

Assessment of Differential Item Functioning of Basic Education Certificate Examination Mathematics Multiple Choice Items

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Abstract

The study assessed the Differential Item Functioning of 2020 Basic Education Certificate Examination (BECE) Mathematics multiple choice test items in Dutsin-Ma Education Quality Assurance, Katsina State, Nigeria. The study adopted Descriptive Survey research design and Ex-Post-Facto research design. The population of the study is 4,881 junior secondary school students in Dutsin-Ma Educational Quality Assurance Zone. A multi-stage sampling technique was used for the study to obtain a sample size of 525 mathematics junior secondary school students (JSS III) which were proportionately drawn from the 10 selected secondary schools that constituted the sample size of the study. The instrument used for data collection was 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items conducted in 2019/2020 academic sessions with reliability indices of 0.75. Data obtained for the study were analyzed using the Scheuneman modified Chi-square statistic to answer all the research questions and chi-square test statistic was employed in testing the null hypotheses at 0.05 level of significant. The results revealed that Basic Education Certificate Examination (BECE) multiple choice mathematics items used in 2020 examinations contain test items that significantly functioned differentially for testees on the basis of gender. Based on the finding, it was recommended that test developers, ministry of education and examination bodies should ensure that Mathematics multiple choice test items are free from differential item functioning (DIF) for adequacy of test credibility and civility.

Keywords: Differential Item Functioning, Invariance, Basic Education Certificate Examination, Mathematics

Introduction

Test is an indispensable tool in teaching and learning process. This tool helps in the promotion of students from one level or class to another and to diagnose the students who has learning deficiencies. Test is a tool for measuring or assessing the knowledge, skills, values and abilities of a student or a group of students in the school setting. According to Owolabi (2019), a test is a tool or systematic procedures for observing and describing one or more characteristics of a student, either using a numerical scale of classification scheme. The variant commonly used in teaching and learning which is often prepared and used by teachers is achievement test. It could be classified into objective or essay types. The multiple-choice type of objective test is describe as flexible and useful type of objective test. Also, multiple choice tests are most reliable because of consistency in scoring the test as well as its fairness to all students. According to Kolawole (2005), multiple choice tests require students to select the answer from a number of possible alternatives. Multiple choice items give the fairest opportunity to testees to prove their competence and testers to prove their integrity. Its objectivity is both in terms of development and in terms of scoring as items cover wider curriculum contents and objectives of instruction. It is adjudged as having good validity since it has the tendency to cover all aspects of learning content (Alonge, 2003).

However, Basic Education Certificate Examination (BECE) used multiple choice tests in their Mathematics questions. Mathematics is a branch of science that deals with the logic of shape, quantity and arrangement. It is a specialized cognitive tool and an undisputed agent of Nations development and wealth creation. Its application is

universal to all learning and everyday living from counting possessions to measuring properties, predicting events, computing taxes/profit, drawing maps/plans, drawing budgets, providing models and synthesizing results. All these are indicating that, mathematics is useful in domestic and business affairs, scientific discoveries, and technological breakthrough, problem-solving and decision-making in different situation of life (Kolawole & Olutayo, 2005). The significance and usefulness of mathematics can never be overemphasized. Mathematics is a subject that develops thinking behaviour in the students (Onal, Inan, & Bozkurt 2017). It important to note that, test used to assess students' performance in schools supposed to measure examinees ability or other traits of interest irrespective of certain factors such as gender, ethnicity, geographical location and school types. Thus, a test item by standards is supposed to be invariant in nature. Therefore, DIF arises when two groups of equal ability levels are not equally able to correctly answer an item (Queensoap & Orluwene, 2019). The two types of DIF are uniform and non-uniform DIF.

Uniform DIF occurs when a group performs better than another group on all ability levels. In the case of non-uniform DIF, members of one group are favoured up to a level on the ability scale and from that point on the relationship is reversed (Karam, 2012). According to Zhang (2006) DIF occurs for an item when one group (the focal group) of examinees is more or less likely to give the correct response to that item when compared to another group (the reference group) after controlling for the primary ability measured in a test. In testing, Item functioning is intended to be invariant with respect to irrelevant aspects of the test-takers, such as gender, location, ethnicity and socio-economic status (Queensoap & Orluwene, 2019). School location means a particular area where a school is located. It can be rural area or urban area (Olutola, 2016). Also, gender is an important variable in the school system. Gender means both the male and female.

