

**DETERMINING THE CONCEPTUAL AND MISCONCEPTUAL
UNDERSTANDING OF JUNIOR SECONDARY SCHOOL STUDENTS'
GEOMETRY KNOWLEDGE USING TWO-TIER DIAGNOSTIC TEST IN OF KOGI
STATE, NIGERIA**

By

Olorunnishola olufikayo Agnes

Department of Science Education
Faculty of Education
Prince Abubakar Audu University,
Anyigba, Kogi State, Nigeria

Corresponding Author: Olufikayoolorunnishola@gmail.com

Abstract

The paper investigated the conceptual and misconception understanding of junior secondary school students' geometry knowledge using two-tier diagnostic test in Yagba west local government area of Kogi State. The total number of junior secondary school students that participated in the study were 219 students selected using simple random sample techniques. The design used was descriptive survey and instruments used for this study was Two Tier Geometry Diagnostic Test (TTGDT). The instrument was validated by two experts from science education of Beune State University, Makurdi, Benue State. The reliability coefficient of 0.76 was obtained. Two research questions and a hypothesis guided the study. Percentages, mean and standard deviation was used to analyze the research questions and the t-test was used to test the hypotheses. The study found out that the use two-tier test to diagnostic test can be used perfectly to evaluate junior secondary school student's geometry misconceptions and their conceptual understanding. And that there was a significant difference in terms of students' misconceptions and their conceptual understanding of geometry knowledge as measured using TTGDT. JSS1 students held more misconceptions than their conceptual understanding of geometry knowledge and it was recommended among other things that teachers of mathematics should note the seriousness of alternative conceptions of such basic mathematics knowledge and be encouraged to develop and use two-tier test to diagnose the area of learning difficulties in mathematics.

Keywords: Conceptual understanding, Misconceptions, Two Tier Geometry Diagnostic Test

Introduction

Whether educated or not, you cannot do without the use of mathematics. Study the trend: before you stand up from your bed, you will want to know the time, what is that? Mathematics. As soon as you are up, you will want to plan how the day will go allocating seconds, minutes and hours to that activities of the day. What is that? Mathematics. Even going to that kitchen to cook requires you to calculate; how many cups of rice or slice of yam or anything to cook. Before stepping out you will have to schedule what time to do what activity of the day and of course that is mathematics. In a nutshell mathematics is synonymous to living.

That is, you cannot live without mathematics. It is the science of numbers. Wikipedia sees it as an area of knowledge that includes such topics as numbers, formulas and related structures, shapes and the spaces in which they are contained, and quantities and their changes.

The role of mathematics towards realizing the nation's scientific and technological aspiration is indisputable. It is the bedrock that provides the springboard for the growth of science and technology. However, no tangible application leading to nation building envisaged, cannot be realized without the conceptual understanding of the geometry knowledge in mathematics. Geometry is linked to many other areas or topics in mathematics, specifically measurement and is used daily by architects, engineers, physicists, land surveyors among others. The word "geometry" the Greek word "geometrein" (geo-earth and trein: measure) (Howse & Howse, 2014). Understanding Geometry is essential for studying automobile engineering, design, and decoration etc. The importance of geometry is evident as it forms a major part of school curriculum from primary to tertiary levels of education as such, the concepts are re-visited in spiral format through these levels of education.

For proper understanding of this conceptual understanding, the word concept is needed to be understood. A concept is an abstract or generic idea generalized from particular instances. Ben-Hur (2016) also notes that concepts are mental structures of intellectual relationships. Ben-Hur (2016) maintains that conceptual understanding involves knowledge of concepts and recognizing their applications. When there is a problem with the conceptual understanding of a students, then, misconception sets in. what is misconception? Misconception" or "alternative" conceptions are those students' incorrect pattern of response, informal ideas, non-mathematical interpretation and conceptions leading to conflict with accepted mathematics views. According to Sam-Kayode and Salman (2016), a misconception is a wrong perception about a concept contrary to the current understanding of natural science. The authors maintain that these misconceptions may not be in agreement with our understanding of science; they might nevertheless have varying degrees of logic and truth. Similarly, a misconception is the result of a lack of understanding or in many cases misconception of a rule invented by learners to explain the patterns they see around them (Mohyuddin & Khalil, 2016).

