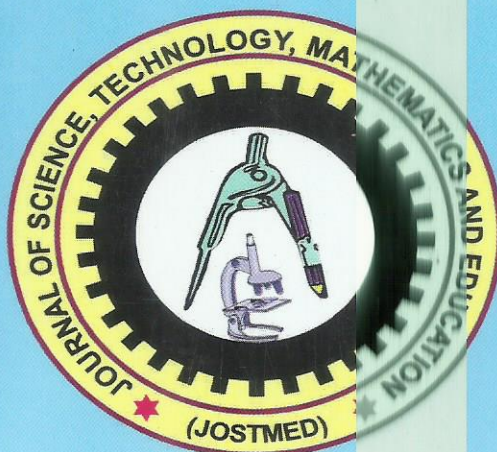


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**ARTICLES AND RESEARCH REPORTS  
ON EDUCATION**



## ANALYSIS OF THE DIMENSIONALITY OF NIGERIAN SENIOR SCHOOL CERTIFICATE EXAMINATION JUNE/JULY 2013/2014 OBJECTIVE TESTS IN GOVERNMENT

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### Abstract

*This study examined and analyzed the dimensionality of the Nigerian Senior School Certificate Examination Multiple-choice Objective Tests in Government. Exploratory research design was adopted for the study. A representative sample of 1,348 out of 3,034 Senior Secondary School Three (SSS III) students from 49 schools participated in the study through multi-stage sampling technique. The June/July series of NECO Senior School Certificate Examination June/July Multiple-choice Objective Tests in Government for the years 2013 and 2014 were adopted as instrument for the study. Data collected were analyzed using Principal Component Analysis and Proximity Matrix Method of the HCA Approach. The findings of this study revealed that 56 items representing 93.33% of the total of 60 items in NECO SSCE June/July Multiple-choice Objective Tests in Government for the two years were unidimensional and no significant difference was observed between the two tests. In conclusion, the two tests were unidimensional. The study recommended that efforts should be intensified toward improving the standard of the test items, that all examining bodies using multiple-choice test instruments should be encouraged to use the Hierarchical Cluster Analysis Approach in test development process.*

**Keywords:** Hierarchical Cluster Analysis, Dimensionality, Senior School Certificate Examination, Government

### Introduction

Testing has been accepted in modern societies as the most objective method of evaluation in schools, industries, private and government establishments. Testing has become one of the most important parameters by which a society adjudges the product of her educational system (Emaikwu, 2012). The essence of testing is to reveal the latent ability of examinee. According to Rivera (2007), a standard test is an instrument that has been carefully prepared in accordance with scientific techniques to measure intelligence, aptitude, or achievement in school subjects. Standard tests are often considered high stake because results are used to make important decisions concerning admission into higher institution of learning, graduation requirements and certification and employment, thus making validity a central issue.

According to Brown (2000), the general concept of validity was traditionally defined as the degree to which a test measures what it claims, or purports to be measuring. Cronbach, (1984) defined validity as a process of examining the accuracy of inference made from a test score. Validity is therefore determined in relation to what particular use for which the instrument is



being considered. Validity can also be referred to as the appropriateness, meaningfulness and usefulness of the specific inferences made from test scores.

Validity is a basic and fundamental issue in test development and evaluation. Validity is necessary because of the major impact which test results can have on the stakeholders involved. Item Response Theory (IRT) is a modern test theory which explains examinees' ability level by using responses to test items. IRT provides a basis for estimating parameters, ascertaining how well data fits a model and investigating the psychometric properties of assessment. It equally helps psychometricians when developing, refining test items and maintaining item banks for examinations. IRT as well provides a complex but reliable way of determining validity of test, it focuses on each item and each individual test taker.

Item Response Theory operates base on three basic assumptions, the first assumption is unidimensionality. Item response models which assumes a single latent ability is referred to as unidimensional. Adedoyin and Adedoyin (2013) pointed out that "what is required for the unidimensionality assumption to be met adequately is the presence of one dominant factor that influences test performance. Local independence is the second assumption; Local independence means that the probability of an examinee getting an item correct is unaffected by the answer given to other items in the test. Administration of a set of items based on a common stimulus such as in the passage-based reading tests and scenario-based science assessments can cause Local Item Dependence (LID).

