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Test construction and validation procedures of senior secondary schools' mathematics teachers of Kano Central Senatorial District, Nigeria

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Abstract

The purpose of this study was to assess competence in test construction and validation procedures of senior secondary schools' mathematics teachers of Kano Central Senatorial District, Kano State, Nigeria. The study adopted survey design. The population of the study was 864 mathematics teachers. A sample of 110 mathematics teachers was drawn using Research advisor table for determining the sample size with 0.05 degree of accuracy at 95% confidence level. Simple random sampling technique was used for the study. The instrument for data collection was Mathematics Test Construction and Validation Questionnaire (MTCVQ). Cronbach alpha was used to determine the reliability coefficient of 0.76. The data collected were analysed using descriptive and inferential statistics. Mean and standard deviation were used to answer the research questions, while Independent sample *t*-test and Analysis of Variance were used to test the hypotheses. Findings revealed that, test construction procedure of mathematics teachers based on professional training (t=5.800, p-value=0.000), years of working experience (F=3.045, p-value=0.032) and validation procedure of mathematics teachers based on school type (t= -2.381, p-value=0.019) was significant. It further revealed that, validation procedures did not differ significantly based on educational qualifications (F=1.617, p-value=0.190). It was recommended among others that both trained and untrained mathematics teachers should put these basic and fundamental test construction and validation procedures mentioned in this study which formed the items in the questionnaire into practice.

Keywords

Mathematics teachers, test construction, validation.

INTRODUCTION

Mathematics is one of the leading core and compulsory subjects in primary, junior and senior secondary schools' curriculum. Sani and Salahuddeen [1] opined that the knowledge of Mathematics is needed if students are to achieve high scores in the sciences. Most students choose Mathematics subject in the senior secondary school because of their interest, ability and its relevance to their future careers. The activities selected in the teaching and learning of Mathematics must nurture plenty of student activities and acquisition of learning skills [2]. Mathematics teachers' competence in test construction and validation procedures at senior secondary schools will help students in tertiary institutions to study Mathematics and other science related courses. The constructed valid and reliable test done by senior secondary schools mathematics teachers contributed alot to the

achievement of students in senior secondary schools and tertiary institutions in the future.

Mathematics achievement test is one which is designed to measure knowledge, understanding or skill in specified subject or group of subjects. The achievement tests give reliable information regarding the decisions taken in the context of mathematics education [3]. Most teachers set Mathematics achievement test questions only on the immediate or most recent weeks or term's work and ignore the rest. Therefore, achievement test questions in Mathematics should be valid and reliable when the questions make a fair coverage of the topic and performance objectives emphasized in the Mathematics curriculum. The constructed test will serve as a major contribution to the need of valid and reliable Mathematics achievement test in senior secondary schools [4]. It is only with this that the students' achievement in the test or examination will be meaningful and relevant [5]. This can be achieved when the Mathematics teachers are competent in test construction and validation of test items.

Test construction is the set of activities involved in evaluating the effectiveness and functionality of the test items. The importance of tests in the educational system is enormous, as it provides a platform by which any significant educational objectives can be achieved [6]. The competency in test construction is an essential tool needed by every teacher if learning and instructional objectives are to be effectively attained [7]. Test construction competency in Mathematics involved constructing a quality tests based on the principles of test construction. This test is designed to assess how much of the content of a course an individual has learned over a period of time [8]. Therefore, before constructing the Mathematics achievement test, the teacher/constructor should analyses the various tests available for testing in the field of Mathematics.

Mathematic test construction competency and teaching material used for constructing valid and reliable tests are one the tool that can be used to evaluate the teachers' competent in test construction. Every classroom teacher is expected to be an expert in the construction of good test items for class assessments. Teachers who served as facilitators of knowledge must have the ability in measuring learning achievements with accuracy [9]. A good test is prepared through a systematic process. The process of Mathematics test development according to Reena and Anisha [3] was completed through five basis steps namely: test conceptualization, test construction, item scoring and analysis, reliability and validity and test standardization. Osadebe [4] construct test with procedures such as planning, item writing, item analysis, composition of items, test theory, reliability, printing and manual preparation. These procedures used to identify the content area, format and table of specification on the test.

Test validation is an ongoing process of determining the appropriateness of the test items whether it meet the criterion of the test construction or it does not meet the criterion. The validity of a test refers to whether the test measures what it is intended to measure [10]. Ukwuoma and Onah [11] opined that validity is the degree to which evidence and theory support the interpretations of test scores entailed by proposed uses of the test. A valid assessment measures what it was designed to measure and results in defensible and accurate interpretations for the intended purposes [12]. The validity of an assessment tool is the extent to which the evidence produced supports the making of valid or accurate inferences. There are many forms of validity including consequential validity (the consequences for learners and teachers) and criterion validity (the criteria for judging the performance of a learner) [13].

