Analysis of Items and Candidates' Mean Score of 2019 Katsina State Basic Education Certificate Examination (BECE) in Mathematics: Implications for Teaching and Learning of Mathematics in Secondary School

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Abstract

The study examined from the Classical Test Theory (CTT) method of data analysis on the number of items set and candidates' mean score (from the mathematics branch of Algebra, Geometry, Trigonometry, and Statistics examined); the difference in mean scores between male and female candidates; boarding and day school candidates of Katsina State 2019 Basic Education Certificate Examination (BECE) in mathematics conducted by Katsina State Education Resource Centre (KSERC). An Ex-post facto design was used for the study. The population of the study consist of all 65,773 (40,804 males and 24,969 females) candidates that sat for the 2019/2020 academic session BECE in Mathematics. Multi-stage sampling techniques were used to select a sample of 500 (319 males and181 females; 193 candidates from boarding schools and the remaining 307 from the day school) candidates. The data for the study was obtained from the BECE in mathematics 2019/2020 Academic session question paper and the candidates' scores. Hypotheses were formulated and tested at α = 0.05 level of significance. The data were analyzed using descriptive statistics and a t-test was used for hypotheses testing. Algebra constituted the highest number of (28) items set while geometry is the least (seven items, candidates mean score = 4.33) for the 2019 BECE in mathematics; There is also, a significant (t = 4.378, df= 498, at p = 0.000) difference in mean score between male and female candidates on items set from the aspect of geometry were among the findings from the study. Implications of the study findings and recommendations were made.

Keywords: *BECE, KSERC, Mathematics*

Introduction

Basic Education Certificate Examination (BECE) is an annual and compulsory examination for the final year students in Junior Secondary School (JSS) leading to the award of a Basic Education Certificate (BEC). It cuts across all JSS subjects and is being conducted by the Katsina State Educational Resource Centre (KSERC). A Credit pass in BECE in mathematics counts for the award of BCE. The awarded BEC is valid for admission into SSS in the State and beyond (Federal Unity and other States schools). BECE as an Annual Standardized Examination (ASE) is constructed, administered, and scored by mathematics teachers under the supervision and sponsorship of KSERC. As much as possible, KSERC is committed to ensuring the setting of higher technical quality and free from bias or error examinations. To achieve these goals various Examinations (BECE, Senior Secondary Certificate Examination Mock, and Senior Secondary School (SSII) qualifying) set by the Centre have undergone rigorous moderation. Thus, except for Katsina State, JSS III students in Federal Unity and other States schools sit for Standardized BECE constructed, administered, scored, and supervised by National Examination Council (NECO).

However, all the examinations conducted by the KSERC are constructed by various subject teachers in secondary schools. Creating a valid and reliable test instrument by a classroom teacher is a time-consuming process and requires the teacher to thoroughly consider the content, goal, and outcome of the assessment process. “Most teachers and trainers are still not capable of developing good achievement tests at any area of learning approximately 60% of the test items the teachers used had mistakes' that needed to be corrected or improve before administration” P.3 (Anikweze, 2013).

Mathematics as a subject has been given a central place in the secondary school curriculum. More periods are allocated to mathematics classes than any other subject. Literature related to teaching and learning secondary school mathematics documents that mathematics has been considered by many as one of the toughest subject matters in schools. Studies involving mathematics identified several factors that contribute to the complexity of the subject matter such as the fear of failure, negative student attitude toward the subject, negative anticipation of the difficulty toward the subject on the part of the learner, and poor training received from earlier schooling. Adding to the inherent complexity of mathematics are the appropriate instructional approaches or techniques used by some teachers in facilitating lessons. To this end, Mathematics Improvement Program (MIP) was established based on the approved memorandum passed to the Katsina State government by the State Ministry of Education on 11th December 2002. The MIP has the responsibilities of assisting in the provision of mathematics teaching resources and materials and providing workshops and counselling services to mathematics teachers and students in schools.

Yet, very little has been achieved, as reports of candidates’ level of achievement in mathematics tests being conducted by KSERC revealed that candidates are not doing well in the subject. In 2017 out of 52, 123 candidates 45, 532 (87.4%) failed to obtain 5 credits including Mathematics and English while in 2018 out of 65,797, 49,822 (75.7%) were without credits in mathematics and English [KSERC, 16th April 2019]. Students' performance in secondary school mathematics

is a product of many factors such as teacher quality, student attitude, level of student motivation, availability of teaching material, quality and administration of test items and e.t.c., Furthermore, Literature on teaching and learning of secondary school mathematics documented that achievement in secondary school mathematics is influenced by teachers/students' negative attitudes; self-concepts, anxiety, peer group influence, gender difference; poor teaching methods; and ineffective mathematics curriculum in secondary school(Yusha'u, 2013; Chaman, et al., 2014; Chand et al., 2021). These are acknowledged. However, from the psychometric point of view, one of the reasons for the low-level achievement in mathematics may probably be due to faulty test items that are being administered to candidates. The use of faulty items may be a result of not conducting a thorough analysis of test items before they are administered to candidates.