Yen (1993) argued that different content areas within a test may impose LID on items measuring the same content area. But Bradlow, Waine and Wang (1999) stated that it is not uncommon for a standardized test to consist of item bundles or testlets. The third assumption of Item Response Theory is monotonicity; Monotonicity assumption stated that as the examinee ability level increases, the probability of the examinee answering any particular test item correctly increases. Ojerinde (2013) stated that without this third assumption there may not be any good reason for testing.

However, it has been argued by researchers that the unidimensionality assumption of Item Response Theory can be problematic. First, unidimensionality assumption is inappropriate for many standardized tests which are constructed from sub-components that are meant to measure different traits (Ansley & Forsyth, 1985). Secondly, when a test is designed purposely to be unidimensional but results from the scores are interpreted multidimensional. Ackerman (1999) stated that if a test is truly multidimensional it becomes impossible to rank order test-takers without implicitly or explicitly weighting the dimensions. Thirdly, some tests are designed with items meant to measure multiple domains of ability.

Dimensionality is a unique aspect of construct validity and the purpose of studying the internal structure of a test is to demonstrate that all the items work coherently, thus art of assessing dimensionality is to find the smallest number of latent ability domains defined in a test. Stevina (2011) said that dimensionality in assessment concerns the number of abilities or constructs assessed by a test or a set of items. In view of the above, Stevina (2011) defined dimensional structure as the relationship between the items on the test and the latent proficiencies believed to be measured by the test.

McDonald (2000) suggested that the issue of dimensionality involves more than (successfully) arriving to a number of proficiencies that account for the item responses. He pointed out that in addition to arriving to the number of dimensions that underlie the item responses, the relationship between the items and dimensions play a crucial role in dimensionality assessment.



In assessment situations a set of items is said to be unidimensional if a single trait underlies the data but multidimensional if multiple traits underlies the data. Multidimensional IRT (MIRT) is a model which explains the relationship between two or more unobservable variables conceptualized as dimensions and the probability of the examinee who is correctly answering a particular test item by the mathematical model (Ackerman, Gierl & Walker, 2003). Items on a given assessment may actually measure different domain of abilities, this is not problematic as long as the assessment is basically measuring the same composite for all students. On some assessments, testees-item interaction could result in different composites of ability being measured for testees with different background.

Like unidimensional model, multidimensional model have two assumptions. These are Monotonicity and Local Independence. Monotonicity assumption stated that as the examinee ability level increases, the probability of the examinee answering any particular test item correctly increases (Smith, 2009). Local Independence is defined as the probability of solving any item independent of the result of any other item. This assumption is said to be controlling for person parameters and item parameters (Embretson & Reise, 2000).

One of the cardinal objectives of education in Nigeria as provided for in National Policy on Education (FGN, 2004) is to prepare the young ones to face future challenges and develop them to meet the manpower needs of the country. Thus it becomes highly imperatives to conduct examinations within and outside the schools as a basis for assessment. Government is one of subjects in the senior secondary school level in Nigeria. According to NECO (2007), Government test has been designed with blueprint/specifications that indicate five (5) underlying structures of the domains being measured. These underlying structures could be viewed as dimensions and each of the content areas is a potential dimension and in view of the importance of the decisions made on the basis of NECO Senior Secondary Certificate test results, this study examined and analyzed the dimensionality of the objective tests in Government.

Assessing dimensionality helps to identify the construct(s) defined by the test developer and examine how well the test measures the underlying structure(s). Also investigating the dimensionality of test items help to strengthen the quality of the test and to identify good or bad performing test items and also help to improve the test items towards production of valid test for the future use. Kane (2006) pointed out that the validation of a proposed test purposes, uses and interpretations should be separated into two stages; development and appraisal. Similarly, Schmaier and Welch (2006) stated that development process and validation serves:

- (a) To provide support that test is serving the intended test purposes or dimensionality,
- (b) To suggest that the test design must be refined and improved through further empirical analysis.

Studies on test dimensionality available in measurement and evaluation literature focus on Test of English for International Communication (TOEIC); Michigan English Language Assessment Battery; Michigan K-12 Science Assessment and Turkish Secondary School Student Selection and Placement Tests.

