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Chained Equipercentile Equating of Senior School Certificate Multiple-Choice Test Items in Chemistry

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ABSTRACT

This study investigated chained equipercentile equating of Senior School Certificate Multiple Choice Test Items in Chemistry conducted by the West African Examinations Council (WAEC), the National Examinations Council (NECO) and National Business and Technical Examination Board (NABTEB). The study adopted the Non-Equivalent Groups Anchor Test design. A sample of 1,461 students was selected among Senior Secondary III students in the southwest geopolitical zone of Nigeria using a multi-stage sampling procedure. The 2017 WAEC, NECO and NABTEB SSCE multiple choice Chemistry papers were used as instruments for data collection. The WAEC, NECO and NABTEB papers yielded coefficients of content validity of 0.78, 0.75, and 0.76 and reliability of 0.81, 0.77, and 0.78 respectively. Data obtained were analysed using mean and percentile rank. Findings of the study showed that there is a difference in the respondents' mean performance on the common items of WAEC, NECO, and NABTEB (μWA = 5.46, μNE = 6.04, μNA = 7.36), and there are differences in the examinees' performance in unique items across the test forms (μWA= 17.32, μNE = 18.03, μNA = 20.48). Also, findings from this study showed that a chained equipercentile score of 20 in WAEC was equivalent to scores of 20 and 23 in NECO and NABTEB respectively, which corresponded to the percentile rank of 75. Based on these findings, the researcher recommended that test developers should ensure high quality of items used by each examining body and uniformity in standards of all examination bodies should be encouraged.

Keywords: chained equipercentile equating, WAEC, NECO, NABTEB, multiple-choice items

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INTRODUCTION

Public examination is an examination which is widely used for processes such as students' selection, entrance examination into higher institutions and placement examination. These usually occur in different forms, which bring about the process of equating. Equating is a process that controls score stability from one test administration to another if the test occurs in different forms (Kolen and Brenann 2004). Equating is a statistical process used in situations where multiple forms of a test exist. Albano (2011) defined equating as a statistical procedure commonly used in testing programmes where administrations across more than one occasion and more than one examinee group can lead to overexposure of items, threatening the security of the test. The main objective of score equating is to give room for interchangeability of scores obtained from both tests to be used. That is, test equating compares test scores of various test forms administered to testees. Ryan (2011) also defined equating as a technical procedure or process conducted to establish comparable scores, with equivalent meaning, on different versions of test forms of parallel test. In the process of equating, anchor items also known as common items and unique items play very vital roles.

Common items are items embedded in the different test forms that are to be equated and these are used to contrast the groups of testees assessing the same skills and abilities that the test measures (Chen, Huang & MacGregor, 2009). Sonya (2011) stated that scores of anchor items are used to make adjustments for differences in test form difficulty, taking into account differences in group performance. Unique items are items that are peculiar to each test form to be equated. Anchor item or common item is a miniature of the total test form, which should be comparably representative of the total test forms in content and statistical characteristics. Shin (2015) mentioned that Common item sets should adequately reflect test specifications as well as form difficulty, that is, anchor sets should be content and statistically representative. They are items that measure the same skills and knowledge the actual test is measuring, the more similar the anchor is to the test, the better (Livingston 2004). A set of anchor items can either be part of each of the test forms (internal anchor) or considered as a separate test (external anchor). When the scores of examinees on the tests is being influenced by scores obtained from the set of anchor items, it can be said to be internal anchor, but when the scores obtained from the set of anchor items does not contribute to the examinees' scores on the test, it is known as external anchor. Internal anchor usually has higher correlation with the test being equated because it contributes to the total score. Anchors with longer items are usually more reliable and more highly correlated with the tests (Dorans, Moses and Eignor, 2010). This study made use of internal

anchor and the unique items which were items peculiar to test forms A, B and C (WAEC, NECO and NABTEB Chemistry multiple choice items respectively). There are two approaches that can be used in equating different forms of test: Item Response Theory (IRT) and Classical Test Theory (CTT).

