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Assessing the Geometry Proficiency of Upper Basic Education Students for Sustainable National Development in Plateau State, Nigeria

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ABSTRACT

The paper evaluated the proficiency levels of Upper Basic Education Three (UBE 3) students in Pankshin LGA, Plateau State, Nigeria. The study employed a cross-sectional survey research design. The population of the study consisted of 3932 students comprising of 1833 males and 2099 females) from 350 UBE schools. Using a population estimate with a precision of 5%, and 10% respectively, the sample consisted18 UBE schools and 393 students made up of 195 males and 198 females formed the sample of the study. The sample sizes were determined using the Probability Proportionate to Size (PPS) sampling technique. A self-developed Geometry Proficiency Scale (GPS) served as the instrument for data collection. The content validity of the GPS was demonstrated through a Test Blue- Print and the judgment of four experts. Cronbach Alpha statistics was used to establish the reliability of the instrument. A coefficient of 0.79 was established which implies that the instrument was reliable. The study was guided by five research questions and all were answered using percentages. The findings showed that the students lacked proficiency in all the four geometry curriculum areas under investigation. Among other things, it was suggested that measurement specialists develop geometry competence instruments that the UBE3 students would utilize to improve their proficiency.

INTRODUCTION

Geometry, the study of shapes and spatial relations is important to both professionals like surveyors, engineers, educational researchers and non-professionals like masons, tailors, and casual workers. It is a useful branch of mathematics which makes it easier to study science and technology. Science and technology are the cornerstones of national development. Therefore, it is necessary that students must become proficient in it. Thus, national development is hampered due to students' lack proficiency in geometry.

The researchers' assessment of the mathematics BECE objective questions for Plateau State from 2018 to 2023 shows that, in addition to trigonometry geometry accounts for 25% of the mathematics items often tested. This percentage suggests that if students fail the geometric items, they will not pass mathematics examination and will not to receive the BECE credit in mathematics. Table 1 displays the percentage summary.

Table 1: Percentage summary of mathematics content areas in BECE Multiple- Choice Questions from 2018-2024

YEAR		NN				
S/N			**AL**	**GEO**	**STA**	**TOAL**
1	2018	21(35%)	19(31.7%)	12(20%)	8(13.3%)	60(100%)
2	2019	27(45%)	12(20%)	12(20%)	9(15%)	60(100%)
3	2020	20(33.3%)	14(23%).	18(30%)	8(13.3%)	60(100%)
4	2021	20(33.3%)	13(21.7%)	15(25%)	12(20%)	60(100%)
5	2022	15(25%)	18(30%)	15(25%)	12(20%)	60(100%)
6	2023	24(40%)	14(23.3%)	18(30%)	4(6.7%)	60(100%)
Average	%	35%	25%	25%	15%	100%

Source: Educational Resource Centre (ERC), JOS; 2018-2023

NN= Numbers and Numeration, AL=Algebra, GEO= Geometry and STA=Statistics

The West African Examination Council (WAEC) Chief Examiners' reports from (2019 to 2023) show that students perform worse in geometry than in any other field of mathematics, despite geometry's importance to national growth. Students that have difficulties will not only fail the external examination, but will be deprived the opportunity to make meaningful contribution towards the development of the country. This calls on the need to determine which materials of the upper basic geometry curriculum the students have mastery and which they have not, Hence the need to conduct studies on the geometry content areas that need remedy to allow for greater devotion to these areas. The researchers developed the 70 objective test items that cover the geometry contents of Three-Dimensional shapes (3-Ds), Angles (An), Plane shapes (Ps) and Geometric constructions (Geo. const.).

Assessment is the corner stone for any national development because it provides the basis for which meaningful decisions are made using empirical evidences. There are different forms of assessments but needs assessments and continuous assessment are key to educational development and by implication, national development. Suurtamm, Thomson, Kim, Moreno, Sayac, Schuka, Silver, Ufer, and Vos (2016) defined assessment as the systematic process of documenting and using empirical data to measure students' characteristics or traits such as knowledge, ideas, skills, values, attitudes and beliefs. In the educational sector, assessment is regarded as an essential instrument and for guiding students towards meaningful learning, which is necessary for national development. Assessment in the school system usually takes the form of testing school subjects including checklists, rating scales, and observation which are the tools of assessment used to evaluate students' proficiency in geometry. With the introduction of the Universal Basic Education in Nigeria, Lower and Middle Basic Education students are between the ages of 12 and 15 and are eligible for the Upper Basic Education. The Upper Basic Education objectives include preparing students for post-secondary education and giving them the entrepreneurial skills necessary to contribute to development of self and the society, among other things.

