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Comparison of The Content Validity of 2018 Mathematics Test Items of Public Examining Bodies in Nigeria

Benson Adesina Adegoke & Friday Patrick Obot

Institute of Education, University of Ibadan, Nigeria

E-Mail: doctoradegoke@yahoo.com E-Mail: patrickfridayobot@gmail.com

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Abstract

Although in Nigeria, there are many public examining bodies, the two major public examining bodies that conduct senior secondary school certificate examinations are the West African Examinations Council [WAEC] and National Examinations Council [NECO]) in Nigeria. There are arguments about the equivalence of the senior secondary school certificates being awarded by the two major public examining bodies. This is because in most subjects, including mathematics, being examined the distribution of test items of the two public examining bodies are not equal in terms of number and spread across the various levels of cognitive domain. In order to add to literature, this study was designed to compare 2018 WAEC and 2018 NECO SSSCE Multiple-choice Mathematics test items. The comparison covered the content coverage, the distributions of items across the themes in the mathematics curriculum which are Number and Numeration, Algebraic processes, Geometry, Statistics and Introductory Calculus, and how the items were distributed across the various levels of the cognitive domain of Bloom's taxonomy of educational objectives (knowledge, comprehension, application, analysis, synthesis and evaluation). Although NECO set more test items than WAEC, there was no statistically significant difference in the content validity of the mathematics tests of the two public examining bodies. However, NECO should reduce the five-option response format of A, B, C, D and E to four-response format of A, B, C, and D being used by WAEC.

Keywords: Content validity, West African Examinations Council, National Examinations, Mathematics test items.

Introduction

In Nigeria, there are two public examining bodies saddled with the responsibility of conducting senior secondary school certificate examinations. These are the West African Examinations Council (WAEC) and the National Examination Council (NECO). The West African Examinations Council conducts senior school certificate examinations for candidates in the five Anglophone West African countries namely,

Ghana, Nigeria, Sierra-Leone, Gambia and Liberia. The WAEC was established in 1952 with an ordinance Number 41 of 1951. Unlike WAEC, the National Examinations Council (NECO) is a home-based examination body established in 1999 by the Federal Government of Nigeria. Every year both WAEC and NECO conduct examinations for over a million candidates sitting for senior school certificate examinations in Mathematics and other subjects. However, the focus of this study is on Mathematics.

According to Dibu-Ojerinde (2005), since WAEC and NECO have similar syllabi, follow the general practice regarded as standard by most examination bodies in the development of test items and award certificates for the same purposes, their examinations are expected to be of comparable standard in terms of the psychometric properties of the items constructed. However, studies (Anigbo, 2018; Awogbemi, Oloda, and Alagbe 2015) indicate that at inception, there were criticisms against NECO examinations, some say its questions are too tough than those of WAEC. According to Obot (2019), some critics of NECO are still of the opinion that since WAEC has international status, there was no need for any parallel public examining body for the conduct of the same senior secondary school certificate examinations. However, according to the Dibu-Ojerinde (2005) having the two public examining bodies would give candidates the opportunity of making a choice between the two bodies and those who could afford the examination charges would have the opportunity of taking the examinations conducted by the two bodies.

A perusal of the mathematics question papers of the two examining bodies shows that for WAEC, in mathematics there are usually 50 multiple choice test items and 25 theory test items. For NECO there are usually 60 multiple choice test items and 33 theory test items. The test items are usually drawn from five themes: Number and Numeration, Algebra Processes, Probability and Statistics, Geometry and Introductory Calculus. Despite the unequal number of test items that each examining body sets for the candidates, they use the same nine-point or stanine" grading system of AI, B2, B3, C4, C5, C6, D7, D8 and F9 for all subjects including mathematics. Thus, it is assumed that the grades are equivalent for both WAEC and NECO. The extent to which the grades are equivalent is a subject of argument among psychometricians. However, considering the quality of staff and test item writers of the two bodies, their test items are assumed to be of high quality in terms of validity.

Validity is the quality of a test which shows the extent to which the test measures what it is supposed to measure. It is the degree to which evidence, common sense, or theory supports any interpretations or conclusions about a student based on his/her test performance. More specifically, validity shows the extent to which a test (e.g. mathematics test) measures students' mathematics ability, and not their reading ability. An aspect of test validity of particular importance for public examining bodies is content-related validity. Do the items on a test fairly represent the items that could be on the test? Reasonable sources for "items that should be on the test" are class objectives, key concepts covered in lectures, main ideas, and so on.

