



# Culture and Differential Item Functioning in National Examinations Council Senior School Certificate Mathematics Multiple Choice Test in Nigeria

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## Abstract

The present study investigated the influence of culture on DIF in National Examination Council Senior School Certificate Mathematics multiple choice test in Nigeria. The study ascertained the instances of test items in NECO SSCE mathematics multiple choice questions that function differently for Ibo and Yoruba testees. To guide the study, three hypotheses were formulated and tested. An ex-post facto research design was employed in the study using 1,200 SSS3 students to obtain data on students' differential performance in mathematics across the different cultural environments. The instrument for data collection was General Mathematics paper I multiple choice test used by NECO in June/July, 2012 that was made up of 60 items. Chi-square goodness-of-fit test statistics was used to test the hypotheses at 0.05 levels of significance. The study revealed that the test item with DIF in NECO SSCE mathematics multiple choice questions significantly differ for testees from Ibo and Yoruba cultural environments and that the test items with DIF in NECO SSCE mathematics multiple choice questions significantly differ for males and females testees from Ibo cultural environment. It equally revealed that the test items with DIF in NECO SSCE mathematics multiple choice questions significantly differ for male and female testees from Yoruba cultural environment. Based on these findings, it was recommended that mathematics teachers should adopt the use of culturally responsive instructional techniques to reduce students' differential performance in mathematics irrespective of gender.

**Keywords:** Culture, DIF, Multiple Choice test, Items bias, Gender

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## INTRODUCTION

Mathematics is a compulsory subject in Nigeria education system because of its importance as emphasized in the National Policy on Education. Mathematics has been found to be very important because it is needed for all scientific, technological research and technical training. It is a fundamental science subject, which acts as a base index for understanding the complexities for most other fields. Mathematics is also rightly described as the language of science, as well as the central intellectual discipline of the technological societies. Its contribution to mankind has given the subject the prominent it enjoys among other school subjects. This had earned it the status of core subject in the school curriculum at both primary and secondary schools levels. Its status has also made it compulsory for any student seeking admission to read any science or science related course in any tertiary institution to secure a credit pass in it. It is in view of this that Adamu (2007) described mathematics as key to scientific and technological advancement in this age and as the lifeblood of modern science.

Despite the importance of mathematics, there have been reports of students' poor performance in the subject at the secondary school level. To demonstrate the trends of mathematics failure in Nigeria secondary schools, the West African Examination Council (WAEC) revealed consistent declining performance in Senior School Certificate Examination (SSCE) results for the past nine years. While the percentage success of the result in 2006 was 39.92% in 2009, it declined to 31.50%. Reasons given by WAEC report for the low-level performance were dearth of qualified teachers, inadequate and dilapidated classrooms as well as other poor conditions in secondary schools across the country (Ojo, 1993). Similarly, Adamu (2007) identified poor quality of instructional techniques employed by teachers, overcrowded nature of the classes and teachers' poor method as some of the factors responsible for students' poor performance in mathematics.

Several research efforts have been made to solve the problem of poor performance in mathematics. Some of these efforts are in the improvement of method of teaching, quality of instructional technique employed by teachers, and method of presentation before the students in order to improve mathematics results in our secondary schools. These efforts have also resulted in the orientation programme for mathematics improvement projects intends to improve mathematics teachers in primary, secondary and tertiary level of education. Despite these efforts, available statistics show that students' performance in the subject is still very poor. It is interesting to note that none of these efforts looked at the inherent unfairness in test item used in determining of learning outcome.