Although, many different techniques are used in measuring the levels of understanding and to identify misconceptions among students, concept maps, multiple-choice tests, interviews and observations are among those frequently employed. However, each has its own limitations. In determining students' understanding of concepts, the use of two-tier diagnostic tests-which evaluate students' understanding better and which are easy to administer, score and apply, is recommended (Kanli, 2015). Also, in advocating different assessment procedure to probe students' understanding of mathematics and science concepts, Bayrak (2013) suggests that information related to erroneous information held to be true by students should be included in the tests that have distracters. This line of thought has included the development of multiple-choice test items that have distracters. This study therefore, employs two-tier diagnostic test to determine the conceptual understanding and misconception of junior secondary student's geometry concepts in Yagba West of Kogi State.

Charles-Ogan (2014) examined the effect of meta-cognitive strategy and the students' mathematics misconceptions in Rivers State. Charles-Ogan used the quasi-experimental design. The sample used was 80 students of SS2 level. Two instruments, Mensuration Misconceptions Test (MMT) and Meta-cognitive Skills Assessment (MSA) with reliability coefficients of 0.86 and 0.78 respectively were used to collect the data. Mean and analysis of covariance were tools used to analyze the data collected. The findings of the study indicated that the misconceptions held by the students in the control group were higher than those of their experimental group counterpart. In other word, the misconceptions of students taught plane

mensuration using meta-cognitive instructional strategy was less than those of their counterpart in the control group. The result further indicated that female students had fewer misconceptions than their male counterparts in both groups. The study in review is related to the ongoing study in the sense that it examined students' mathematics knowledge, specifically plane mensuration knowledge about cognition and their misconceptions, and in Rivers State, Nigeria.

Idenhen and Omoifo (2015) examined the development and validation of a two-tier multiple choice diagnostic instrument for assessing senior secondary school students' conceptions of selected mathematical concepts in Edo state, Nigeria. The instrument; Two-Tier multiple – choice diagnostic test for assessing Students' Conceptions of Mathematics Ideas (SCMI) was a 30-item instrument specifically designed to identify right conceptions in a limited and clearly defined basic concepts in Numeration, Algebra, Measurement, Geometry and statistics of the senior secondary school mathematics curriculum. The study was guided by 4 research questions. The sample of the study consisted of 87 male and female students from three senior secondary schools in Oredo local government area of Edo state. Analysis of the students' response showed a difficulty index ranging from 30 to 70 percent and discriminating index of between 0.3 and 0.6, and Kuder Richardson formular 20 for reliability coefficient of 0.85. The result further showed that at least 50 percent of the students had right conceptions in 12 out of the 30 items. The SCMI instrument diagnosed 29 significant misconceptions in 21 of the items.

In a related development, Surif and Mokhtar (2012) carried out a study on conceptual and procedural knowledge in problem solving among Eastern Finland students. The descriptive quantitative research design was used to measure secondary year 4 students' problem solving in mathematics. A total of 200 students were randomly drawn from 4 schools in one district and used as respondents in the study. Data were obtained through a set of test with reliability coefficient of 0.86 which measure levels of conceptual knowledge and procedural knowledge. The data were analyzed to determine the correlation between conceptual knowledge and procedural knowledge (*r coefficient value =.687, p value =0.000*). The findings showed that the level of conceptual knowledge and procedural knowledge was weak. The result also indicated that there was a moderate correlation between problem solving based on conceptual and procedural knowledge. The study revealed that problem solving based on conceptual and procedural knowledge was weak probably because most of the students may have alternative conceptions of the mathematics concepts under investigation and may also have poor control of mathematics process skills.

