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Evaluation of performance appraisal in mathematics and physics: An empirical study of WAEC and NECO SSCE

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Abstract

This study evaluated the performance appraisal process of the West Africa Examinations Council (WAEC) and National Examinations Council (NECO) Senior School Certificate Examinations (SSCE) in both Mathematics and Physics from 2013 to 2023 in Owo High School, Owo, Ondo State, Nigeria. Quantitative research design was employed for data collection as secondary source for both examination and analyzed examination results employing Institutional Based Entrance Rating (IBER) and RUGIPO Based Examination Rating (RBER) models using R of version 3.6.1. Findings revealed no significant relationship and difference in students' performance appraisal for both WAEC and NECO in Mathematics and Physics, an indication that both examination bodies have strengths in assessing students' knowledge and understanding except for WAEC in 2019 and 2020 that experienced a slightly significant comparative improvement of correlation coefficients greater than 0.5 at 5% level of significance. This study showed that WAEC and NECO successes or failures are not significantly correlated to establish a justification for the students' poor performances in Mathematics and Physics intermittently.

Keywords: Performance appraisal, Mathematics, Physics, WAEC, NECO, SSCE

1. Introduction

Education is one of the basic human needs that serve as the total process of human learning by which knowledge is imparted and skills developed for enabling us to live a balanced life and contribute to society in the best way. Science and technology as the basis for industrial and national development when properly and well harnessed could bring about economic and social happiness by providing and improving the welfare of the citizenries especially in developing countries like Nigeria.

Consequently, the teaching and learning of science has become a great concern to all sectors of education in the country most especially secondary schools as it not only occupy a strategic place in the educational system of Nigeria, it is also a link between the primary and university levels of education. According to Asikhia (2010) ^[4], education at secondary school level is supposed to be the bedrock and the foundation towards higher knowledge in tertiary institutions that serve as an investment as well as an instrument that can be used to achieve a more rapid goal in the economic, social, political, technological, scientific and cultural development of a country but it is rather unfortunate that secondary schools today are not measuring up to these standards, thereby calling for public outcries over the persistently poor performance of secondary school students in public examinations.

According to Nwokocha and Amadike (2005) ^[7], academic performance of students is the yardstick for testing the educational quality of a nation. Hence, it is expedient to maintain a high performance in internal and mostly external examinations. For some years now, reports on the pages of newspapers and research findings have shown the abysmal performance of students of secondary schools in public examinations and the persistent decline in students'

performance in public examinations is not only frustrating to the students and the parents but its effects are equally grievous on the society and nation as a whole.

The Senior School Certificate Examinations are a critical milestone in the Nigerian education system as they determine students' progression to higher education and future career prospects. Mathematics and Physics are crucial subjects in the SSCE curriculum for science oriented classes and their assessment plays a significant role in determining performance of students. Despite their importance, there is a need to evaluate the effectiveness of the performance appraisal in these core science subjects to ensure that they are fit for purpose.

Performance appraisal is a crucial aspect of educational assessment as it provides feedback on students' learning outcomes and informs instruction. In Nigeria, the West African Examinations Council (WAEC) and National Examinations Council (NECO) are solely responsible for conducting SSCE public examinations that are externally moderated and enjoy a lot of public confidence. However, there is a growing concern about the effectiveness of these examinations in assessing the performance of students as this research work aims to evaluate the performance appraisal of students using Mathematics and Physics SSCE examinations conducted by WAEC and NECO as a yardstick.

Adebule (2004) ^[1] reported a consensus of opinion about the fallen standard of education in Nigeria in which parents and government are in total agreement that their investment in education is not yielding the desired appropriate dividends. Statistics from the reports of the West African Examinations Council chief examiners indicated a general decline in the performance of candidates in Mathematics for the May/June of 2010, 2011, 2012 and 2015 examinations which did not significantly differ from those of the previous years but recorded an improvement for the 2013 and 2014 examinations. These downward trends of students' performance especially in backbone subjects like Mathematics, English, Chemistry, Physics and Biology cannot be over emphasized, hence, the need for this research to evaluate the performance of students in Mathematics as related to Physics which is also a core science subject that can bring about societal developments in pursuance of Nigerian Government Vision 20:2020.

Secondary school is the basic foundation of any future academic excellence for measuring proficiency of achievements in a given skill or body of knowledge hereby giving rooms for comparison. It is admitted that no educational system is problem free but the decay in Nigerian educational system is becoming embarrassing as rightly pointed in Ogunsaju (1990) ^[9] describing this ugly situation as calamitous. Though, brilliant students can still be found in public schools but the higher percentages of failure in SSCE examinations tend to rubbish the good ones among them.

