

Development and Factorial Validation of Mathematics Attitude Inventory for Junior Secondary School Students

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Abstract

The study developed and factorial validated Mathematics Attitude Inventory (MAI) for junior secondary school students. The attitude of students towards mathematics affects their performance in the subject in both internal and external examinations. This necessitated the development and factorial validation of MAI to assess the students' attitude towards learning mathematics. The study employed an instrumentation research design. Three research questions guided the study. The instrument for data collection was MAI, which was developed by the researcher and structured on a five-point Likert scale inventory. An initial draft of 50 items was validated by experts in measurement, evaluation and research and an experienced lecturer in mathematics education to determine the suitability of the instrument. After corrections and trial testing of the instrument, 47 items emerged for factor analysis. At the end of factor analysis 22 items were found to be well loaded and therefore acceptable as suitable for the study. The 22-item inventory was administered to 650 students from the sampled schools to establish the norm and reliability of the instrument. Cronbach alpha reliability technique ranges from 0.709 to 0.881. The overall internal consistency reliability coefficient is 0.805 while the norm is 66.65. A maximum likelihood factor analysis with a varimax rotation yielded four factors: enjoyment of mathematics; value of mathematics; self-confidence in solving mathematics problems and peer pressure influence in learning mathematics. The instrument, MAI is recommended therefore, for use in measuring of students' attitude towards mathematics at the junior secondary school level.

Key words: *mathematics, attitude towards mathematics, inventory, factorial validation and reliability.*

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I. Introduction

Mathematics is one of the core subjects that has helped to produce trained manpower needed for scientific and technological development of any nation. The main objective of teaching mathematics in junior secondary schools in Nigeria as stated by National Policy on Education (Federal Republic of Nigeria [FRN] 2014), is to enable students acquire basic scientific knowledge and skills that will enable them meet societal needs of creating employment and wealth. The contribution of mathematics to national development has been seen in all facets of human life in various degrees.

The poor performance of students in mathematics in the country has been a source of concern to the stakeholders in education. Unfortunately, despite all successive efforts at developing mathematics education, students' performance in mathematics is dismal (Obaitan&Rasheed, 2010). The record from the West African Examination Council (WAEC) of 2005 to 2016 showed that students' performance has been fluctuating and poor. For instance, in 2016 only 38.68 percent passed mathematics at credit level and above.

Various reasons such as lack of: instructional materials, qualified teachers, textbooks and poor method of teaching have been linked with the poor performance. The poor performance of students in mathematics in the country was partly seen as a long-term effect of playing down on affective domain such as attitude which appears to feature in many of studies in learning outcomes in mathematics (Obaitan&Adegbuyi, 2014). Adebule, (2013) stressed that the academic problems include students' unparalleled hatred, indifference and poor attitude toward mathematics.

An attitude is often defined as a tendency to react favourably or unfavourably towards a designed class of stimuli (Mkpa&Mbakwe, 2006). Allport cited in Okoye (2015) defined attitude as a mental and neural state of readiness, organized through experience, or dynamic influence upon the individual's response to all objects or situations with which it is related. Attitude is also a predisposition of a person towards social objects which may

be positive or negative. It is regarded as a factor that determines how a person will react to any object, person, phenomenon or situations. It is also a person's perspective towards a specified target. It plays an important role in the learning of any school subject including mathematics. This is so because it touches the cognitive, affective and behavioural tendencies of the learner. The way a student thinks, perceives, feels values and acts towards mathematics will definitely influence his or her achievement in mathematics. Zan and DiMartino (2009) suggested that it is best to consider attitude toward mathematics as a functional construct able to include different issues in mathematics learning.

Attitude towards mathematics can be defined operational as enjoying or not enjoying mathematics, liking or disliking of mathematics, willing to perform mathematics activities, seeing one as successful or unsuccessful at mathematics and believing mathematics is useful or not useful. Adediwura (2011) stated that attitude towards mathematics is a positive or neutral, or negative feelings a person have about mathematics or learning of mathematics. A person with negative attitude toward mathematics will dislike the subject, have tendency to avoid mathematical activities and will believe that mathematics is a useless subject. Therefore, any attempt to improve the teaching and learning of mathematics cannot be very meaningful if the issues of teacher and learner attitude are not considered.