In this study, the researchers examined the Classical Test Theory (CTT) method of data analysis on the number of items set and candidates' mean score (from the mathematics branch of Algebra, Geometry, Trigonometry, and Statistics examined) in Katsina State 2019 BECE in mathematics and its implication to KSERC as well as in teaching and learning of secondary school mathematics. Specifically, the study determined:-

i. Several items are set and candidates' mean scores in each aspect of algebra, geometry, trigonometry, statistics and Number and Numerals.
ii. The difference in gender in the mean scores of candidates in each aspect of algebra, geometry, trigonometry, statistics and Number and Numerals.
iii. The difference in school type in the mean scores of candidates in each aspect of algebra, geometry, trigonometry, statistics and Number and Numerals.

Research Questions

The study was guided by the following research questions:-

i. What is the number of item sets and candidates' mean scores in each aspect of algebra, geometry, trigonometry, statistics and Number and Numerals?
ii. What is the difference in the mean scores in gender in each aspect of algebra, geometry, trigonometry, statistics and Number and Numerals?
iii. What is the difference in the mean scores in school type in each aspect of algebra, geometry, trigonometry, statistics and Number and Numerals?

Hypotheses

The following hypotheses were tested at $\alpha = 0.05$ level of significance

Ho_1: There is no significance difference in the mean score of gender in each aspect of algebra, geometry, trigonometry, statistics and number and numerals.

Ho_2: There is no significance difference in the mean score of school type in each aspect of algebra, geometry, trigonometry, statistics and number and numerals

Methodology

An Ex-post facto design was used for the study because the scores obtained (males and females scores, boarding and day school candidates scores) for the independent variables had already occurred and could not be manipulated. Kerlinger (as cited in Cohen, et al., 2007) defined ex-post facto as research in which the independent variables have already occurred and in which the researcher starts with the observation of a dependent variable or variables.

The population of the study consist of all 65,773 (40,804 males and 24,969 females) candidates that sat for the 2019/2020 academic session BECE in Mathematics (KSERC,2019) distributed within the schools in each of the 12 Education Zones of the State whose Mean $_{age}$ stood at 14 years. Multi-stage (random; proportionate stratify) sampling techniques were used. For the initial stage, Computer-generated random numbers were used to select six out of the twelve zones The six sample zones had a population of 42,674 (26003 Male; 16671 Females) 2019 BECE candidates in mathematics. A proportionate stratified random sampling technique was used in the second stage to select the sample of 500 students as shown in Table 5

Table 1: Distribution of the Sample used for the Study

Zone	Baure	Faskari	Funtua	Katsina	M/Fashi	Safana	Total
Male	26	29	70	110	62	22	319
Female	15	16	40	62	35	13	181
Total	41	45	110	172	97	35	500

From Table 1 above 500 (319 males and181 females) candidates is a sample with Katsina zone having the highest (172) number of sample students.

While the last stage is sorting out candidates from boarding and day schools Table 5) which resulted in having 193 candidates from boarding schools and the remaining 307 from the day schools.

The data for the study was obtained from the BECE in mathematics 2019/2020 Academic session question paper and the candidates' scores. The 2019 BECE in mathematics consists of two sections (A &B). Section A is the 60 multiple-choice items with four (a, b, c, & d) options format and is dichotomously scored, with one mark for each item. The second section B is the essay type where the candidate is expected to answer all the questions. The 60 items that constituted the BECE in Mathematics have 15 items each covering the content of the four (Algebra, Geometry, Trigonometry, Number and Numerals, and Statistics) Mathematics concepts principles and skills taught and examined in JSS General Mathematics. It is time-restricted within 2 hours candidate is expected to answer all the questions.

The BECE items are usually constructed by a team of five subject specialists from each zone to ensure the content validity of the items that constituted the BECE. A moderatos team under the supervision of the Director Examination KSERC is usually set up to select the items for final inclusion into the BECE. Another sub-committee in charge of vetting scores of all marked scripts is also constituted before the final result is approved by the management of KSERC.