Mathematics as the science of reasoning is the nucleus of all other sciences which occupies central position in education laying strong emphasis on both theory and practical and is typically considered by majority of the populace to be the fundamental subject for measuring students' performance (either success or failure). In particular, Mathematics is said to serve as a critical filter or gateway to many high-status occupations as quantitative skills are crucial in such profession. In addition, Mathematics achievements are considered to be a better indicator of school effects because it is thought to be less influenced by family background and home effects than other subjects (Heyneman, 2005) ^[5]. Therefore, this research work focuses on students' performance in both Mathematics and Physics as an appraisal for WAEC and NECO. In order for a test to have predictive validity, there must be a statistically significant correlation between test score and the criterion being used to measure the validity. In a research conducted by Obioma and Salawu (2007) ^[8] discovered that out of all O'level examination bodies in Nigeria, Students' performance in WAEC examination is the best predictor of performance appraisal in higher institution when they are admitted into any Nigeria Universities.

Ajayi and Awogbemi (2020) ^[2] studied the relationship between WAEC and NECO examination in Mathematics results from Osun State and discovered that there is a statistically significant relationship. Whereas, Mamman and Eya (2014) ^[6] studied performance pattern in Mathematics for ten years consecutively from 2004 to 2013 and opined that there existed an unstable performance pattern in the observed and predicted rates indicating less than 50% of the candidates passed at credit level in Nasarawa State, Nigeria. There is no significant difference in students' performance in WAEC and NECO Mathematics based on gender but location (Urban or Rural) of the school is a factor as revealed by study in Cross River State (Anagbogu, Ihejiamazu and Ekpo, 2014) ^[3].

A correlation analysis of students' achievement in WAEC and NECO Mathematics from four selected secondary schools in Ifedayo local government area of Osun State revealed that there is a significant positive relationship between Mathematics performance in WAEC and NECO (Ajayi and Awogbemi, 2012) ^[2] whereas performance of students in Mathematics has been persistently poor over the years. Moreover, the projection between 2014 and 2020 reveals poor performance in mathematics except a drastic step is taken to rescue the situation (Mamman and Eya, 2014) ^[6].

2. Methodology

Research work is motivated by recent declined trends in the success rate of students' performance in Mathematics and other core science subjects such as Physics, Chemistry, Biology, etc for both WAEC and NECO. Data collected for this study were scores of students in Mathematics and Physics for Senior School Certificate Examinations (SSCE) from 20013 to 2023 for both WAEC and NECO as extracted from the result broadsheet records of Owo High School, Owo, Ondo State, Nigeria.

The nature of the data used is secondary but qualitative in nature as they possess some characteristics which can be distinguished on the basis of relative amounts as this makes it possible for objects to be ranked. Research instrument used for the ranking data of grades and scores in Mathematics and Physics of SSCE examinations conducted by WAEC and NECO is termed Institutional Based Entrance Rating (IBER) and RUGIPO Based Examination Rating (RBER) hereby making necessary and sufficient provisions for the use of Spearman's ranking correlation.

Grades	Scores	IBER (points)	RBER (points)
A1	75-100	12	4
B2	70-74	10	3.5
B3	65-69	8	3.25
C4	60-64	6	3
C5	55-59	4	2.75
C6	50-54	2	2.5
D7	45-49	0	2.25
E8	40-44	0	2
F9	0-39	0	0

2.1 Procedures for Computing Spearman's Ranking Correlation Coefficient

Subject the data (observations) to the following procedures

1. Designate the n pairs of observations from a bivariate population $(X_1, Y_1), (X_2, Y_2), \dots, (X_n, Y_n)$
2. Each X is ranked relative to all other observed values for X from smallest to largest (in order of magnitude). The rank of X_i (ith value of X) is denoted by $R(X_i)$ and $R(X_i) = 1$ is the smallest observed value of X
3. Each Y is ranked relative to all other observed values for Y from smallest to largest (in order of magnitude). The rank of Y_i (ith value of Y) is denoted by $R(Y_i)$ and $R(Y_i) = 1$ is the smallest observed value of Y
4. If ties (observations ranked same) occur among the X 's or among the Y 's, each tied value is assigned the mean of the rank positions for which it is tied
5. Data consisting of nonnumeric observations must be capable of being ranked as described or appropriate.

