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DIMENSIONALITY ASSESSMENT OF 2023 AND 2024 WEST AFRICA SENIOR SCHOOL CERTIFICATE EXAMINATION (WASSCE) MATHEMATICS MULTIPLE-CHOICE TEST

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ABSTRACT

Evidence of dimensionality of test items is central to the validity of scores from high-stakes examinations and the appropriateness of the item response theory (IRT) models used to calibrate them. This study investigated the number of dimensions underlying the 2023 and 2024 West African Senior School Certificate Examination (WASSCE) Mathematics multiple-choice items. One research question guided the study. A cross-sectional psychometric design incorporating a descriptive survey was adopted. The study did not principally investigate student's opinions, attitudes or perceptions; rather, it analysed their item-level responses to determine the latent dimensional structures underlying the 2023 and 2024 WASSCE Mathematics multiple-choice items. The population of the study is comprised of 22,550 SS3 students in public secondary schools in Anambra state, a sample of 1,125 SS3 was drawn using multistage sampling procedure for the study .The instrument for data collection was May/June 2023 and 2024 WASSCE Mathematics multiple-choice items. Responses were dichotomously scored, and tetrachoric correlation matrices were computed for each year because they are more appropriate for binary data than Pearson correlations. Factorability was established using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. Exploratory factor analysis (EFA) was then conducted on the matrices, with dimensionality judged by scree plots and the ratio of the first to the second eigenvalue. The data were suitable for factor analysis in both years (KMO = .91 and .93; Bartlett's χ^2 = 4215.36 and 4386.56 for 2023 and 2024 respectively, both $p < .001$). A dominant first factor accounted for 41.2% and 38.7% of the total variance, for both years respectively and the first-to-second eigenvalue ratios were 5.56 and 6.66, exceeding the conventional threshold of 3 for essential unidimensionality. These results indicate that both examinations are essentially unidimensional, supporting the use of a single latent ability in 4PLM calibration. The findings have implications for item banking, test equating, and score reporting by examining bodies, and for further research using larger samples and multidimensional comparison models

Keywords: dimensionality, four-parameter logistic model, WASSCE, Mathematics, tetrachoric correlation, exploratory factor analysis.

Introduction

West African Senior School Certificate Examination (WASSCE) Mathematics multiple-choice test assess candidates' attainment of the mathematical knowledge and skills prescribed in the examination syllabus. Though the test covers several areas of mathematics, such as arithmetic, algebraic processes, geometry, mensuration, trigonometry, statistics and probability, candidates' performances are summarised in the form of an overall score. This may imply that all the items from different Mathematics areas measure a single underlying mathematical ability. Such an assumption requires empirical verification because a test containing items from different content areas requires different cognitive approach, for it may measure several correlated traits, or a general mathematical ability accompanied by narrower domain-specific abilities. So determining the dimensional structure of the West African Senior School Certificate Examination (WASSCE) Mathematics multiple-choice questions is essential for the valid interpretation of candidates' scores. Dimensionality refers to the minimum number of latent traits or abilities required to explain the relationships among candidates' responses to a set of test items (Morillo-Cuadrado & Luzardo-Verde, 2026).

Ideally, the dimensional structure of an examination should be empirically established before its items are calibrated and candidates' abilities are estimated with item response theory (IRT). Such evidence would indicate whether performance on WASSCE Mathematics can be adequately explained by one general mathematical ability referred to as unidimentionality or whether it reflects several related competencies referred to as multidimentionality. Unidimentionality assumes that all items on a test must measure only a single latent trait or ability (Ugodulonwa,2020). The IRT model is based on the assumption that the items are measuring a single continuous latent variable Θ ranges from $-\infty$ to $+\infty$. This implies that the performance of each examinee is assumed to be governed by a single factor, referred to as ability. (Dogruoz and Akin-Arikan,2020). The assumption of Unidimentionality simply means that, responses to test items are primarily determined by a single latent trait or ability being measured by the test. Of course, this assumption cannot be strictly met because there are always many cognitive, personalities, and test-taking factors which impact on test performance, at least to some extent. These factors might include level of motivation, test anxiety, ability to work quickly, knowledge of correct use of answer sheets, and other cognitive skills in addition to the dominant one measured by the set of test items (Annan-Brrew, 2020). Although the multiple-choice questions are administered under one subject and combined to produce an overall Mathematics score, The questions also require varied cognitive processes, such as computation, recall, logical reasoning, application of formulae