Wilson (2000) assessed the dimensionality of Listening and Reading Comprehension items in the TOEIC (Test of English for International Communication). The study involved native speakers of Japanese and Korean. The results show unidimensionality for the Listening Comprehension (LC) but not for the Reading Comprehension (RC) across the subgroups.

Jiao (2004) evaluated the dimensionality of the Michigan English Language Assessment



Battery (MELAB). Stout's procedure was employed to test two hypotheses generated in the study. The results of the study indicated that both Listening and Grammar, Cloze Vocabulary and Reading (GCVR) tests were unidimensional. It revealed that the global GCVR test was unidimensional, but for subgroup (gender, native language and proficiency level) the results were inconsistent across methods regarding the dimensionality of both forms.

Jang and Roussos (2007) investigated into methodologies for conducting a conditional covariance-based nonparametric dimensionality assessment using data from two forms of the Test of English as a Foreign Language (TOEFL). The results of exploratory study revealed that TOEFL tests involved two dominant dimensions. The results indicated that Test of English as a Foreign Language (TOEFL) test items violated the unidimensionality assumption of IRT.

Li, Jiao and Lissitz (2012) validated the test structure and dimensionality of Michigan K-12 Science Assessment with application of multidimensional item response theory (IRT) models. It was discovered that multiple content areas with single subject often exist in large scale achievement test which both violated the assumptions of the unidimensional IRT model.

Also Ozbekbastug (2012) assessed the dimensionality of items in Social Science subtest of the Turkish Secondary School Student selection and placement Tests of 1999, 2000 and 2001. The results of the study indicated multidimensionality of the Social Science subtests across the years 1999, 2000 and 2001.

The findings in the above empirical studies on dimensionality of test items are diversified and varied and this shows that more studies are still required. None of the available studies was on NECO senior school certificate objective tests in Government. In order to fill these gaps, the researcher decided to conduct a study to investigate the dimensionality of items in the Nigerian Senior School Certificate Examination June/July Multiple-choice Objective Tests in Government of the years 2013 and 2014.

### **The Purpose of the study**

The purpose of this study however, was to analyze the dimensionality of the NECO Senior School Certificate Examination June/July Multiple-choice Objective Tests in Government of the years 2013 and 2014.

### **Research Questions**

This study specifically sought answers to the following research questions:

- (i) What is the dimensionality of the NECO Senior School Certificate Examination June/July Multiple-Choice Objective Tests in Government in years 2013 and 2014?
- (ii) Is there any difference in the dimensionality of the NECO Senior School Certificate Examination June/July Multiple-Choice Objective Tests in Government in years 2013 and 2014?

### **Methodology**

This study adopted exploratory survey research design. The population of this study consisted of all senior secondary school students (SSS) in all 1,735 public senior secondary schools in South-western states of Nigeria. A total sum of One thousand three hundred and forty-eight (1,348) out of 3,034 (SSS III) students that registered for Government in the final senior school certificate examinations in 49 public senior secondary schools participated in the study. Multi-stage sampling technique was adopted for the selection of the respondents.

The years 2013 and 2014 June/July series of the NECO Senior School Certificate Multiple-



Choice Objective Tests in Government were adopted and used as instruments in this study. These tests consisted of sixty (60) items each. The researcher was of the opinion that both the validity and reliability of these tests might have been determined by the relevant unit of the National Examination Council (NECO) before administration, hence the issues of validity and reliability estimation of these tests/ test items were not addressed.

In administration of the instrument, the researcher visited each of the selected schools and administered the instruments to the selected students with the help of research assistants. The data collected from this study were subjected to analysis with due consideration to the two (2) research questions generated earlier, Principal Component Analysis (PCA) and Proximity Matrix Method of Hierarchical Cluster Analysis Approach were used for the analysis using SPSS version 21.

## Results

**Research Question One:** What is the dimensionality of the NECO Senior School Certificate Examination June/July Multiple-Choice Objective Tests in Government in years 2013 and 2014?

