

DEVELOPMENT AND VALIDATION OF MATHEMATICS ACHIEVEMENT TEST FOR PRIMARY SCHOOL PUPILS

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ABSTRACT : *The aim of this study was to construct and validate a mathematics achievement test for primary six school pupils, Four research questions were employed in constructing the study. The design of the study is instrumentation research design. Using random sampling technique via balloting 10 primary schools was drawn from 54 primary schools in Obio Akpor L.G.A. Through stratified random sampling technique 858 primary six pupils were drawn from the population of 2928 primary six pupils from Obio/Akpor L.G.A. The Form I MAT was face-validated in terms of clarity of words and plausibility of distracter by specialist in Educational Measurement and Evaluation and mathematics teachers. The Form II MAT consist of what was administered to 858 pupils and their response were used in determining proportions of pupils who showed mastery ability. The findings of this study show that the MAT is a valid and reliable instrument for measuring achievements in mathematics tests.*

KEYWORDS: Test, Mathematics achievement test, development and validation.

INTRODUCTION

Mathematics is the foundation for the economic and technological development of any nation. It has been asserted that without mathematics there cannot be any modern developed Society (Ukeje, 2005). This accounts for the reason why Mathematics is made a compulsory subject at the Primary and Secondary School levels in Nigeria (Federal Republic of Nigeria, 2008). Thus, mathematics is expected to help in accelerating social, economic and technological progress of any Society. The final analyses depend on the effective teaching and learning of mathematics in schools. Mathematics is the gate and key of the Science. Mathematics is a Science by any criterion, an efficient and necessary tool used for all Sciences like Physics, Chemistry, Engineering and Medicine. It could be aptly remarked as “Mathematics is a Science of all Sciences and Art of all Arts” (Jayanthi, 2014). Mathematics is considered to be the father of all sciences. Napoleon remarked that- “*The progress and improvement of mathematics is linked to the prosperity of the state*” (Mahanta & Islam, 1989). Numerical ability test are designed to measure the candidate’s

capacity to manipulate the use of numbers to correctly solve problems (Ann, 2004; Olatoye & Adekoya, 2011).

Academic achievement in mathematics seems to be one of the predictors of people's success in their career. Achievement in Mathematics is important in order to understand how society functions. Mathematics is significant in our daily life. The need for high quality professional development program in mathematics and science have become increasingly important in the current climate of educational reform (Blank, Alas, & Smith, 2007). Mathematics is an important school subject because it is associated with more academic and career opportunities (Akinsola and Tella, 2003). Burton cited in Agwagah and Usman (2003) relates the importance of mathematics to the scientific, industrial, technology and social progress of a society. All these account for the reason why mathematics is made compulsory at the first and the second level of education.

The primary school level is very important in any educational system because it is the first level of education, any default at this level would permeate to other levels of the educational system. To realize the objectives of teaching mathematics at any level of the educational system in the Society, there is need to monitor and maintain the quality of the educational processes and products. One major way of monitoring the quality and standards of the teaching and learning of mathematics in schools is through the assessment of the learning outcome of the pupils, which is via a good quality test. Tests and other evaluation instruments are used during the instructional process to guide, direct, and monitor students' learning progress towards the attainment of the course objectives (Alonge, 2004; Kolawole, 2010). This monitoring of learning achievements in mathematics involves the processes of testing, measurement, assessment and evaluation.