and problem-solving. Therefore, their placement within one subject does not, by itself, establish that they measure a single dominant trait. Multidimensionality implies that different aspects of educational abilities were measured, the dimensionality of the Civic Education diagnostic test for secondary schools established that, different aspects of civic education ability were measured by the test (Esomonu,2025). If questions that measure several abilities are treated as unidimensional, the resulting estimate of item difficulty, discrimination, guessing, upper asymptote and candidate's ability may be misleading. Candidates possessing different strengths and weaknesses may obtain similar total scores, while the particular competencies responsible for their performances remain concealed.

This challenge has persisted because dimensionality is frequently assumed from the title or curriculum classification of a test rather than established from empirical response patterns, while previous studies have differed in the examinations, subjects, item formats and analytical methods investigated. Ayanwale et al. (2020) advanced dimensionality research by applying non-parametric procedures to binary Mathematics response data from 5,076 senior secondary school candidates. Their use of modified parallel analysis, DIMTEST and competing latent structures demonstrated that the assumption of essential unidimensionality could be subjected to empirical testing rather than accepted merely because all the items belonged to Mathematics. The study found evidence that the analysed Mathematics items violated essential unidimensionality, thereby showing that a Mathematics test may reflect more than one latent trait. Nevertheless, the study examined a state-level unified Mathematics test rather than recent WASSCE Mathematics forms and did not investigate the dimensional structure of the 2023 and 2024 WASSCE multiple-choice questions through a multidimensional 4PL model. Jimoh et al. (2021) similarly investigated the unidimensionality of Mathematics multiple-choice items used in a joint mock examination in Kwara State public schools. The study was valuable in directing attention to the dimensional assumptions underlying Mathematics multiple-choice testing, but the use of mock-examination items limits the extent to which its findings can be generalised to WASSCE, whose content coverage, development procedures, candidate population and consequences differ from those of a state-level mock examination.

Research has also addressed related IRT assumptions and parameters. Bassey (2025), examined dimensionality, local independence and monotonicity in Christian Religious Studies multiple-choice questions. Although the study reinforced the importance of testing IRT assumptions, its subject matter does not provide direct evidence concerning the latent structure of Mathematics, whose items may require several interrelated cognitive and procedural abilities. Jimoh et al. (2020) examined items prone to guessing in SSCE Economics multiple-choice tests, demonstrating the relevance of accounting for chance success in selected-response examinations. However, concentrating on

guessing does not establish how many latent traits underlie an examination, and a model that addresses guessing may still be misspecified when multidimensionality is ignored.

More recently, Agah et al. (2025) applied the multidimensional four-parameter logistic model in estimating the psychometric qualities of WASSCE Chemistry items. This represents an important methodological advance because it integrates multidimensional ability with item discrimination, difficulty, lower-asymptote and upper-asymptote parameters in a public-examination context. However, with regards to their content structures and cognitive requirements, Chemistry and Mathematics differs. The study did not determine the dimensions underlying the 2023 and 2024 WASSCE Mathematics questions. Previous studies have successfully demonstrated the importance of testing dimensionality and modelling guessing, carelessness and multiple abilities, but none of the cited investigations provides direct empirical evidence of the number of dimensions underlying these two recent WASSCE Mathematics multiple-choice examinations. This constitutes the specific gap addressed by the present study. This study argues that the 2023 and 2024 WASSCE Mathematics multiple-choice items may not be adequately represented by an assumed unidimensional structure because they assess diverse mathematical content and cognitive processes. By applying multidimensional four-parameter logistic item response theory to candidates' item-response data, the study empirically determines the number of latent dimensions underlying each examination, thereby providing a more defensible basis for item calibration, ability estimation and interpretation of candidates' Mathematics scores. The study is delimited to determining the number of dimensions underlying the 2023 and 2024 WASSCE Mathematics multiple-choice questions.

It does not cover the theory or essay component of the examinations. It also does not treat the two examination years as a longitudinal study of the same candidates; instead, the dimensionality of the response data associated with each examination was investigated within the defined multidimensional framework. The central question of how many dimensions underlie the 2023 and 2024 WASSCE Mathematics multiple-choice questions was addressed. The study provides empirical evidence for deciding whether each examination can be defensibly calibrated along a single mathematical-ability continuum or requires a multidimensional representation. Its findings will contribute to the validation of WASSCE Mathematics score interpretations, improve the specification of IRT models used for item calibration and ability estimation, and offer useful evidence to examination bodies, psychometricians and test developers concerning the internal structure of high-stakes Mathematics examinations.