Classical test theory assumes that there are no perfect measures of ability, observed score (X) of each testee is comprised of True Score (T) and random error (E) (Wiberg, 2004; Schumacker, 2005). CTT makes use of traditional item and sample dependent statistics which include item difficulty and item discrimination estimates, which are focused on testee assessment at the test score level (Schumacker, 2005). CTT equating approach was used in this study, it involves Linear and equipercentile equating methods. Livingston (2004) described equipercentile equating as an equating method used to equate scores obtained from testees on the new form to scores obtained from testees on the reference form. Scores from the new form are to be transformed to the scores on the reference form that have the same percentile rank in that group.

The main concern in equipercentile equating is to find a score y on form Y that has the same percentile rank as a score x on form X. Other common equipercentile-like equating methods are frequency estimation equipercentile and chained equipercentile methods (Hou, 2007). The procedure in frequency estimation method considers two scores from two different test scores (X and Y) to be comparable if the two scores have the same percentile rank. Chained equipercentile equating method, an equating method which was used in this study, has been found more appropriate to use when there is variation in the ability of examinees that will be administered the different test forms (Holland, von Davier, Sinharay, & Han, 2006; Kolen and Brennan, 2004; Wang, Lee, Brennan & Kolen 2008). This procedure is referred to as chained equipercentile equating because it includes "a chain of two equipercentile equatings, one in population 1 and another in population 2. This equating method involves conversion of scores which are chained together to yield a conversion of form X scores to form Y scores; form X scores are converted to scores on the common items based on the answers supplied by examinees in population 1 using equipercentile equating method. Then the set of scores from the common items are equated to form Y scores based on the answers supplied by examinees from population 2. Lastly, the two conversions above will be linked to obtain conversion of scores of form X to form Y scores (Livingston 2004). Chained equipercentile equating in this study, considered

the conversion of examinee scores in WAEC, NECO and NABTEB Chemistry Multiple Choice items equated as they correspond to the same percentile rank.

There are different public examination bodies in Nigeria that conduct standardized test, they include West African Examinations Council (WAEC), National Examinations Council (NECO), National Business and Technical Examination Board (NABTEB), Unified Tertiary Matriculation Examination (UTME), Interim Joint Matriculation Board (IJMB), National Teachers Institute (NTI) and others. In this study, WAEC, NECO and NABTEB which are of importance to this study are briefly discussed.

West African Examinations Council (WAEC)

West African Examinations Council which has its headquarters in Accra, Ghana and the Nigeria headquarters in Yaba, Lagos (WAEC Diary, 2004), was established in 1952 and has contributed to education in Anglophonic countries of West Africa Ghana, Nigeria, Sierra Leone, the Gambia and Liberia. WAEC has the sole function of organizing and conducting secondary school and public examinations in these West Africa countries. The council conducts examination such as SC/GCE O' levels and other examinations. WAEC as an international organization has obviously played a unique role in maintaining international academic standard.

National Examination Council (NECO)

National Examination Council (NECO) was established in 1999 due to the challenges faced by WAEC and also the steady upturn in the number of candidates who register for SSCE year on year in Nigeria. NECO's maiden June/July SSCE was conducted in the year 2000 and had since continue to conduct senior school Certificate Examination (SSCE) twice in a year, June/July for internal candidates and November/December for external candidates (that is students who are not enrolled in the school system) alongside with the West African Examinations Council.

National Business and Technical Examinations Board (NABTEB)

The National Business and Technical Examinations Board came into existence in 1992 to domesticate craft subjects examinations which were then conducted by Pittman's and Royal Society of Arts of London and City and Guilds of London Institute in conformity to the provisions of the National Policy on Education. The examinations are taken twice a year, in May/June for internal students, that is, School-based candidates, and in November/December for external students (private candidates).

