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ASSESSMENT OF UNIDIMENSIONALITY OF THE 2021 BASIC SCIENCE TEST OF DELTA STATE BASIC EDUCATION CERTIFICATE EXAMINATION

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ABSTRACT

This study is an assessment of the unidimensionality of the 2021 basic science test of the Delta State Basic Education Certificate Examination. In the study, three research questions were raised and answered. A triangulation research design was adopted for the study. 140,959 JSS III students in all the 475 public secondary schools in Delta State constituted the population of this study. 1,000 junior secondary school (JSS) III students were selected from the population using proportionate stratified, simple random, and convenience sampling techniques. The Basic Education Certificate Examination, the Basic Science Test (BST), and the Physical and Health Education Test (PHET) were the instruments used for data collection. The Basic Education Certificate Examination Basic Science Test (BST) was obtained from the Exams and Standard, Ministry of Basic and Secondary Education, Delta State. The tests were administered to the selected students. The collected data were collated and analysed in line with the research questions. Person separation reliability index and Item Characteristics curve were used to answer research question 1, and the chi-square goodness of fit was used to answer research question 2. Factor analysis using Principal Component Analysis of the varimax method was used to answer research question 3. The first finding revealed that all 60 items measured a single construct. The second finding revealed that out of a total of 60 items, 50 had a good fit in the overall model, while the remaining 10 did not. The last finding revealed that the BST is highly reliable. Based on the findings, it can be concluded that unidimensionality played a complementary role in developing tests for assessment. It can also be concluded that out of a total of 60 items, 50 have a good fit in the overall model, while the remaining 10 do not, and that all 60 items measure a single construct, showing evidence of unidimensionality. The study recommended that Delta State Education Resource Unit, which has the responsibility of developing basic science test items for BECE, pilot test-generated items before their administration to students for the purpose of examinations.

Keywords: Basic Science, unidimensionality, Test

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INTRODUCTION

Basic science, formerly known as integrated science, refers to scientific research and study that aims to expand our understanding of natural phenomena and fundamental principles. It is concerned with uncovering the underlying mechanisms, laws, and theories that govern the natural world, without necessarily focusing on immediate practical applications. Basic science forms the foundation upon which applied sciences and technologies are built.Indeed, teaching basic science at the upper basic school levels (Junior Secondary School grades 1 to 3, often abbreviated as JSS 1-3) plays a crucial role in laying a solid foundation for future scientists and individuals interested in pursuing scientific fields. During these early educational stages, students are introduced to the fundamental concepts, principles, and methods of various scientific disciplines.

All other science subjects such as Physics, Chemistry, Biology, Mathematics including some aspects of Technology and Agriculture stemmed from Basic Science. Consequently, Basic Science is taught in Upper Basic School levels (JSS 1-3) in order to lay a solid foundation for the scientists. The subject is always handled by core professional teachers who understand the prerequisites, methods of teaching the subject and able to monitor and measure the level of achievement of learners in the subject content.

According to Obilor and Akpan (2020), the merits of Basic Science and Science in general, cannot be overestimated in the development of science and technology in such areas as industries, health, agriculture, commerce, transportation, information, communication and the environment. Basic Science does not only provide a holistic view of science, scientific education for non-specialist, but also increases potential for problem solving.Science, according to Raymond and Ryan (2012), is practiced through the use of concepts, establishment of relationships between concepts, and deployment of acquired skills and techniques in fact-finding and problem-solving. Basic Science is taught in standard classrooms and equipped laboratories so designed to meet the requirements of approved curriculum.The curriculum of Basic Science and Technology is a product of the restructuring and integration of four primary and upper basic school science curricula namely; Basic Science, Basic Technology, Physical and Health Education and Computer Studies/Information Communication Technology (FRN, 2014). The number of disciplines provided in primary and upper basic schools was decreased in accordance with the 2010 presidential summit on education recommendations. The recommendations were made in light of input from curriculum implementation in schools, which identified repetition and concept duplication as the main contributors to curriculum workload. The summit also makes the case for the necessity of supporting creative approaches to teaching and learning that stimulate learners' critical and creative thinking. They also advocate for the inclusion of emerging topics that are of national and international concern, such as gender sensitivity, globalisation, and entrepreneurship, as well as the promotion of a holistic view of science at the Basic Education level (Ogbeba, Enemarie & Ajayi, 2019). In cognizance with the importance ofscience and technology, Basic Science and Technology are taught in Upper Basic schoolsin Nigeria to prepare a base for any science andtechnological development. It is essential to begin making plans for a solid basic scientific education for her population as early as possible if any nation—especially Nigeria—is to grow scientifically and technologically. This is becausechildren begin career exploration at a veryyoung age. To move with this pace, BasicScience is taught at the primary school so as tocatch the pupils' heart young. As a follow up,Basic Science and Technology is taught at theupper basic level to enable students to build upand concretize the knowledge of science theyhad at the primary school level and to lay thefoundation for the study of the core sciencesubjects such as