The results of researches in the field of evaluation, Flores (2000), and Lam (1995) showed that it is evident that a test may be bias, which may unfairly influence examinee's scores due to the presence of irrelevant, non-target constructs which are related to gender; ethnicity, race, linguistic background, socio-economic status or handicapping conditions (Flores, 2000; Lam, 1995), differences in upbringing environment, cultures (Fortunes, 1985). The general concept is that as much as possible test constructed should represent the best test one could obtain. But if a test so constructed is unfair or yields different scores for subgroups for instance (gender, location, religion, socio-economic background and culture) with the same ability as evident from their scores, then such a test is said to be biased or function differentially (Zumbo, 1999). This phenomenon is termed Differential Item Functioning (DIF). Differential Item Functioning (DIF) occurs when examines from different groups shows differing probabilities of success on the item after matching on the underlying ability that the item is interested to measure

(Zumbo, 2009). In essence, DIF occurs when people from different group with the same ability have systematically different responses to test items. DIF of an item can therefore be understood as a lack of conditional independence between an item response and group membership (often gender or ethnicity) giving the same latent ability or trait (Clickman, Seal & Eisen, 2009).

Admittedly, one of the explanation for different responses to test items for people with the same ability is culture. For instance, Price-William, Gordon and Ramirez in Eibisine (2014) reported that the rate of development of universal types of mathematics abilities varied among culture. Lave (1988) and Scribner (1986) averred that cultural variables such as economic specialization, schooling, and number word system have influence on mathematical knowledge. According to them, mathematical thinking used by students to solve problem, the intellectual tools students acquire from their culture and other support parents provide help them develop mathematical knowledge. Therefore, socio-cultural influences such as values, beliefs, communication patterns, and socio-economic conditions prevailing in students cultural groups may influence the way in which they make sense of mathematics terms and the way in which they solve them (Guillerman & Sheron, 2001). As such, students' performance in a test is influenced by cultural activities students engaged in for a long period of time (Lipka, 1991). This suggests that cultural influences that shape the ways in which students interpret and solve mathematics problems affect their performance in the subject.

Significantly, Ercikan (1998) reported that different groups of examinees may have different multidimensional ability distribution due to language and culture. From this perspective, two examinees from different cultural environment may be functioning differentially in each of the components of mathematics. For example, mathematics has these components viz arithmetic and geometry. Arithmetic is related to gain, loss discount, interest charges and cheques among other things which is different from geometry. Geometry has to do with the study of properties of shapes. A student from Ibo cultural environment whose culture favour trades and spatial components of mathematics as depicted in apprenticeship to various trade is reflected in such topics as interest rate, simple interest, profit and loss fractions, percentages and exchange rates. The trade and spatial aspects of mathematics are specifically reflected in Ibo culture is in their construction of houses especially the thatching of the roof which obeys a certain order that suggests the criss-crossing relationship of line, parallels, vertically and horizontally such that the general outlay is graphical and has some rectangle or square in between. Thatching also exposes ideas of inclination, made so to allow rain drop to slide off the rooftops (Odili & Okpobiri, 2011). Similarly, a student from Yoruba whose cultural activities involves weaving by intertwining of ropes to make a perfect cloth materials and measurement of items of clothing with the use of arm lengths, will understand computation, measurement, patterns and relations, combinatory and probability and areas and volumes. This shows that the average Nigerian student in secondary school already has some mathematics inside of him which is used in lives quantifications, measurement, estimations, calculations of periods, recurrence of peculiar events and age even before coming to school depending on his cultural environment.

Therefore, the nature of mathematics is related to culture as such those whose cultural activities are related to a given mathematical components are likely to do better than individuals whose activities are not related to that mathematics component when test items reflect them. Test items in this aspect of mathematics may be simple to an individual from such cultural environment. Thus, there is the need to investigate through research the influence of culture on

DIF in mathematics in National Examination Council Senior School Certificate Examination, given the cross cultural groups that take the examinations.

### **Purpose of the Study**

The study specially focused on:

- Investigating the instances of test items with DIF in NECO SSCE mathematics multiple choice questions that functioned differently for testees from Ibo and Yoruba cultural environments.
- Determining the instances of test items with DIF in NECO SSCE mathematics multiple choice questions that functioned differently for male and female testees from Ibo cultural environment.
- Ascertaining the instances, of test items with DIF in NECO SSCE mathematics multiple choice questions that functioned differently for male and female testees from Yoruba cultural environment.