Public examination is necessary and required for ensuring that uniform standard is maintained in the conduct of examination by the examination bodies that certify candidates for Senior School Certificate Examination (SSCE). This examination is referred to as standardized tests. In Nigeria, WAEC, NECO, NABTEB and JAMB are the main examination bodies that conduct standardized tests at secondary school level. They can be referred to as national examination. It is a test conducted annually to communicate valuable information about students' achievement status to decision maker (Stiggins, 2008). Obioma and Salau (2007) opined that public examination are school examinations that are accessible to the general public and conducted by known bodies using test that have appropriate psychometric properties.

These three examination bodies (WAEC, NECO and NABTEB) administer questions in most subjects at SSCE level in two parts; the objective paper and the essay paper, while science subjects involve practical examination as the third paper. Multiple-choice test is the most widely used among the types of objective test in the school system for assessment purpose and also in public examination. This can be due to its applicability, flexibility, and ease of use (Olutola, 2016). Multiple choice test is said to be the most versatile of the objective tests. Large number of examinees can be assessed over broad content using multiple choice items, this increases its validity. Also, it has a high level of reliability because there can be a larger number of items on a test, and they are less susceptible to guess work. They allow an extensive coverage of subject content, thus making it useful in public examination.

Chemistry is one of the core sciences subjects that has been offered since the inception of SSCE, a public examination. Chemistry at SSCE level consists of two papers, paper I and II. Paper I is the practical aspect of the examination while paper II is further divided into two: multiple choice format and the essay format. Candidates who register for Chemistry at SSCE level must attempt the three parts (i.e practical, essay and multiple-choice tests) for assessment purpose. Chemistry syllabus supplies information and skills needed to guide students in reading for higher cognitive learning of chemistry, it helps to prepare students who want to study science related courses at the higher institution. Chemistry related specialist studies like biochemistry, medicine, geology, pharmacy, industrial chemistry, pure chemistry and engineering require at least credit level pass in Chemistry. Taking into account the usefulness of Chemistry in the technological development of the nation, it is

expected of students taking it to have more interest in the subject and perform better. Available reports of Nigerian secondary school students' performance in Chemistry are unsatisfactory (WAEC, 2016 & Kenni, 2020). There has been inconsistency of students' performance who sat for WAEC Chemistry from 2007 – 2019 (WAEC, 2020).

Senior School Certificate Examination Chemistry syllabus prepared by the three examination bodies (WAEC, NECO and NABTEB) always influence the content area of what is taught in schools. This is derived from the curriculum produced by the Nigerian Educational Research and Development Council (NERDC). It reflects in the mode and type of examination questions set by the examination bodies which are expected to measure the same construct. It is almost impossible to construct various test forms that are accurately parallel. In order to compare the scores obtained from the different test forms, a statistical process called equating can be applied. This study, therefore, investigated chained equipercentile equating of WAEC, NECO and NABTEB SSCE Chemistry multiple choice items.

Statement of the Problem

There are various forms of certification examination bodies that make use of multiple forms of tests. Each of the test forms has different items, but each form is supposed to measure the same thing. The major examination bodies responsible for certification at the senior secondary level in Nigeria have curriculum content that are similar in nature. Scores obtained from these tests should be comparable so as to ensure uniform standard, consistency and fairness.

It has been observed that candidates, educational institutions, employers of labour and other end users have preference for certificates of certain examination bodies when compared to others (Daramola, Owolabi & Olutola, 2018). For some time now, there has been prevalent criticism of examination bodies in Nigeria among some institutions and employers of labour as some of them prefer candidates with credit passes in the SSCE conducted by WAEC to those conducted by NECO and NABTEB. There are misconceptions about the quality of examinations conducted by the three examination bodies.