Biology, Chemistry andPhysics at the senior secondary level ofeducation.To achieve this, tests are the tools to give feedback on what a person has learnt to obtain feedback that will determine thepresence or absence of these exploration. The Basic Science Test (BST) used by the Delta State Basic Education Certificate Examination (BECE) is an example of a standardized achievement test. It is used by the examination body to assess the extent to which the students have achieved the objectives of the Basic Science Curriculum. It is usually taken at the end of Upper Basic Education for certification and promotion purpose. Those who pass the test, alongside other subjects, are promoted to the senior secondary school stage of education. As a result of the importance of the Basic Science Test to scientific and technological development, there is a need to ascertain its psychometric properties in terms of validity and reliability. For any test items to achieve its aim, the test items must meet up with the theoretical scale for item selection using the item parameters (Oyiborhoro, Odili & Osadebe, 2023).

Oyiborhoro, Odili and Osadebe (2023) stated that an achievement test can be studied from different perspectives and the items in the test can be evaluated according to different theories. Two of such theories are the Classical Test Theory (CTT) and the Item Response Theory (IRT). These theories are the two major frameworks that are used in educational measurement to develop, evaluate, determine the reliability and validity of tests, as well as improve the quality of test items. These frameworks are based on different assumptions and use different statistical approaches. There are basically four assumptions of item response theory (IRT), the unidimensionality assumption is a trait based assumption which explained that test items are to measure only one particular subject area at a given time (Okagbare, Ossai and Osadebe).

Item Response Theory (IRT) models play a prominent role in psychometric theory. In these models, the properties of a measurement instrument are completely described in terms of the properties of the items, and the responses are modelled as functions of item and person parameters. While many of the technical challenges that arise when applying IRT models have been resolved (example, Model Parameter Estimation), the assessment of model fit remains a major hurdle for effective IRT model implementation (Hambleton & Han, as cited in Orheruata, 2015). The assessment of the IRT model fit to item response data is one of the crucial steps before an IRT model can be applied with confidence to estimate proficiency or ability levels of examinee (Embretson & Reise, 2010). The most important assumptions underlying these models are the unidimensionality of the items. It is commonly assumed that only one ability or trait is necessary to "explain," or "account" for examinee test performance. Item response models that assume a single latent ability are referred to as unidimensional. The assumption of a unidimensional latent space is a common one for test constructors since they usually desire to construct unidimensional tests to enhance the interpretability of a set of test scores in basic science.

A test can be unidimensional within one population of examinees and not unidimensional in another. Consider a test with heavy cultural loading. This test could appear to be unidimensional for all populations with the same cultural background, but, when administered to populations with varied cultural backgrounds, the test may have more than a single dimension underlying test performance (Mallikarjuna, 2014). Examples of this situation are seen when the factor structure of a particular set of test items varies from one cultural group to another. Another common example occurs when reading comprehension is a factor in solving math problems. In one subpopulation in which all examinees can comprehend the questions, the only trait affecting test performance is mathematics ability.

Statement of the Problem

In spite of the periodic reforms in the Nigerian educational system, many students have continued to perform poorly in various subjects at various levels of education. In order to stem the tide of poor performance in this all-important subject, successive governments and other education related agencies of both the public and private sectors have variously made relevant contributions toward the improvement of teaching and learning of basic science subjects despite the concerted efforts of successive governments at empowering and standardizing of Basic Education in Delta state. It is due to this persistent nature, researchers and educational institutions have conducted many studies to uncover the underlying reasons behind this failure. The failure in basic science test could be that the items measured different thing instead of basic science trait based. This necessitated the study to assess the unidimensionality of the 2021 basic science testof Delta State Basic Education Certificate Examination**.**

Research Questions

The following research questions guided the study:

1. What is the evidence of unidimensionality of the 2021 Basic Science Test?
2. What is the Overall Model Fit of the 2021 Basic Science Test?
3. What is the Item Response Function of the 2021 Basic Science Test?