Some teachers see assessment as an isolated activity from the teaching and learning processes of the pupils without utilizing the goals and benefit of assessment in the classroom. Some of the teachers see assessment mainly for the purpose of grading the pupils. Nigeria teachers do not seem competent enough to develop the desired instruments necessary for the effective operation of the continuous assessment. These instruments as at present do not exist in many primary school subjects including Mathematics. The study is carried out to construct a valid and reliable test in mathematics for primary school students. It has been observed that most teachers are not good in constructing test in their various subject areas. The constructed test will serve as a major contribution to the need for valid and reliable Mathematics Achievement Test (MAT) in primary schools. One of the greatest problems in the primary schools in Nigeria is that teachers after assuming to have covered the mathematics curriculum would resort to assessing students with unreliable Mathematics Achievement Test that lack psychometric properties. Most teachers hurriedly copy questions from any past question paper to compose their summative achievement test. As a result, teachers do not establish validity and reliability for such test. The unreliable Mathematics Achievement Test administered during the primary schools' examination, is often used to assess students. The use of poorly designed Mathematics Achievement Test (MAT) is a major problem as it affects students' interest and achievement in Mathematics. It has already been pointed out that poorly designed tests could make the students loose interest in a particular subject (Osadebe, 2001; Ohuche & Akeju, 1998), and beside lead to wrong assessment and decision on pupils' performance on the subject. Primary school education is the foundation to other educational

levels and as such constructing test that are not highly valid will be detrimental to the advancement of other levels of education as mathematics plays a fundamental role in Education.

Therefore, there is the need for experts to construct enough valid and reliable tests with psychometric properties, for use in primary schools. It is not uncommon that primary school students score poorly in examination. They are often assessed with poorly prepared Achievement Tests. The content areas of their tests in Mathematics are not spread out to cover the content of mathematics curriculum

The construction and validation of a mathematics achievement test (MAT) is a criterion referenced mastery test, which is aimed at determining the degree of mastery attained by primary five school students in mathematics tests. Most Nigeria mathematics teachers employ Norm-referenced tests in assessing their students' performance. It is of great necessity for specialist in educational measurement and evaluation constructs and validate test of mathematics for use in evaluating student's mastery tests in primary schools. In developing and validating a mathematics test (MTs) it is important for the test developer to have in mind the type of standardized achievement test to be developed.

Mathematics test are important tools in studying mathematics and mathematics related courses. This explains why the Federal Republic of Nigeria (FRN) adequately emphasized students' acquisition of skills in most educational documents. However, despite the usefulness and important of mathematics test which was attached on the acquisition of these criterion referenced mastery tests, there is scarcity of valid and reliable test for evaluating students proficiency in the tests. Most teachers do not seem competent enough to develop valid and reliable assessment instrument in primary mathematics subject. This then implies that these teachers may have been relying on incorrect data generated with faulty instruments. In this regards primary school mathematics teacher are not exceptions. This is because most of the test for assessing performance in classroom situation is Teacher-made test, and these are test usually constructed by classroom teacher who are non-experts, the items are poorly written and lacks psychometric properties, and as such the quality of the test is not known.

The lack of existence of standardized test items, which are constructed by expert with good quality such as the validity and reliability of the instrument, for assessing achievement in most of the school subjects including mathematics in Nigeria primary schools possess a great problem in all subjects, including Mathematics Achievement Test. In this regards primary school mathematics teachers are not exceptions, one valid way of tackling the problem of this study, that is scarcity of valid and reliable test for evaluating pupil's proficiency in this study is the development and validation of Criterion referenced test in mathematics for evaluating pupil's mastery of the mathematics test.

The following research questions guided the study.

1. What is the content validity index (CVI) for the mathematics test?
2. What is the cut-off score of the mathematics achievement test.?
3. Determine reliability coefficients of the test measuring the various mathematics test?
4. Establish the difficulty, distracter indices of the mathematics test?

METHODS

The study was conducted using instrumentation. Instrumentation research is defined by Kpolovie (2010, p.467) as the science of test development. Instrumentation research is employed for test construction if test is used for measuring and evaluating psychological traits, it therefore follows logically that without instrumentation research, human abilities or social and psychological constructs cannot be satisfactorily measured and evaluated. This shows how crucial and indispensable an overview of instrument research is

Population for the study comprised all the primary six pupils in public primary schools in Obio-Akpor Local Government Area in Rivers State. The researcher decided to use primary six pupils, reasons been that primary school is the foundational level of any educational attainment, which forms a basis for mathematics related courses. The population of these pupils in 2014/2015 academic session is 2928. (Source: Obio-Akpor L. G. A. Education Authority).