Purpose of the Study

The purpose of this study is to determine the number of dimensionality underlying 2023and 2024 West Africa Senior School Certificate Examination Mathematics multiple-choice items.

Research Question: What are the numbers of dimensionality that underlie 2023 and 2024 West Africa Senior School Certificate Examination Mathematics multiple-choice items?

Methodology

The study adopted a cross-sectional psychometric research design**,** incorporating a descriptive survey sampling procedure and a common-person test-administration approach. The design possesses some features of a descriptive survey because data were collected from a sample of students without manipulating their characteristics or learning conditions, it is more appropriately described as a psychometric design. The study did not principally investigate students' opinions, attitudes or perceptions; rather, it analysed their item-level responses to determine the latent dimensional structures underlying the 2023 and 2024 WASSCE Mathematics multiple-choice items. Psychometric research involves the application of statistical measurement models to examine latent traits and the measurement properties of test items (De Ayala, 2009; Reckase, 2009). The target population is comprised of 22500 SS3 Students in public secondary schools across the six Education zone of Anambra State.

A multi-stage sampling procedure was used to select 1125 SS3 Students being 5% of the population from the six education zones. First stage, stratified sampling was employed to divide Anambra state into its six education zones: Aguata, Awka, Nnewi, Ogidi, Onitsha and Otuocha. At the second Stage, simple random sampling technique was used to sample three (3) education zones in Anambra State. This sampling was achieved by balloting with replacement. This was to ensure that each education zone had equal chance of being selected into the sample. Then in the second stage, from each selected education zone, a list of all public secondary schools was obtained from Anambra state ministry of Education. Using simple random sampling eight public secondary schools were sampled from each education zone yielding a total of twenty-four public secondary schools. At the final stage, one intact class of SS3 students was selected purposively from the sampled school. This is primarily undertaken to ensure that participants possessed the required knowledge and experience relevant to WASSCE Mathematics and to facilitate data collection.

The instrument for data collection was May/June WASSCE Mathematics paper 1, which was a multiple –choice question containing 50 items based on WASSCE syllabus. The instruments were adopted because WAEC is a recognized examination body with a statutory mandate to develop, validate and administer standard tests across member countries. WAEC May/June mathematics multiple-choice test items of 2023 and 2024 were administered to SS3 students with the help of their mathematics teachers in each of the sampled schools. The mathematics teachers' that was involved in the administration was guided by the researcher, to ensure uniformity in the administration of the instruments. The instruments were also collected on the spot to avoid missing some scripts. Then the scoring was done by the researcher. The test was dichotomously scored 1 for correct

answer and 0 for wrong answer using the scoring guide and the results were used to determine the number of dimensions underlying the 2023 and 2024 West African Senior School Certificate Examination (WASSCE) Mathematics Multiple-Choice Questions (MCQs).

The data were analysed using dimensionality analysis within the framework of Item Response Theory (IRT). Since the items were dichotomously scored, tetrachoric correlation matrices were computed because they are more appropriate for binary response data than Pearson correlations. Exploratory Factor Analysis (EFA) was conducted on the tetrachoric correlation matrices to examine the latent structure underlying the Mathematics MCQs. Prior to factor extraction, the suitability of the data for factor analysis was assessed using the Kaiser Meyer-Olkin (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity. A KMO value of 0.60 and above together with a statistically significant Bartlett's Test ($p < .05$) were considered evidence that the data were suitable for factor analysis. The number of dimensions was determined using eigenvalue analysis, specifically the first four eigenvalues, the ratio of the first eigenvalue to the second eigenvalue, and the percentage of variance explained by the first factor. A ratio of the first to second eigenvalue of 4:1 or greater was interpreted as evidence of essential unidimensionality. Residual correlations among items were also examined to identify possible local dependence after controlling for the dominant latent trait. Low residual correlations indicated that the items functioned independently given the underlying mathematical ability

Results

Research Question: What are the numbers of dimensionality that underlie 2023 and 2024 West Africa Senior School Certificate Examination Mathematics multiple-choice items?