Statement of the problem

It is in realization of the numerous uses of geometry in nation building and everyday living that Nigeria as a nation accords the study of mathematics, in which geometry is a very important aspect, a priority as one of the core subjects in school curriculum. Several research studies have concentrated on factors external to the learner that influence learning and that can improve performance, such as teaching methods and strategies, teacher variables, instructional materials, and classroom environments (Obasi, 2014; Akor & Onah, 2015; Ode, Odoh, & Amana, 2016) without considering learners' internal factors such as intelligence, lack of understanding among others in the learning process. Ben-Hur (2016) notes that how rich and exciting the hands-on activity, without learners' understanding of geometry concepts, principles, terms, operations, skills and generalizations, success in the learning outcome would still constitute a great problem.

As students advance, new concepts will increasingly be added to old conceptual knowledge. Failure of students to gain conceptual understanding of the first concept may likely

become harder and harder for them to catch up and may resort to simply memorizing algorithms that they apply without proper understanding. As important as geometry is, it is the aspect of mathematics students have most difficulty in understanding. Abdullah and Zakaria (2013) reported that geometry is one of the least understood and most disliked mathematics subjects and source of frustration to students. Also, Mamman and Isah (2014) reports that students hold the view those geometrical concepts are most difficult to learn and understand. These remarks, according to Chambers (2012), were as a result of lack of understanding and incorrect interpretations (misconceptions) of geometry concepts and ideas arising from their prior knowledge.

This study therefore seeks to determine the conceptual understanding and misconception of junior secondary school students' geometry knowledge using two-tier diagnostic test in Yagba west local government Area of Kogi State.

Purpose of the Study

The purpose of this study is to determine the level of students' conceptual understanding of geometry knowledge and their misconception at Junior Secondary School level. Specifically to:

1. Identify the percentage of JSS 1 students having correct conceptions of geometry knowledge as measured using a two-tier diagnostic test.
2. Determine the difference in the mean scores among JS1 students' conceptual understanding and misconception (alternative conception) of geometry as measured using TTGD

Research Questions

1. What is the percentage of JSS 1 students having correct conceptions of geometry knowledge as measured using a two-tier diagnostic test?
2. What is the difference in the mean scores of JSS1 students' conceptual understanding and misconception of geometric knowledge measured using TTGDT?

Research Hypothesis

The hypothesis was tested at $P < 0.05$

There is no significant difference in the mean scores among students' conceptual understanding and their misconceptions of geometry knowledge as measured using two-tier multiple-choice diagnostic test.

Methodology

The data collected were analyzed with respect to answering the research questions and testing the hypothesis formulated for the study. The study adopted partial credit model in scoring. In this model, student received a score of 2 marks if he/she responded correctly to the first tier (content choice) and correctly to the second tier (reasoning part), signifying full conceptual understanding of geometry concepts. Also correct answer to the content part and wrong reason attracted a score of 1 mark, signifying partial understanding (misconception) while wrong answer and correct reason or wrong answer and wrong reason earned 0 marks, signifying no conceptual understanding or lack of knowledge. Kuder Richardson formula 20 was used to determine the reliability coefficient of the instrument which yielded 0.76. Data collected were analyzed using frequency counts and percentages as well as descriptive statistics of mean and standard deviation to answer the remaining research questions. The hypothesis formulated was tested using t-test statistic at 0.05 level of significance.

Result Analysis

Research Question One: What is the percentage of JSS 1 students having correct conceptions of geometry knowledge as measured using a two-tier diagnostic test? Table 2 presents the analysis of research question one.