The sub-field of mathematics known as geometry examines the shapes of individual objects, spatial relationships, and the characteristics of surrounding shapes. It also makes concrete abstract ideas and images and fosters critical and spatial thinking, creativity, problem solving, communication, logical argument, visualization, and proofs (Hodanova & Nocar, 2016, Fabiyi, 2017).

The paper refers to the term "student proficiency" as how effectively the Upper Basic Education students have mastered the geometry content and subtopics. It is extremely difficult for a student to pass mathematics at credit level in the SSCE(WAEC, NECO, or NABTEB) or to participate in entrepreneurial activities that call for the application of geometric concepts if they do not have mastery of the content areas of the Lower Basic Education geometry. Geometry always makes up a sizable component of the Basic Education Certificate Examination (BECE), therefore, students who lack mastery in the subfield cannot pass the mathematics examinations.

The goal of sustainable national development is to empower people in the economy. Will lead to the development of the countryand as anticipated to continue over time without compromising the ability of future generations to meet their own needs. It justifies the special duties that people like teachers must play in promoting sustainable development, which will bring about peace and economic empowerment and expansion. This implies that the creation and uptake of new technologies, the shift from an agrarian to an industrial economy, and the overall, measurable improvement in the standard of living of the populace (Sustainable Development Commission, 2011, Ajie, & Nwanyanwu, 2021), cannot be accomplished without the effective teaching and learning of geometry.

The cognitive load theory, which was developed by John Sweller and associates in the 1980s and 1990s, served as the foundation for the investigation. The theory is based on two widely held beliefs that "there is a limit to how much new information the human brain can process at one time and that there is no known limit to how much stored information can be processed at one time," and how the human brain learns and uses knowledge (Centre for Educational Statistics and Evaluation, 2017). Thus, the amount of information the human working memory can process at any given time, is significant to this paper. Geometry is a subject that just requires students to recall their existing knowledge and its application is necessary. For example, students cannot succeed in geometry if they do not already grasp the fundamentals of mathematics, such as addition, subtraction, multiplication, division, linear measures, and area measures. This may result in cognitive overload, which is why it is necessary for students to fully grasp one subject before moving to another. Prior knowledge serves as the foundation for new knowledge discovery. Therefore, students are able to design new mathematical knowledge when they are able to apply it existing experiences(Asma & Dallel, 2020).

Fabiyyi (2017) found that eight of the 23 geometry topics that were taught to senior secondary school students in Ekiti State, were deemed difficult to master, these are congruent triangles, circle theorems, construction and locus, surface areas and volumes of solid figures, latitude and longitude, coordinate geometry, bearings, and distances were among the topics covered, while 12 ideas were thought to be easy. These include Theorems on triangles, circles, polygons, quadrilaterals, lengths, areas and parameters of plane figures among them. Research by Wanlor, Dalong, and Falade (2023) on the assessment of UBE 3 students in Plateau State showed that the concepts of scale drawing, the use of scale factors in calculating length,

areas and volume of similar shapes, construction of line segments, and construction of angles were found to be extremely difficult to learn, whereas areas of plane figures and angles of plane shapes were found to be simple.

The causes of the shortcomings included that they were based on students' perceptions of the geometry contents. The content areas that the students found more difficult would have been revealed if these studies had created tests covering the geometric content areas. Unlike the WAEC Chief Examiners, who stated that students do poorly in geometry, these studies did not reflect the real performance of the students in that sub-field. Thus, this paper seeks to ascertain the proficiency level of the Upper Basic Education students in the geometry topics as outlined in the 3- Year Upper Basic Mathematics Education Curriculum Guide which students are supposed to master before starting their Post Basic Mathematics Education Programme.

Given geometry'srelevance to national development of the country and the difficulty of applying science and technology without geometry, greater care must be taken when evaluating students' mastery in geometry contents. The paper aims to evaluate the geometry proficiency and to remedy the low performance of UBE 3 students before their BECE examination since geometry as a major contributor to students poor performanc (chief examiners' report for 2019–2023).

The following research questions were raised for the study:

1. How capable are the Pankshin LGA UBE 3 students in solving problems involving 3-D shapes problems?
2. What is the extent to which the Pankshin LGA UBE 3 students can solve problems involving angles?
3. What is the extent to which the Pankshin LGA UBE 3 students can solve problems involving plane shapes?
4. What is the extent to which the Pankshin LGA UBE 3 students can solve Geometric Constructions problems?
5. What is the extent to which the Pankshin LGA UBE 3 students can solve geometry problems from the 3-Year Upper Basic Education Curriculum?