A sample of 858 primary six pupils was used for the study. The researcher used simple random sampling technique via balloting to draw 10 primary schools from 54 primary schools in Obio-Akpor L.G.A. Then stratified random sampling technique was used to draw 858 primary six pupils from the population of 2928 primary six pupils from Obio-Akpor L.G.A. The instrument for this study is titled "Mathematics Achievement Tests" (MAT) for primary six pupils. This Mathematics Achievement Test was based on five sections of mathematics curriculum for primary six pupils. Items were constructed on: 1. Number, 2. Fractions, 3. Profit and loss, 4. Distance, speed and time, 5. Lines, angles & triangles

Test items constructed on each mathematics test is based on, the cognitive domain specifications. The following Procedures would be considered in this study, for development and validation of criterion-referenced test, they are; Specifying of the content outline, Specification of the domain, Determination of test formats and length, Building the test blueprint, Item writing, Face validation of the items, Establishing content validity, Determination of cut-off point, Pilot testing, Statistical item analysis, Item selection, Item arrangement, Final administration, Production of test.

The 50 multiple choice objective item MAT developed was face validated by five experts in educational measurement and evaluation and experience mathematics teachers for clarity and ambiguous item removed. The face-validated items were submitted to two content experts who jointly rated the items relevance in terms of how closely related they match the objective or cognitive specification.

The following procedure was adopted in analyzing the data of this study.

1. The content validity index (CVI) of Mathematics achievement test was computed based on the joint ratings by two specialists.
2. Cut- off point: In order to decide whether a pupils has mastered an objective or not we need to see whether he/she has met the standard of minimal acceptable performance that would constitute mastery. This was done using Angoff method.
3. The reliability coefficient of the mathematics was established using test –retest method
4. The difficulty, and distracter indices of Mathematics Achievement Test was computed using their respective formula.

Difficulty Index

The formula is given as; $D = \frac{U+L}{NU+NL}$

Where D = difficulty index

U=Number in group meeting criterion who answered correctly

L= Number of group not meeting criterion but answered correctly

N_u= Number in group who met criterion

N_L= Number in group not meeting criterion.

Distracter Index

The formula is given as: $D_1 = \frac{X_1-V_L}{NU+NL}$

Where D₁ =Distracter Index.

X₁ = Number of students which did not meet criterion and not answer the item correctly.

V_L= Number of students who met criterion but did not answer the item correctly.

While N_u and N_L retains their former interpretations

RESULTS

The results of the data analysis are shown in the tables below

Research Question 1:

What is the content validity index (CVI) for the mathematics test?

The content validity index (CVI) of Mathematics Achievement Test was computed based on the joint ratings of relevance of MAT items by two content specialists.

Table showing Joint ratings of the relevance of MAT items, by two content specialists. Rating on 50 items relevance of MAT.

Specialist 1

		Item rated 1&2	Item rated 3&4	TOTAL
Specialist 2	Items rated 1&2	(a) 4	(b) 8	a+ b=12
	Items rated 3&4	(c) 6	(d) 32	c+ d=38
	TOTAL	a+c= 10	b+d=40	a +b+c+d=50

This was carried out using a 4-point rating scale,4 stands for very relevant,3 stands for quite relevant,2 stands for somewhat relevant, and 1stands for not relevant.

- Cell 'a' indicates number of items rated 1&2 by first and second content specialist.
- Cell 'b' indicates the number of items rated 3&4 by first content specialist and then 1&2 by second content specialist.
- Cell 'c' indicated the number of items rated 1&2 by first content specialist and then 3&4 by the second specialist.
- Cell 'd' indicated the number of items rated 3&4 by both content specialists.

Thus, $CVI = \frac{b+d}{a+b+c+d} = \frac{40}{4+8+6+32} = \frac{40}{50} = 0.80$

This implies that 80% of items which is equivalent to 40 items out of 50, as they were rated quite relevant and very relevant to the component objectives.

Research Question 2

What is the cut-off score of the mathematics achievement test.?