Purpose of the Study

The purpose of this study is to assess the unidimensionality of the 2021 basic science testof Delta State Basic Education Certificate Examination. The study basically:

1. showed the evidence of unidimensionality of the 2021 Basic Science Test;
2. ascertained the Overall Model Fit of the 2021 Basic Science Test;
3. determined the Item Response Function of the 2021 Basic Science Test;

RESEARCH METHOD

A triangulation research design was adopted for the study. Triangulation research design allows for a multi-method approach to studying the psychometric properties of an instrument (Kpolovie, 2016). Considering the study's goal was to validate an already-in-use instrument, this approach is now suitable.140,959 JSS III students in all the 475 public secondary schools in Delta State during the 2021/2022 academic session constituted the population of this study. The inclusion of all 475 public secondary schools ensured a comprehensive representation of the JSS III student population in Delta State.

1,000 junior secondary school (JSS) III students in public secondary schools in Delta State form the sample of this study. Proportionate stratified, simple random and convenience sampling techniques was employed in drawing the sample. In doing this, the researcher estimated the percentage of the sample size in relation to the overall size, which resulted in 0.71%. Basic Education Certificate Examination, Basic Science Test (BST), Physical and Health Education Test (PHET) and Physical and Health Education Test (PHET) were the instruments used for data collection. The Basic Education Certificate Examination Basic Science Test (BST) was obtained from the Exams and Standard, Ministry of Basic and Secondary Education, Delta State. The tests contain 60 multiple choice questions having five options; one key and four distracters (Oyiborhoro, Odili and Osadebe, 2023).

The basic science and technology test, Physical and Health Education Test (PHET) of 2021was used to collect data from the sample population. Basic science teachers in schools visited helped as research assistant in the administration and invigilation of the test

instruments. The test was administered within the limited time as specified the examination body in Delta State. The correct response for an item was assigned 1 and incorrect response was assigned 0 to indicate the unidimensionality of the tests. Person separation reliability index and Item Characteristics Curve were used to answer research question 1, Chi-square goodness of fit was used to answer research question 2, factor analysis using Principal Component Analysis of the varimax method was used to answer research question 3.

PRESENTATION OF DATA

Research Question 1: What is the evidence of unidimensionality of the 2021 Basic Science Test?