Several studies give evidence that compared boys to girls' lack of confidence in doing mathematical sums and view mathematics as male domain (Leder, 2002; Meelisan & Luyten 2008). Males enroll in more mathematics classes, they dominate professions that enquire higher level of mathematical knowledge (mathematical abilities than their male counterparts and males and females differ in their attributions for success and failure in mathematics (Leder, 2002). In addition, the impact of school location on students' performance cannot be . Onah (2011) and Owoeye (2002) noted that students in urban areas achieved more than students in the rural areas in science subjects. The findings of Olutola (2011) revealed that students from urban schools performed better in NECO multiple choice Biology items. In addition, the results of Obinne and Amali (2014) research showed that some of the items in the West African Examinations Council (WAEC) and National Examinations Council (NECO) for 2000 and 2001 functioned differently which indicated the existence of DIF effects thus, measuring what they were not supposed to measure. Also, the result of Ihechu and Madu (2016) study revealed that items significantly function differentially by school location for urban and rural examinees in National Examination Council Agricultural multiple choice test items. Other studies like Essen (2015), Wen-ling and Rui (2008), Omorogiuda and Iro-Aghedo (2016), Olutola (2015), Agah (2013) and Akanwa, Ihechu and Nkwocha (2018) also point to the fact that differences significantly occur in test item functioning based on gender and other heterogeneous groups of any given population. However, there is the need for research in identification of DIF in test items used in measurement of achievement in mathematics. This study therefore, assessed Mathematics multiple choice test items that are biased in respect to gender and school location in 2020 Basic Education Certificate Examination (BECE) in Dutsin-Ma Education Quality Assurance, Katsina State, Nigeria.

Purpose of the Study

The purpose of the study was to assess test items that are biased in respect to gender and school location in Mathematics of Basic Education Certificate Examination in Dutsin-Ma Education Quality Assurance, Katsina State, Nigeria. Specifically, the study sought to find out percentage of items in the 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items functioned differentially by:

- i. gender
- ii. school location.

Research Questions

The following research questions were asked in the study:

1. What percentage of items in the 2020 Basic Education Certificate Examination (BECE) multiple choice

mathematics items functioned differentially by

- i. gender?
- ii. school location?

Hypotheses

The following hypotheses were formulated to guide the study

1. There is no significant difference between male and female students on the percentage of items which functioned differentially in the 2020 Basic Education Certificate Examination (BECE) mathematics multiple choice test examination.
2. There is no significant difference between urban and rural students on the percentage of items which functioned differentially in the 2020 Basic Education Certificate Examination (BECE) mathematics multiple choice test examination.

Methodology

The study adopted descriptive survey research design and ex-post-facto research design. The population of the study is 4,881 junior secondary school students in Dutsin-Ma Educational Quality Assurance Zone. A multi-stage sampling technique was used for the study. Based on Krejcie and Morgan's (1971) formula for determining sample size from a known population, a total sample size of 525 Mathematics junior secondary school students (JSS III) were proportionately drawn from the 10 selected secondary schools that constituted the sample size of the study. The instrument used for data collection was 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items conducted in 2019/2020 academic sessions. The instrument was re-validated by two experts from Educational Measurement and Evaluation unit, Federal University Dutsin-Ma, Katsina State, Nigeria. The instrument was administered once in the area that was not part of the sample. The data obtained was analyzed using Kuder Richardson Formular 20 with reliability indices of 0.75. Data obtained for the study were analyzed using the Scheuneman modified Chi-square statistic to answer all the research questions and chi-square test statistic was employed in testing the null hypotheses at 0.05 level of significant.