The cut-off score was determined using Angoff method. Where panel of experts, examine every item on the test and estimate the percentage of the minimally acceptable cut- off score.

Table 4.2 Determination of cut-off score using Angoff method.

TEST ITEM	EXPERT 1	EXPERT 2	EXPERT 3	EXPERT 4	EXPERT 5	AVERAGE PERCENTAGE
1	75	60	45	60	50	58
2	50	60	50	60	55	55
3	55	50	55	55	60	55
4	60	65	40	55	60	56
5	55	50	55	60	50	54
6	60	60	40	60	50	54
7	50	40	30	55	45	44
8	65	55	60	50	50	56
9	60	50	50	55	60	55
10	50	50	50	50	50	50
11	55	55	60	50	55	55
12	60	50	60	45	55	54
13	65	40	60	55	60	56
14	65	50	65	55	60	59
15	50	50	55	45	50	50
16	55	60	50	50	50	54
17	55	60	50	50	50	54
18	40	50	55	50	50	49
19	50	50	50	50	50	50
20	70	50	50	55	70	59
21	55	50	60	55	50	54
22	55	50	50	55	60	54
23	55	60	50	50	55	55
24	50	50	60	55	55	55
25	60	60	60	50	40	54
26	50	60	50	50	60	54
27	60	55	60	50	50	55
28	60	55	65	60	60	60
29	40	50	50	50	50	48
30	60	55	55	50	60	56
31	60	50	55	55	55	55
32	55	50	55	55	60	55
33	50	60	60	50	60	56
34	60	50	55	50	55	54
35	60	60	55	60	65	60
36	55	50	55	55	60	55
37	55	50	45	50	50	50
38	50	45	40	55	50	48
39	60	60	50	50	50	54
40	50	60	50	55	60	55
41	55	60	50	50	60	55
42	50	55	50	60	60	55
43	60	45	55	40	50	50
44	50	60	60	50	60	56
45	60	55	55	55	50	55
46	55	55	50	55	55	54
47	55	60	50	50	55	54
48	50	50	40	50	50	48
49	50	60	50	55	60	55
50	55	50	60	55	50	54
CUT-OFF SCORE						54.

In determining the cut-off score using Angoff method, each of the expert examine, every item on the test, with regards to item content, in order to determine the maximum number of items an examinee must answer correctly in order to be considered in the mastery group. The sum of the percentage across the set of items was computed by the five experts and the average of the scores across all the experts were used to establish a minimally acceptable performance for the MAT. A cut-off score of 54% was reached for the MAT. In the item selection, 10 out of 50 MAT items, which constitute 20% of the 50 MAT items, were dropped on the bases, that they did not meet the cut-off score, as they were rated less than 54% by the experts. The remaining 40 MAT items were

rated 54% and above, which imply that 80% of the 50 MAT items were relevant, and as such was selected for the final study.

Research question 3

What is the reliability coefficient of the mathematics achievement test?

To answer the research question test-retest method was used for the computation of the data, using the three statistics such as P_o , k and P_c which stands for P_o determines the degree of agreement of decision made on two administrations of a test, k measure degree of agreement uncontaminated by chance. While P_c measures the proportion of individual to have consistent classification. These were computed using Data obtained from the 858 students in MAT based on their score

Table 4.1: showing decision based on test 1 & 2.

TEST	TEST 1				P_o	K	P_c
		MASTERY	NON-MASTERY	TOTAL			
2	MASTERY	A (398)	B (107)	505	0.73	0.46	0.50
	NON-MASTERY	C (121)	D (232)	353			
	TOTAL	519	339	858			

The reliability coefficient of the Mathematics Achievement Test (MAT) was computed using test-retest method, with three statistics P_o , P_c and K . the data obtained from the 858 students in the Mathematics Achievement Test based (MAT) on their scores shows that 398 students were consistently classified as masters, 232 were consistently classified as non-masters, 107 were classified as non-masters, in test form 1 and masters for test form 2, while 121 were classified as masters in the test form 1 and non-masters in test form 2. From the study the $P_o = 0.73$, $K = 0.44$ and $P_c = 0.52$. The computation of P_o , K and P_c .

