirmatory factor analysis of the six sub-scales of students Mathematics Engagement scale which comprised 45 items that was constructed by Adegbuyi and adegoke in (2017) through EFA and PA, was carried out on a sample of 1600 which is different from the initial 1008 samples used for EFA. Table 2 gives the detail information of the fit indices of student

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mathematics engagement scale. The table shows that student mathematics engagement scale is not one dimensional nor two or three, up to four-dimensional scale as the fit indices of the engagement scale was not significant under one to four dimensions. Even one cannot say that the scale shows good model fit under five dimensions as the model only fitted after the removal of cognitive engagement. So the results of table 2 clearly show that student mathematics engagement scale have six dimensions as all the fit indices under the 6-dimensional model satisfied the model fit criteria. Not only that, the result of model fit confirmed the result of Parallel analysis from the previous work of the Adegbuyi & Adegoke (2017) which retained six factors.

Research Question 2: Do the students Mathematics Engagement items show convergent validity?

Based on the results obtained from the fit indices, proper examination of standardized regression weight of the six models was done and computation of composite reliability was carried out. The result is shown on the table 3.

Table 3: Validity Index of students Mathematics Engagement item

Item		Factor(F)	LD	LD^2	$1-(LD)^2$	$X=\sum 1-(LD)^2$	$\sum FLD$	$Y=(\sum FLD)^2$	$Z=\sum X\&Y$	$CR=\frac{Y}{Z}$
c17	<--	PERANG	**0.571**	0.32604	0.673959	6.985419	7.745	59.98503	66.97044	**0.895694**
c9	<--	PERANG	**0.643**	0.41345	0.586551					
c2	<--	PERANG	**0.685**	0.46923	0.530775					
c3	<--	PERANG	**0.665**	0.44223	0.557775					
c5	<--	PERANG	**0.675**	0.45563	0.544375					
c8	<--	PERANG	**0.588**	0.34574	0.654256					
c11	<--	PERANG	**0.668**	0.44622	0.553776					
c14	<--	PERANG	**0.686**	0.4706	0.529404					
c6	<--	PERANG	**0.673**	0.45293	0.547071					
c10	<--	PERANG	**0.639**	0.40832	0.591679					
c7	<--	PERANG	**0.641**	0.41088	0.589119					
c15	<--	PERANG	**0.611**	0.37332	0.626679					
d8	<--	POSAFF	**0.596**	0.35522	0.644784	3.832686	3.604	12.98882	16.8215	**0.772156**
d9	<--	POSAFF	**0.601**	0.3612	0.638799					
d7	<--	POSAFF	**0.636**	0.4045	0.595504					
d1	<--	POSAFF	**0.576**	0.33178	0.668224					
d2	<--	POSAFF	**0.615**	0.37823	0.621775					
d3	<--	POSAFF	**0.58**	0.3364	0.6636					
e6	<--	NEGAFF	**0.606**	0.36724	0.632764	5.185461	4.715	22.23123	27.41669	**0.810865**
e4	<--	NEGAFF	**0.632**	0.39942	0.600576					
e5	<--	NEGAFF	**0.656**	0.43034	0.569664					
e3	<--	NEGAFF	**0.657**	0.43165	0.568351					
e1	<--	NEGAFF	**0.598**	0.3576	0.642396					
e2	<--	NEGAFF	**0.607**	0.36845	0.631551					
e7	<--	NEGAFF	**0.48**	0.2304	0.7696					
e8	<--	NEGAFF	**0.479**	0.22944	0.770559					
f2	<--	POSBEH	**0.633**	0.40069	0.599311	1.814759	1.885	3.553225	5.367984	**0.661929**
f3	<--	POSBEH	**0.606**	0.36724	0.632764					
f1	<--	POSBEH	**0.646**	0.41732	0.582684					
g2	<--	NEGBEH	**0.537**	0.28837	0.711631	2.69714	2.268	5.143824	7.840964	**0.656019**
g1	<--	NEGBEH	**0.635**	0.40323	0.596775					
g3	<--	NEGBEH	**0.621**	0.38564	0.614359					
g4	<--	NEGBEH	**0.475**	0.22563	0.774375					
c16	<--	COGNIT	**0.69**	0.4761	0.5239	2.442775	2.487	6.185169	8.627944	**0.716876**
c12	<--	COGNIT	**0.624**	0.38938	0.610624					
h1	<--	COGNIT	**0.63**	0.3969	0.6031					
h2	<--	COGNIT	**0.543**	0.29485	0.705151					

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Table 3 displays the standardized regression weight of each item of students mathematics engagement scale to their corresponding latent variable. All the loadings are greater than 0.4 (bolded under the column labeled 'LD'), which showed a good level of convergent validity. Not only that, the composite reliability (CR) of each of the construct of student mathematics engagement scale was computed the values of CR ranged from 0.66 to 0.90. These results supported the work of They said that; for a good convergent validity, the value of CR for each construct should be between 0.60 to 0.90.