2.2 Mathematical Computing Procedural for Spearman's Ranking Correlation Coefficient

Let Karl Pearson's correlation coefficient be

$$r = \frac{S_{xy}}{S_x S_y} \quad 1$$

$$S_{xy} = \left(\frac{1}{n} \sum xy \right) - \left(\frac{1}{n} \sum x \right) \left(\frac{1}{n} \sum y \right)$$

$$S_x = \left[\left(\frac{1}{n} \sum x^2 \right) - \left(\frac{1}{n} \sum x \right)^2 \right]^{1/2}$$

$$S_y = \left[\left(\frac{1}{n} \sum y^2 \right) - \left(\frac{1}{n} \sum y \right)^2 \right]^{1/2}$$

$\sum x$ and $\sum y$ are equal to zero since x and y are deviations from the means

$$r = \frac{\left(\frac{1}{n} \sum xy \right)}{\left[\left(\frac{1}{n} \sum x^2 \right) \left(\frac{1}{n} \sum y^2 \right) \right]^{1/2}} = \frac{\sum xy}{[(\sum x^2)(\sum y^2)]^{1/2}} \quad 2$$

Let r_s be the rank correlation coefficient and rewrite equation (2) as

$$r_s = \frac{\sum xy}{[(\sum x^2)(\sum y^2)]^{1/2}} \quad 3$$

here, x and y are the rank deviations from the means of the ranks.

Now,

$$\begin{aligned} \sum x^2 &= \sum \left[X - \frac{1}{2}(n+1) \right]^2 \\ &= \sum \left\{ \left[X - \frac{1}{2}(n+1) \right] \left[X - \frac{1}{2}(n+1) \right] \right\} \\ &= \sum \left[X^2 - (n+1)X + \frac{1}{4}(n+1)^2 \right] \end{aligned}$$

$$\sum x^2 = \sum X^2 - (n+1) \sum X + \frac{n}{4}(n+1)^2 \quad 4$$

same thing applicable to $\sum y^2$

$$\sum y^2 = \sum Y^2 - (n+1) \sum Y + \frac{n}{4}(n+1)^2 \quad 5$$

From equation (4), X is representing set of n natural numbers, for

$$\sum X^2 = 1^2 + 2^2 + \dots + n^2 = \frac{n}{6}(n+1)(2n+1) \quad 6$$

$$\sum X = 1 + 2 + \dots + n = \frac{n}{2}(n+1) \quad 7$$

substituting equations (6 and 7 into 4)

$$\begin{aligned} \sum x^2 &= \frac{n}{6}(n+1)(2n+1) - \frac{n}{2}(n+1)^2 + \frac{n}{4}(n+1)^2 \\ &= \frac{2n(n+1)(2n+1) - 6n(n+1)^2 + 3n(n+1)^2}{12} \\ &= \frac{2n(n+1)(2n+1) - 3n(n+1)^2}{12} \\ &= \frac{2n(2n^2 + 3n + 1) - 3n(n^2 + 2n + 1)}{12} \\ &= \frac{4n^3 + 6n^2 + 2n - 3n^3 - 6n^2 - 3n}{12} \\ &= \frac{n^3 - n}{12} = \frac{n(n^2 - 1)}{12} = \frac{n}{12}(n^2 - 1) \\ &= \frac{1}{12}n(n^2 - 1) \end{aligned} \quad 8$$

similarly,

$$\sum y^2 = \frac{1}{12}n(n^2 - 1) \quad 9$$

If d_i is the difference between the ranks $R(X_i)$ and $R(Y_i)$ then

$$\sum d_i^2 = \sum [R(X_i) - R(Y_i)]^2 \quad 10$$

by equation (9), $R(X_i) = x$ and $R(Y_i) = y$,

$$\begin{aligned} \sum d_i^2 &= \sum (x - y)^2 = \sum (x^2 + y^2 - 2xy) \\ \sum d_i^2 &= \sum x^2 + \sum y^2 - 2 \sum xy \end{aligned} \quad 11$$

substituting equations (8 and 9 into 11),

$$\begin{aligned} \sum d_i^2 &= \frac{1}{12}n(n^2 - 1) + \frac{1}{12}n(n^2 - 1) - 2 \sum xy \\ 2 \sum xy &= \frac{1}{6}n(n^2 - 1) - \sum d_i^2 \\ \sum xy &= \frac{1}{2} \left[\frac{1}{6}n(n^2 - 1) - \sum d_i^2 \right] \\ \sum xy &= \frac{1}{12}(n^2 - 1) - \frac{1}{2} \sum d_i^2 \end{aligned} \quad 12$$