Kpolovie, Ololube and Ekwebelem (2011) mentioned that some Universities in Nigeria and abroad denied candidates with NECO certificate based on speculations about the integrity of NECO. Olutola (2011) mentioned in his studies that SSCE conducted by WAEC has higher standard when compared to SSCE conducted by NECO. Also, the study of Kenni (2020) revealed that there is significant difference in the performance of students that sat for Chemistry in 2015 and 2018 WASSCE and

NECO, candidates performed better in WAEC than NECO. The study of Salako, Adegoke and Ogundipe (2017) showed that WAEC and NECO successes in Mathematics and Physics are not correlated. Bandele and Adewale (2013) on the other hand submitted that WAEC, NECO and NABTEB are comparable and equivalent when the coefficients of reliability and validity of Mathematics achievement examination conducted by the three examination bodies were compared. Likewise, the study of Udofia and Udoh (2017) showed that WAEC and NECO are similar and comparable when comparative analysis of WAEC and NECO SSCE Mathematics was carried out. Therefore, it is imperative to conduct a study by conversion of units of WAEC, NECO and NABTEB so that scores obtained from them could be directly compared. This will help to confirm if the above assertions are true. Hence, this study, using Chained equipercentile equating, equated WAEC, NECO and NABTEB Senior School Certificate Multiple Choice Items in Chemistry.

Objectives of the study

The main objective of this study is to analyse the chained equipercentile equating of WAEC, NECO and NABTEB Senior School Certificate Multiple Choice Test Items in Chemistry. Specifically, the study examined the:

1. profile of students' performance on the common items of WAEC, NECO and NABTEB Senior School Certificate Multiple Choice Test Items in Chemistry;
2. profile of students' performance on the unique items of WAEC, NECO and NABTEB Senior School Certificate Multiple Choice Test Items in Chemistry; and
3. results of chained equipercentile equating of WAEC, NECO and NABTEB Senior School Certificate Multiple Choice Test Items in Chemistry using percentile ranking.

Research Questions

The following research questions were answered in the study:

1. What is the profile of students' performance on the common items of WAEC, NECO and NABTEB Senior School Certificate multiple-choice test items in Chemistry?
2. What is the profile of students' performance on the unique items of WAEC, NECO and NABTEB Senior School Certificate multiple-choice test items in Chemistry?
3. What are the results of chained equipercentile equating of WAEC, NECO and NABTEB Senior School Certificate multiple-choice test items in Chemistry using percentile ranking?

MATERIAL AND METHODS

The Non-Equivalent Groups Anchor Test design (NEAT) also known as Common items Non-Equivalent Group (CINEG) design was used in this study because the aim of the study is to equate WAEC, NECO and NABTEB Senior School Certificate multiple choice test items in Chemistry. All public senior secondary schools in South-west, Nigeria constituted the study population. South-west is one of the geopolitical zones in Nigeria, consisting of six states (Ekiti, Ondo, Ogun, Lagos, Osun and Oyo). It is predominantly a Yoruba speaking area, and Agriculture is their major source of income. The target population for this study is all senior secondary III (SS III) Chemistry students.

Simple random sampling technique was used to pick three states (Ogun, Ondo and Ekiti) out of the six states in South-West, Nigeria. Simple random sampling technique was also used to select five public senior secondary schools in each senatorial district in each state. In total, 45 public senior secondary schools were selected. Purposive sampling technique was used in this study to select senior secondary three (SS III) Chemistry students from all the 45 public senior secondary schools that were selected. These students are in the best position to respond to instrument that was used in this research because they were expected to have completed a significant part of senior school certificate Chemistry syllabus and they were preparing for WAEC, NECO and NABTEB examinations. Purposive sampling technique was used to select Chemistry students in each of the selected senior secondary schools as intact classes were used. A total number of 1,461 Chemistry students were eventually selected as samples for the study.