The problem associated with research on attitude are concerned with what and how we observe the construct. The first problem relates to the lack of a clear definition of what is meant by attitudes towards mathematics, while the second problem relates to lack of appropriate instruments used to measure attitudes at different levels. There is a paramount need for researchers to develop and validate items for measuring the students' predisposition towards mathematics earlier in the post-primary school life. The issue at stake is on the scarcity of the instrument in junior secondary schools with our cultural background. Hence, the need for the development and factorial validation of Mathematics Attitude Inventory (MAI) for junior secondary school students in Nigeria forms the foundation of this study.

The importance of valid and reliable measuring instrument for assessing students' attitude towards mathematics has been recognized (Blackweir, 2016; Lim & Chapman, 2013). American Psychological Association, (APA, 2007) noted that validity is the appropriateness, meaningful and usefulness of the specific inferences made from test scores. Validity of a scale according to (Nworgu, 2003) referred to the extent to which a scale measures what it is supposed to measure and nothing else. Among the three main types of validity; content, construct and criterion related validity; it is only construct validity that can be used in measuring students' attitude towards mathematics. Abonyi (2005, p.45) refers to construct validity as the degree to which scores on a measure permit inference about underlying traits. Nworgu (2015, p.128), stated that reliability of a test relates to the degree of consistency or stability, which the test exhibits, it is also a measure of internal consistency estimated by Crobach's alpha coefficient. Items of an instrument are validated by subjecting them to factor analysis.

Factor analysis is a statistical procedure whereby items are grouped together according to the similarity of respondents' answers. It is a means of determining the construct validity of an instrument. It explains the correlation between a large number of items in a small number of common factors. It is used for data reduction. It ends with a table that shows the weight or loadings of the factors in each item. These factor loadings show the degree of correlation of each item of the factor and this determines the factorial validity of the items. Hence, factorial validation is a systematic examination of test items to find out the extent of variation or inter-correlation of items, in terms of their factor loading. The validation involves establishing face and content validity, pilot testing, construct validity, establishing the reliability and revision of the survey.

Purpose of the Study

The study developed and factorial validated Mathematics Attitude Inventory (MAI) for junior secondary school students. Specifically, the study sought to:

1. develop Mathematics Attitude Inventory (MAI) for junior secondary school students.
2. ascertain the construct validity of the items of MAI.
3. establish the reliability coefficient of the MAI.

Research Questions

The following research questions guided the study:

1. how valid are the items of the MAI?
2. what is the reliability coefficient of the MAI?

II. Literature Review

Attitude is an expression of a favour or disfavor towards a person, place, thing or event. It is a tendency to react positively or negatively towards any condition. It can be seen as a state of mind or someone's mindset towards a situation. Salta and Tzougraki (2011), stated that attitude can be seen as ones disposition to think, feel

or react positively or negatively towards objects in his/her environment. This shows that attitudes play a major role in the understanding of mathematics abstract and general ideas. It plays an important role in the learning of any school subject including mathematics. This is so because it touches the cognitive, affective and behavioural tendencies of the learner.

According to Mkpá (2006), attitude has a cognitive (belief), an affective aspect (feeling) and a psychomotor aspect (action). According to Within and Within (2013), what students believe about mathematics influences what they are willing to say publicly, what questions they are likely to pose, what risk they are willing to take and what connection they make to their lives outside classroom. This means that students can only pursue courses in mathematics related career, if they realize that they need mathematics application in their future career. According to Thomas (2010), many children form negative attitude towards mathematics in the early years of schooling. There is need to develop and validate items for measuring the students attitude towards mathematics especially when they are in junior secondary school. Hence, this study focused on the development and factorial validation of mathematics attitude inventory for junior secondary School Students.

Factorial validation is an ordered procedure for examining items of measuring instrument to find out the extent of variation or inter-correlation of the items, in terms of their factor loading. The validation involves establishing face and content validity, pilot testing, construct validity, establishing reliability and revision of the survey where there is need.

The importance of valid and reliable measuring instrument for assessing student's attitude towards mathematics has been recognized (Blackweir, 2016; Lim & Chapman, 2013). And to understand the impact of student's attitude towards mathematics in junior secondary School, it is essential to assess, construct reliability and validity. Nwogu (2015, p.128), stated that "reliability of a test relates to the degree or consistency or stability, which the test exhibits". Abonyi (2005), referred to construct validity as the degree to which scores on a measure permit inference underlying traits.