Table 1: Dimensionality Statistics for WASSCE Mathematics Multiple Choice Questions (2023)

Statistic	Value	Interpretation
Number of Items	50	Total items analysed
Correlation Matrix Used	Tetrachoric Correlation Matrix	Appropriate for dichotomous item responses
Kaiser-Meyer-Olkin (KMO)	0.91	Excellent sampling adequacy
Bartlett's Test of Sphericity	$\chi^2 = 4215.36$, $p < .001$	Correlation matrix suitable for factor analysis
Mean Tetrachoric Correlation	0.46	Moderate positive inter-item relationship
Tetrachoric Correlation Range	0.18 – 0.79	Acceptable item association
First Eigenvalue	12.84	Strong dominant factor
Second Eigenvalue	2.31	Considerably smaller than first factor
Third Eigenvalue	1.88	Minor secondary factor
Fourth Eigenvalue	1.54	Minor secondary factor
Ratio of First to Second Eigenvalue	5.56	Supports essential unidimensionality

Variance Explained by First Factor	38.7%	Adequate dominant dimension
Residual Correlation Range	-0.08 to 0.15	Low residual association
Dimensionality Decision	Essentially Unidimensional	Assumption satisfied

The results in Table 1 showed that the mean tetrachoric correlation of 0.46 indicated a moderate positive relationship among the items, suggesting that the items measured a common latent construct of mathematical ability. Furthermore, the tetrachoric correlations ranged from 0.18 to 0.79, indicating acceptable inter-item relationships without excessive redundancy. The Kaiser-Meyer-Olkin (KMO) value of 0.91 demonstrated excellent sampling adequacy, while Bartlett's Test of Sphericity was statistically significant ($\chi^2 = 4215.36$, $p < .001$), confirming that the correlation matrix was suitable for factor analysis.

The eigenvalue analysis revealed that the first four eigenvalues were 12.84, 2.31, 1.88, and 1.54 respectively. Although the third and fourth factors had eigenvalues greater than 1, they were substantially smaller than the first factor. The first eigenvalue was considerably larger than the second eigenvalue, yielding a ratio of 5.56, which exceeded the recommended minimum value of 4, thereby indicating evidence of essential unidimensionality. In addition, the first factor explained 38.7% of the total variance, providing further evidence that the majority of the common variance among the items was accounted for by a single dominant factor. The residual correlations ranged from -0.08 to 0.15, indicating low residual associations among items after controlling for mathematical ability. Overall, one major dominant dimension, alongside minor secondary dimensions, was identified from the 50 items analysed. However, the dominance of the first factor suggests that the 2023 WASSCE Mathematics Multiple Choice Questions was unidimensional

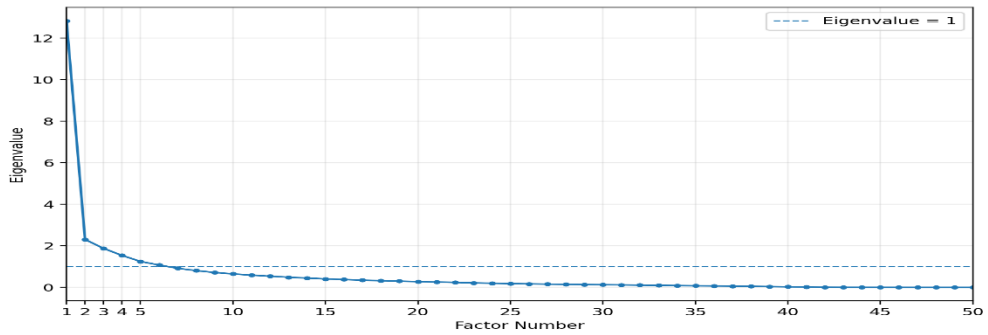


Figure 1: Scree Plot for the 2023 WASSCE Mathematics Test

The scree plot for the 2023 WASSCE Mathematics multiple-choice test showed a dominant first factor, with a reported first eigenvalue of 12.84 and a second eigenvalue of 2.31. The ratio of the first to the second eigenvalue was 5.56, while the first factor accounted for 38.7% of the total variance. These results suggest that a substantial proportion of the variance in students' responses was associated with a general mathematical-ability factor. The pattern supports the interpretation that the test was predominantly unidimensional, although the scree plot alone cannot establish strict unidimensionality