### Verifying the assumption of unidimensionality

In order to provide answer to Research Question 1, IRT assumption of unidimensionality was verified using exploratory Principal Component Analysis (PCA) before Hierarchical Cluster Analysis (HCA) procedure was computed to assess the dimensionality of the NECO Senior School Certificate June/July Multiple-choice Objective Tests in Government in the years 2013 and 2014. The approach to determine the number of factors by selecting those for which the Eigenvalues are greater than 1 known as the Kaiser–Guttman Rule was used. This value means that these factors account for more than the mean of the total variance in the items and the results are presented below:

**Table 1: Principal Component Analysis - Eigenvalue and Percentage of Variance Explained**

Component	Eigenvalue	Variance Explained	
		%	Cumulative %
1	2.736	19.388	19.388
2	.682	4.831	24.219
3	.573	4.059	28.278
4	.476	3.374	31.651
5	.436	3.093	34.744
6	.379	2.685	37.429
	.....	.....	.....

For 2013 NECO Senior School Certificate June/July Multiple-choice Objective Test in Government, the Eigenvalues reported in Table 1 show only one component meeting the rule, the first component had Eigenvalue greater than 1 (i.e. 2.736) while other components had Eigenvalues below 1 which is a strong evidence of unidimensionality.

Also for 2014 NECO Senior School Certificate June/July Multiple-choice Objective Test in Government in Table 2, eleven components meeting the rule i.e. had Eigenvalues greater than 1, which is an evidence of multidimensionality. However, Comrey and Lee (1992) warned that if the instrument contains a large number of items, a large number of Eigenvalues will meet this rule. Gorsuch (1983) suggested that the rule is most accurate when there are fewer



than 40 items, the sample size is large, and the number of factors is expected to be between [ $n$  of variables divided by 5] and [ $n$  of variables divided by 3]. In case of this study, the condition of large sample size is met; however, there are more than 40 items (i.e. 60 items).

**Table 2: Principal Component Analysis - Eigenvalue and Percentage of Variance explained**

Component	Eigenvalue	Variance Explained	
		%	Cumulative %
1	16.672	27.786	27.786
2	3.602	6.004	33.790
3	2.340	3.900	37.690
4	2.273	3.788	41.478
5	1.773	2.956	44.433
6	1.693	2.822	47.255
7	1.408	2.347	49.602
8	1.166	1.943	51.545
9	1.124	1.874	53.419
10	1.070	1.783	55.202
11	1.042	1.737	56.939
12	.940	1.566	58.505
....	....	....	....

The result indicated of eleven components to represent the data is doubtful. Reckase (1979) recommended that a percentage of 20 or more of the total variance explained by the first principle component is necessary for the data to be viewed as unidimensional. By examining the magnitude of the total variance explained (27.786) for the first factor. Therefore, the data suggested a lack of no violation unidimensionality assumption, thus the NECO 2014 Senior School Certificate June/July Multiple-choice Objective Test in Government is unidimensional.

Sequel to the above Hierarchical Cluster Analysis procedure was used to assess the dimensionality of the NECO Senior School Certificate June/July Multiple-choice Objective Tests in Government in years 2013 and 2014. Due to the lack of a formal criterion for cluster solution in HCA-CCPROX Van Abswoude, Vander Ark, and Sijsman (2004) suggest that the researcher should rely on priori theoretical expectations about the true dimensionality structure of the data. In the case of this study, since the NECO Senior School Certificate Government blueprint indicates five (5) underlying structures and each structure could be viewed as a potential dimension, so five-cluster solution were adopted from HCA-CCPROX.

**Table 3: Dimensions of NECO Senior School Certificate June/July Multiple-choice Objective Test in Government (2013)**

Dimension 1	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10, Q11, Q13, Q14, Q15, Q16, Q17, Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q26, Q27, Q28, Q29, Q30, Q31, Q32, Q33, Q34, Q35, Q36, Q37, Q38, Q39, Q40, Q42, Q43, Q45, Q46, Q47, Q48, Q49, Q50, Q51, Q52, Q53, Q54, Q55, Q57, Q58, Q59, Q60
Dimension 2	Q12
Dimension 3	Q41
Dimension 4	Q44
Dimension 5	Q56



Table 3 presents the analysis of the 60 test items in the 2013 NECO Senior School Certificate June/July Multiple-choice Objective Test in Government. The above results shows that the item appears to split into five (5) dimensions and items are assigned to each dimension. Dimension 1 had fifty-six (56) members out of sixty (60) members and all the remaining four dimensions i.e. Dimensions 2 to 5 had only one member each. The above result indicates that 56 items that forms the first dimension is representing 93.33% of the total number (60) of the items in the test and One (1) item that forms a distinct dimension representing 1.66% in each of the remaining other four (4) dimensions. In view of the above results it is substantially enough to accept that the test is unidimensional.