### **Hypotheses**

The following hypotheses were formulated to guide the study at 0.05 level of significance:

- The instances of test items with DIF in NECO SSCE mathematics multiple choice questions does not significantly differ for testees from Ibo and Yoruba cultural environments.
- The instances of test items with DIF in NECO SSCE mathematics multiple choice questions does not significantly differ for male and female testees from Ibo cultural environment.
- The instances of test items with DIF in NECO SSCE mathematics multiple choice questions does not significantly differ for male and female testees from Yoruba cultural environment.

### **Theoretical Framework**

The theoretical framework of this study is anchored on the theory of multiple intelligence. This theory was propounded by Gardner (1985) and it posits that individuals have different intelligence and that the mind is not a holistic entity, but instead consists of distinct, independent modules. According to Gardner (1985) intelligence is an aspect of human activities, that is made up of many independent components. The theory listed seven independent components of intelligence such as (1) linguistic intelligence used in musical appreciation, composition and performance, (2) mathematical-logical intelligence used in arithmetic, numerical calculation and logical reasoning, (3) spatial intelligence used in arranging objects spatially, as well as visual art and finding one's way around, (4) bodily-fkinesthetic intelligence use in sport, dancing or simple everybody movement and dexterity, mechanical component which have to do with ability to work with objects, (5) interpersonal intelligence used in relating to others, interpreting social signal outcomes and (6) interpersonal intelligence used in understanding and prediating one's own behavior and in indentifying aspects of the self and one's own personality. These

components are in agreement with Piaget and Inhelder (1976) assumption that intelligence development is influenced by activities. The position is also supported by Gardner (1985) that depending on what an individual is doing the various independent components of intelligence can be differentially influenced by culture. Thus, the fact that our activities are inherent in our culture, it stands to show that the different aspects of intelligence can develop based on the activities in our culture.

Essentially, Gardner (1985) theory of multiple intelligence appears to be a reasonable and sound explanation of influence of culture on students' performance in the various aspects of mathematics viz: algebra, arithmetic, statistics, geometry and trigonometry. Drawing from Gardner's proposition the aspect of intelligence that has to do with spatial will be more related to a cultural activity that has to do with ability to visualize a space. Whereas trading abilities may align with Gardner's (1985) mathematical-logical intelligence used in arithmetic, numerical calculation and logical reasoning. Based on this premise, differential item functioning in mathematics should be said to have its root in the theory of multiple intelligence, since culture independently determine what individuals sense and perceive within their environment, predict behavior, as well as, performance difference between two groups of comparable ability or performance.

### **Concept of Differential Functioning (DIF)**

A test that exhibits DIF is one that is unfair to a subgroup of the general population in which it is being used. DIF occurs when two groups (reference group and focal group) that are matched in terms of their relevant knowledge and skills perform differently in an item (Umoinyang, 2011). DIF is a threat to test validity and invalidates interpretation of the test results for some groups of the same population (Pido, 2012). DIF occurs when examinees of the same ability do not have the equal probability of getting an item correct (Perrone, 2006; Roever, 2005). This arises mainly due to the sex, cultural, ethnic, religious, or class background of the examinees. Item bias manifest itself in context, language and item structure and format bias (Rovwer, 2005). Content bias refers to a situation where knowledge and or skills tested are not part of the educational background of the examinees. Lack of familiarity with content in test items disadvantages individuals in their performance. The individual's responses to items are not based on other irrelevant abilities. Language bias occurs where words in items have different or unfamiliar meanings for different examinee subgroups. The item has difficult vocabulary, group specific language, and vocabulary and reference pronouns. Item structure and format bias occurs where there is ambiguity in the instructions, items stem or options. The content or clues and explanations given to successfully complete the task provided disadvantage individuals in some subgroups (Perrone, 2006).