The scripts are usually marked by the subjects' teachers on invitation and attendance to a 5-day marking orientation organized by the KSERC. To ensure marking is free of bias, inter-zonal script marking is adopted.

The data were analyzed using SPSS version 16 software for computing descriptive statistics for the mean and Standard deviation and t-test for Null hypotheses testing.

Results

Table 2a: Distribution of Items set based on the five branches of mathematics taught at Junior Secondary school

Mathematics branch	Items
Algebra	3,4,5,7,8,9,13,15,16,17,18,19,20,21,22,23,25, 26,27,28,29,30,31,32,33,34,36, and 37
Geometry	35,51,52,53,54,55, and 57
Trigonometry	56,58,59, and 60
Statistics	38,39,40,41,42,43,44,45,46,47,48,49,and 50
Number & Numerals	1,2,6,10,11,12,14, and 24

The result in Table 2a above shows the distribution of 2019 BECE items set under each mathematics branch taught and examined at JSS

Table 2b: Number and percentages of items set and candidates' mean score in 2019 BECE mathematics

Items in	Algebra	Geometry	Trigonometry	Statistics	Number &Numerals	Total
No	28	7	4	13	8	60
Per cent	46	12	7	22	13	100
Mean	19.76	4.33	2.03	7.61	6.30	40.03

Table 2b above, shows the number and percentages of items set and candidates' mean score with Algebra having 28 (46%) out of the 60 items of the 2019 BECE in mathematics.

Table 3: Showing the outcomes from the Ho_1 tested at $\alpha = 0.05$ level of significance

Item in Algebra	**Number of candidates**	**Mean**	**Stand. Deviation**
Gender Male	291	20.72	4.63
Female	209	18.42	5.88
T-test	t	Degree of Freedom	Sig(2-tail)
	4.903	498	.000
Item in Geometry	**Number of candidates**	**Mean**	**Stand. Deviation**
Gender Male	291	4.61	1.66
Female	209	3.94	1.70
T-test	t	Degree of Freedom	Sig(2-tail)
	4.378	498	.000
Item in Trig	**Number of candidates**	**Mean**	**Stand. Deviation**
Gender Male	291	2.34	1.35

Female	209	1.59	1.41
T-test	t	Degree of Freedom	Sig(2-tail)
	6.023	498	.000
Item in Statistics	**Number of candidates**	**Mean**	**Stand. Deviation**
Gender Male	291	8.40	2.970
Female	209	6.53	3.04
T-test	t	Degree of Freedom	Sig(2-tail)
	6.874	498	.000
Item in Num&Nume	**Number of candidates**	**Mean**	**Stand. Deviation**
Gender Male	291	6.40	1.48
Female	209	6.04	1.70
T-test	t	Degree of Freedom	Sig(2-tail)
	2.515	498	.012

Table 3 displayed the results of the mean score and Ho_1 on gender differences in each aspect of algebra, geometry, trigonometry, statistics and number and numerals.

Table 4: Showing the outcomes from the Ho_2 tested at $\alpha = 0.05$ level of significance

Item in Algebra	**Number of candidates**	**Mean**	**Stand. Deviation**
School Boarding	193	19.02	.408
Day	307	19.94	.297
T-test	t	Degree of Freedom	Sig(2-tail)
	1.875	498	.061
Item in Geometry	**Number of candidates**	**Mean**	**Stand. Deviation**
School Boarding	193	3.80	1.45
Day	307	4.06	1.49
T-test	t	Degree of Freedom	Sig(2-tail)
	1.909	498	.057
Item in Trig	**Number of candidates**	**Mean**	**Stand. Deviation**
School Boarding	193	1.70	1.31
Day	307	2.24	1.46
T-test	t	Degree of Freedom	Sig(2-tail)
	4.142	498	.000
Item in Statistics	**Number of candidates**	**Mean**	**Stand. Deviation**
School Boarding	193	7.40	3.13
Day	307	5.09	3.88
T-test	t	Degree of Freedom	Sig(2-tail)
	6.985	498	.000
Item in Num&Nume	**Number of candidates**	**Mean**	**Stand. Deviation**
School Boarding	193	6.32	168
Day	307	6.21	1.58
T-test	t	Degree of Freedom	Sig(2-tail)
	6.695	498	.487

Table 4 above, revealed the mean score and result of **Ho_2** tested at $\alpha = 0.05$ level of significance on the difference between boarding and day school in each aspect of algebra, geometry, trigonometry, statistics and number and numerals.

