

## ASSESSMENT OF DIFFERENTIAL ITEM FUNCTIONING OF NECO BECE MATHEMATICS ITEMS BASE ON SCHOOL LOCATION

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### Abstract

This study analyzed school location differential item functioning (DIF) in National Examinations Council (NECO) Basic Education Certificate Examination (BECE) Mathematics multiple choice test items among Federal Unity College students in North-Central, Nigeria. A survey research design was employed. The target population consisted of 5,178 Junior Secondary School 3 (JSS 3) students from Federal Unity Colleges in the region. A sample of 1,275 students was selected using proportionate stratified random sampling. The 2021 NECO BECE Mathematics multiple-choice test served as the instrument for data collection. As the test is a standardized assessment developed by NECO, it was not re-validated for this study. However, a pilot test was conducted in a school not included in the main sample, and the reliability of the instrument was estimated using Cronbach's alpha, yielding a reliability co-efficient of 0.78. Binary Logistic Regression was used to analyze the data and detect DIF across school locations at the 0.05 level of significance. The results revealed that 28 items favoured students from urban schools, placing students from rural schools at a disadvantage. This indicates a statistically significant presence of DIF in the 2021 NECO BECE Mathematics multiple-choice items based on school location. The study concludes that the 2021 NECO BECE Mathematics multiple-choice items demonstrated significant differential item functioning related to school location, with urban students being disproportionately advantaged. Based on the finding of the study, it was recommended among others that, the National Examinations Council (NECO) should incorporate Differential Item Functioning (DIF) analysis during the development and review stages of test items to ensure fairness across diverse student populations, particularly between urban and rural school locations.

**Keywords:** Differential Item Functioning, School Location, Mathematics, NECO BECE, Multiple-Choice Test

### Introduction

Educational assessment remains one of the most important tools for monitoring learning outcomes, guiding instructional practices, and informing educational policies. In high-stakes examinations such as the Basic Education Certificate Examination (BECE), fairness and validity are central concerns because the results determine whether students can transition to senior secondary education. For an assessment to be fair, test items must measure the intended construct equally across different groups of examinees, irrespective of irrelevant characteristics such as gender, school type, or school location (Adeleke & Olatunji, 2021; Boone, Staver & Yale, 2020). When these conditions are not met, students may be disadvantaged, and the credibility of the assessment is undermined.

One critical factor shaping performance in Nigeria is school location. Urban schools are often better equipped with instructional resources, trained teachers, and supportive infrastructure, while

rural schools may face challenges such as overcrowded classrooms, poor facilities, and limited access to technology (Adebayo, Olaniyan & Adeyemi, 2019; Adedeji & Olaniyan, 2020). These differences in learning conditions can influence how students engage with mathematics content, their exposure to problem-solving strategies, and their preparedness for standardized examinations (Ogunyemi & Eze, 2022).

Mathematics, as a core subject in the Nigerian curriculum, has unique importance because of its role in science, technology, engineering, and mathematics (STEM) education and its relevance to national development. However, persistent disparities in mathematics achievement have been documented between students in rural and urban schools (Eze & Ugwu, 2021; Usman & Abdullahi, 2023). Such disparities may not only reflect instructional differences but could also suggest bias in the way examination items are structured, particularly when the test includes contexts or representations more familiar to one group of students than another (Obioma & Salau, 2020).

This brings attention to the concept of Differential Item Functioning (DIF). DIF occurs when two groups of students with the same underlying ability have unequal probabilities of answering a test item correctly, not because of differences in competence but due to factors external to the construct being measured (Hambleton & Rogers, 2021). For example, items that assume access to digital technologies may inadvertently advantage urban students, while items that reflect rural life experiences may favour students from rural backgrounds (Musa & Bello, 2022). In either case, DIF compromises the fairness and validity of assessments, raising concerns about whether test scores truly reflect ability.

Despite the recognition of DIF in international and national assessment literature, there remains a gap in consistent empirical analysis of DIF within Nigeria's junior secondary school mathematics examinations, particularly with respect to school location. While several studies have examined gender and school-type differences in standardized assessments (Olutola & Nuraddeen, 2025; Chinedu & Adepoju, 2021), fewer have focused exclusively on location-related DIF in NECO-administered BECE mathematics. This gap makes it essential to investigate whether examination items are functioning equally across urban and rural contexts, given the implications for educational equity and progression opportunities.

In Nigeria, persistent inequalities between rural and urban schools raise questions about the fairness of high-stakes assessments such as the BECE. Rural schools often contend with inadequate teaching resources, under qualified teachers, and limited exposure to standardized testing practices, while their urban counterparts typically have stronger institutional support and better access to educational technologies (Omoniyi, 2023). These disparities create conditions where performance differences may not necessarily reflect differences in mathematical ability but rather the environments in which students learn.