Item bias can occur when a characteristic of the item that is not relevant to the test purpose differently influences responses of examinee groups (Ercikan & Lyong-Thomas, 2013). There is an expectation that if an item on a test is not biased, then examinees from two groups who have equal overall ability ought to have the same probability of correctly responding to it. When examinees from different groups that have comparable ability levels have different probabilities of getting on item correct, differential item functioning (DIF) is said to occur (Hambleton, Swaminathan & Rogers, 19991).

It is important to analyze whether items have DIF for at least two reasons. The presence of DIF signals potential bias and bias has an impact on validity of inference drawn from group

comparison. Therefore DIF items, if confirmed to represent underlying bias, are often removed from future administration of a test. Second, items that exhibit DIF may have implications for curriculum and instruction (Lane, Wang & Magone, 1996), particularly if no reason for bias can be found. For example, test items that are presented in a multiple choice item format may consistently exhibit DIF favouring one group, whereas items presented in constructed response item format may favour another group. In this case, if no bias is established, it may be desirable to ensure that all groups receive adequate instruction in completing all types of test items, and that test contain balanced proportions of various item types. DIF should be distinguished from differences in overall group ability.

## **METHODS**

### **Design**

This study adopted the ex-post facto research design. This design was deemed suitable because it enables the researcher to collect data that can reveal DIF in mathematics among students from Ibo and Yoruba cultural environments.

### **Population of the study**

The population of the study was senior secondary school students in class three who are preparing for the senior school certificate examination among the Ibo and Yoruba in Owerri North and West Local Government Area of Imo State and Ibadan North-East and South-West Local Government Areas of Oyo State. The choice of SSS3 students was informed by the fact that they have covered the NECO mathematics syllabus.

### **Sample and Sampling Technique**

The sample comprised one thousand two hundred (1,200) SSS3 students made up of six hundred (600) students each from Ibo and Yoruba cultural environments using proportionate random sampling. The multi-stage sampling technique was adopted to select the sample for the study. In the first stage, one state each was purposively drawn from the South-East and South-West. Second, a cluster of inhabitants who are predominantly Ibo and Yoruba respectively was sampled. This gave rise to Owerri North and West Local in Imo state and Ibadan North-East and South-West Local Government Area in Oyo State which are predominantly inhabited by the Ibo's and Yoruba's. Third, the researcher used the random sampling technique to select six (6) senior secondary schools from each of the two chosen Local Government Areas in Imo and Oyo States respectively. In all, twenty-four (24) secondary schools were sampled for the study. Having done that, fifty (50) SSS3 students were drawn from each of the schools thereby giving a total sample size of 1,200.

### **Instrument for Data Collection**

The instrument for data collection was General Mathematics Paper I Multiple choice Test used by NECO in the June/July 2012 SSCE. It has sixty items in the multiple choice format. The instrument was a standardized test developed by experts in NECO as such there was no need for validation and reliability because the test is already valid and reliable.

## Method of Data Collection

The mathematics teachers in the various secondary schools administered the test to the SSS3 students. The students were given the test after receiving instrument for the test. The students completed the test for two hours under the supervision of their teachers.

## Method of Data Analysis

The data collected using the instrument were analyzed so as to enable the researcher to test the hypotheses. The chi-square goodness-of-fit test statistics was used to test the hypotheses at 0.05 level of significance.

## RESULTS

### Hypothesis 1

The instances of test items with DIF in NECO SSCE mathematics multiple choice questions does not significantly differ for testees from Ibo and Yoruba cultural environment.

Table 1: Chi-square goodness-of-fit test on significant difference in the instances of test items with DIF in NECO SSCE mathematics multiple choice questions that differ for Ibo and Yoruba cultural environments.