The 2017 WAEC, NECO and NABTEB Chemistry multiple-choice papers were adapted and used as instrument for data collection in this study. The papers comprised unique and anchor items for this study. Each test form had unique items and a set of anchor (common) items that were positioned as a block at numbers 11 - 30 in each test form. Test form A (WAEC), test form B (NECO) and test form C (NABTEB) contained 30, 40 and 30 unique multiple-choice items respectively, and each test form also contained 20 multiple-choice common/ anchor items. The reliability of the instruments (Test forms A, B and C) was determined by the researcher using measures of internal consistency. This was done by using the split-half method. Coefficients of reliability obtained for forms A, B and C were 0.81, 0.77 and 0.78 respectively while coefficients of content validity of 0.78, 0.75 and 0.76 were obtained for forms A, B and C respectively. These show that the instruments are valid and reliable. The data collected from this study were analyzed with the use of descriptive statistics of mean

and percentile rank to answer the three research questions generated. Mean was used to answer research questions one and two and research question three was answered using percentile rank.

RESULTS

Research Question one: What is the profile of students' performance on the common items of WAEC, NECO and NABTEB Senior School Certificate multiple-choice test items in Chemistry?

Mean and standard deviation of students' common items scores from test forms A, B and C were computed.

Table 1: Mean of Respondents' Performance in Common Items

Test form	No. of students	Mean	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
A	495	5.46	16	1	2.74	.514	.537
B	485	6.04	15	1	2.71	.917	1.487
C	481	7.36	17	1	3.58	.496	-.337

Results in Table 1 showed that the mean performance of respondents in common items in test form A was 5.46, while respondents' common items scores in test forms B and C had the mean performance of 6.04 and 7.36 respectively. Respondents' highest scores in the three test forms were 16, 15 and 17 respectively and their lowest score was 1. Also, test forms A, B and C had standard deviation of 2.74, 2.71 and 3.58 respectively. The three test forms (A, B and C) had skewness of .514, .917 and .496 respectively. Their positive skewness values indicated that all the scores from common items of the test forms are clustered to the left at the low values, the distribution is moderately skewed. Difference in their mean performance suggested that there was difference in the examinees' proficiency level, as a result, Chained equipercentile equating method was found suitable to equate examinees' scores in this study.

Research Question two: What is the profile of students' performance on the unique items of WAEC, NECO and NABTEB Senior School Certificate multiple-choice test items in Chemistry?

Mean scores of testees were used to determine the performance of respondents in unique items of the test forms.

Table 2: Descriptive Statistics of Respondents' Performance in Unique Items

Test form	No of students	Mean	Maximum	Minimum	Standard deviation	Skewness	Kurtosis
A	495	17.32	40	6	5.25	1.008	1.267
B	485	18.03	48	6	7.01	1.346	2.356
C	481	20.48	45	4	7.35	-1.072	0.983

The results in Table 2 showed the performance of testees on the unique items. Test form C with a mean performance of 20.48, standard deviation of 7.35, skewness of -1.072 and kurtosis of .983 indicated best performance. The skewness value of -1.072 showed that test form C scores clustered to the right at the high values and the kurtosis value of 0.983 indicated that the distribution of scores is relatively flat. Test form B with better performance had mean score of 18.03, standard deviation of 7.01, skewness of 1.346 and kurtosis of 2.356 while testees who did test form A had the least performance. The mean score of test form A was 17.32 and standard deviation of 5.25. The skewness and kurtosis values are 1.008 and 1.267 respectively. Positive skewness shows that mass of the scores is clustered to the left at the low values.

Research Question three: What are the results of chained equipercentile equating of WAEC, NECO and NABTEB Senior School Certificate multiple-choice test items in Chemistry using percentile ranking?

Percentile ranks were used to determine the equivalence of scores obtained from WAEC, NECO and NABTEB such that scores with the same percentile ranks were considered equivalent.