Recall from equation (3),

$$r_s = \frac{\sum xy}{[\sum x^2 \sum y^2]^{1/2}}$$

substituting equations (8, 9 and 12 into 3),

$$\begin{aligned}
 r_s &= \frac{\frac{1}{12}(n^2 - 1) - \frac{1}{2}\sum d_i^2}{\left\{\left[\frac{1}{12}n(n^2 - 1)\right]\left[\frac{1}{12}n(n^2 - 1)\right]\right\}^{1/2}} \\
 &= \frac{\frac{1}{12}(n^2 - 1) - \frac{1}{2}\sum d_i^2}{\frac{1}{12}n(n^2 - 1)} \\
 &= \frac{\frac{1}{12}n(n^2 - 1)}{\frac{1}{12}n(n^2 - 1)} - \frac{\frac{1}{2}\sum d_i^2}{\frac{1}{12}n(n^2 - 1)} \\
 &= 1 - \frac{12\sum d_i^2}{2n(n^2 - 1)} \\
 r_s &= 1 - \frac{6\sum d_i^2}{n(n^2 - 1)} = 1 - \frac{6S}{(n^3 - n)}
 \end{aligned}$$

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here S is the sum of the differences squared of rank for all observations ($S = \sum d_i^2$).

Hence, equation (13) is the test statistic for Spearman's rank correlation coefficient. The test statistic is also the measure of association which is a measure of the degree of correspondence between the ranks of the sample observations rather than between the observations themselves. It is however, thought of as a measure of the strength of the relationship between the sample X and Y values as an estimate of the strength of the relationship between X and Y in the sampled population.

33 Analysis and Discussion of Results

Year	Exam	IBER	RBER
2013	WAEC	0.2581 (NS)	-0.0105 (NS)
	NECO	0.1623 (NS)	0.2504 (NS)
2014	WAEC	-0.1205 (NS)	-0.4375 (S)
	NECO	0.0602 (NS)	0.1952 (NS)
2015	WAEC	0.3083 (NS)	0.1140 (NS)
	NECO	0.2465 (NS)	0.0563 (NS)
2016	WAEC	0.1548 (NS)	-0.1930 (NS)
	NECO	0.1972 (NS)	0.3003 (NS)
2017	WAEC	0.3523 (NS)	-0.0395 (NS)
	NECO	-0.2555 (NS)	-0.1519 (NS)
2018	WAEC	0.1784 (NS)	0.3723 (NS)
	NECO	-0.3252 (NS)	-0.3320 (NS)
2019	WAEC	0.8605 (S)	0.8373 (S)
	NECO	0.3054 (NS)	0.3225 (NS)
2020	WAEC	0.5565 (S)	0.5565 (S)
	NECO	-0.1941 (NS)	-0.1941 (NS)
2021	WAEC	-0.3754 (S)	-0.3734 (S)
	NECO	0.2259 (NS)	0.1698 (NS)
2022	WAEC	0.0996 (NS)	0.0063 (NS)
	NECO	0.1427 (NS)	0.1462 (NS)
2023	WAEC	0.4167 (S)	0.3814 (S)
	NECO	0.2921 (NS)	0.2858 (NS)

*S = Significant

*NS = Not Significant

Two models (ratings) were adopted for the students' performance appraisal analysis which reflected IBER and RBER having same statistical significance as both were of different correlation coefficient values ranging from -0.4376 to 0.8605 for both WAEC and NECO except for the year 2014 WAEC examination that inferred different in statistical significance for IBER ($\rho = -0.1205$ with $p > 0.05$) and RBER ($\rho = -0.4376$ with $p < 0.05$) whereas performance of students in 2020 exhibited same corresponding correlation coefficient values for WAEC and NECO in both IBER and RBER with same significance level ($\rho = 0.5565$ with $p < 0.05$ and $\rho = -0.1941$ with $p > 0.05$ respectively).

Negative correlation coefficients (indicating a declining trend for students' performance in Physics and Mathematics) were recorded for WAEC, 2013 (RBER with $\rho = -0.0105$ on $p > 0.05$ an evidence that it is not statistically significant); WAEC, 2014 (IBER with $\rho = -0.1205$ on $p > 0.05$ denoting statistical insignificance while RBER with $\rho = -0.4376$ on $p < 0.05$ pointing out statistical significance); WAEC, 2016 (both IBER & RBER with $\rho = -0.1548$ on $p > 0.05$ and $\rho = -0.1930$ on $p > 0.05$ respectively, hereby implying statistical insignificance); WAEC, 2017 (RBER with $\rho = -0.0395$ on $p > 0.05$ indicating statistical insignificance) and NECO, 2017 (both IBER & RBER with $\rho = -0.2555$ on $p > 0.05$ and $\rho =$

-0.1519 on $p > 0.05$ respectively, denoting statistical insignificance); NECO, 2018 (both IBER & RBER with $\rho = -0.3252$ on $p > 0.05$ and $\rho = -0.3320$ on $p > 0.05$ respectively, hereby pointing out statistical insignificance); NECO, 2020 (both IBER & RBER with $\rho = -0.1941$ on $p > 0.05$, an indication that it is statistical insignificance) and WAEC, 2021 (both IBER & RBER with $\rho = -0.3754$ on $p < 0.05$ and $\rho = -0.3734$ on $p < 0.05$ respectively, an evidence of statistical significance).