Table 2

Frequency and Percentage of JSSI Students holding Right Conceptions of each

Geometry Concept in the TTGDT (n = 219)

Item	tier 1 No(%)	tier 1 & 2 No(%)	Item	tier 1 No(%)	tier 1 & 2 No (%)
1	180(85.8)	164(74.8)	16	111(50.7)	17(7.8)
2	169(77.2)	91(41.6)	17	154(70.3)	92(42.0)
3	184(84.0)	142(64.8)	18	100(45.7)	24(10.9)
4	129(58.9)	55(25.1)	19	116(53.0)	22(10.0)
5	126(57.5)	23(10.5)	20	141(64.4)	34(15.5)
6	120(54.8)	45(20.5)	21	128(58)	19(8.7)
7	162(74.0)	99(45.2)	22	160(73.1)	94(43.0)
8	90(41.1)	29(13.2)	23	104(47.5)	19(8.7)
9	129(58.9)	54(24.6)	24	113(57.6)	39(17.8)
10	160(73.1)	88(40.2)	25	81(37.0)	16(7.3)
11	150(65.5)	33(15.0)	26	105(47.9)	21(9.6)
12	97(44.3)	24(10.9)	27	108(49.3)	24(10.9)
13	97(44.3)	22(10.0)	28	126(57.5)	34(15.5)
14	108(49.3)	23(10.5)	29	164(74.9)	120(54.8)
15	101(46.1)	25(11.4)	30	137(62.6)	100(45.6)

Result of the analysis in Table 2 revealed that 21 of the 30 items have less than 40 percent of the students with right conceptions. Furthermore, the result of the analysis in Table 2 indicates that only in 9 of the 30 items did at least 40 percent of the students have right conceptions. In particular, the concept of plane shape (recognizing and identification of plane shape) has 74.8 percent of the students with the right conception (Item1). The least percentage of students with right conception is from the concept of perimeter involving calculations (7.3%) for (Item 25). Others include 41.6%, 64.8%, 45.2%, 40.2%, 42%, 43%, 54.8%, and 45.6% for items 2, 3, 7, 10, 17, 22, 29 and 30 respectively. This implies that students have right conceptions in all the thirty items. However, percentage of students with right conceptions

varied from item to item and from each geometric concept to concept. On average, only 24.21% of students responded correctly at both tiers signifying conceptual understanding. This indicates that on average, 24.21% of students had understanding of the geometry knowledge. 34.41% who scored correct responses at the tier 1 level, either guessed the answer or only had partial knowledge that they used to achieve the correct responses while 17.17% of these students lack the knowledge of the geometry concepts, skills and generalizations.

Research Question Two: What is the difference in the mean scores of JSS1 students' conceptual understanding and misconception of geometric knowledge measured using TTGDT?

Table 2

Mean and Standard Deviation of Students' Conceptual Understanding and Misconception Scores in TTGDT Group

	N	Mean(\bar{x})	Std. Deviation
Misconception (first Tier-only)	219	17.66	3.99
Conceptual Understanding (both Tiers)	219	13.79	4.60
Mean Difference		3.87	

Result of the analysis in Table 2 showed that the mean misconception scores of students (students who gave right answers to the content knowledge only but wrong reason or wrong answer and wrong reason) is 17.6 with the standard deviation of 3.99, while the mean conceptual understanding (those students who supplied the correct answer to both the first tier (content knowledge) and second tier (reasoning part) leading to conceptual understanding of geometry concept under study is 13.79 with standard deviation of 4.60. The mean score difference between students' misconception and their conceptual understanding score is 3.87 in favor of the misconception (first tier only). This suggests that students may have learned geometry facts without adequate understanding of the concepts involved.

Hypothesis: There is no significant difference between the mean scores of students' conceptual understanding and their misconceptions of geometric knowledge as measured using two-tier multiple-choice diagnostic test.

Table 3

T-test Results of Students' Conceptions and Misconceptions of Geometry Knowledge as Measured using Two-Tier Diagnostic Test

Group	no	\bar{x}	SD	df	t	p	Decision p<0.05
Misconception		219	17.66	3.99			
					217	9.40	.06 s
Conceptual Understanding		219	13.79	4.60			

Note: NS – Not Significant @ $p > 0.05$, S – Significant @ $p < 0.05$

The result of the analysis in Table 3 presents a summary of t-test comparison of students' misconceptions and conceptual understanding of geometry knowledge as measured using TTGDT. According to the results of the analysis shown in the Table 3, $t = 9.40$ and $p = 0.06$. Since the significant value (p) is greater than the set significant value for the test ($p < 0.05$), the hypothesis of no significant difference between students' mean conceptual understanding scores and misconception score of geometry knowledge under study was not accepted. This implies that there is a significant difference between students' misconception and conceptual understanding scores of geometry knowledge. In other words, the students have difficulty in understanding geometry knowledge as measured using two-tier diagnostic test. For 18 of the items, no students gave the correct underlying reason.