Research Question 4

What are the difficulty and distracter indices of the Mathematics Achievement Test?

After scoring and collating the pupils were group under mastery and non-mastery group base on their total scores in relation to the cut-off point of 54%. Therefore, the difficulty index and distracter were computed. The results obtained are as presented in table 4.4

Table 4.2: Difficulty and distracter index of the MAT items.

ITEMS	DIFFICULTY INDEX	DISTRACTED INDEX			
		A	B	C	D
1	0.62	0.02	0.02	0.05	**
2	0.57	0.04	0.00	**	0.10
3	0.49	0.02	0.04	**	0.21
4	0.50	0.02	0.08	0.03	**
5	0.68	**	0.01	0.02	0.00
6	0.49	0.06	**	0.03	0.04
7	0.40	0.05	**	0.03	0.04
8	0.62	0.00	0.02	0.04	**

9	0.33	0.03	**	0.02	0.03
10	0.35	0.04	0.04	**	0.03
11	0.58	0.01	0.01	**	0.03
12	0.64	0.00	0.02	0.03	**
13	0.28	**	0.03	0.02	0.01
14	0.57	0.00	0.02	**	0.01
15	0.38	0.06	0.00	**	0.01
16	0.66	0.03	0.03	**	0.00
17	0.37	0.02	0.07	0.05	**
18	0.39	0.03	**	0.02	0.04
19	0.54	0.02	0.03	**	0.02
20	0.62	**	0.03	0.02	0.02
21	0.43	0.05	0.01	0.01	**
22	0.64	0.02	0.04	**	0.02
23	0.48	0.01	**	0.02	0.45
24	0.55	0.03	0.02	**	0.02
25	0.36	0.02	**	0.02	0.01
26	0.56	**	0.03	0.02	0.04
27	0.36	0.03	**	0.06	0.04
28	0.36	0.02	0.02	0.01	**
29	0.52	**	0.03	0.04	0.04
30	0.27	0.02	0.01	0.00	**
31	0.31	0.01	0.00	**	0.01
32	0.60	0.05	0.02	**	0.04
33	0.60	0.03	0.02	0.05	**
34	0.38	0.05	0.04	-0.06	**
35	0.35	0.04	0.01	**	0.03
36	0.49	0.02	0.02	0.03	**
37	0.38	0.04	0.03	**	0.04
38	0.40	0.05	0.03	0.04	**
39	0.47	0.02	**	0.02	0.06
40	0.58	0.03	**	0.01	0.03
41	0.55	0.03	0.02	**	0.03
42	0.33	**	0.02	0.03	-0.05
43	0.40	0.03	**	0.04	0.03
44	0.29	0.03	0.01	0.00	**
45	0.33	0.02	0.04	0.07	**
46	0.52	0.03	0.03	0.02	**
47	0.47	0.03	0.00	0.05	**
48	0.62	0.02	0.05	**	0.02
49	0.54	**	0.00	0.01	0.10
50	0.40	0.02	**	0.02	0.02

** = key option

From Table 4.4, the value of difficulty index lies between 0.27 and 0.68. Item number 5 has the largest value (0.68) and item number 30 has the smallest value (0.27). Item difficulty indices MAT relates to the percentage or proportion of students answering each item correctly. The difficulty indices shows prepared items had an average difficulty. Only five items were found to be easy. The indices were used in arranging MAT items according to their increasing order of difficulty

DISCUSSION OF FINDINGS

The Content Validity Index (CVI) was computed based on the joint ratings of the relevance of MAT items by two test experts/subjects specialists. Thus, based on the ratings obtained from the two raters a value of 0.80 was obtained which indicates 80% of the 50 MAT items were rated relevant by the specialists. This is in line with Otuoku (2009), whose Content Validity Index (CVI) was also computed using joint ratings of the relevance of mathematics test items by subjects specialists based on their ratings obtained from two raters a value of 0.74 was obtained also Jayanthni (2014) researched on development and validation of achievement test in mathematics, had validity coefficient of 0.942.