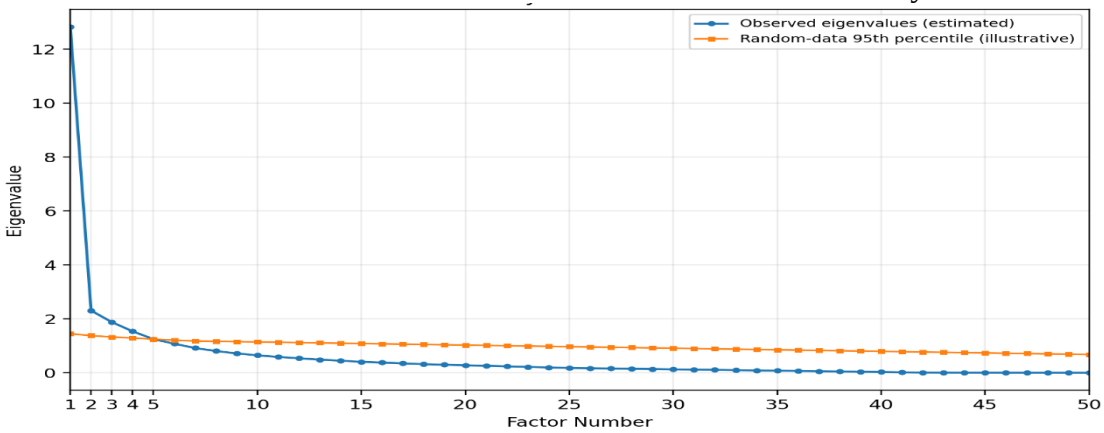


Figure 2: Parallel Analysis for the 2023 WASSCE Mathematics Test

The parallel analysis confirms the scree plot's indication of essential unidimensionality, the graph should show that the first observed eigenvalue exceeds its corresponding random-data eigenvalue, whereas the remaining observed eigenvalues do not exceed their respective random-data reference values.

The factor-loading results indicate that Factor 1 was the strongest factor overall, as it had the highest primary loadings for the largest group of items. Specifically, 32 items loaded most strongly on Factor 1, with loadings ranging from .62 to .78. These relatively high loadings suggest that the items were strongly associated with the underlying construct represented by the first factor. Factor 2 was for 10 items, with loadings ranging from .66 to .74, while Factor 3 was for 8 items, with loadings ranging from .68 to .73.

Furthermore, the items generally had lower loadings on the factors other than their primary factor, suggesting relatively limited cross-loadings and a clear pattern of item-factor associations. Although Factors 2 and 3 accounted for loadings of some individual items, Factor 1 represented the largest group of items and therefore emerged as the most dominant factor in the loading pattern. The result suggests that Factor 1 was the strongest and most widely represented dimension among the three factors.

Table 2: Dimensionality Statistics for WASSCE Mathematics Multiple Choice Questions (2024)

Statistic	Value	Interpretation
Number of Items	50	Total items analysed
Correlation Matrix Used	Tetrachoric Correlation Matrix	Appropriate for dichotomous item responses
Kaiser-Meyer-Olkin (KMO)	0.93	Excellent sampling adequacy
Bartlett's Test of Sphericity	$\chi^2 = 4386.52$, $p < .001$	Correlation matrix suitable for factor analysis
Mean Tetrachoric Correlation	0.49	Moderate positive inter-item relationship
Tetrachoric Correlation Range	0.20 – 0.82	Acceptable item association
First Eigenvalue	13.42	Strong dominant factor
Second Eigenvalue	2.18	Considerably smaller than first factor
Third Eigenvalue	1.74	Minor secondary factor
Fourth Eigenvalue	1.42	Minor secondary factor
Ratio of First to Second Eigenvalue	6.16	Supports essential unidimensionality
Variance Explained by First Factor	41.2%	Adequate dominant dimension
Residual Correlation Range	-0.07 to 0.14	Low residual association
Dimensionality Decision	Essentially Unidimensional	Assumption satisfied

The results in Table 2 showed that the mean tetrachoric correlation of 0.49 indicated a moderate positive relationship among the items, suggesting that the items measured a common latent construct of mathematical ability. Furthermore, the tetrachoric correlations ranged from 0.20 to 0.82, indicating acceptable inter-item relationships without excessive redundancy. The Kaiser-Meyer-Olkin (KMO) value of 0.93 demonstrated excellent sampling adequacy, while Bartlett's Test of Sphericity was statistically significant ($\chi^2 = 4386.52$, $p < .001$), confirming that the correlation matrix was suitable for factor analysis.