Group	Observed frequency	Expected frequency	DF	Level of significance	Decision
Ibo	27	30	1	0.05	Rejected
Yoruba	20	30			

$$x^2 \text{ Cal.} = 3.63; \text{ Crit. } x^2 = 3.84$$

Table 1 presents chi-square goodness-of-fit test on significant difference in the instances of test items with DIF in NECO SSCE mathematics multiple choice questions that differ for testees from Ibo and Yoruba cultural environments. From the table, the calculated  $x^2$  value is greater than the critical  $x^2$  value, therefore the hypothesis is rejected. This suggests that the test items with DIF in NECO SSCE mathematics multiple choice questions significantly differ for testees from Ibo and Yoruba cultural environments.

### Hypothesis 2

The instances of test items with DIF in NECO SSCE mathematics multiple choice questions does not significantly differ for male and female testees from Ibo cultural environment.

Table 2: Chi-square goodness-of-fit test on significant difference in the instances of test items with DIF in NECO SSCE mathematics multiple choice questions that differ for male and female testees from Ibo cultural environment.

Group	Observed frequency	Expected frequency	DF	Level of significance	Decision
Male	18	30	1	0.05	Rejected
Female	12	30			

$$x^2 \text{ cal.} = 15.6; \text{ Crit. } x^2 = 3.84$$

Table 2 presents chi-square goodness-of-fit test on significant difference in the instances of test items with DIF in NECO SSCE mathematics multiple choice questions that differ for male and female testees from Ibo cultural environment. From the table, the calculated  $x^2$  value is greater than the critical  $x^2$  value, therefore the hypothesis is rejected. This suggests that the test items with DIF in NECO SSCE mathematics multiple choice questions significantly differ for male and female testees from Ibo cultural environment.

### Hypothesis 3

The instances of test items with DIF in NECO SSCE mathematics multiple choice questions does not significantly differ for male and female testees from Yoruba cultural environment.

Table 3: Chi-square goodness-of-fit test on significant difference in the instances of test items with DIF in NECO SSCE mathematics multiple choice questions that differ for male and female testees from Yoruba cultural environment.

Group	Observed frequency	Expected frequency	DF	Level of significance	Decision
Male	8	30	1	0.05	Rejected
Female	5	30			

$$x^2 \text{ cal.} = 36.97; x^2 = 3.84$$

Table 3 presents chi-square goodness-of-fit test on significant difference in the instances of test with DIF in NECO SSCE mathematics multiple choice questions that differ for male and female testees from Yoruba cultural environment. From the table, the calculated  $x^2$  value is greater than the critical  $x^2$  value, therefore the hypothesis is rejected. This implies that the test items with DIF in NECO SSCE mathematics multiple choice questions significantly differ for male and female testees from Yoruba cultural environment.

## DISCUSSION

**The instances of test items with DIF in NECO SSCE mathematics multiple choice questions does not significantly differ for testees from Ibo and Yoruba cultural environments.**

Analysis of differential item functioning (DIF) of responses by students in NECO SSCE mathematics multiple choice questions in June/July 2012, showed that the instances of test items with DIF in NECO SSCE mathematics multiple choice questions significantly differ for testees from Ibo and Yoruba cultural environment as presented in table 1. The result indicated that the test contain items that function differently for testees from Ibo and Yoruba cultural environment.



In effect the instances of test items with DIF in NECO SSCE mathematics multiple choice questions depend on those experiences and activities of the cultural groups. This finding is consistent with that of Greenfield (1997) that culture and society shape mental functioning, individual have predisposed notions of how to respond to questions, solve problems among others. The predisposition may influence the way in which students interpret materials presented in test and the ways in which students respond to test items. This result further support that of Schliemann, Carraher and Ceci (1997) that the quality of culture in which one lives plays a dominant role in performance and development of mathematics knowledge. According to them, there are mathematical thinking used by students to solve problems that arise in customary activity such as play, trade, farm activities and work. Also, Williams. Gordon and Ramirez (1969) stated that the rate of development of universal types of mathematical abilities varied among culture. This finding further buttressed the finding of Lave (1988) and Scribner (1986) that cultural variables such as economic specialization, schooling and number—word system have influence on mathematical knowledge. They further reported that mathematical thinking used by students to solve problems, the intellectual tools students acquire from their culture and other support parents provide help them (students) develop mathematical knowledge.