**Table 4: Dimensions of NECO Senior School Certificate June/July Multiple-choice Objective Test in Government (2014)**

Dimension 1	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q10, Q11, Q12, Q13, Q14, Q15, Q16, Q17, Q18, Q19, Q20, Q21, Q22, Q23, Q24, Q25, Q27, Q28, Q29, Q30, Q31, Q32, Q34, Q35, Q36, Q37, Q38, Q39, Q40, Q41, Q42, Q44, Q45, Q46, Q47, Q48, Q50, Q51, Q52, Q53, Q54, Q55, Q56, Q57, Q58, Q59, Q60
Dimension 2	Q9
Dimension 3	Q26
Dimension 4	Q33
Dimension 5	Q49

Table 4 presents the analysis of the 60 test items in the 2014 NECO Senior School Certificate June/July Multiple-choice Objective Test in Government. Table 2 above shows five (5) dimensions and items are assigned to each dimension. Dimension 1 had fifty-six (56) members out of sixty (60) members and all the remaining four dimensions i.e. Dimensions 2 to 5 had only one member each. The above result indicates that 56 items that forms the first dimension is representing 93.33% of the total number (60) of the items in the test and One (1) item that forms a distinct dimension representing 1.66% in each of the remaining other four (4) dimensions. In view of the above results it is substantially enough to accept that the test is unidimensional.

The above results is in conformity with Orlando, Sherbourne and Thissen (2001) which stated that that if the value of the first factor is substantially greater than the next, the factor structure is deemed to have sufficiently satisfied the assumptions of unidimensionality, and thus the NECO Senior School Certificate June/July Multiple-choice Objective Tests in Government in years 2013 and 2014 are unidimensional.

**Research Question Two:** Is there any difference in the dimensionality of the NECO Senior School Certificate Examination June/July Multiple-Choice Objective Tests in Government in years 2013 and 2014?

To provide answer to research question 2, the results of all analyses using exploratory Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA) procedure on dimensionality of the NECO Senior School Certificate Multiple-choice Objective Tests in Government in years 2013 and 2014 presented in tables 1 to 4 ( on pages 8 and 10) above are considered. Since there is no statistically significant differences between the dimensionality of the two tests even across methods, it is sufficiently enough to state that there is no difference between the dimensionality of NECO Senior School Certificate June/July Multiple-choice Objective Tests in Government in years 2013 and 2014, thus there is no difference between the dimensionality of the NECO Senior School Certificate June/July Multiple-choice Objective Tests in Government in years 2013 and 2014.



## Discussion

The findings of this study indicate that NECO Senior School Certificate June/July Multiple-choice Objective Tests in Government for the years 2013 and 2014 were found to be inconsistent across methods regarding the dimensionality of both tests. The results of exploratory principal factor analysis for 2013 test reveals one distinct factor with eigenvalue of 2.736 which accounted for 19.388 the total explained variance. For 2014 NECO Senior School Certificate June/July Multiple-choice Objective Tests in Government, the analysis shows one distinct factor and many small other factors. However, it should be noted that the first factor which has an eigenvalue of 16.672 only accounted for 27.786% of the total explained variance. It would be definitely preferable if more variance was accounted for by the first factor.

However, Hambleton in Wiberg (2004) explained that findings such as this are not uncommon and that as long as there is one factor with distinctively larger eigenvalue, it is possible to assume that there is unidimensionality in the test. Note also that there are 10 factors with relevant eigenvalues above 1 and together they accounted for 29.15% of the total explained variance. Reckase (1979) suggests that unidimensionality can be investigated through eigenvalues in factor analysis and that a test is concluded to be unidimensional if when plotting the eigenvalues (from the largest to be the smallest) of the inter-item correlation matrix, there is one dominant first factor. Reckase (1979) also gave another possibility to conclude unidimensionality is to calculate the ratio of the first and second eigenvalues. If the ratio is high, i.e. above a critical value, the test is unidimensional. In this study the first method described is used for the year 2013 test and the second method for the year 2014.