Content validity refers to the comprehensiveness of the instrument in covering the content areas that have been treated during instruction [10]. A content validity required the test experts in the field of mathematics to check the list of content area and the test blueprint. The experts will sort out whether or not the selected items covered the content area indicated. For an instrument to be fit, it should be designed to measure validity and also do that consistently which is called reliability [14]. If Mathematics instrument provides evidence of validity and reliability, it is considering valid and reliable instrument for education assessment [15]. Therefore, validity and reliability are two important characteristics of behavioral measure and are referred to as psychometric properties [16].

In test construction and validation, it is paramount to ascertain first of all, if the constructed test meets laid down standards that is having the qualities expected of a good test items [5]. One of these qualities is content validity. Content validity of the test, which requires the

determination of the adequacy of each item was ensured through careful planning of the test, satisfying the adequacy of sampling of test items models of the construct to be measured and the meticulous analysis of the test items of experts [3]. When a test has content validity, the items on the test should represent all the range of possible items the test should cover. The developers must be reasonably sure that the content selected for test items is likely the one that has received instructional emphasis and conclusion. In subjects where instructional objectives are clearly stated in terms of intended learning outcomes, it is easier to develop test items that sample the content adequately, as in Mathematics where facts and skills are well known [17]. Due to the inability of mathematics teachers to construct a good test for assessing students achievement in mathematics, students would face with the challenge of written their final examination. This was because, some of the mathematics teachers did not know how to construct a valid and reliable test items that would measure student competency. Also, teachers construct test items that are not align with the test blueprint. Therefore, the present study made its necessity to conduct this research.

Statement of the problem

Most senior secondary schools' mathematics teachers of Kano central senatorial district hurriedly copy questions from any past question paper to design their summative achievement tests. Some teachers do not establish validity and reliability for such tests. As a result, they are often constructed tests with poorly prepared achievement tests. The content areas of their Mathematics achievement tests in are not spread out to select the test items based on the content of the topics. As such, poor test construction skills by mathematics teachers might result in the false assessment of students' achievement in Mathematics. The greatest challenge faced by teachers has been the competency in development of reliable and valid items [18]. Therefore, it was as a result of the use of unreliable achievement test poorly designed by mathematics teachers, and the need to provide a more valid and reliable Mathematics achievement test in senior secondary school, that the researcher conceived the idea to carry out a research on test construction and validation procedures of senior secondary schools' mathematics teachers of Kano central senatorial district, Kano State, Nigeria.

Purpose of the study

The purpose of this study was to assess the competence of test construction and validation procedures of senior secondary schools' mathematics teachers of Kano central senatorial district, Kano State, Nigeria. Specifically, the objectives of the study were to determine the: (1) test construction procedure of senior secondary schools' mathematics teachers based on professional training; (2) test construction procedure of senior secondary schools' mathematics teachers based on years of working experience; (3) validation procedures of senior secondary schools' mathematics teachers based on school type; (4) validation procedure of senior secondary schools' mathematics teachers based on educational qualification.

Research questions

The following research questions were raised to guide the study: (RQ1) is there any significant difference in the test construction procedure of senior secondary schools' mathematics teachers based on professional training?; (RQ2) is there any significant difference in the test construction procedure of senior secondary schools' mathematics teachers based on years of working experience?; (RQ3) is there any significant difference in the validation procedure of senior secondary schools' mathematics teachers based on school type?; (RQ4) is there any significant difference in the validation procedures of senior secondary schools' mathematics teachers based on educational qualification?

Hypotheses

The following hypotheses were tested at 0.05 level of significance: (H01) there is no significant difference in the test construction procedure of senior secondary schools' mathematics teachers based on professional training; (H02) there is no significant difference in the test construction procedure of senior secondary schools' mathematics teachers based on years of working experience; (H03) there is no significant difference in the validation procedures of senior secondary schools' mathematics teachers based on school type; (H04) there is no significant difference in the validation procedures of senior secondary schools' mathematics teachers based on educational qualification.