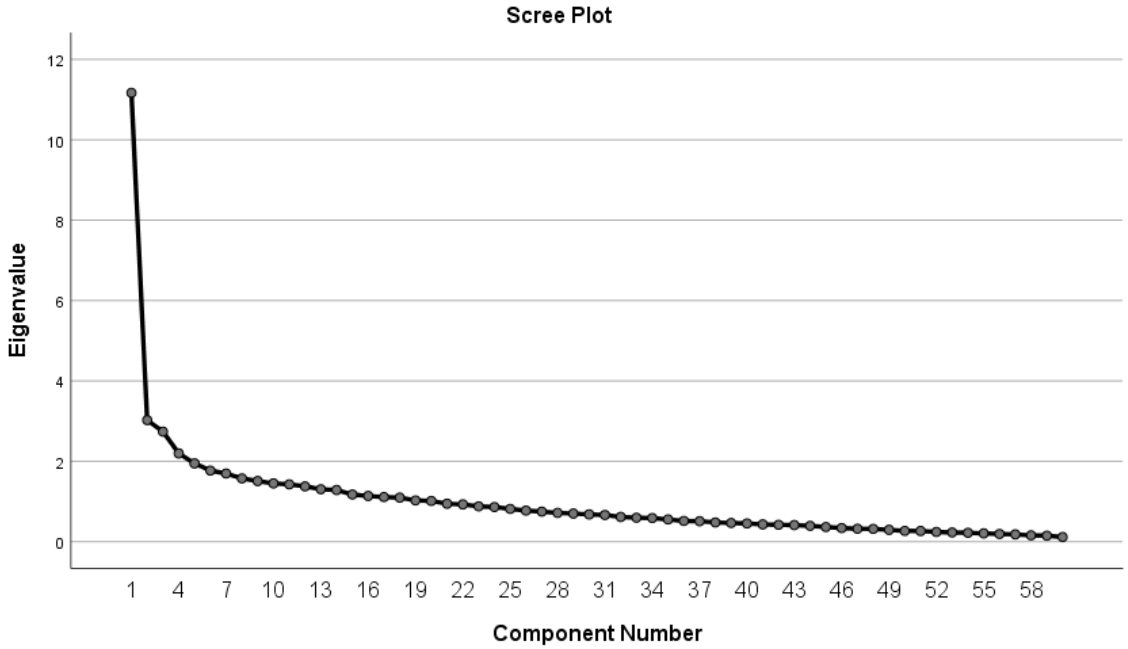


Fig 1: Scree Plot for the BST

The scree plot for the BST is shown in Fig 1. A close look at the scree plot in the figure reveals that there is just one construct before the breaking point of the plot. This effectively illustrates the BST's underlying construct's unidimensionality. One construct is measured by each item.

Research Question 2: What is the Overall Model Fit of the 2021 Basic Science Test?

Table 1: Item Fit Statistics of the BST

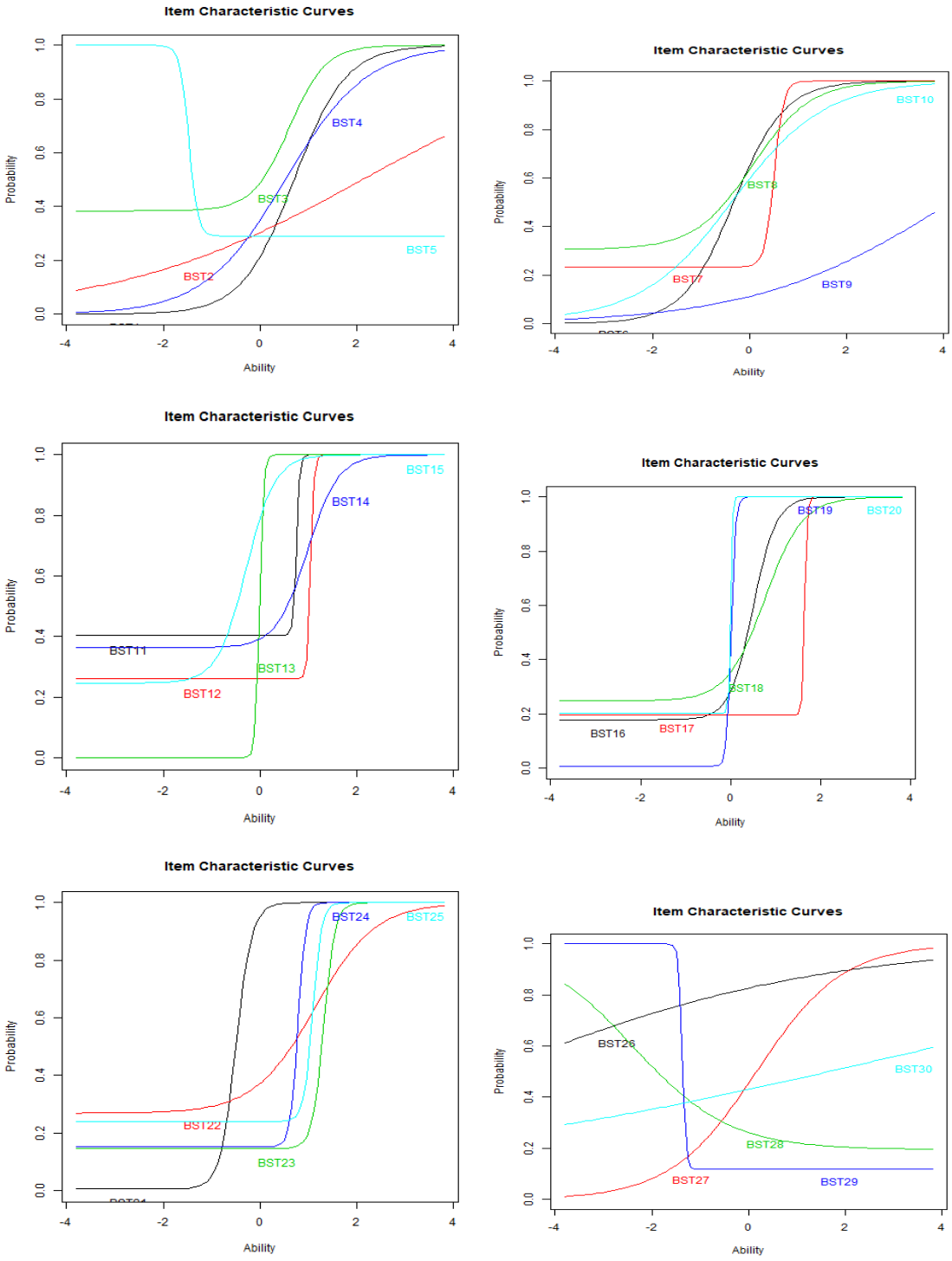
Item No	Chi-square	Sig.	Remark
BST24	3.239	.862	√
BST4	3.439	.842	√
BST47	3.556	.829	√
BST33	4.017	.778	√
BST56	4.162	.761	√
BST7	4.170	.760	√
BST1	4.229	.753	√
BST17	4.371	.736	√
BST57	4.540	.716	√
BST15	4.700	.697	√
BST19	4.928	.669	√
BST58	5.007	.659	√