Table 3: Summary Showing Chained Equipercentile Equating of WAEC, NECO and NABTEB SSC Chemistry Multiple-choice Papers

WAEC (FORM A)	NECO (FORM B)	NABTEB (F0RM C)
9	8	10
10	9	11
11	10	12
14	14	16
17	17	19
18	18	21
20	20	23

Results in Table 3 revealed that scores of 9, 10, 11, 14, 17, 18 and 20 in WAEC (test form A) was equivalent to scores of 8, 9, 10, 14, 17, 18 and 20 in NECO (test form B) and same with scores of 10, 11, 12, 16, 19, 21 and 23 in NABTEB (test form C). Figure 4 is a graphical representation of a line graph showing percentile rank of SSCE Chemistry multiple choice papers scores.

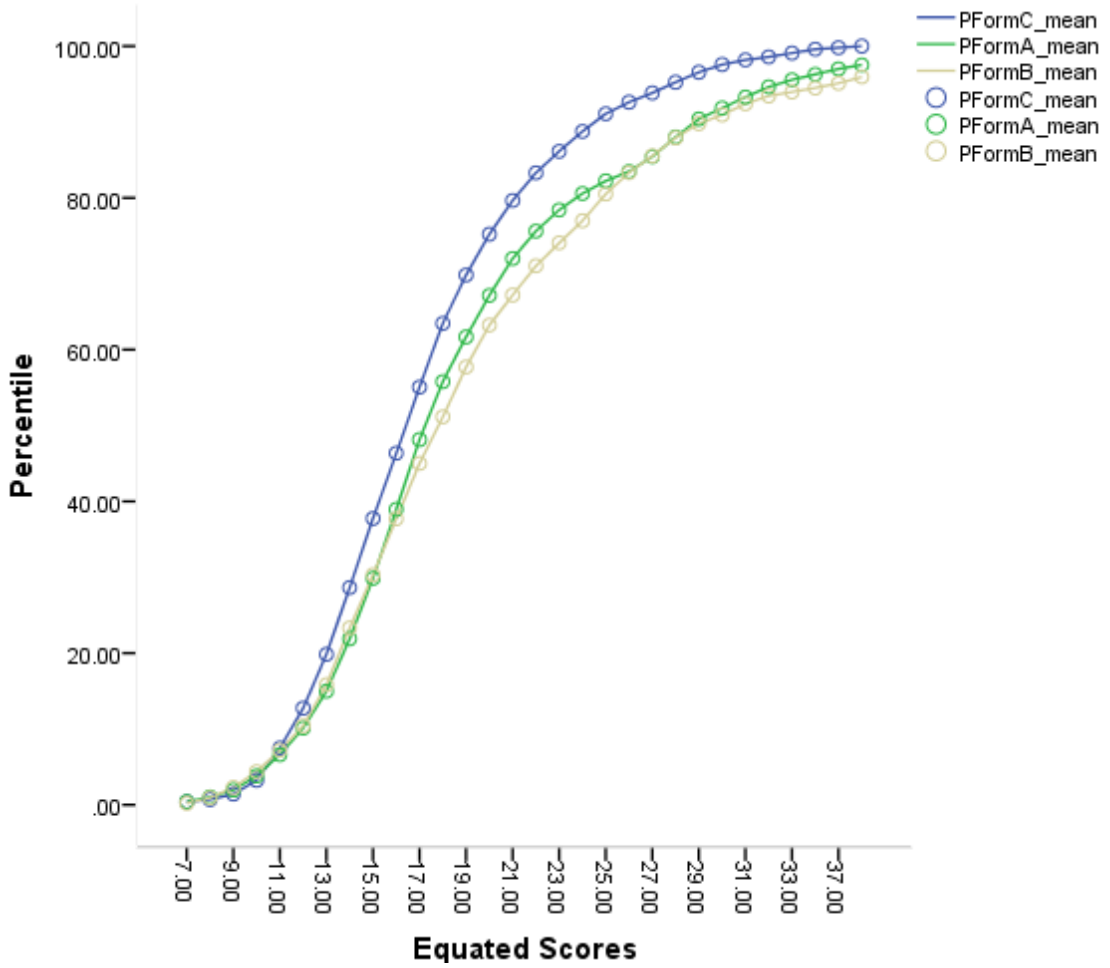

Figure 1: Percentile rank of scores on WAEC, NECO and NABTEB SSCE Chemistry multiple choice papers