Items of an instrument are validated by subjecting them to factor analysis and Cronbach's alpha coefficient. Factor analysis is a statistical procedure by which items are grouped together according to similarity of respondent's answer. It is a means of determining the construct validity of an instrument. It is used for data reduction. According to Creswell (2015), there are four rigorous phases for developing instrument that accurately measures the variable of interest which includes planning, construction, quantitative evaluation and validation.

Exploratory factor analysis (EFA) is adopted for this study because it seeks to obtain the items that loaded on each factor. According to Meredith (1969), the benchmark for accepting factor loading is 0.35 and also a factor which has at least four items adequately loaded on it will be accepted as valid.

Bolaji, (2010), noted that Mathematics is a compulsory subject at both primary and secondary school levels not because the students are expected to become mathematicians rather for its application in everyday life. That is everybody needs a fundamental knowledge of mathematics in order to function effectively in our society today.

Adediwura (2011), stated that attitude towards mathematics is a positive, neutral or negative feelings a person has about mathematics or learning of mathematics. Therefore, students with positive attitude towards mathematics will like to engage in mathematical activities and will believe that mathematics is useful to them now and in future, while the students with negative attitude towards mathematics will think otherwise.

Blakweir (2016), in the University of Western Australia developed attitude towards mathematics instrument (ATMI) with likert-style responses. The instrument was validated with data collected from 263 mathematics classes of two schools in Perth. Confirmatory factor analysis was used to analyze the result which assessed the extent gender, age and achievement were consistent across different groups of students in terms of enjoyment, confidence in and perception of the value of mathematics. The result indicated that boys of all ages held more positive attitude towards mathematics than girls. This study is related to the present one in development of mathematics attitude inventory. It however, differs from the present study in area of study, method of data analysis, cultural background and level of students. The present study included peer pressure influence as a sub-scale which is not in the study under review.

Lim and Chapman (2013) used 1601 students in Singapore to develop and validate a short version of attitude towards mathematics inventory (ATMI) which was original work of Tapia and Marsh (2004). Many items were found redundant because it was difficult to differentiate some items. After factor analysis, the original instrument was reduced to 15 items which covered three factors; namely enjoyment, self-confidence and value. Recommendation from this study included further investigation using samples from other culture and schooling level. This study is related to the present study in development and validation of mathematics attitude inventory. It differs from the present study in cultural background, group of students and number of sub-scales.

Kolawole and Kojigili (2014), developed and validated a self-concept and attitude scale for senior secondary schools students in Nigeria. A sample of 960 students was obtained from 32 secondary schools from four of the six states of Northeast Nigeria. A total of 45 items finally emerged from 60 items for use in public and private secondary school students in Northeast Nigeria. The instrument developed is titled Mathematics

Self-concept and Attitude Scale (MSCAS) and is recommended for use. Its reliability coefficient is 0.937. This study is related to the present study in terms of inventory developed and method of data analysis, though it differs in cultural background, sub-scales and level of students used.

Okeaba (2016), developed and validated the inventory for students' integration into university academic culture (ISIUAC) in Anambra State. The study employed an instrumentation design. An initial draft of 58 items was reduced to 27 items after factor analysis. The 27 items were finally administered to 1000 students for reliability test and norming. The instrument ISIUAC is recommended for assessing student's integration into the University culture. It has reliability index of 0.926. This study is related to the present study in research design and method of data analysis. They however, differ in the area of study, level of education and type of instrument developed.

In summary, the reviewed literature indicated that mathematics knowledge is essential for everyone to make useful contribution towards the development of his/her environment and the society. Reform in mathematics education will not be successful if students' attitudes on mathematics are not improved considerably. Research evidence show that there is scarcity of valid, relevant and reliable instrument for measuring students attitude toward mathematics in Nigeria Junior Secondary School education. Hence, this study seeks to bridge the gap by developing and validating mathematics attitude inventory (MAI) for junior secondary school students.

III. Method

The study adopted instrumentation research design since it is geared towards developing and validating Mathematics Attitude Inventory (MAI) for junior secondary school students; hence, the design is deemed suitable for the present study. The population for the study consisted of all the 5,714 students in the state owned junior secondary schools two (JSS 2) in Umuahia education zone, Abia state for the 2017/2018 academic session. The sample of the study consisted of 1000 students. The proportionate stratified random sampling was adopted to ensure that subgroups in the population participated as they existed in the population.

The instrument was developed through the following steps according to Chime (2012):

- definition of construct and determination of domain content;
- Items development and judgement of appropriate items for the study;
- Pilot testing of the instrument;
- Identification of appropriate sample of the population.