However, positive correlation coefficients (an indication for a rising trend of students' performance in Physics to Mathematics) were recorded for WAEC, 2013 (IBER with $\rho = 0.2581$ on $p > 0.05$ denoting statistical insignificance); NECO, 20013 (both IBER & RBER with $\rho = 0.1623$ on $p > 0.05$ and $\rho = 0.2504$ on $p > 0.05$ respectively, an indication of statistical insignificance); NECO, 2014 (both IBER & RBER with $\rho = 0.0602$ on $p > 0.05$ and $\rho = 0.1952$ on $p > 0.05$ respectively, an evidence of statistical insignificance); WAEC & NECO, 2015 (both IBER & RBER with $\rho = 0.3083$ & 0.1140 on $p > 0.05$ and $\rho = 0.2465$ & 0.0563 on $p > 0.05$) respectively which is an indication of statistical insignificance; NECO, 2016 (both IBER & RBER with $\rho = 0.1972$ on $p > 0.05$ and $\rho = 0.3003$ on $p > 0.05$ respectively, pointing out statistical insignificance); WAEC, 2017 (IBER with $\rho = 0.3523$ on $p > 0.05$ denoting statistical insignificance) and WAEC, 2018 (both IBER & RBER with $\rho = 0.1784$ on $p > 0.05$ and $\rho = 0.3723$ on $p > 0.05$ respectively, denoting statistical insignificance).

In addition, WAEC & NECO, 2019 (both IBER & RBER with $\rho = 0.8605$ & 0.8373 on $p < 0.05$ indicating statistical significance for WAEC and $\rho = 0.3054$ & 0.3225 on $p > 0.05$ denoting statistical insignificance for NECO); WAEC, 2020 (for both IBER & RBER with $\rho = 0.5565$ on $p < 0.05$ indicating statistical significance); NECO, 2021 (both IBER & RBER with $\rho = 0.2259$ on $p > 0.05$ and $\rho = 0.1698$ on $p > 0.05$ respectively, pointing out statistical insignificance); WAEC & NECO, 2022 (both IBER & RBER with $\rho = 0.0996$ & 0.0063 on $p > 0.05$ and $\rho = 0.1427$ & 0.1462 on $p > 0.05$) respectively which is an indication of statistical insignificance and WAEC & NECO, 2023 (both IBER & RBER with $\rho = 0.4167$ & 0.3814 on $p < 0.05$ pointing out statistical significance and $\rho = 0.2921$ & 0.2858 on $p > 0.05$ indicating statistical insignificance) respectively.

4. Conclusion

The study examined an empirical evidence for performance appraisal of students in both WAEC and NECO from 2013 to 2023 using Mathematics and Physics as a yardstick of measuring consistency, efficiency and sufficiency relating to successes and failures recorded. A quantitative comparatively analysis was carried out on performance of candidates in the two selected subjects for years under reviewed using Spearman's rank correlation coefficient based on adopted IBER and RBER models to validate the significance of successes and failures recorded from both WAEC and NECO SSCE examinations in Owo High School, Owo, Ondo State, Nigeria.

Two models which are IBER and RBER were adopted for rating candidates' performance, these Adopted IBER and RBER models generally reflected lower levels of insignificant ($p > 0.05$) correlation coefficients either positive or negative except for WAEC in 2019 and 2020 having above 0.5 positive correlation coefficients at high levels of significance ($p < 0.05$). The performance appraisal for students of both WAEC and NECO in Mathematics and Physics for years under reviewed have no significant relationship except for WAEC in 2019 and 2020 that experienced a comparatively significant improvement in terms of relationship between Mathematics and Physics. This significant improvement in the correlation coefficients may be as a result of curriculum reforms, availability and utilization of innovative instructional materials, strategies and practices for teaching, introduction of centralized promotional examinations for SSS 2 students, attendance of seminars, conferences and training & retraining of teachers, investment in education and hard work on the part of the students.

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