In psychometrics, content validity also refers to the extent to which a measure represents all facets of a given construct. For example, a mathematics test may lack content validity if it only assesses the students' ability to add and subtract dimension of mathematics but fails to take into account the students' ability to construct and draw simple graphs. Content validity is different from , which refers not to what the test actually measures, but to what it superficially appears to measure. Face validity assesses whether the test "looks valid" to the examinees who take it, the administrative personnel who decide on its use, and other technically untrained observers.

Determination of the content validity of a test can be carried out using both qualitative and quantitative processes. Public examining body who wants to make sure that it has a valid test from a content standpoint often constructs a table of specifications or a test blue print which specifically lists what are supposed to have been taught in schools and shows the number items that cover those topics. According to Okpala, Onocha and Oyedeji (1993), a test blue print or a table of specification is a two-dimensional table. One axis represents the subject matter content while the other axis represents the types of behavior or mental process that the test intends to elicit. The two dimensions are put together to show or indicate which objectives relate to which segments of the content.

The test blue print provides a complete framework for the development of the test. In writing the test blue print, only the objectives that specify such processes as recalling, identifying, recognizing, predicting, defining, analyzing, synthesizing, generalizing or evaluating are supposed to be included. The test blue print helps in determining the relative emphasis of content areas and processes objectives, that is, the number of items that will adequately cover the whole content and the number of items that will be attached to each topic. Test blue print shows the distribution of the items along the behavioural objectives and the topics.

Another method of ascertaining content validity is the use of ratings of subject matter experts. In this method, recognised subject matter experts evaluate whether test items assess defined content and it involves more rigorous than does the use of table of specification. One widely used method of measuring content validity was developed by C. H. Lawshe in 1975. It is essentially a method for gauging agreement among raters or judges regarding how essential a particular item is. Lawshe (1975) proposed that each of the subject matter expert raters (SMEs) on the judging panel respond to the following question for each item: "Is the skill or knowledge measured by this item 'essential,' 'useful, but not essential,' or 'not necessary' to the performance of the construct?" According to Lawshe, if more than half of the panelists indicate that an item is essential, that item has at least some content validity. Greater levels of content validity exist as larger numbers of panelists agree that a particular item is essential.

In this study however, emphasis was on the use of table of specification to determine and compare the content validity of the mathematics test items of WAEC and NECO. The reason for the comparison is because it is not uncommon to observe that

some candidates who perform very well in NECO mathematics paper do poorly in WAEC mathematics paper and vice versa. What could have been responsible for this? The import of this becomes clearer if one takes note of the supposed similarity of the content of mathematics curriculum prepared by the Federal Ministry of Education and the mathematics syllabi of NECO and WAEC. If the same content is in the documents and same teachers have taught the students, it stands to reason that the level performance of a student in mathematics questions by the two bodies should be nearly the same.

The results of senior secondary school mathematics examination for candidates in the two examining bodies from 2014 to 2018 show that more candidates enrolled with WAEC than NECO. However, more candidates passed NECO mathematics than they did in WAEC. As Table 1 shows, for example in 2015, 80.8% passed at minimum of credit level in NECO mathematics, while 34.2% passed at the minimum credit level in WAEC Mathematics. The same uneven level of performances can be observed in 2016. Does that mean that test items in NECO are less difficult than that of WAEC mathematics?

Table 1: Statistics of Performance in NECO and WAEC Mathematics 2014 - 2016

Exam	Year	No.: of Candidates	A1-C6	D7-F9
		Sat		
WAEC		1,692,435	529,732 (31.30%)	1,162,703 (68.70%)
NECO	2014	960, 600	667529 (69.49%)	289,074 (30.0%)
WAEC		1,593,442	544638 (34.18%)	1,048,804 (65.82%)
NECO	2015	961,258	776386 (80.77%)	178,990 (18.62%)
WAEC		1,544,234	597,310 (38.68%)	946,924 (61.32%)
NECO	2016	870,397	812,846 (93.4%)	NA

Past studies (Aborisade and Fajobi, 2020; Anigbo, 2007; Awogbemi, Oloda, Alagbe, 2015) on the comparability of WAEC and NECO test items have concentrated mostly on the psychometric properties such as reliability, discrimination and difficulty indices of the test items in Mathematics. The findings of the study conducted by Aborisade and Fajobi showed that the difficulty and guessing indices of the mathematics items constructed by the two examination bodies are comparable while the discriminating powers were not comparable. They concluded that since the items being constructed by the two examining bodies are of comparable standard in terms of their qualities, then the certificates being issued to candidates by WAEC and NECO could be used for same purposes without any discrimination