Findings

i. Algebra constituted the highest number of items set, and mean score (28 items, candidates mean score = 19.76) while geometry is the least (seven items, candidates mean score = 4.33) for the 2019 BECE in mathematics.
ii. Objectives items of 2019 BECE in mathematics are not proportionally distributed across the five (Algebra 46%, geometry 12%, trigonometry 7%, statistics 22%, number and numerals 13%) branches of mathematics taught at the Junior Secondary School.
iii. There is a significant ($t = 4.903$, $df= 498$, at $p = 0.000$) difference in the mean score between male and female candidates on items set from the aspect of algebra.
iv. There is also, a significant ($t = 4.378$, $df= 498$, at $p = 0.000$) difference in the mean score between male and female candidates on items set from the aspect of geometry.
v. Significant differences is observed between male and female candidates on items set from aspect of trigonometry ($t = 6.023$, $df= 498$, at $p = 0.000$), statistics ($t = 6.874$, $df= 498$, at $p = 0.000$), and number and numerals ($t = 2.515$, $df= 498$, at $p = 0.012$).
vi. There is no significant difference in the mean scores of candidates from boarding and day schools on item set from aspect of algebra ($t = 1.875$, $df= 498$, for $p > \alpha$) , geometry ($t = 1.875$, $df= 498$, for $p > \alpha$), and number and numerals ($t = 6.695$, $df= 498$, for $p > \alpha$) .

Discussion

In discussing the results from the study, the limitation of the study for excluding community and private types of schools must be acknowledged. The discussion focused on the data whose unit of analysis is 500 marked scripts for the 2019 /2020 Academic Session, Katsina State BECE in mathematics.

To achieve the objective I of the study, research question i was answered and the result was shown in Table 1a and this was summarized in Table 1b. from the result in Table 1b, mathematics concepts, principles and skills examined under algebra consist of 28 (46%) out of the 60 items of the 2019 BECE objectives items and candidates mean score of 19.76 was obtained. While the least was geometry aspect (seven items, candidates mean score = 4.33)as shown in table A. Finding from this, revealed that Algebra constituted the highest number of items set, and mean score (28 items, mean score = 19.76) while geometry is the least (seven items, candidates mean score = 4.33) for the 2019 BECE in mathematics. Finding from this also shows that the objectives items of 2019 BECE in mathematics are not proportionally distributed across the five (Algebra 46%, geometry 12%, trigonometry 7%, statistics 22%, number and numerals 13%) branches of mathematics taught at the Junior Secondary School.

Research question ii was answered and the result was shown in Table 3 this was used to achieve objective ii of the study. From the result as shown in Table b, the following mean scores were observed for male candidates on items set from aspect of algebra =20.72; geometry = 4.61; trigonometry = 2.34; statistics = 8.40 and number and numerals = 6.40. While for the female

candidates the following were observed, for algebra = 18.42; geometry = 3.94; trigonometry = 1.59; statistics = 6.53 and number and numerals = 6.04. These (mean scores) were used to test the **HO_1** at $\alpha = 0.05$ level of significance. For items set from the aspect of algebra and geometry, male candidates' and female candidates' mean scores = 20.92, 18.42 and 3.80 and 4.06 respectively. However, the differences (2.5 and 2.06) in the mean score between male and female candidates are statistically significant for t = 4.903, df= 498, at p = 0.000 and t = 4.378, df= 498, at p = 0.000 Thus the Ho was rejected for $p < \alpha$ and conclude there is a significant difference in mean score between male and female candidates on items set from the aspect of algebra and geometry. Finding from this revealed that there is a significant (t = 4.903, df= 498, at p = 0.000) difference in mean score between male and female candidates on items set from the aspect of algebra. There is also, a significant (t = 4.378, df= 498, at p = 0.000) difference in the mean score between male and female candidates on items set from the aspect of geometry.

Similarly significant differences is observed between male and female candidates on items set from aspect of trigonometry (t = 6.023, df= 498, at p = 0.000), statistics (t = 6.874, df= 498, at p = 0.000), and number and numerals (t = 2.515, df= 498, at p = 0.012). Thus, the HO1 tested for each aspect was rejected for $p <\alpha$. Findings from this revealed that male and female candidates differ significantly in the mean scores of items set from the aspect of trigonometric, statistics, and number and numerals. This implies that the male candidates performed better than females and the difference in the mean scores cannot occur by chance. The finding is also in agreement with previous studies reported by Maliki, et al., 2009; Zehiuwa, (2014); Oribhabor, (2019) and Yusuf et al., (2022) on the significant difference between male and female candidates in mathematics performance.