BST31	5.108	.647	√
BST30	5.252	.629	√
BST26	5.287	.625	√
BST41	5.538	.595	√
BST48	5.544	.594	√
BST8	5.780	.566	√
BST38	5.877	.554	√
BST54	5.938	.547	√
BST50	6.240	.512	√
BST22	7.064	.422	√
BST2	7.100	.419	√
BST44	7.576	.371	√
BST13	7.721	.358	√
BST51	7.740	.356	√
BST14	8.118	.322	√
BST45	8.600	.283	√
BST60	8.727	.273	√
BST6	9.042	.250	√
BST12	9.266	.234	√
BST37	9.646	.210	√
BST20	9.724	.205	√
BST52	9.781	.201	√
BST11	9.909	.194	√
BST10	9.972	.190	√
BST40	10.079	.184	√
BST55	10.450	.164	√
BST59	10.820	.147	√
BST53	11.028	.137	√
BST16	11.508	.118	√
BST5	11.726	.110	√
BST29	12.368	.089	√
BST3	12.437	.087	√
BST32	12.943	.074	√
BST21	12.968	.073	√
BST23	13.326	.065	√
BST27	13.537	.060	√
BST42	13.576	.059	√
BST35	14.214	.048	√
BST9	14.923	.037	X
BST39	15.952	.026	X
BST49	16.478	.021	X
BST25	18.521	.010	X
BST43	18.518	.010	X
BST28	19.210	.008	X
BST36	18.914	.008	X
BST34	21.329	.003	X
BST46	25.180	.001	X
BST18	31.823	.000	X

Key: √ = Good Fit; X = Not Good Fit
Criterion = p>0.05

Table 1 shows the chi-square goodness of fit statistics, which was used to determine the overall model fit of the 2021 Basic Science Test. The p-value ranged from 0.000 to 0.862, as indicated in the Table. Items are considered to have a good fit in the overall model if their p-value is greater than 0.05 and to have no good fit if their p-value is less than 0.05. Out of a total of 60 items, 50 have a good fit in the overall model based on this criterion, while the remaining 10 do not.

Research Question 2: What is the Item Response Function of the 2021 Basic Science Test?