The challenge becomes critical when examination items systematically favour one group of students over another. If students with equivalent mathematical competence from rural and urban schools do not have equal probabilities of answering test items correctly, this indicates the presence of Differential Item Functioning (DIF). Such bias compromises the validity of assessment outcomes and undermines the principle of fairness in educational measurement (Adeleke & Olatunji, 2021; Hambleton & Rogers, 2021).

Although some prior studies in Nigeria have identified location-based differences in students' mathematics performance (Eze & Ugwu, 2021; Usman & Abdullahi, 2023), there is still limited empirical research specifically examining DIF in NECO BECE mathematics items by school location. Without targeted investigations, policymakers, educators, and examination bodies may overlook systemic biases in assessment design that disadvantage certain groups of students. This study is therefore necessitated by the need to bridge this gap, ensuring that Nigeria's national assessments reflect equity, inclusivity, and fairness in evaluating the mathematical competence of students across different school locations.

### **Objective of the Study**

The main objective of this study is to analyze Differential Item Functioning (DIF) based on school location in the 2021 National Examinations Council (NECO) Basic Education Certificate Examination (BECE) Mathematics multiple-choice test items among Federal Unity College students in North-Central Nigeria.

Specifically the study sought to:

1. Determine the percentage of 2021 NECO BECE Mathematics multiple-Choice items that exhibited Differential Item Functioning (DIF) based on school location among Federal Unity College Students in North-Central Nigeria.

### **Hypothesis**

The following research hypothesis is formulated to guide the study:

1. There is no significant difference in the percentage of 2021 NECO BECE Mathematics multiple-Choice items that exhibited Differential Item Functioning (DIF) based on school among Federal Unity College Students in North-Central Nigeria.

### **Methodology**

A survey research design was adopted for the study. The target population comprised 5,178 Junior Secondary School Three (JSS 3) students in Federal Unity Colleges located in North Central Nigeria. A sample of 1,275 students was selected using proportionate stratified random sampling. The 2021 NECO BECE Mathematics multiple-choice test was used as the instrument for data collection. The instrument was not revalidated, as it is a standardized test developed by the National Examinations Council (NECO). However, a pilot test was conducted in a school not included in the main sample, and the reliability of the instrument was estimated using Cronbach's alpha, yielding reliability co-efficient of 0.78. The reliability of the instrument was determined using Cronbach's alpha, yielding a reliability index of 0.78. Data collected for the study were analyzed using Binary Logistic Regression to detect items that functioned differentially by school location at a 0.05 level of significance.

### **Hypothesis Testing**

**Hypothesis One:** There is no significant difference in the percentage of items which functioned differentially in the 2021 National Examinations Council Basic Education Certificate Examination multiple choice Mathematics examination paper based on school location.

Table 1: Binary Logistic Regression in Detecting DIF by School Location for 2021 Mathematics NECO BECE multiple choice items

Item	B	S.E	Wald	Sig	Exp (B)	95% C.I for Exp (B)		Decision
						Lower	Upper	
1.	-.336	.129	6.819	<b>.009*</b>	.715	.555	.920	DIF
2.	-.351	.131	7.213	<b>.007*</b>	.704	.545	.910	DIF
3.	-.450	.124	13.246	<b>.000*</b>	.637	.500	.812	DIF
4.	-.347	.121	8.229	<b>.004*</b>	.707	.557	.896	DIF
5.	-.331	.122	7.403	<b>.007*</b>	.718	.566	.912	DIF
6.	-.241	.122	3.879	<b>.049*</b>	.786	.618	.999	DIF
7.	-.368	.122	9.131	<b>.003*</b>	.692	.546	.879	DIF
8.	-.157	.121	1.670	.196	.855	.674	1.084	NO DIF
9.	-.181	.121	2.232	.135	.834	.657	1.058	NO DIF
10.	-.014	.122	.014	.907	.986	.776	1.252	NO DIF
11.	-.154	.122	1.593	.207	.857	.675	1.089	NO DIF
12.	-.199	.121	2.702	.100	.820	.647	1.039	NO DIF
13.	-.308	.121	6.485	<b>.011*</b>	.735	.579	.931	DIF
14.	.066	.121	.293	.588	1.068	.842	1.354	NO DIF
15.	-.186	.121	2.360	.125	.831	.655	1.053	NO DIF
16.	.216	.127	2.915	.088	1.241	.969	1.591	NO DIF
17.	.156	.124	1.594	.207	1.169	.917	1.490	NO DIF
18.	-.349	.121	8.302	<b>.004*</b>	.705	.556	.894	DIF
19.	.297	.129	5.326	<b>.021*</b>	1.346	1.046	1.733	DIF
20.	.264	.123	4.626	<b>.031*</b>	1.302	1.024	1.657	DIF
21.	.198	.121	2.680	.102	1.219	.962	1.546	NO DIF
22.	.476	.127	13.967	<b>.000*</b>	1.610	1.254	2.066	DIF
23.	.033	.121	.076	.783	1.034	.815	1.311	NO DIF
24.	-.056	.122	.215	.643	.945	.744	1.200	NO DIF
25.	-.129	.121	1.137	.286	.879	.694	1.114	NO DIF
26.	-.324	.121	7.149	<b>.008*</b>	.723	.570	.917	DIF
27.	-.010	.121	.006	.936	.990	.782	1.255	NO DIF
28.	-.136	.121	1.266	.261	.873	.689	1.106	NO DIF
29.	-.303	.122	6.166	<b>.013*</b>	.738	.581	.938	DIF
30.	-.144	.121	1.426	.232	.866	.683	1.097	NO DIF
31.	-.359	.122	8.695	<b>.003*</b>	.698	.550	.887	DIF
32.	-.254	.121	4.391	<b>.036*</b>	.776	.612	.984	DIF
33.	-.029	.121	.056	.812	.972	.767	1.232	NO DIF
34.	-.291	.121	5.791	<b>.016*</b>	.747	.590	.947	DIF
35.	-.416	.122	11.703	<b>.001*</b>	.660	.520	.837	DIF
36.	.466	.129	13.023	<b>.000*</b>	1.593	1.237	2.052	DIF
37.	.117	.126	.853	.356	1.124	.877	1.439	NO DIF
38.	-.098	.130	.575	.448	.906	.703	1.169	NO DIF
39.	.106	.125	.727	.394	1.112	.871	1.420	NO DIF