A cross-sectional survey research design was adopted for the study. The population of the study was made up of 3932 Upper Basic Education Three (UBE 3) students comprising of 1833 males and 2099 females from 350 schools. A sample of 393 made up of 195 males and 198 females was drawn from this population using a 10% precision of population estimate As suggested by Anikweze (2017). With a 5% population estimate precision a sample of 18 schools was taken out of the 350 schools as obtained in the Area Directorate Office, Pankshin. The Probability Proportionate Sampling (PPS) method was used to select a sample of the 18 schools.

The Geometry Proficiency Scale (GPS) served as instrument for data collection in the study. the GPS consisted of two parts section A and B. Section A contained the respondents' bbackground information, and Section B had the geometry problems taken from the Upper Basic Education 3-year mathematics Education Curriculum. A 70 multiple choice objective test items with four options A–Dconstituted the instrument. Twelve items numbering 1–12 were on Section B1were on 3-D shapes; items 13–31 (19 items) on angles were in Section B2; items 32–60 (29 items) on plane shapes were in Section B3, and items 61–70 (10 items) on geometric construction were in Section B4. The correct answer (key) received a score of 1mark, while any incorrect answers received a score of zero. To determine the examinee level of proficiency in each of these content areas, the sum of the results from all the four categories of contents were converted to 100%.

A table of specifications was developed which produced 12 items for 3-Dimensional shapes (3-Ds), 19 items for Angles (An), 29 items for Plane Shapes (Ps), and 10 items for Geometric Constructions (Geo. Const.). The content validity of the instrument was established using the test blue print and professional opinions of four experts : Two Upper Basic Education school (UBE) mathematics teachers from the Pankshin Local Government Area Directorate office, Plateau State, and two Tests and Measurement specialists from the Federal College of Education Pankshin in Plateau State. A reliability value of 0.79 was estimated after the test's reliability was assessed using the test-retest method on four secondary schools selected from the Mangu Local Government Area of Plateau State. The instrument was therefore adjudged trustworthy.

Simple percentages were utilized to analyse the data and provide answers to the research questions. In order to determine the examinee level of proficiency in each of these content areas and the overall geometric contents, the right scores from sections B1 through B4 were added up and then converted to percentages. A score of 75% was set as criterion for mastery of a content area or geometry as a whole.

RESULTS

Research Question One

How capable are the Pankshin LGA UBE 3 students in solving problems involving 3-D shape problems?

Table 2: Percentage Pass of the UBE 3 Students in 3-D Shapes Geometry Content

Content Area	No of items	Sampled Size	Total scores obtained	Total scores obtainable	% pass	Decision
3-D Shapes	12	393	1664	4716	35%	Not competent

Table 2 reveals that all the 393 test takers responded to the 12 items about 3-D shapes. Their projected raw scores for the 12 items, assuming all questions were answered correctly, were 4716, however their total raw scores (points attained) were 1664. Upon converting these by dividing the obtained scores by the available scores and the result multiplied by 100%, gave a 35% pass rate. Since the computed percentage score was below the 75% threshold value, it was concluded that the examinees lacked the ability to solve problems involving 3-D shapes.

Research Question Two

What is the extent to which the Pankshin LGA UBE 3 students can solve problems involving angles?

Table 3: **Percentage Pass of the UBE 3 Students in Angles Geometry Content**

Content Area	No of items	Sampled Size	Total scores obtained	Total scores obtainable	% pass	Decision
Angles	19	393	2477	7467	33%	Not competent

Table 3 reveals that all the 393 test takers responded to the 19 items on Angles. Their projected raw scores for the 19 items, assuming all questions were answered correctly, were 7467, but their total raw scores (points achieved) were 2477. The percentage pass was 33% when these were converted by dividing the scores earned by the scores that could be earned and multiplying the result by 100%. The computed percentage was below the criteria value of 75%, Hence it implied that the examinees were not proficient in solving problems involving angles.

Research Question Three

What is the extent to which the Pankshin LGA UBE 3 students can solve problems involving plane shapes?