The result in Table 4 was used in achieving objective iii of the study. From the result in Table C the following mean scores were observed for candidates from boarding school on items set from the aspect of algebra =19.02; geometry = 3.80; trigonometry = 1.70; statistics =7.40 and number and numerals = 6.32. While for the candidates from day school the following were observed, for algebra = 19.94; geometry = 4.06; trigonometry = 2.24; statistics = 5.09 and number and numerals = 6.21. These (mean scores) were used to test the **HO_2** at $\alpha = 0.05$ level of significance and the result was also, shown in Table C although, the difference in the mean score of the candidates from boarding and day schools in the items set from the aspect of algebra is 0.92 with candidates from day school having highest mean score while in the items set from the aspect of geometry the difference is 0.26 with candidates from day school having the highest mean score. However, these differences in the mean scores between candidates from boarding and day schools in item set from aspect of algebra (t = 1.875, df= 498, at p = 0.61) , geometry (t = 2.515, df= 498, at p = 0.57) and number and numerals (t = 6.695, df= 498, at p = 0.487) were not statistically significant at $p > \alpha$. Thus the HO2 was retained and conclude that there is no significant difference in the mean scores of candidates from boarding and day schools on item set from aspect of algebra (t = 1.875, df= 498, for $p > \alpha$) , geometry (t = 1.875, df= 498, for $p > \alpha$), and number and numerals (t = 6.695, df= 498, for $p > \alpha$) . This implies the difference in the mean scores observed between boarding and day school candidates occurred by chance only. Although, mean score differences of 0.54 and 2.34 were observed between candidates from boarding and day schools candidates on items set from the aspect of trigonometry and statistics. However, these differences in the mean scores (0.54 and 2.34) were statistically significant for

p< α as shown in Table C, thus the HO2 was rejected for p < α. Finding from this revealed that it is a statistically significant (t = 4.142, df= 498, for p =0.000) difference in the mean score of items set from the aspect of trigonometry and also, significant (t = 6.985, df= 498, for p =0.000) difference was observed from the items set from the aspect of statistics. The study is in agreement with Zehiuwa, (2014) who observed that boarding students perform better in secondary mathematics than day students, it is also in agreement with the similar study reported by Yusuf, et al., (2022) who observed significant (t = 11.947, df = 498, p = 0.000) difference in the mean scores between day and boarding school candidates.

Implications of the Study Findings

The analysis of Item, sets for the 2019 BECE in mathematics and candidates' mean scores revealed facts on the nature of the BECE items in mathematics and disparity in gender and school types among the candidate's performances. These may warrant immediate action by school administrators, teachers and the KSERC in charge of Measurement and Evaluation

From the findings of the study, the items set are not proportionate -normally distributed as the percentages of items set for each aspect of Algebra, geometry, trigonometry, statistics and number and numeration are not proportional. For instance, the finding of the study shows Algebra constituted 46% of the items set while trigonometry had 7% only. This may likely affect the process of teaching and learning Junior secondary school mathematics as teachers and students tend to concentrate on the aspect of the items that have the highest proportion of items thereby neglecting or concentrating less on the remaining aspects like geometry and trigonometry. that are examinable by KSERC.

Disparity observed in the mean scores performances between the variables understudy may have an implication on the allocation of teaching and learning of mathematics materials to schools. However, this shall not rather cause the disparity that needs to be studied.

Conclusion

The study was carried out to analyze the items set for the 2019 BECE in mathematics conducted by KSERC. It also determined the difference in candidates' mean scores performances under the two main (gender, school types) variables in the 2019 BECE in mathematics. Problems in teaching and learning JSS mathematics, especially the cumulative failures of candidates in mathematics have been of great concern to stakeholders in education. The study reviewed literature documented related to teaching and learning of secondary mathematics and identified gaps which if addressed will hopefully improve the teaching and learning as well as measuring students' achievement in mathematics. Implications of the study findings in teaching and learning of JSS mathematics have been identified and recommendations were made based on the findings from the study.

Recommendations

There is a need for the Department of Measurement and Evaluation of KSERC to ensure an equal proportion of items set (at least 12%) from each aspect of Algebra, geometry,

trigonometry, statistics and number and numeration before the final approval of the items. Measures to be taken by KSERC in collaboration with Quality Assurance Zonal Education Offices Inspectorate Division and to ensure syllabus coverage by mathematics teachers as the differences observed in the main scores between boarding and Day schools may likely be due to lack of syllabus coverage. Workshops and seminars on test item constructions are to be organized at least twice a year by the KSERC. A similar study on the other examinable subjects by KSERC is to be carried out by researchers.

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