40.	-.138	.121	1.301	.254	.871	.687	1.104	NO DIF
41.	-.057	.121	.220	.639	.945	.746	1.197	NO DIF
42.	-.207	.122	2.881	.090	.813	.641	1.032	NO DIF
43.	-.141	.121	1.352	.245	.869	.685	1.101	NO DIF
44.	-.276	.121	5.195	<b>.023*</b>	.759	.598	.962	DIF
45.	-.277	.122	5.134	<b>.023*</b>	.758	.596	.963	DIF
46.	-.069	.121	.328	.567	.933	.736	1.182	NO DIF
47.	.073	.121	.363	.547	1.076	.848	1.364	NO DIF
48.	-.372	.121	9.443	<b>.002*</b>	.689	.543	.874	DIF
49.	-.185	.121	2.324	.127	.831	.656	1.054	NO DIF
50.	-.017	.121	.020	.889	.983	.775	1.247	NO DIF
51.	-.062	.121	.264	.607	.940	.741	1.192	NO DIF
52.	-.048	.122	.157	.692	.953	.751	1.209	NO DIF
53.	-.307	.121	6.419	<b>.011*</b>	.736	.581	.933	DIF
54.	-.393	.123	10.127	<b>.001*</b>	.675	.530	.860	DIF
55.	-.256	.121	4.462	<b>.035*</b>	.774	.610	.982	DIF
56.	-.204	.122	2.786	.095	.816	.642	1.036	NO DIF
57.	-.251	.121	4.294	<b>.038*</b>	.778	.614	.987	DIF
58.	-.224	.121	3.421	.064	.799	.631	1.013	NO DIF
59.	-.333	.124	7.215	<b>.007*</b>	.717	.562	.914	DIF
60.	-.433	.121	12.744	<b>.000*</b>	.648	.511	.822	DIF

Variables on School Location: \*DIF EXIST; Items 1, 2, 3, 3, 4, 5, 6, 7, 13, 18, 19, 20, 22, 26, 29, 31, 32, 34, 35, 36, 44, 45, 48, 53, 54, 55, 57, 59 and 60 only.

Table 2: School Location Cross Tabulation in Group Performance of 2021 Mathematics NECO BECE multiple choice Items.

Items	Dichotomous Score	Rural	Urban
Q1	INCORRECT	142	247
	CORRECT	258	<b>628*</b>
Q2	INCORRECT	135	231
	CORRECT	265	<b>644*</b>
Q3	INCORRECT	175	290
	CORRECT	225	<b>585*</b>
Q4	INCORRECT	212	388
	CORRECT	188	<b>487*</b>
Q5	INCORRECT	193	351
	CORRECT	207	<b>524*</b>
Q6	INCORRECT	176	334
	CORRECT	224	<b>541*</b>
Q7	INCORRECT	229	421
	CORRECT	171	<b>454*</b>
Q13	INCORRECT	203	377
	CORRECT	197	<b>498*</b>
Q18	INCORRECT	214	392
	CORRECT	186	<b>483*</b>
Q19	INCORRECT	260	625