#### **The instances of test items with DIF in NECO SSCE mathematics multiple choice questions does not significantly differ for male and female testees from Ibo Cultural environment**

Analysis of differential item functioning (DIF) of responses by students in NECO SSCE mathematics multiple choice questions in June/July 2012, showed that the instances of test items with DIF in NECO SSCE mathematics multiple choice questions significantly differ for male and female testees from Ibo cultural environment as presented in Table 2. In effect the test had items that measured different things for male and female testees from Ibo cultural environment with the same latent ability in mathematics. Therefore, the instances of test items with DIF in NECO SSCE mathematics multiple choice questions had items that are indepth in male activities and experiences in Ibo cultural environment. This result supported that of Doo Little and Cleary (1987) that males are better on word problem and algebra items favoured females and Beller and Gafni (1996) that measurement items and terms involving problem solving favoured males.

They also considered the age levels and concluded that gender-related DIF becomes larger as age increases.

#### **The instances of test items with DIF in NECO SSCE mathematics multiple choice questions does not significantly differ for male and female testees from Yoruba Cultural environment**

Analysis of differential item functioning (DIF) of responses by students in NECO SSCE mathematics multiple choice questions in June/July 2012, showed that the instances of test items with DIF in NECO SSCE mathematics multiple choice questions significantly differ for male and female testees from Yoruba cultural environment as presented in Table 3. In effect the test had items that measured different things for male and female testees from Yoruba cultural environment with the same latent ability in mathematics. Thus, the instances of test items with DIF in NECO SSCE mathematics multiple choice questions had item concepts that are in-depth in male activities and experiences in Yoruba cultural environment. This result agreed with that of Abedalaziz (2010a) that gender-related DIF is a constant concern on larger scale standardized achievement test in mathematics because differences between female and male are often found,

The result also tallies with that of Escorial (2004) that there are evidences of gender DIF in Advance Progressive Matrices Test among applicants to a private university. It was attributed to visuo-spatial nature of the test. Males were performing better. Furthermore, another study by Abedalaziz (2010b) found that numerical ability math items favoured female examinees, whereas items involving special and deductive abilities favoured males.

## CONCLUSION AND RECOMMENDATION

This study aimed at ascertaining the influence of culture on DIF in mathematics in National Examination Council Senior School Certificate Examination, It specifically determined how the index of DIF varies with different cultures in the different areas of mathematics. The following conclusions are drawn on the basis of data analyzed in the study. First, test items in NECO SSCE mathematics multiple choice questions contained items that function differentially for testees from the different cultural groups such as Yoruba and Ibo respectively. This means that such items measured different things for testees of the same latent ability across the different cultural groups. Second, the analysis of data showed that NECO SSCE General Mathematics Paper I multiple choice test in June/July, 2012 had items that function differently for male and female testees with the same latent ability across the different cultural groups. This is because culture influences the ways in which people construct knowledge and create meaning from experience and in mathematics, the individual construction of meanings takes place in interaction with the culture of environment. Based on the findings of the study, the following recommendations were made:

- Culture has been demonstrated to influence DIF in NECO mathematics test items based on gender in different cultural environments. As such mathematics teachers need to adopt the use of culturally responsive instructional technique to reduce students' differential performance in mathematics irrespective of gender. This is because the students culture can be used to teach mathematics and this may make mathematics teaching and learning meaningful. This will afford the teachers and students to gain insight into the various components of mathematics.
- Mathematics teachers should motivate their students to engage in mathematics thinking in their local parlance, using local examples of things that they can see, recognize in their quantities, shapes and cultural application.

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