Hierarchical Cluster Analysis (HCA) procedure presented showed five dimensions for each of the tests. The result indicates that the first dimension in each of the tests has 56 members which represent 93.33% of the total items in each of the test. The membership of the first dimension is substantial enough to conclude that the tests did not violate the IRT assumption of unidimensionality, thus the two tests are unidimensional.

Findings in this study revealed that NECO Senior School Certificate June/July Multiple-choice Objective Tests in Government for the years 2013 and 2014 conformed to the assumption of unidimensionality. These findings were in agreement with studies of Jiao (2004); Tomblin and Zhang (2006) and Deng, Wells and Hambleton (2008). However, these findings against the previous studies of Jang and Roussos (2007); Li, Jiao and Lissitz (2012). The findings of these studies showed a clear violation of unidimensionality assumption in the tests assessed.

## Conclusion and Recommendations

Considering the findings of this study, it was concluded that the NECO Senior School Certificate June/July Multiple-choice Objective tests in Government for the years 2013 and 2014 were unidimensional. It was recommended that the National Examinations Council (NECO) should intensify efforts toward improving the standard of the test items. It is also recommended that all examining bodies using multiple-choice test instruments should be encouraged to use the Non-parametric conditional covariance-based Hierarchical Cluster Analysis Approach in test development process.

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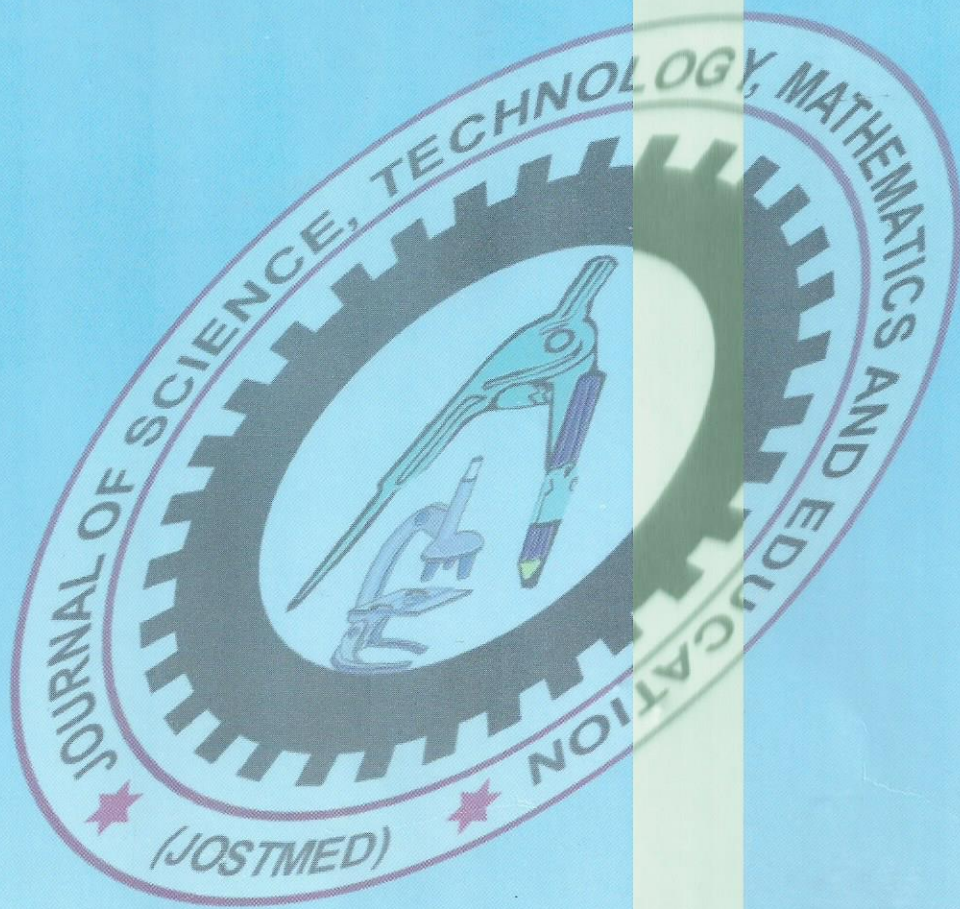


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