Table 4: Percentage Pass of the UBE 3 Students in Plane Shapes Geometry Content

Content Area	No of items	Sampled Size	Total scores obtained	Total scores obtainable	% pass	Decision
Plane Shapes	29	393	3699	11397	32%	Not competent

Table 4 reveals that all the 393 test takers responded to the 29 items on Plane Shapes. Their projected raw scores for the 29 items, assuming all questions were answered correctly, was to be 11397,but their total raw score (points attained) was 3699. The percentage pass was 32% when they were converted by dividing the scores earned by the scores that could be earned and multiplying the result by 100%. The computed value was below the criteria value of 75%. Hence, it was deduced that the examinees were not proficient in solving problems involving plane shapes.

Research Question Four

What is the extent to which the Pankshin LGA UBE 3 students can solve Geometric Constructions problems?

Table 5: Geometric Construction Performance Percentage Pass of UBE 3 Students

Content Area	No of items	Sampled Size	Total scores obtained	Total scores obtainable	% pass	Decision
Geometric Construction	10	393	1400	3930	36%	Not competent

Table 5 reveals that all the 393 test takers responded to the 10 items Geometric Constructions. . Their projected raw scores for the 10 items assuming all questions were answered correctly, was 3930, but their total raw scores (points achieved) was 1400. The percentage pass was 36% when they were converted by dividing the scores obtained by the scores that could be acquired and multiplying the result by 100%. The computed value was below the 75% criterion. Hence, it was concluded that the examinees lacked proficiency in solving problems involving geometric constructions.

Research Question Five

.What is the extent to which the Pankshin LGA UBE 3 students can solve geometry problems from the 3-Year Upper Basic Education Curriculum?

Table 6: The percentage of UBE 3 students that passed the UBE Geometry course

Content Area	No of items	Sampled Size	Total scores obtained	Total scores obtainable	% pass	Decision
Geometry	70	393	9240	27510	34%	Not competent

Table 6 reveals that all the 393 test takers responded to the 70 items about Upper Basic school geometry contents. Their projected raw scores for the 70 items, assuming all questions were answered correctly, was 27510, but their total raw scores (points achieved) was 9240. The percentage pass was 34% when they were converted by dividing the scores obtained by the scores obtainable and multiplying the result by 100%. The computed score was below the criteria value of 75%. Thus, it was deduced that the examinees were not proficient in answering the geometry problems in the Upper Basic Education school geometry contents.

DISCUSSION OF FINDINGS

The findings of the study on the sampled UBE 3 students revealed that the students lacked the ability to solve problems involving all the contents of 3-D shapes (35%), angles (33%), plane shapes (32%), and geometric constructions (36%). The findings showed that on the entire geometry curriculum of the 3-Year Upper Basic Education curriculum, the students had an average percentage of 34%, which was below the 75% criterion score. The findings agree with the findings of Fabiyi (2017) who found that the senior secondary school students in Ekiti State found these geometry contents challenging to learn: Congruent triangles, circle theorems, construction and locus, solid figure surface areas and volumes, latitude and longitude, coordinate geometry, bearings, and distances. Similarly, a related study by Wanlor, Dalong, and Falade (2023) who evaluated geometry topics learnt by the Upper Basic three students in Pankshin and found that teachers do not teach all of the curriculum's geometry topics and that concepts like scale drawing, using scale factors to calculate length, areas, and volume of similar shapes, building line segments, and building angles were particularly challenging to learn. As a result, it further supported the findings of the Chief Examiners' Reports (2019–2023) of the West African Examination Council (WAEC), who reported that students do worse in geometry than in any other subject of mathematics.

CONCLUSION

The study's conclusions showed that the examinees were not proficient in the full geometry curriculum of the three-year upper basic education, in mathematics namely: 3-D shapes, angles, plane shapes, and geometric construction. In order to improve their performance in mathematics and support Nigeria's sustainable national growth, the Upper Basic school mathematics teachers should constantly evaluate their upper basic education students' geometrical proficiency

Recommendations

Based on the findings of the study, the following recommendation were put forth:

1. Experts in Research, Measurement, and Evaluation should create a geometry test tool that the UBE mathematics teachers can use to assess their students' geometric proficiency.
2. The Plateau State Universal Basic Education Board (PSUBEB) should give UBE teachers Geometry Tool Kits, mathematical Sets, Graph Books and other instructional materials to help UBE teachers to teach the geometry contents very well.
3. The PSUBEB should organize seminars and conferences to train mathematics teachers in Upper Basic schools on how best to teach and learn geometry contents.
4. The mathematics teachers in Upper Basic schools should continuously assess their students' geometric proficiency levels and assist in setting up remedial instruction for those who lack it.

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