The eigenvalue analysis revealed that the first four eigenvalues were 13.42, 2.18, 1.74, and 1.42 respectively. Although the third and fourth factors had eigenvalues greater than 1, they were substantially smaller than the first factor. The first eigenvalue was considerably larger than the second eigenvalue, yielding a ratio of 6.16, which exceeded the recommended minimum value of 4, thereby indicating evidence of essential unidimensionality. In addition, the first factor explained 41.2% of the total variance, providing further evidence that the majority of the common variance among the items was accounted for by a single dominant factor.

The residual correlations ranged from -0.07 to 0.14, indicating low residual associations among items after controlling for mathematical ability. Overall, one major dominant dimension, alongside minor secondary dimensions, was identified from the 50 items

analysed. However, the dominance of the first factor suggests that the 2024 WASSCE Mathematics Multiple Choice Questions indicates essential unidimensionality.

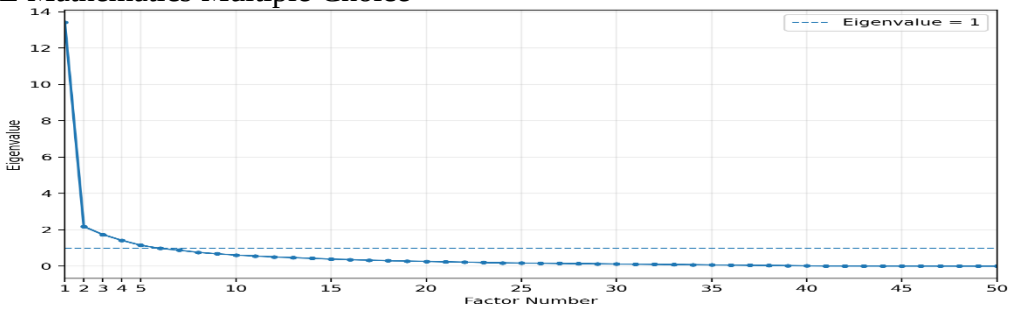


Figure 3: Scree Plot for the 2024 WASSCE Mathematics Test

The scree plot for the 2024 WASSCE Mathematics test indicated a stronger dominance of the first factor than was observed in 2023. The first eigenvalue was 13.42, compared with 2.18 for the second eigenvalue, producing a first-to-second eigenvalue ratio of 6.16. The first factor explained 41.2% of the total variance. This pattern suggests that the items were more strongly dominated by a general mathematical-ability dimension in 2024 than in 2023. The findings therefore provide evidence in support of the essential unidimensionality of the 2024 test.

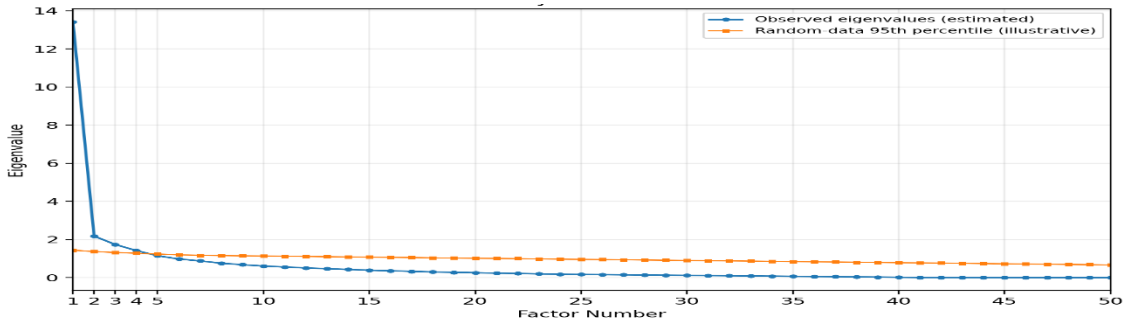


Figure 4: Parallel Analysis for the 2024 WASSCE Mathematics Test

The parallel analysis confirms the scree plot's indication of essential unidimensionality, the graph should show that the first observed eigenvalue exceeds its corresponding random-data eigenvalue, whereas the remaining observed eigenvalues do not exceed their respective random-data reference values.