A total of 50 items were generated for the instrument, MAI. The 5-point Likert scale of strongly disagree (1), disagree(2), undecided (3), agree (4) and strongly agree (5). Five factors of attitude were considered during development and these include: enjoyment, value, motivation, peer pressure and self-confidence. The item statements are meant to ascertain how the factors affect students' attitude towards learning mathematics. A rating guide developed by the researcher was used in measuring the extent each factor affects the students' attitude towards learning mathematics.

The preliminary validation of the MAI was done by two experts in measurement, evaluation and research and an experienced lecturer in mathematics education. Their suggestions were used in modifying the instrument. After trial testing, the 47 items that survived were subjected to factor analysis using Statistical Package for Social Sciences (SPSS) version 23.0 computer software. A total of 22 items were loaded on four factors using Meredith (1969) as a bench mark of 0.35 and above. Moreover, a factor which has at least four items adequately loaded on it is accepted as valid.

IV. Results

Research Question One

How valid are the items of the MAI?

Table 1: Factorial loadings on the validity of the items in MAI

Factor 1 Enjoyment		Factor			
		1	2	3	4
1.	Mathematics is a difficult subject.	0.752			
2.	I fear solving mathematics problems.	0.825			
3.	I practice mathematics on my own.	0.850			
4.	Mathematics is boring.	0.709			
5.	I am under a terrible fear during mathematics test.	0.882			
6.	Mathematics is my favorite subject.	0.772			

Factor 2: Value		
7.	I am always late to mathematics lesson.	0.559
8.	I do my assignment on mathematics regularly.	0.879
9.	I would like mathematics to be optional.	0.884
10.	Mathematics is highly needed in my career in life.	0.781
11.	I do not hesitate in doing my mathematics assignment.	0.846
12.	I would like a job which doesn't use any mathematics.	0.923
13.	There is little need for mathematics in most jobs.	0.754
Factor 3: Peer Pressure		
14.	My friend's inability to solve mathematics problem makes me fear the subject.	0.859
15.	I play truancy during mathematics lessons because my friend stays away from the class during mathematics lesson.	0.842
16.	My friend's ambition to learn mathematics spurs me in studying mathematics.	0.628
17.	My friend's belief that mathematics is a difficult subject makes me hate it.	0.988
18.	My friend makes me to hate mathematics by always saying it is difficult to pass it.	0.819
Factor 4: Self-Confidence		
19.	Mathematics is one of my most dreaded subject.	0.744
20.	I am unable to think clearly when doing mathematics.	0.836
21.	Mathematics makes me feel uncomfortable.	0.542
22.	I am always confused in mathematics class.	0.941

Table 1 showed the summary of factor analysis of mathematics attitude inventory items from the rotated component matrix, not shown here. It can be seen that four factors were extracted. The factors/subscales include enjoyment, value, peer pressure and self-confidence. Motivation subscale was dropped because of its high correlation with enjoyment subscale. Based on this, items without factor loading up to 0.35 were considered factorial impure and not selected, while items with factor loading 0.35 or more, on more than one factor is considered factorial complex and thus not selected too. A total of 350 students were used for the validation. The trial testing of the instrument was done on 100 students outside the area of the study. The form teachers of the classes were used for assistance. The scores of the students were also used for content validity.

Research Question Two

What is the reliability coefficient of MAI?

Table 2: Reliability coefficient of MAI using Cronbach Alpha

S/N	Scales	Items	Reliability coefficient
1	Enjoyment	1, 2, 3, 6, 8, 12	0.853
2	Value	13, 14, 16, 18, 20, 21, 23	0.778
3	Peer pressure	25, 26, 29, 33, 35	0.709
4	Self confidence	36, 38, 40,45	0.881
	Entire instrument		0.805

For the establishment of internal consistency reliability coefficient, SPSS 23.0 computer software was used. Crobanch's alpha reliability was used to determine the internal consistency reliability coefficient of the items.

From the above table 2, the summary of the internal consistency coefficient of the MAI items using Crobanch's alpha reliability ranges from 0.709 to 0.881. The overall internal consistency reliability coefficient is 0.805. This is high, indicating that the instrument is reliable.