Results

Research Question 1: What percentage of items in the 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items functioned differentially by gender

Table 1: Scheuneman Chi -square Gender differential Item Functioning Indices for 2020 Basic Education Certificate Examination (BECE) Multiple Choice Mathematics Items Functioned Differentially by Gender

Items	χ^2	Items	χ^2	Items	χ^2
1	14.87**	21	8.32	41	10.53*
2	10.65*	22	7.76	42	7.65
3	9.98*	23	5.98	43	16.51**
4	5.46	24	4.66	44	6.22
5	3.87	25	6.23	45	4.43
6	4.96	26	16.65**	46	10.98*
7	10.76	27	8.42	47	5.65
8	8.54	28	11.65*	48	14.87**
9	16.86**	29	10.22*	49	4.98
10	10.13*	30	7.21	50	6.17
11	11.43*	31	6.76	51	15.65**
12	14.67**	32	13.87**	52	8.54
13	15.19**	33	14.87**	53	5.22
14	12.88*	34	6.67	54	9.04
15	10.76*	35	6.11	55	13.87*
16	7.54	36	15.76**	56	8.31
17	11.55*	37	9.09	57	17.76**
18	12.32*	38	16.98**	58	14.54**
19	11.11*	39	15.65**	59	4.76
20	8.87	40	6.54	60	7.54

** or * significant at the 0.05 level, df= 4 critical $\chi^2 = 9.49$

From Table 1, it can be seen that 29 items representing 48% in 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items significantly function differentially for testees on the basis of gender. The above result showed that Basic Education Certificate Examination (BECE) multiple choice mathematics items used in 2020 examinations contain test items that significantly functioned differentially for testees on the basis of gender. Generally, the Scheuneman modified Chi-square comparing 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items for female and male flagged 29 items with significantly differential items functioning ($p < .05$) DIF. It was revealed that, 15 items out of 29 items representing 52% in 2020 BECE multiple choice items mathematics, that displayed DIF favoured female while 14 items out of 29 items representing 48% were in favour of male.

Hypothesis One: There is no significant difference between male and female students on the percentage of items which functioned differentially in the 2020 Basic Education Certificate Examination (BECE) mathematics multiple choice test examination.

Table 2: Chi-square Summary of 2020 BECE mathematics Differential items Functioning in Favour of Male and Female Students

Gender	Percentage	Item favoured due to DIF	Df	Chi-square	Sig.(2-tailed)
Male	48	14(14.5)			
Female	52	15(14.5)	1	0.03	0.853
Total	100	29			

χ^2 tabulated at 0.05 level of significant with 1 df = 3.84

Data in Table 2 shows that the chi-square calculated value of 0.03 is less than the tabulated chi-square value of 3.84 when tested at 0.05 level of significance with 1 degree of freedom. Therefore, the null hypothesis one is thereby uphold.

Research Question Two: What percentage of items in the 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items functioned differentially by school location?

Table 3: Scheuneman Chi-square School Location Differential Item Functioning Indices for 2020 Basic Education Certificate Examination (BECE) Multiple Choice Mathematics Items Functioned Differentially by School Location

Items	χ^2	Items	χ^2	Items	χ^2
1	7.76	21	9.06	41	12.65*
2	13.12*	22	7.98	42	7.76
3	10.12*	23	10.32*	43	11.83*
4	15.87**	24	16.97**	44	15.98**
5	8.54	25	11.67*	45	6.55
6	6.12	26	5.42	46	16.73**
7	8.32	27	8.77	47	5.47
8	14.87**	28	14.32**	48	14.18**
9	7.83	29	10.53*	49	16.32**
10	11.76*	30	7.61	50	13.56**
11	6.09	31	13.89**	51	5.16
12	13.65**	32	5.21	52	12.63*
13	10.87*	33	8.49	53	8.93
14	8.07	34	15.76**	54	16.56**
15	12.76*	35	5.09	55	15.54**
16	17.19**	36	6.47	56	7.43
17	4.98	37	10.63**	57	10.87*
18	9.99*	38	11.63*	58	4.87
19	15.76**	39	6.45	59	13.33**
20	10.34*	40	13.87*	60	17.24**

** or * significant at the 0.05 level, df= 4 critical $\chi^2= 9.49$

Data in Table 3 revealed that a total of 35 test items representing 58% of 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items differentially functioned for candidates from urban and rural areas. The above result showed that mathematics multiple-choice test items used in BECE 2020 examinations, contain test items that significantly functioned differentially for testees on the basis of school location. Generally, the Scheuneman modified Chi-square comparing 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items for rural and urban flagged 35 items with significantly differential item functioning ($p < .05$). It was revealed that, 16 items out of 35 items representing 46% in 2020 BECE, that displayed DIF favoured students in rural areas while 19 items out of 35 items representing 54% were in favour of students' from urban areas.