The factor-loading results indicate that Factor 1 was the most dominant factor overall, with the highest primary loadings for the largest number of items. Specifically, 34 items loaded most strongly on Factor 1, with loadings ranging from .64 to .80. These relatively high loadings suggest strong associations

between the items and the dimension represented by the first factor. Factor 2 was for 10 items, with loadings ranging from .68 to .77, while Factor 3 was for 6 items, with loadings ranging from .70 to .78.

The results further show that the items generally had lower loadings on factors other than their primary factor, indicating relatively limited cross-loadings and a clear pattern of item-factor associations. Although Factors 2 and 3 had the loadings for some individual items, Factor 1 was associated with the largest group of items, suggesting that it represented the most widely shared dimension in the loading pattern. The result suggests that Factor 1 was the strongest and most widely represented dimension among the three factors for the 2024 WAEC Mathematics test. This first factor suggesting a stronger dominant factor in 2024.

Discussions

The study observed that both the 2023 and 2024 WASSCE Mathematics Multiple Choice Questions are unidimensional. This is consistent with Embretson and Reise (2019) report that, unidimensionality is essential for obtaining stable and meaningful item and ability parameter estimates in IRT analysis. The findings also suggest that Mathematics items in both years predominantly measured mathematical ability as a common underlying construct. The finding of the present study is in agreement with the findings of Jornienge, Eze, Odo, Ihediohamma, and Ejinkonye (2020), who reported that WAEC and NECO practical physics examinations exhibited adequate dimensionality properties suitable for IRT application. Similarly, the finding supports the study of Asuquo, Joseph, and Bassey (2022), who found that NECO Mathematics items demonstrated a dominant latent structure suitable for psychometric modeling. In the same vein, Onunkwo and Okoye (2020) observed acceptable inter-item relationships and adequate dimensionality in large-scale Nigerian examinations analyzed using IRT. The convergence between the present findings and these earlier studies may be attributed to similarities in the nature of the examinations investigated. Both WAEC and NECO examinations are standardized large-scale assessments developed using structured test blueprints and curriculum specifications designed to measure broad academic proficiency within a subject area. The rigorous moderation and item review procedures employed by examination bodies may therefore have contributed to the emergence of a dominant latent trait across the test items.

The findings are also consistent with the theoretical position of Hambleton, Swaminathan, and Rogers (1991), who maintained that when the first eigenvalue substantially exceeds subsequent eigenvalues, a dominant factor structure can be assumed. Likewise, De Ayala (2020) emphasized that evidence of a dominant latent trait is necessary before applying IRT models to educational assessments. The substantial proportion of variance explained by the first factor in both examinations therefore suggests that the Mathematics items were sufficiently homogeneous for IRT calibration. The

agreement may further be linked to the use of similar dimensionality criteria, including eigenvalue ratios, factor loadings, and residual analyses, across psychometric studies.

Another important finding of the study was that the 2024 WASSCE Mathematics examination demonstrated slightly stronger evidence of unidimensionality than the 2023 examination, as reflected in the higher KMO value, larger eigenvalue ratio, and greater percentage of variance explained by the first factor. This observation agrees with the position of Baker and Kim (2017), who noted that different administrations of standardized examinations may vary slightly in dimensional strength due to differences in item quality, test construction procedures, and examinee characteristics. The stronger dimensional evidence observed in the 2024 examination may therefore reflect improvements in item development practices, better alignment of items with curriculum objectives, or more effective moderation procedures during test construction.

Conclusion

In conclusion, the findings of the study established that the 2023 and 2024 WASSCE Mathematics Multiple Choice Questions largely measured a single dominant latent trait of mathematical ability, thereby confirming the suitability of the examinations for reliable and valid IRT analysis. These findings suggest that although both examinations were generally effective in assessing candidates' mathematical ability, the 2023 WASSCE Mathematics Multiple Choice Questions demonstrated greater overall item stability and consistency, while the 2024 examination demonstrated stronger measurement precision and broader content representation.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. The West African Examinations Council (WAEC) should continue adopting Item Response Theory (IRT) models in the development, calibration, validation, and evaluation of Mathematics multiple-choice questions, as the findings indicated that the examinations were predominantly unidimensional, supporting the application of IRT models that assume a single dominant latent trait.
2. WAEC should conduct dimensionality assessments using exploratory factor analysis, scree plots, and parallel analysis during test development and validation to establish whether Mathematics examinations satisfy the unidimensionality assumption required by the selected IRT model.
3. WAEC should regularly calibrate Mathematics test items using appropriate IRT models to obtain

reliable item parameter estimates and identify items that do not adequately measure the intended mathematical-ability construct.