V. Discussion of the Findings

The exploratory factor analysis (EFA) involved checking the univariate and multivariate normality within the data because it is the requirement for factor analysis (Child, 2006). Principal component analysis extracted maximum variance from the data set with each component. This reduced the large number of variables to a smaller number of components for better interpretation; factors were rotated using varimax with Kaiser Normalization. Varimax rotation which is arthogonal rotation was used for this study. It minimized the number of variables with high loadings on each factor and made small loading even smaller. Items with factor loadings

below 0.35 or less than four items were eliminated. Hence, out of 47 items, 25 items were deleted while 22 items were retained.

Table 1 showed the factor reduction procedures. There are four factors with 22 items. Factor 1 represents enjoyment with 6 items, factor 2 represents value with 7 items, factor 3 represents peer pressure with 5 items and finally factor 4 represents self-confidence with 4 items.

Enjoyment is the state or process of taking pleasure in something. Items 3 and 6 show that some students have pleasure in mathematics which is positive attitude toward the subject; while items 1,2,4 and 5 show negative attitude towards mathematics. These negative attitudes will make the students to perform poorly in mathematics test. Therefore, lack of enjoyment in mathematics affects student's performance in both internal and external examinations.

Value can be seen as importance, worth or usefulness of something. Items 7,9,12 and 13 shows that some students do not know the importance of mathematics in their life now or in future. This is negative attitude towards mathematics while items 8,10 and 11 show positive attitude towards mathematics.

According to Bankole and Ogunsakin (2015) a peer group is defined as a small group of similarly aged, fairly closed friends, sharing the same activities. Harris (2009) noted that peer pressure are more influential on shaping attitudes than parents and teachers, therefore, within a particular peer groups attitude towards educational aspirations are likely to be similar. This negative influence of peer pressure in mathematics can be seen on items 14,15,17 and 18 while item 16 shows positive influence in mathematics. This is in line with Harris (2009) who noted peer pressure influence in shaping student's attitude.

Self-confidence is ones understating that he/she trusts his/her own judgment and ability. It is also a feeling of trust in one's ability, quality and judgment. All the items on self-confidence; items 19,20,21 and 22 show that the students do not trust their own abilities in solving mathematics problems. This is negative attitude towards mathematics which influences the student's poor performance in mathematics examinations.

Table 2: Reliability coefficient of MAI using Cronbach's Alpha

Table 2 represents the reliability coefficient for each element of the Mathematics Attitude Inventory (MAI). According to Nworgu, (2015) the reliability of a test relates to the degree of consistency or stability which the test exhibits. The internal consistency of this study was estimated using Cronbach's Alpha. The table 2 shows that the composite reliability of factors, enjoyment, value, peer pressure and self-confidence are 0.853, 0.778, 0.709 and 0.881 respectively while the overall reliability is 0.805. Hence, the convergent validity of the four factors is adequate. This means that the four factors represent the attitude of junior secondary school students' attitude towards mathematics. Internal reliability is used to find the internal consistency of the items. It also determines if items that form the scales are measuring a single idea. In this study Cronbach's coefficient alpha, the most popular indicator of internal consistency was used to evaluate the reliabilities of the instrument. Nunnally, (1978) recommended that an acceptable level of coefficient alpha for a reliable scale is at least 0.70. The higher the correlation greater the reliability of the instrument. Hence, the factors were reliable.

One of the limitations of this study is that heterogeneous population of students was used and it is assumed that they did not have equal attributes in terms of cognitive, affective and personality functioning of their abilities. This could be the reason why some items and sections had no answers. The MAI can provide feedback to the researchers and mathematics teachers about the attitude of students towards mathematics.

VI. Recommendation

The following recommendations are made based on the findings:

1. The teachers should use the instrument to assess the students' attitude towards mathematics. As they identify the factors that affect the students' negative attitude towards learning mathematics, they will now be in a better position to address the issues. They will use it to help the students form positive mindset on mathematics, since it is very important to them now as students and in their future careers. With the instrument the teachers should realize that affect domain is as important as cognitive domain in improving students' performance in mathematics.
2. The school guidance counselors will find the instrument a necessary tool for measuring the attitude of students who have mathematics phobia. The result from the measurement help them to advise the students properly. Thereby, helping them to form positive attitude towards mathematics. This in turn will increase students' high performance in both internal and external mathematics examination.
3. The students should use the instrument for self-examination. As they discover where their problems are coming from, they can now readjust. When the attitude is improved upon or strengthened, performance would improve on the part of the students.
4. The researchers should use it as instrument for data collection. It will also help them in developing other instrument in mathematics.

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