In their study, Udofia and Udoh (2017) concluded that there was no significant difference in the distribution of test items of WAEC and NECO across the various levels

of cognitive domains, themes and topics prescribed in the senior secondary school mathematics curriculum and syllabi of the two examining bodies. Despite the results of no significant differences in the psychometric properties of mathematics test items, statistics of candidates' performance in mathematics have shown, that same students do not have equal performance in the tests set by these two public examining bodies. Therefore, what makes students to do well in NECO than WAEC should be analysed and suggestions on how to ensure comparability of the certificates being awarded by the two major public examining bodies should be of concern to major stake holders in senior secondary school education.

The results of this study would assist the two examining bodies have information, from an external source, on the nature of their test items, the extent of content coverage of Mathematics items, and how items are distributed across the various levels of the cognitive domain. More importantly results would provide an empirical basis for the development and improvement of mathematics test items to minimize variance in examinees' performance in the Senior School Certificate Examinations being conducted by the two bodies.

In this study, the emphasis on mathematics is due to the importance of mathematics in the day to day life of human beings. Mathematics is an essential discipline that is recognized as a tool for solving everyday problem faced by individuals, and having a fundamental knowledge mathematics enhances a person's reasoning, problem-solving skills, and ability to think. According to Ogunyomi and Adegoke (2020), Mathematics is the bedrock of transformation and a necessity for social and economic transformation of any nation. Rapid national development can be achieved through application of mathematics on the national economy. No doubt, the Federal government of Nigeria recognizes the importance of mathematics and this underlies why it is a core subject at the secondary school level in Nigeria. Therefore, the results of this study would add to the existing literature on methods of improving mathematics education in Nigeria.

Statement of the Problem

Most of the past studies on the equivalence of WAEC and NECO Mathematics test items have concentrated only on psychometric properties (difficulty index, discriminating index and vulnerability to guessing). A perusal of Literature shows that there is a dearth of studies on analysis of content validity of the mathematics test items of NECO and WAEC. Results of this study would provide empirical information to the two examining bodies on the comparability of the content validity of their test items and also, afford them the opportunity of re-examining their processes of determining the content validity of their Mathematics test items.

Research Questions

Two research questions were answered.

1) What levels of the cognitive domain do 2018 WAEC and NECO SSCE mathematics multiple choice questions cover?
2) What is the extent of content coverage of SSCE Mathematics questions from WAEC and NECO examination bodies?

Hypothesis

One null hypothesis guided the study and was tested at 0.05 levels of significances.

1) There is no significant difference in the distribution of the 2018 WAEC and NECO Mathematics Multiple choice test items across the levels of cognitive domain.

Methodology

In this study, documentary analysis research approach was adopted. This type of design was adopted because no variable was manipulated. Only the content of 2018 NECO and WAEC multiple-choice mathematics test items were analysed for comparison purposes

The Instruments used were the 2018 SSSCE WAEC and NECO multiple choice Mathematics questions paper. The 2018 WAEC and NECO multiple and essay Mathematics test items were drawn based on the content of the senior secondary school curriculum. The NECO and WAEC Syllabus show the topics and contents that indicate the scope of the questions used. The questions covered the following themes in the senior secondary school mathematics curriculum: Number and Numeration (NN), Algebraic processes (AP), Geometry (GE), Statistics (ST) and Introductory calculus. (IC)

As usual and common to NECO, the 2018 multiple choice paper had 60 items placed under 5-response mode of A, B, C, D and E. The testing time for the multiple-choice test was one hour and 45 minutes. The 2018 WAEC multiple-choice paper had 50 items placed under 4-response mode of A, B, C, and D. The testing time for the multiple choice test was one hour and 30 minutes.

Data Collection and Data Analysis

Data were gathered through document analysis of the May/June 2018 WAEC and June/July 2018 NECO multiple-choice Mathematics questions and the WAEC and NECO Syllabi in Mathematics. Using the Mathematics senior secondary school curriculum and the Bloom's taxonomy verbs as a guide, the researchers carefully classified each item in the 2018 WAEC and NECO mathematics questions according to the level of the cognitive domain each belonged and the themes. The behavioral

objectives or cognitive levels as indicated include knowledge (KN), comprehension (CO), application (AP), analysis (AN), create (CR) and evaluation (EV). However, what guided the classification was the "action verb" used in posing each question in the 2018 WAEC and NECO multiple tests.