The graph in Figure 1 showed that scores from all the test forms are comparable, the distribution of scores had similar shape. Though scores obtained from test forms A and B (WAEC and NECO) were more equivalent than those from test form C (NABTEB).

DISCUSSION

The results of the study revealed that examinees differed in their proficiency level because the mean performance on their common items scores on the three test forms A, B and C were 5.46, 6.04 and 7.36 respectively. This result might be attributed to differences in the proficiency level of testees who sat for the three test forms. This implied that the use of chained equipercentile equating method, an

equipercentile equating method used when testees' abilities differed is suitable for this study. This also suggests that the condition for carrying out scores equating for WAEC, NECO and NABTEB multiple choice items in Chemistry was not violated. This is in agreement with the findings of Holland, et.al (2006), Kolen and Brennan, (2004) and Wang et al (2008). The researchers all found out that when the proficiency level of the examinees that sit for the different test forms are at variance, chained equipercentile equating method is found appropriate to equate the test forms.

This study also showed that there were differences in the performance of examinees in unique items across the test forms with mean performance of 17.32, 18.03 and 20.48 in test forms A, B and C respectively. This result is in line with the findings of Kolen and Brennan (2004) that constructing multiple forms of tests that are parallel is almost impossible. It therefore, becomes imperative for equating to take place because it adjusts for differences in difficulty across test forms that are constructed as similar as possible in difficulty and content just like the senior school certificate examinations that were examined in this study.

Results from Chained equipercentile equating of WAEC (test form A), NECO (test form B) and NABTEB (test form C) Senior School Certificate Chemistry multiple choice papers with the use of percentile ranking showed that scores of 9 in WAEC was equivalent to scores of 8 and 10 in NECO and NABTEB respectively. This finding is in line with that of Bandele and Adewale (2013) whose study revealed that WAEC, NECO and NABTEB were comparable and equivalent when the validity and reliability coefficient of Mathematics achievement examination conducted by the three testing agencies were compared. The finding disagrees with Alfred's (2011), that there was a significant difference in the difficulty level of Economics multiple choice items conducted by WAEC, NECO and NABTEB. Chained equipercentile equating also revealed that scores of 14 in WAEC was equivalent to 14 in NECO and 16 in NABTEB. This finding validates the outcome of the study of Udofia and Udoh (2017) that WAEC and NECO senior secondary Mathematics examination are similar and comparable at .05 level of significance. This finding negates that of Salako, Adegoke and Ogundipe (2017) that WAEC and NECO successes in Mathematics and Physics were not correlated. Further results revealed by chained equipercentile equating in this study showed that though multiple-choice items of WAEC, NECO and NABTEB tended to be equal, WAEC and NECO were more equivalent.

CONCLUSION

It can be concluded from this study that examining bodies, most especially those considered in this study (WAEC, NECO and NABTEB) should consider maintaining uniform standard across the test forms through equating, so as to avoid comparison of their papers and certificates among candidates, parents and stakeholders. Government's desired goal on establishing these examining bodies can therefore be achieved.

On the basis of the findings of this study, the following recommendations are proposed:

1. Test developers are encouraged to ensure high quality of items used by each examining body
2. Uniformity in standards of all examination bodies should be encouraged and this can be attained by employing experts in measurement and evaluation who will serve as monitoring team for constructing and conducting of examination as well as certification.

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Data Availability Statement: The data for this study is available on request

Conflicts of Interest: No potential conflict of interest was reported by the authors.

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