RESEARCH METHOD

The study adopted a survey research design. The population for this study comprises of 864 senior secondary schools' mathematics teachers of Kano central senatorial district, Kano State, Nigeria. A sample of 110 mathematics teachers was drawn for the study using Research advisor [19] table for determining the sample size with 0.05 degree of accuracy at 95% confidence level. Simple random sampling technique was used to select two schools from each Local Government Area. Making a total number of sixteen (16) schools. The sample of teachers was selected proportionally according to the population of teachers in the schools selected for the study. A total number of teachers to form the sample for the study was two hundred and eighteen (218) mathematics teachers.

The instrument used for data collection was Mathematics Test Construction and Validation Questionnaire (MTCVQ), adapted from Salihu [9]; Teachers Ability Questionnaire on Test Construction (TAQTC). The questionnaire consisted of sections A and B. Sections A consisted the bio-data of the respondents as follows: gender, school, educational qualification and teaching experience, while section B consisted of 25 items that will measured test construction (15 items) and validation (10 items) procedures of senior secondary schools' mathematics teachers. The questionnaire adopted the Likert format by using a four point Likert scale with the following responses: Always (A), Almost Always (AA), Sometimes (ST), and Not at All (NA). It has the following scores as A=4, AA=3, ST=2, and NA=1. A pilot test was conducted on 30 mathematics teachers from other senatorial district (Kano north senatorial district) to determine the reliability of the instrument using Cronbach's alpha. A coefficient of 0.76 was obtained. Data obtained from the mathematics teachers were used for data analysis. Means and standard deviations were used to answer the research questions, while Independent sample *t*-test and Analysis of Variance (ANOVA) were used to test hypotheses at 0.05 alpha level of significance. All analysis was carried out using SPSS (version 20) statistical package.

RESULT AND DISCUSSION

The results of data analysis are presented based on descriptive statistics and comparative analysis based on: professional training, year of working experience, school type, and educational qualification.

Descriptive statistics

The results of descriptive statistical analysis based on professional training, school type, year of working experience, and educational qualification, are presented in Table 1.

Table 1. Descriptive statistics of test construction and validation procedures

Attribute	N	%	M	SD
Professional training				
Trained	78	70.9	44.58	5.146
Untrained	32	29.1	38.56	4.384
Year of working experience				
0-9 years	20	18.2	39.70	6.334
10-19 years	43	39.1	42.95	4.957
20-29 years	28	25.5	44.39	5.287
30 years and above	19	17.2	43.53	5.929
School type				
Public schools	77	70.0	28.21	4.284
Private schools	33	30.0	30.21	3.416
Educational qualification				
NCE/ND	61	55.5	28.64	4.390
B.Ed/B.Sc/HND	37	33.6	28.32	3.742
M.Ed/M.Sc	10	9.1	30.90	3.635
PhD	2	1.8	32.50	0.707

Note: N=Number of sample, M=Mean, SD=Standard Deviation.

Table 1 indicates the following. First, the trained mathematics teachers' mean score was 44.58 with a standard deviation of 5.146, while untrained mathematics teachers obtained the mean score of 38.56 with a standard deviation of 4.384. This result shows that trained mathematics teachers had a better mean scores than untrained mathematics teachers.

Second, the mean scores of mathematics teachers based on years of working experience was 39.70 (0-9 years), 42.95 (10-19 years), 44.39 (20-29 years), and 43.53 (30 years and above) with a standard deviation of 6.334, 4.957, 5.287 and 5.929 respectively. This result shows that 20-29 years' mathematics teachers had a better mean scores followed by 30 years and above mathematics teachers.

Third, the mean scores of public schools' Mathematics teachers was 28.21 with a standard deviation of 4.284, while private schools' mathematics teachers obtained the mean score of 30.21 with a standard deviation of 3.416. This result shows that private schools' mathematics teachers had a better mean scores than public schools' mathematics teachers.

Fourth, the mean scores of mathematics teachers based on educational qualification was 28.64 (NCE/ND), 28.32 (B.Ed/B.Sc/HND), 30.90 (M.Ed/M.Sc), and 32.50 (PhD) with a standard deviation of 4.390, 3.742, 3.635 and 0.707 respectively. This result shows that mathematics teachers with PhD and Masters Degree had a better mean scores than those with B.Ed, B.Sc, HND, NCE and ND.

Comparative analysis based on professional training

This is addressed to RQ1 and H01. Professional training was taken as a variable. It was having two categories: trained and untrained. Therefore, *t*-test was used to compare the test construction procedure between trained and untrained. The analysis results is presented in Table 2.