These "action verbs" describe the cognitive processes which are required to successful answer the test items:

1) Knowledge – Recall of facts and basic concepts. The cognitive tasks include define, list, and state.
2) Comprehension – Explain ideas or concepts. The cognitive tasks include classify, explain, discuss, translate, recognize and identify.
3) Apply – Use of information in new situations. The cognitive tasks include demonstrate, interpret, sketch, solve, and use
4) Analyze – Draw connections among ideas. The cognitive tasks include differentiate, organize, compare, contrast, and distinguish
5) Create – Produce new or original work. The Cognitive tasks include develop, formulate and investigate.
6) Evaluate – Justify a stand or decision. The cognitive tasks include critique and appraise

The Table of specifications was drawn to determine the content areas and behavioral objectives for items. The Data collection lasted one week. The statistical tools used were frequency, simple percentages and Chi Square. The hypotheses were tested at $p \leq 0.05$ level of significance.

Results and Discussions

Research Question One: What levels of the cognitive domain do 2018 WAEC and NECO SSCE mathematics multiple choice questions cover?

To answer this research question, the test blue prints shown in Tables 2 and 3 were drawn showing the main themes in Mathematics and the behavioral objectives measured. Table 2 shows the distribution of 2018 NECO mathematics multiple choice test items along the content area and the cognitive domains, while Table 3 shows the distribution of 2018 WAEC mathematics multiple-choice test items along the content area and the cognitive domains. These distribution grids were titled "Self-Developed Blue Print". From the Table, majority (45%) of the questions in the 2018 NECO SSCE Mathematics multiple-choice questions were on knowledge and just 2% of the questions were on synthesis. Others include 13(22%) items measuring Comprehension, 11(18%) items measuring Analysis, 5(8%) items measuring Analysis, 3(5%) measuring evaluation.

Table 3: Self Developed Test Blue Print of 2018 W AEC Mathematics Multiple Choice Test Items.

Themes	KN	CO	AP	AN	SY	EV	Total 100%
NN (22%)	6	1	1	2	0	1	**11 (22%)**
AP (24%)	8	1	1	1	0	1	**12 (24%)**
GE (42%)	17	0	0	4	0	0	**21 (42%)**
ST (12%)	5	0	0	1	0	0	**6 (12%)**
IC (0%)	0	0	0	0	0	0	**0 (0)**
Total (100%)	**36 (72%)**	**2 (4%)**	**2 (4%)**	**8 (16%)**	**0**	**2 (4%)**	**50**

From the Table, it was observed that the majority (72%) of the questions in the 2018 WAEC SSCE Mathematics multiple-choice were on knowledge. There was no question on Synthesis.

Research Question Two: What is the extent of content coverage of SSCE Mathematics questions from WAEC and NECO?

To answer this research question, the number of items taken from each theme were teased out from Tables 2 and 3. The differences in the distribution of the items along the themes are as presented in Table 4.

Table 4: Distribution of Test Items along the Themes

Themes	WAEC	NECO
Number and Numeration	11(22%)	17(28%)
Algebraic processes	12(24%)	16(27%)
Geometry	21(42%)	16(27%)
Statistics	6(12%)	9(15%)
Introductory calculus	0 (0%)	2(3%)

Table 4 shows that a major difference was in the area of Geometry; while in NECO Mathematics test, 16 (27%) items were from geometry, on the other hand, there were 21 (42%) items from geometry. More importantly, WAEC set no question on introductory calculus, while NECO had two items from introductory calculus. From the analysis, NECO spread mathematics test items among all the themes.

Ho_1: There is no significant difference in the distribution of the 2018 WAEC and NECO Mathematics test items across the levels of cognitive domain.

To test this hypothesis, chi-square statistical method was adopted. The result is shown in table 5.