Discussion

The finding from the result in Table 1 showed that students have right conceptions in all the 30 items of the geometry concepts under investigation. However, only in 9 items out of 30 items did at least 40% of students were found to hold right conception. It showed that for all the items, 58.62% of the students responded correctly at the tier 1 level, whereas only 24.21% responded correctly at both tiers indicating that on average, 24.21% of students had understanding of the geometry concepts. 34.41% who scored correct responses at the tier 1 level, either guessed the answer or only had partial knowledge that they used to achieve the correct responses while 17.17% students lack the knowledge of the geometry concepts. It also, revealed that percentage of students who answered correctly the content part was higher than the percentage of students who answered both tiers of the test.

This finding is in agreement with Surif and Mokhtaar (2012), Idehen and Omoifo (2015) that the number of students holding correct conceptions of geometry concepts were fewer than the number holding misconceptions and the level of conceptual understanding of students in mathematics is weak which they attributed to their prior experience, preconceptions, cultural background, lower level or inadequate thinking and reasoning abilities which current teaching and assessment practices do not promote.

The mean difference between students' conceptual understanding (answering both tiers correctly) and their misconception (answering only content part) is 3.88 as shown in Table 2 is significant as was confirmed in Table 3, indicating that students least understood the geometry concepts or lack understanding or have partial content knowledge. This may probably be because students may have memorized certain facts relating to geometry knowledge without conceptual understanding.

Result of the analysis shown in Table 3 illustrates that students hold various misconceptions in all the topics of geometry concepts under investigation. However, 38 significant misconceptions in 30 items of the geometry concepts were found to be held by students. These misconceptions may have arisen by the complexity of the concepts, existing students' conceptions, daily-life experience and missing interpretations. Furthermore, result in Table 2 showed the mean misconception scores of students was higher than the mean conceptual understanding score with the mean difference of 3.88 which is statically significant as confirmed in Table 3. This implies that the JSS1 Students had held more misconceptions and lack the knowledge of geometry.

This finding is in conformity with the finding of Sam-Kayode and Salman (2016), Mohyuddin and Khalil (2016), Idehen and Omoifor (2015), Charles-Ogan (2014), Bayrak (2013) that majority of students have varying degree of misconceptions and errors across all

the conceptual areas of mathematics and only few of them were found to answer correctly two-tier questions, and as such performed better at the first tier of the items which require the content knowledge for correct response signifying partial knowledge.

Conclusion

It is concluded that only 24.1% of students had understanding of the geometry knowledge showing a weak geometry conceptual understanding; 34.41% had partial knowledge (students answering only the content part), while 17.17% lacked the knowledge of the geometry. The instrument established that students' achievement was higher with mainly the content part of the items (first tier) and decreased with the reason part of the items (second part) or with both parts of the items. There was significant difference in terms of students' misconceptions and their conceptual understanding of geometry knowledge as measured using TTGDT. JSS1 students held more misconceptions than their conceptual understanding of geometry knowledge.

Recommendations

Based on these findings, the researcher recommends that:

1. School authorities should encourage mathematics teachers to use two tier test instrument to elicit students conceptual understanding and misconceptions (alternative conceptions) of basic mathematics knowledge.
2. Teachers of mathematics should note the seriousness of alternative conceptions of such basic mathematics knowledge and be encouraged to develop and use two-tier test to diagnose the area of learning difficulties in mathematics
3. The state primary and secondary education board should initiate or support workshops, seminars and in-service training programmes aimed at giving serving teachers the opportunity to learn how to develop and use two-tier tests as the best assessment model for diagnosing achievement and learning difficulties.

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