Table 2 revealed that the *t*-value of 5.800 and *p*-value of 0.000 was obtained. Since the obtained *p*-value (0.000) is less than the alpha value of 0.05, it implies that the test construction procedure of senior secondary schools' mathematics teachers based on professional training was significant. On this basis, the hypothesis which states that, there is no significant difference in the test construction procedure of senior secondary schools' mathematics teachers based on professional training was therefore rejected.

Table 2. The difference in the test construction procedure based on professional training

Variable	N	M	SD	*df*	*t*-value	*p*-value
Trained	78	44.58	5.146	108	5.800	.000
Untrained	32	38.56	4.384			

Comparative analysis based on year of working experience

This section is addressed to RQ2 and H02. Year of working experience was taken as a variable. It was having four levels: 0-9 years, 10-19 years, 20-29 years, and 30 years and above. Therefore, ANOVA was used to compare the test construction procedure between the levels. The analysis results is presented in Table 3.

Table 3. ANOVA in the test construction procedure based on years of working experience

Source	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between Group	274.196	3	91.399	3.045	.032
Within Group	3181.522	106	30.014		
Total	3455.718	109			

Table 3 revealed that the *F*-value of 3.045 and *p*-value of 0.032 was obtained. Since the obtained *p*-value (0.032) is less than the alpha value of 0.05, it implies that the test construction procedure of senior secondary schools' mathematics teachers based on years of working experience was significant. On this basis, the hypothesis which states that, there is no significant difference in the test construction procedure of senior secondary schools' mathematics teachers based on years of working experience was therefore rejected. Scheffe's test was further performed to establish where the difference exists, in Table 4.

Table 4 revealed that significant difference exists in the test construction procedure between teachers with 0-9 years and those with 20-29 years in favour of 0-9 years of working experience. This shows that the direction of significance moves from 0-9 years of working experience.

Table 4. Scheffe Post Hoc Analysis on the difference based on years of working experience

Working Experience		Mean Difference	Std. Error	Sig.
(i)	(j)	(i-j)		
0-9 Years	10-19 years	-3.253	1.483	.193
	20-29 years	-4.693*	1.604	.041
	30 years and above	-3.826	1.755	.198
10-19 Years	20-29 years	-1.439	1.330	.760
	30 years and above	-.573	1.509	.986
20-29 Years	30 years and above	.867	1.628	.963

Note: *=The mean difference is significant at the 0.05 level.

Comparative analysis based on school type

This is addressed to RQ3 and H03. School type was taken as a variable. It was having two categories: public and private. Therefore, *t*-test was used to compare the test construction procedure between public and private school. The analysis results is presented in Table 5.

Table 5 revealed that the *t*-value of -2.381 and *p*-value of 0.019 was obtained. Since the obtained *p*-value (0.019) is less than the alpha value of 0.05, it implies that the validation procedure of senior secondary schools' mathematics teachers based on school type was significant. On this basis, the hypothesis which states that, there is no significant difference in the validation procedure of senior secondary schools' mathematics teachers based on school type was therefore rejected.

Table 5. The difference in the validation procedure based on school type

Variable	N	M	SD	*df*	*t*-value	*p*-value
Public schools	79	28.21	4.284	108	-2.381	.019
Private schools	31	30.21	3.416			

Comparative analysis based on educational qualification

This section is addressed to RQ4 and H04. Educational qualification was taken as a variable. It was having four levels: NCE/ND, B.Ed/B.Sc/HND, M.Ed/M.Sc, and PhD. Therefore, ANOVA was used to compare the validation procedure between the levels. The analysis results is presented in Table 6.

Table 6 revealed that the *F*-value of 1.617 and *p*-value of 0.190 was obtained. Since the obtained *p*-value (0.190) is greater than the alpha value of α=0.05, it implies that the validation procedure of senior secondary schools' mathematics teachers based on educational qualification was not significant. On this basis, the hypothesis which states that, there is no significant difference in the validation procedure of senior secondary schools' mathematics teachers based on educational qualification was therefore accepted.

Table 6. ANOVA in the validation procedure based on educational qualification

Source	Sum of Squares	*df*	Mean Square	*F*	Sig.
Between Group	81.417	3	27.139	1.617	.190
Within Group	1779.574	106	16.788		
Total	1860.991	109			

Discussion of findings

The finding of this study shows that trained mathematics teachers had a better mean scores than untrained mathematics teachers of Kano central senatorial district, Kano State, Nigeria. Also, the Independent sample *t*-test on Table 2 indicated that the test construction procedure of senior secondary schools' mathematics teachers

based on professional training was significant. This finding supported the result of Salihu [9] who revealed that there is a significant difference in the mean ability of test construction between professional teachers and non-professional teachers of Economics. The result of this study contradicts with the findings of Inko-Tariah and Okon [20] who showed that lecturers' knowledge of test construction procedures does not differ significantly based on professional training. Also, Ovat and Ofem [21] found no significant influence of professional training on lecturers' utilization of test blueprint in learners' assessment in schools. This result was surprising a one would expect teachers with training in test construction to be more knowledgeable in test construction skills.