Research question 3: Are items of each of the dimensions of Students Mathematics engagement scale unidimensional?

Unidimensionality of each of the dimension of student mathematics engagement scale was carried out to show the pattern of relationship between each construct and their corresponding items.

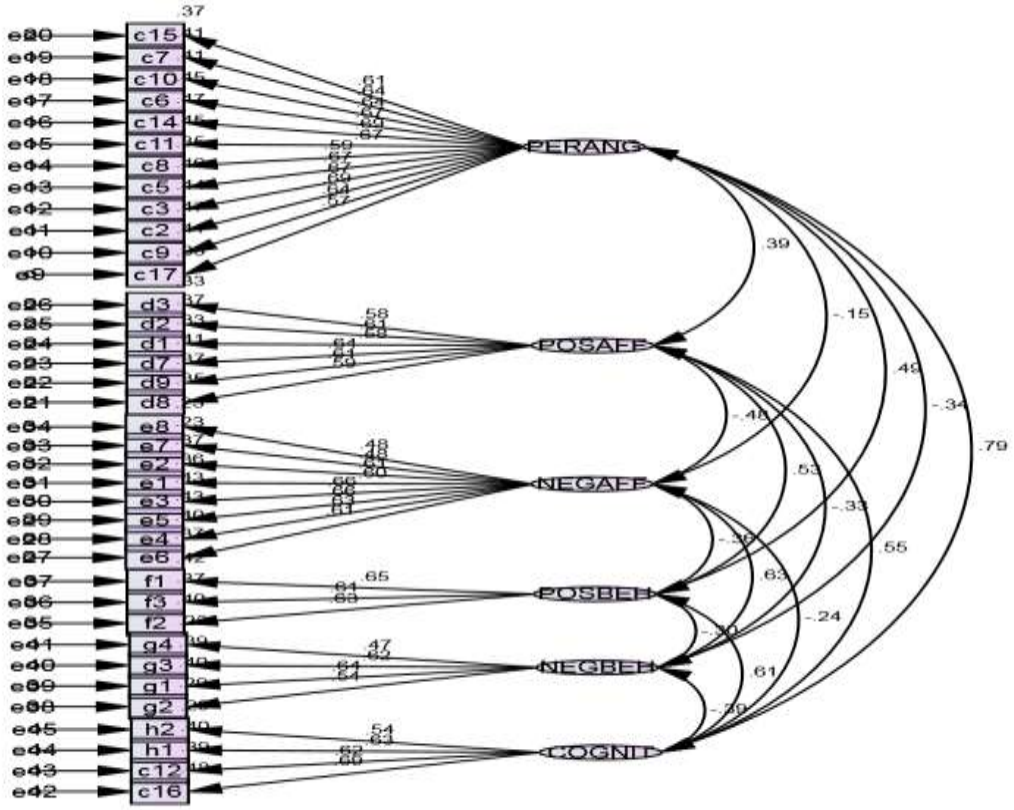

Figure 1: The unidimensionality of Student Mathematics Engagement items and their corresponding factors.

To answer this research question, the 37 items that show convergent validity were verified to ascertain the unidimensionality of the items to their respective factors through confirmatory factor analysis. After this verification, The result of Figure 1 show that all the item under each of the construct of students mathematics engagement scale have strong relationship with their underline latent variable**.** No cross loading of items onto two or more factors. Each of the item unidimensionally loaded onto its corresponding factor. The result also shows that student mathematics engagement scale have six dimensions (six sub-scales).

CONCLUSION

The main outcomes of this research are as follows:

The validated student mathematics engagement items have good fit indices with only six Models. This shows that the construct (Student Mathematics Engagement) have six dimensions.

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The validated student mathematics engagement items were unidimensional. This implies that the test measures only one latent trait (Student Mathematics Engagement).

The composite reliabilities of each of the sub-scales of the SMES ranged from 0.66 to 0.90. The value clearly indicated that the six sub-scales of student mathematics engagement scale were highly reliable and valid.

RECOMMENDATIONS

Based on the results of this work, the following suggestions were made:

Educators and researchers who may be willing to validate survey instruments should make use of confirmatory factor analysis during the validation of their instruments, as this will produce a solid and robust instrument.

The validated scale can be used to develop a way for schools to comply with learning assessment standards and not to depend on the use of standardised achievement tests alone.

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