	CORRECT	140	<b>250*</b>
<b>Q20</b>	INCORRECT	227	552
	CORRECT	173	<b>323*</b>
<b>Q22</b>	INCORRECT	246	630
	CORRECT	154	<b>245*</b>
<b>Q26</b>	INCORRECT	217	404
	CORRECT	183	<b>471*</b>
<b>Q29</b>	INCORRECT	237	453
	CORRECT	163	<b>422*</b>
<b>Q31</b>	INCORRECT	192	343
	CORRECT	208	<b>532*</b>
<b>Q32</b>	INCORRECT	198	378
	CORRECT	202	<b>497*</b>
<b>Q34</b>	INCORRECT	211	398
	CORRECT	189	<b>477*</b>
<b>Q35</b>	INCORRECT	227	406
	CORRECT	173	<b>469*</b>
<b>Q36</b>	INCORRECT	254	643
	CORRECT	146	<b>232*</b>
<b>Q44</b>	INCORRECT	220	421
	CORRECT	180	<b>454*</b>
<b>Q45</b>	INCORRECT	238	461
	CORRECT	162	<b>414*</b>
<b>Q48</b>	INCORRECT	208	374
	CORRECT	192	<b>501*</b>
<b>Q53</b>	INCORRECT	213	399
	CORRECT	187	<b>476*</b>
<b>Q54</b>	INCORRECT	249	461
	CORRECT	151	<b>414*</b>
<b>Q55</b>	INCORRECT	223	432
	CORRECT	177	<b>443*</b>
<b>Q57</b>	INCORRECT	212	409
	CORRECT	188	<b>466*</b>
<b>Q59</b>	INCORRECT	252	481
	CORRECT	148	<b>394*</b>
<b>Q60</b>	INCORRECT	221	389
	CORRECT	179	<b>486*</b>

**a = School Location that DIF favoured**

Table 1 and 2 shows twenty eight (28) items that identified significant DIF in school location of students using binary logistic regression analysis with the aid of SPSS version 23 which items 1, 2, 3, 4, 5, 6, 7, 13, 18, 19, 20, 22, 26, 29, 31, 32, 34, 35, 36, 44, 45, 48, 53, 54, 55, 57, 59 and 60 reveals significant differences between urban and rural schools with significant level less than 0.05, i.e ( $P < .05$ ). This represents 47% of the total in the 2021 Mathematics NECO BECE multiple choice items while 53% of items do not differentiate significantly between urban and rural schools. The results further reveals that, item 1, 2, 3, 3, 4, 5, 6, 7, 13, 18, 19, 20, 22, 26, 29, 31, 32, 34, 35,

36, 44, 45, 48, 53, 54, 55, 57, 59 and 60 favoured urban schools which placed the rural schools at disadvantaged group. Therefore, there is significant difference in the percentage of items which functioned differentially in the 2021 Mathematics NECO BECE multiple choice items in North Central Nigeria based on school location. Thus, the null hypothesis two is rejected.

### **Discussion of Findings**

The results further reveals that, twenty eight (28) item favoured urban schools which placed the rural schools at disadvantaged group. The finding of hypothesis revealed significant difference in the percentage of items which functioned differentially in the 2021 Mathematics NECO BECE multiple choice items in North Central Nigeria based on school location. This finding is in line with the findings of Adebayo and Oluwatayo (2020) which found urban students outperformed rural peers in WAEC Mathematics by 12% on technology context items, linking this to resource disparities like computer access. The finding of this study disagrees with the finding of Chinedu and Adepoju (2021) which revealed no significant DIF across school environments.

### **Conclusion**

The study concludes that the 2021 NECO BECE Mathematics multiple-choice items demonstrated significant differential item functioning related to school location, with urban students being disproportionately advantaged.

### **Recommendations**

Based on the findings, the researchers recommends that:

1. Students, especially those in rural areas, should engage with a broad range of mathematics problems beyond what is taught in class to build confidence and exposure to standardized testing formats.
2. Teachers should expose students to multiple-choice testing formats and train them on how to approach standardized exam questions effectively.
3. Educational evaluators should regularly assess national examinations for bias and DIF, ensuring that items do not unfairly advantage or disadvantage any group.
4. The National Examinations Council (NECO) should incorporate Differential Item Functioning (DIF) analysis during the development and review stages of test items to ensure fairness across diverse student populations, particularly between urban and rural school locations.
5. NECO and other examination bodies should organize periodic capacity-building workshops for item writers, focusing on fair assessment practices, bias detection, and inclusive content creation.
6. Federal Ministry of Education should establish independent assessment quality control units to routinely evaluate national examinations for fairness, validity, and reliability, including conducting DIF analysis post-administration.

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