Hypothesis Two: There is no significant difference between urban and rural students on the percentage of items which functioned differentially in the 2020 Basic Education Certificate Examination (BECE) mathematics multiple choice test examination.

Table 4: Chi -square Summary of 2020 Basic Education Certificate Examination (BECE) Mathematics Multiple Choice Test Examination

School location	Percentage	Item favoured due to DIF	Df	Chi-square	Sig.(2-tailed)
Rural	46	16(17.5)			
Urban	54	19(17.5)	1	0.26	0.612
Total	100	35			

χ^2 tabulated at 0.05 level of significant with 1 df = 3.84

Data in Table 4 showed that the chi-square calculated value of 0.26 is less than the tabulated chi-square value of 3.84 when tested at 0.05 level of significance with 1 degree of freedom. Therefore, the null hypothesis two is thereby uphold.

Discussion of Findings

The results in one and two revealed that 29 items representing 48% in 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items significantly function differentially for testees on the basis of gender. The above result showed that Basic Education Certificate Examination (BECE) multiple choice mathematics items used in 2020 examinations contain test items that significantly functioned differentially for testees on the basis of gender. Generally, the Scheuneman modified Chi-square comparing 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items for female and male flagged 29 items with significantly differential items functioning ($p < .05$) DIF. It was revealed that, 15 items out of 29 items representing 52% in 2020 BECE multiple choice items mathematics, that displayed DIF favoured female while 14 items out of 29 items representing 48% were in favour of male. The corresponding hypothesis affirmed that there is no significant difference between male and female students on the percentage of items which functioned differentially in the 2020 Basic Education Certificate Examination (BECE) mathematics multiple choice test examination. The finding is similar with the finding of Akanwa, Ihechu and Nkwocha (2018).

The results in table three and four revealed that a total of 35 test items representing 58% of 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items differentially functioned for candidates from urban and rural areas. The above result showed that mathematics multiple-choice test items used in BECE 2020 examinations, contain test items that significantly functioned differentially for testees on the basis of school location. Generally, the Scheuneman modified Chi-square comparing 2020 Basic Education Certificate Examination (BECE) multiple choice mathematics items for rural and urban flagged 35 items with significantly differential item functioning ($p < .05$). It was revealed that, 16 items out of 35 items representing 46% in 2020 BECE, that displayed DIF favoured students in rural areas while 19 items out of 35 items representing 54% were in favour of students' from urban areas. The corresponding hypothesis affirmed that there is no significant difference between urban and rural students on the percentage of items which functioned differentially in the 2020 Basic Education Certificate Examination (BECE) mathematics multiple choice test examination. The finding is in agreement with the finding of Ihechu and Madu (2016) and Olutola, (2011).

Conclusion

The researchers concluded that Basic Education Certificate Examination (BECE) multiple choice mathematics items used in 2020 examinations contain test items that significantly functioned differentially for testees on the basis of gender and school location.

Recommendations

On the basis of the findings and conclusion, the following recommendations are made:

- i. Test developers, ministry of education and examination bodies should ensure that Mathematics multiple choice test items are free from differential item functioning (DIF) for adequacy of test credibility and civility.
- ii. Test experts and developers should consider the use of Scheuneman modified chi-square in determining differential item functioning. This approach provides an intuitive and flexible methodology for detecting DIF.

- iii. Examination bodies should organize training for item developers on the construction of valid, reliable and fair test especially in the area of DIF. In addition, items flagging DIF should be revised, modified or eliminated from the test.

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