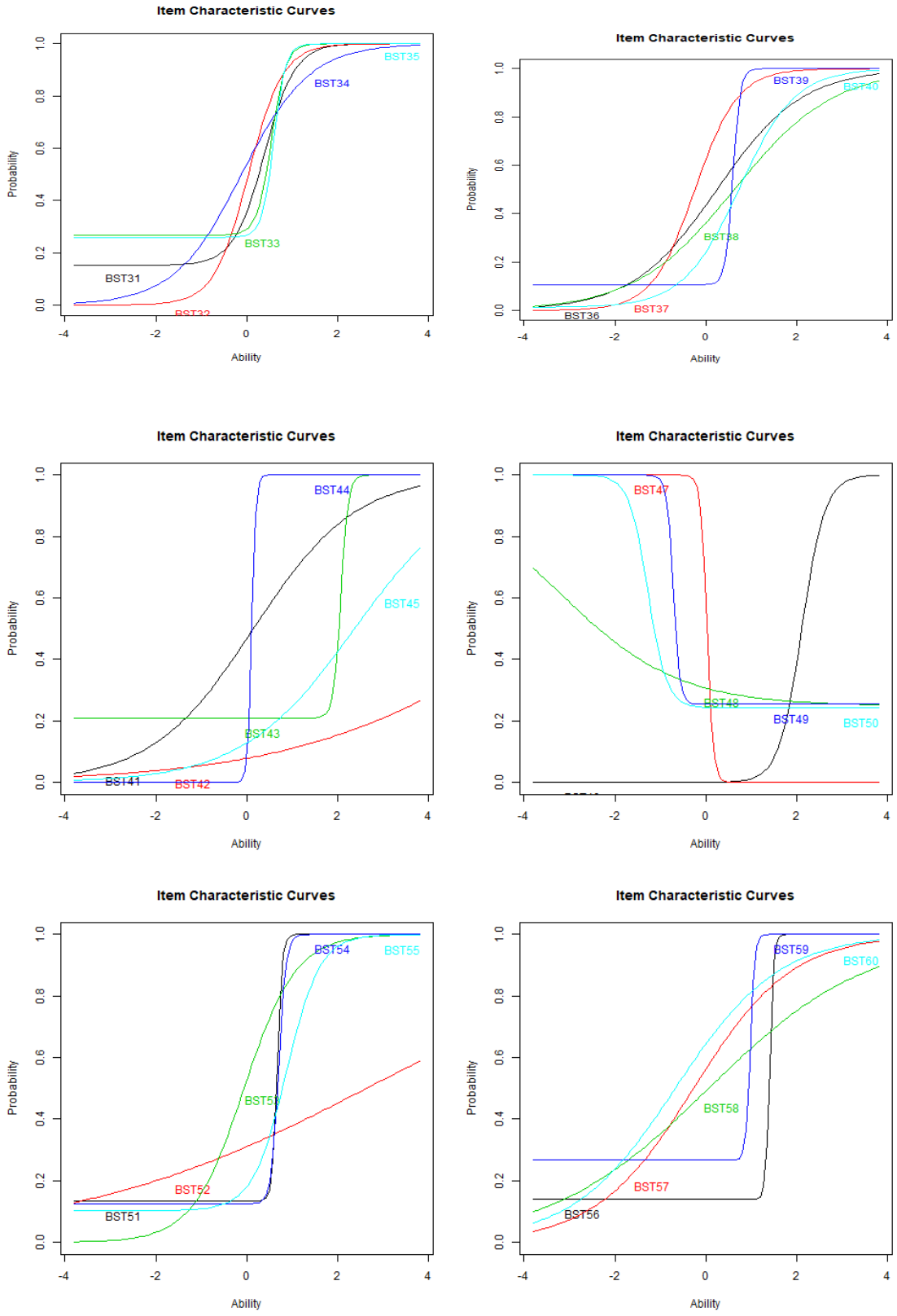


Fig 2: Item Characteristics Curve for the 60 items of the BST

The Item Characteristics Curve for the 60 items of the BST is seen in Fig. 2, and it forecasts the percentage or quantity of items that an examinee would properly answer as a function of theta. The right X-axis is in number-correct units, whereas the left Y-axis is in proportionally

correct units. In this scenario, ICC forecast each examinee's BST response at 89.49% or its equal.

DISCUSSION OF FINDINGS FROM DATA

Evidence of Unidimensionality of the 2021 Basic Science Test

The first finding revealed that all the 60 items measured a single construct, as shown in the scree plot in figure 1. An individual characteristic (ability or domain) dimension is necessary for unidimensional models. A factor analysis was carried out for the results of the test that was given to the students in order to extrapolate the BST's unidimensionality. According to Field (2013), "eigenvalues and variance, scree plot and communalities can be used to extrapolate or establish components, characteristics, or underpinning constructs." The need for extrapolating the unidimensionality of an instrument that is in fact measuring only one domain or construct—or even more than one factor with the use of eigenvalues—was emphasized by Georgiev (2008) that any factors with eigenvalues greater than 1 should be preserved as the factors that the scale measures, according to the Guttman-Kaiser criterion. Furthermore, Guttman-Kaiser advocated for accepting "factors which account for 70% and above of the variance as the fundamental construct."Another method for figuring out a scale's unidimensionality or underlying construct is to analyze the scree plot. The general guideline for analyzing the scree plot is quite straightforward. The key construct under investigation is presumably the traits, structures, or factors that appear before the elbow joint or breaking point in the scree plot graph. Checking the communalities after construct extraction is also necessary. If the communalities are low, the extracted constructs only explain a small portion of the variation; more constructs may therefore be considered to be in view and may be able to better explain the entire variance. To find substantial unidimensionality extraction at larger than 0.50, dimension reduction analysis was used. There is just one construct before the elbow joint, according to a close inspection of the scree plot in figure 2. This effectively illustrates the BST's underlying construct's unidimensionality. According to the scree plot, each item measures the same construct, which is the ability of test takers in Basic Science.