The cut-off scores of the mathematics test were established by using Angoff method. The cut-off score are computed as shown in table 4.2 which indicate that the cut-off score of the mathematics test as 54%. This study is in agreement with the finding of Otuoku (2009), where he had a standard of minimally acceptable performance of 45%, where he used Contrasting group's method to established minimally acceptable performance of 45% as cut- off score in the Development and Validation of Mathematics (MT) Test for SS1 Students.

The reliability coefficient of the Mathematics Achievement Test (MAT) was computed using test-retest method, with three statistics P_o , p_c and k . the data obtained from the 858 students in the mathematics achievement test based (MAT) on their scores shows that 398 students were consistently classified as masters, 107 were classified as non-masters in test form 1 and masters in test form 2, 121 were classified as masters in test form 1 and non-masters in test form 2 while 232 were classified as non- masters in test 1&2.

This is in line with Otuoku (2009) findings using the three statistics $P_o = 0.55$, $K = 0.12$, and $P_c = 0.49$. The difficulty indices of MAT items range from 0.27 to 0.68. All the distracters of items possess positive except item 34. This is in agreement with Jayanthni (2014) researched on development and validation of achievement test in mathematics. The study aimed at developing and validating an achievement test in mathematics for high school students of standard 10 in Chennai district in India. 150 multiple choice objective test items were developed from 10TH Standard Mathematics syllabus. The answer sheets were evaluated and marks were prepared to perform item analysis though the result shows the value of facility index lies between 0.20 and 0.78. Item number 19 has largest value 0.78 and item number 139 has smallest value 0.20. Essien (2007) Researched on development and validation of a test on geographic skills (TOGS) for senior secondary schools. The study aimed at constructing and validating multiple-choice objective test items on the geographic skills emphasized in SSII syllabus on geography. In carrying out the research, 14 items were developed and had a difficulty indices range from 0.18-0.75

Muhammad, Zeeshan, Muhammad & Ali Akbar (2012) researched on the Development and Validation of an Aptitude Test for Secondary School Mathematics Students in Pakistan. The study shows the value of difficulty index lies between 0.13 and 0.83. Item number 22 has the largest value (0.83) and item number 23 has the smallest value (0.13). Otuoku (2014) researched on development and validation of mathematics test for SS1 students. The study aimed at constructing and validating a mathematics test. The study show the value of difficulty indices of mathematics test items ranges from 0.111 to 0.981 all the distracters of items possess positive value

CONCLUSION

The Mathematics Achievement Test is a valid evaluation instrument. The content validity index (CVI) was found perfect. Based on the numbers obtained from 2 raters, the value of CVI was 0.80, this was carried out on a 4-point rating scale very relevant, quite relevant, somehow relevant, and not relevant.

The Mathematics Achievement Test (MAT) was found to be highly reliable with three statistics P_o , P_c and k . the computation shows that $P_o = 0.73$, $P_c = 0.52$, and $k = 0.44$. The Mathematics Achievement Test (MAT) was found to be of appropriate difficulty index and distracted positively. The Mathematics Achievement Test items are suitable test items. The suitability of the items was a function of the average rating score accorded each item of the appropriateness of each item

RECOMMENDATIONS

Based on the findings of the study, the following recommendations were made;

1. Teachers, researchers and relevant educational agencies should always establish the content validity index of any instrument they develop, for measuring educational achievements in order to ensure the items are valid that is, relevant to the course objective.
2. There should always be established cut-off scores or a predetermined proficiency level by teachers and relevant educational agencies, in order to determine mastery level of the specified objectives
3. Teachers, researcher and relevant educational agencies, should ensure that the instrument they develop for measuring achievements is reliable, as instrument of measuring achievement are used in decision making of achievement of pupils.
4. Teachers, researchers and relevant agencies, should always carry out item analysis in order to determine the difficulty, distracter indices of each of the items, especially when carrying out achievement test. This is recommended because items that are too difficult or too easy are not effective for measuring achievements, items of average difficulty are more appropriate

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