The finding of this study shows that 20-29 years' mathematics teachers had a better mean scores followed by 30 years and above mathematics teachers. Also, the one-way ANOVA on Table 3 indicated that the test construction procedure of senior secondary schools' mathematics teachers based on years of working experience was significant. Furthermore, Scheffe's test was performed and revealed that significant difference exists in the test construction procedure between teachers with 0-9 years and those with 20-29 years of working experience. The result of this study contradicts with the findings of Inko-Tariah and Okon [20] showed that lecturers' knowledge of test construction procedures does not differ significantly based on years of experience. This finding is not in agreement with Adodo [22] who found that years of experience not to make any significant difference on teachers' knowledge of test construction procedures. This finding also is not in agreement with the findings of Awonui and Agyei [23] who concluded that there was no significant difference between mathematics teachers who had taught between 1-5 years and above five years in the test construction of test items in the schools in terms of their knowledge of principles of test construction.

The finding of this study shows that private schools' mathematics teachers had a better mean scores than public schools' mathematics teachers. Also, the Independent sample *t*-test on Table 5 indicated that the validation procedure of senior secondary schools' mathematics teachers based on school type was significant. This finding supported the result of Salihu [9] who revealed that there was a significant mean difference in ability between public school teachers and private school teachers of Economics in content validity. This finding also supported the findings of Onuka and Atsua [24] revealed that School-Based Assessment in Economics in private schools had greater content coverage than what obtains in public schools. Bassey et al. [25] indicated that teachers in the private secondary schools and their counterparts in public secondary schools differ significantly in their job performance.

The finding of this study shows that mathematics teachers with PhD and Masters Degree had a better mean scores than those with B.Ed, B.Sc, HND, NCE and ND. Also, one-way ANOVA on Table 6 indicated that the validation procedure of senior secondary schools' mathematics teachers based on educational qualification was not significant. This finding supported the findings of Olasehinde-Williams et al. [26] who suggested that teacher training tends to have a debilitating influence on subject content knowledge as those who obtained their degree in the same or even a related subject to the ones they teach tend to have lower scores in the test of knowledge of subject matter content. Through the study of secondary school students in Kenya by Waseka et al. [27] showed the expected result that teachers with the Bachelor of Education qualification significantly influenced their students' performance, it also revealed the unexpected outcome with the discovery that teachers with the Master of Education or Diploma qualifications did not significantly influence the performance of their students. The finding of this study contradict with the results of Abe and Adu [28] indicated that, there was significant difference in the performance of students taught by NCE and B.Sc. Ed teachers in Mathematics. However, the study of Williams and Ikpa [29] showed that teachers' qualifications have no impact on their level of competencies in attaining educational objectives of senior secondary education in Rivers State, Nigeria.

CONCLUSION

Based on the findings of this study, it can be concluded that untrained secondary school mathematics teachers lack the requisite skills in test construction procedures. It is evident therefore that teachers need to be trained in test construction so as to adequately construct test items that would be sufficient in establishing the

learning done at all levels of Blooms Taxonomy. It is clearly shows that teachers with 20 years and above constructed more valid and reliable test than those less experienced teachers. There is a difference in the adequacy of teachers' test items base on their type of school. This is because teachers in private schools mostly constructed test items that meet the levels of testees' cognitive domain of learning objectives. However, the test items used by some public schools' mathematics teachers in their internal assessment are of substandard, not meeting the requirement for standard of test items. Therefore, training can improve the quality of assessment regardless of teachers' educational qualification.

Based on the findings of the study, the following recommendations were made. Firstly, both trained and untrained mathematics teachers should put these basic and fundamental test construction and validation procedures mentioned in this study which formed the items in the questionnaire into practice. Secondly, courses, seminars and workshops on test construction procedures should be organized in senior secondary schools to help teachers gain competence in test construction in order to ensure quality assessment in schools. Thirdly, both public and private schools' mathematics teachers should have the actual blue print of their test since it allows content areas to link up with the instructional objectives at various levels of the cognitive domain. Fourthly, teaching qualification must be seen as a pre-condition for entry into the teaching profession.

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