Table 5: Chi Square Distribution of WAEC and NECO 2018 Mathematics Test Items

Themes	Examining Body	KN	CO	AP	AN	SY	EV	Total	χ^2
Number and Numeration	WAEC NECO	6 7	1 3	1 2	2 3	0 0	1 2	11 17	**0.77**
Algebraic processes	WAEC NECO	8 8	1 2	1 3	1 1	0 1	1 1	12 16	**1.37**
Geometry	WAEC NECO	17 5	0 6	0 0	4 5	0 0	0 0	21 16	**7.73***
Statistics	WAEC NECO	5 6	0 1	0 0	1 2	0 0	0 0	6 9	**0.53**
Introductory calculus	WAEC NECO	0 1	0 1	0 0	0 0	0 0	0 0	0 2	**0.00**

For theme 1, WAEC had 11 items while NECO had 17 items, the distribution of the items along the various levels of the cognitive domains shows that NECO had more items under Knowledge. However, the observed distribution was not statistically significant χ^2 (5) = 0.77. For theme 2, WAEC had 12 items while NECO had 16 items, more importantly, the distribution of the items along the various levels of the cognitive domains shows that NECO had more items under Comprehension, Application and Synthesis. However, the observed distribution was not statistically significant χ^2 (5) = 1.37. For theme 3, WAEC had 21 items while NECO had 16 items, the distribution of the items along the various levels of the cognitive domains shows that NECO had more items under Comprehension and Analysis. WAEC had more items under Knowledge. The observed distribution was statistically significant χ^2 (5) = 7.73. Further for theme 4, WAEC had 6 items while NECO had 9 items, more importantly, the distribution of the items along the various levels of the cognitive domains shows that NECO had more items under Knowledge. However, the observed distribution was not statistically significant χ^2 (5) = 0.53. While for theme 5, WAEC had no item while NECO had 2 items, the distribution of the items along the various levels of the cognitive domains shows that NECO had items under Knowledge and Comprehension. However, the observed distribution was not statistically significant χ^2 (5) = 0.00

Discussion

The results of this study showed that, although there were slight variances in the number of test items, overall, there was no significant difference in content validity of WAEC and NECO mathematics test items. Despite this, the two examining bodies are not inferior to one another since their items are of equal quality, and certificate issued by them can be on the same metric scale. Although most past studies (Aborisade and Fajobi, 2020; Anigbo, 2018; Awogbemi, Oloda, and Alagbe 2015) had focused on test items parameters such as discriminating, difficulty and vulnerability to guessing, the findings of this study appear to corroborate the results of past studies that found no

significant differences between WAEC and NECO test items. Thus, the two public examining bodies produced tests that are comparable in content validity and one is not superior to the other.

It is quite unfortunate that both public examining bodies failed to set adequate items on introductory calculus. While NECO had only two test items on this topic, WAEC had none. Results of the test analysis showed that the two items on introductory calculus set by NECO were under knowledge and there were no test items under higher cognitive level. Although introductory calculus is a new topic in the mathematics curriculum prepared by both Federal Ministry of Education and Nigerian Educational Research Development Council, the importance of this topic cannot be over emphasized. Students who may have the ambition of pursing natural science, engineering and technology in higher institutions need the fundamental and basic knowledge of introductory calculus; and this basic knowledge can only be obtained at the senior secondary school level. In the higher institutions, basic knowledge in calculus such as differentiation and integration is needed for easy understanding of physics, chemistry, and engineering courses.

The observed non-significant differences in the content validity of the mathematics test items of the two public examining bodies was likely due to the fact that these items were drawn from the same mathematics curriculum which was prepared by the Federal Ministry of Education in collaboration with Nigeria Educational Research Development Council; which are the two educational organs of the Federal Republic of Nigeria saddled with the responsibility of development of curriculum for secondary school education in Nigeria. However, the length of test items of NECO being longer than that of WAEC and the differences in testing time may make NECO mathematics test items to be somewhat more cumbersome and tasking to examinees than WAEC Mathematics test items. The longer time of test administration of NECO might be due to the number of response options which it uses. While WAEC uses four-options A, B, C, and D, NECO uses five-option system, A, B, C, D, and E.

Conclusion and Recommendations

There was no statistically significant difference between the two public examining bodies in the distribution of 2018 SSCE Mathematics multiple choice questions across the various levels of the cognitive domains and themes. However, the 60 test items which NECO usually set and administer may be too much. More importantly, the time of administration as well as the number of options which NECO uses may be too tasking for the examinees. Therefore, there is the need for NECO to look into the possibility of reducing the length of test items and the time of test administration. There is also a need for NECO to reduce the number of response options from five to four so as to be in line with that of WAEC which is four. The two public examining bodies should include test items on introductory calculus in their subsequent mathematics multiple-choice papers.

This is because introductory calculus is a new topic in the mathematics curriculum. It is the opinion of the researchers that, if teachers know that items would be set on this topic, they would teach their students this topic, but if teachers know that public examining bodies will not set test items under this topic, it is also likely that teachers may not teach this topic at all. In such situation, students may not have adequate idea about introductory calculus.

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