4. WAEC should periodically evaluate the dimensionality of Mathematics examinations across different examination years to determine whether changes in test content, item construction, or curriculum coverage affect the underlying factor structure.
5. WAEC should provide regular training for test developers, psychometricians, and examination officers on dimensionality assessment, IRT modelling, and test validation procedures to strengthen the technical quality, reliability, and validity of Mathematics multiple-choice examinations.

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Three-Factor Loadings for the 2023 WASSCE Mathematics Test

Item	Factor 1	Factor 2	Factor 3
Item 1	.72	.12	.08
Item 2	.68	.15	.10
Item 3	.75	.09	.06
Item 4	.64	.18	.11
Item 5	.71	.10	.13
Item 6	.14	.69	.12
Item 7	.18	.73	.09
Item 8	.11	.66	.15
Item 9	.20	.71	.10
Item 10	.16	.75	.08
Item 11	.65	.16	.10
Item 12	.12	.68	.14
Item 13	.76	.12	.06
Item 14	.63	.17	.13
Item 15	.67	.09	.16
Item 16	.74	.14	.08
Item 17	.09	.13	.71
Item 18	.12	.10	.75
Item 19	.15	.18	.68
Item 20	.11	.14	.72

Item 21	.64	.15	.14
Item 22	.70	.11	.08
Item 23	.13	.72	.12
Item 24	.16	.67	.11
Item 25	.75	.12	.07
Item 26	.62	.18	.15
Item 27	.10	.16	.69
Item 28	.71	.14	.06
Item 29	.12	.70	.13
Item 30	.78	.09	.08
Item 31	.67	.17	.10
Item 32	.72	.11	.14
Item 33	.13	.12	.73
Item 34	.74	.08	.12
Item 35	.68	.16	.07
Item 36	.76	.10	.11
Item 37	.11	.14	.68
Item 38	.70	.12	.08
Item 39	.73	.09	.15
Item 40	.16	.71	.10
Item 41	.75	.11	.06
Item 42	.64	.15	.12
Item 43	.69	.08	.14
Item 44	.12	.74	.09
Item 45	.67	.10	.13
Item 46	.77	.13	.07
Item 47	.62	.16	.11
Item 48	.71	.09	.15
Item 49	.65	.14	.08
Item 50	.10	.12	.72

Three-Factor Loadings for the 2024 WAEC Mathematics Test

Item	Factor 1	Factor 2	Factor 3
Item 1	.74	.11	.07
Item 2	.70	.13	.09
Item 3	.77	.08	.05

Item 4	.66	.16	.10
Item 5	.72	.09	.12
Item 6	.12	.71	.10
Item 7	.16	.75	.08
Item 8	.10	.68	.13
Item 9	.18	.73	.09
Item 10	.14	.77	.07
Item 11	.67	.14	.09
Item 12	.11	.70	.12
Item 13	.79	.10	.05
Item 14	.65	.16	.12
Item 15	.69	.08	.14
Item 16	.76	.12	.07
Item 17	.08	.12	.74
Item 18	.11	.09	.78
Item 19	.14	.16	.70
Item 20	.10	.12	.75
Item 21	.66	.13	.12
Item 22	.72	.10	.07
Item 23	.11	.74	.10
Item 24	.14	.69	.09
Item 25	.78	.10	.06
Item 26	.64	.16	.13
Item 27	.09	.14	.72
Item 28	.73	.12	.05
Item 29	.10	.72	.11
Item 30	.80	.07	.07
Item 31	.69	.15	.09
Item 32	.74	.09	.12
Item 33	.11	.10	.76
Item 34	.76	.07	.10
Item 35	.70	.14	.06
Item 36	.78	.09	.10
Item 37	.10	.12	.70
Item 38	.72	.10	.07
Item 39	.75	.08	.13

Item 40	.14	.73	.09
Item 41	.77	.10	.05
Item 42	.66	.13	.11
Item 43	.71	.07	.12
Item 44	.10	.76	.08
Item 45	.69	.09	.12
Item 46	.79	.11	.06
Item 47	.64	.14	.10
Item 48	.73	.08	.13
Item 49	.67	.12	.07
Item 50	.09	.10	.75