Overall Model Fit of the 2021 Basic Science Test

The second finding revealed that out of a total of 60 items, 50 have a good fit in the overall model, while the remaining 10 did not. The Maximum Likelihood Estimate (MLE) was employed to gauge the examinee's aptitude. A popular method for estimating model parameters that is sufficiently successful given a big sample and a good model application is the maximum likelihood estimate (Longford, 2008). The terms "likelihood" and "maximum" both refer to probability or possibility. Hence, the event with the greatest likelihood is said to have maximum likelihood. The probability of participants giving accurate and incorrect answers, as well as the logistic parameter used, will determine the highest opportunity; hence, the maximum ability value is determined by iterative calculation (Baker, 2001).The above finding implies that the test generally is within the ability of the testees. The likelihood of the test subjects answering most of the test items correctly is high. This result supports the fundamental tenet of IRT, as stated by Thompson (2009), according to which the likelihood of a correct or keyed response depends on a subordinate trait or ability, denoted by the Greek letter theta (), with a scale typically depicted as ranging from -3 to 3, with 0.0 representing average ability.Many researchers have advocated and employed the use of maximum likelihood estimation for the development of assessment tools. Han (2016), for instance, claimed that the Maximum Likelihood Estimation (MLE) method is among the most popular because of its capacity to produce objective estimations. In their study of the development and standardization of an agricultural science achievement test for senior secondary school students in Taraba State, Nigeria, Egunsola, Denga, and Pev (2014) used the Maximum

Likelihood estimation technique to analyze their test and discovered that the test items had a high level of validity based on a one-parameter item response theory model.

Item Response Function of the 2021 Basic Science Test

The last finding revealed that the BST is highly reliable. Reliability in item response theory is usually inferred from the Item Characteristics Curve (ICC). The ICC is pictorially displayed in Figure 1. Reliability in this case is conceived as the person separation reliability or item separation reliability. The aforementioned finding is consistent with Kpolovie and Emekene's (2016) item response theory validation research of advanced progressive matrices in Nigeria, which employed the same methodology and yielded a reliability index for the test of 0.94. The results concur with those of Ani (2014), who used item response theory in the development and validation of an economics multiple-choice test. Based on the three-parameter model (3pl) model, the findings of her investigation indicated that 49 items on the multiple-choice question in economics were reliable.The result is also compatible with Eleje and Esomonu's result (2018). A test to gauge secondary school pupils' proficiency in quantitative economics was developed and validated by the authors. Item Response Theory (IRT) three-parameter logistic model (3PL) analysis was performed using SPSS and Bilog MG to determine the item difficulty, item discrimination, and guessing value. The test's empirical reliability was 0.86. The test was determined to be of high reliability, validity, and quality.The results appear to be consistent with the research of Ezechukwu, Oguguo, Ene, and Ugorji (2020), which used item response theory to evaluate the psychometric features of the Economics Achievement Test (EAT) (IRT). Similar to the current study, two common IRT models—one-parameter logistics (1PL) and two-parameter logistics (2PL) models—were used. One-parameter and two-parameter logistic models were used to establish the reliability and validity of each item as well as the entire test. The results showed that the gadget was extremely trustworthy and suitable for use.

Conclusion

Based on the findings, it can be concluded that unidimensionality played a complementary role in when developing tests for assessment. It can also be concluded that out of a total of 60 items, 50 have a good fit in the overall model, while the remaining 10 did not,that all the 60 items measured a single construct, showing evidence of unidimensionality.

RECOMMENDATION

In respect of the findings and conclusion, the following recommendations are made:

1. Delta State Education Resource Unit load with the responsibility of developing basic science test items for BECE should pilot test generated items before their administration to students for the purpose of examinations.
2. Delta State Ministry of Education should organize training and invite professional who are expert in measurement to educate teachers on the implication of unidimensionality in tests.
3. Delta State Ministry of Education examination unit and Education Resource departments should adopt the assumption of unidimensionality in IRT and prepare staff in the formation of tests items and the identification of biased items.

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