Gender Influence on Misconceptions of Concepts in Geometry Among Senior Secondary School Students in Ogun State, Nigeria

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Abstract

A bid to address what causes poor achievements in mathematics examinations among secondary school students led to the present study whose main objective was to examine the influence of gender on conceptions of geometry in selected geometrical concepts and sub-concepts among senior secondary schools students in Ogun State, Nigeria. A total of 757 students from 56 co-educational schools in the State participated in the study. A researcher-designed 26-item questionnaire on Geometry Conception Test (GCT) validated by six experts was used for data collection. A reliability index of 0.83 was obtained for the instrument using the Pearson Product Moment Correlation Coefficient. The identified misconceptions and alternative conceptions were validated by two university lecturers and two secondary school mathematics teachers. Frequency counts, percentages and Chi-square statistics were employed to analyse the data collected for the study. The finding showed that correct conceptions, misconceptions and alternative conceptions exist among students in learning geometry. Also, the number of students with misconceptions and alternative conceptions were more than those with correct conceptions of geometry in 23 (items) out of the 26 selected concepts of geometry. A significant difference existed in the number of male and female students with correct conceptions, misconceptions and alternative conceptions of geometry, $\chi^2 = 8.95$, $p < 0.05$. It was recommended that teachers should give correct conceptions of geometrical concepts using real-life examples from the students' environments and engage both sexes in practical activities that would enable them to discover the correct properties of geometrical shapes.

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Introduction

Mathematics is a tool for solving human problems, it is also useful in the development of science and technology in any nation. Aspect of mathematics which everyone is aware of such as shapes of objects, sizes, lengths, distances and designs of different types are all embedded in geometry. Geometry is defined as the mathematics of measurements and the relationships of lines, angles, shapes and their properties (Adu, 2004; Tuttuh-Adegun, Sivasubramaniam & Adegoke, 2010). These shapes come as either plane shapes such as triangles, rectangles, squares, rhombus, circles, trapeziums, kites and so on or as solid shapes such as cubes, cuboids, cylinders, cones, pyramid, prisms, spheres and other solids found all around us.

The trends in students' achievement in West African Senior School Certificate Examinations (WASSCE) for May/June between 2006 and 2014, showed that the overall performance of students who passed mathematics at credit level was less than 60% of the total entry of the candidates going by results of the years considered in this study. Also, as important as mathematics is, the West African Examinations Council's Chief Examiners' Reports in May/June 2007, 2008, 2009, 2010,

2011, 2012, 2013 and 2016 revealed that many candidates avoided questions on geometry while those who attempted them did them poorly. This indicated that questions on geometry were unsatisfactorily attempted by the candidates.

A major factor among others identified in respect of such performance had to do with mix ups in their understanding clarifications of geometrical concepts and sub-concepts (during classes) (Johnston-Wilder & Mason, 2005). This is probably due to the previous incorrect ideas which students were exposed to before their classroom experiences, which could likely lead to misconception in geometry classes (Abimbola, 2013; Aysen, 2012; Hewson, 2007; Novak, 2003).

These previous ideas brought into the classroom by students can be correct conceptions, misconceptions or alternative conceptions. Correct conceptions are ideas that agree with scientifically accepted ideas or knowledge. Also, misconceptions could be termed as ideas which are in contrast to or in disagreement with accepted scientific ideas or knowledge (Abimbola, 2013). Alternative conception is a term used to describe a learner's autonomous conceptions of natural phenomena, which is neither wrong nor right nor in conflict with accepted scientific knowledge but expresses learners' views about the conception of natural phenomena which is neither wrong nor right nor in conflict with accepted scientific knowledge but expresses learner's views about the concept idiosyncratically (Abimbola, 2013; Hewson, 2007). The correct ideas referred to in this case might have gone through the process of transformation or correction from either misconceptions or alternative conceptions to acceptable ideas.

Studies by George and Charles-Ogan (2015) and Siefa (2013) submitted that students' views on different concepts in mathematics must not be overlooked but should be investigated to find out the reasons why they hold incorrect conceptions. Also, finding solutions to such incorrect ideas as well as finding ways of correcting them stirs up need for a research of this kind. An American scholar named Wellington in a publication in 2009 narrated a scenario in a mathematics class at a New York City public high schoolwhere a student was asked to say whether a shape it was a square or a rectangle. The response of the student was amazing due to the fact that, the student was confused about the identity of the shape. A square can be said to be a special rectangle because a square has four sides which are all of equal length as well as four angles which are also equal. This implies that the student had a wrong conception of the properties of a square. A square can as well be defined as a special rectangle whose opposite sides are equal. It can also be termed a parallelogram with a right angle. Hence, a square is a parallelogram with a right angle, and thus is a rectangle.

Gagne (1965) and Ausubel (1968) state some of the learning theories that supported the idea of conceptions of learners in classroom situations. According to Gagne (1965), Balogun (2010) and Charles-Ogan (2014) learning from the stables of meaningful instructions occurs in phases or in hierarchies and it takes place when learners acquire knowledge from the known to unknown, from the simple to the complex or from the concrete to the abstract. Gagne's submission was that learning takes place if relevant previous skills are already in existence in the learner's memory. Ausubel (1968), however, purported that a learner's stage of development and what the learner knew before the classroom experience are factors when it comes to learning, and these contribute to achievements in school. Pre-classroom experiences are factors that cannot be avoided when we consider what can influence students' conceptions in the classroom. Among these are past mathematics experiences before classroom situations and the learner's previous ideas which could be correct or erroneous. The erroneous or incorrect ideas can be grouped as misconceptions.

Looking at the roles of gender on human activities, we can say that gender indirectly dictates what we do and how we do them. Gender is the term that categorises humans as either male or female and the realities of the differences are distinctly displayed. Gender is sometimes determined by the way we act, respond to situations, reason and do things. It can also be determined by our

appearances or mode of dressing, gesture, occupation, social network and the roles played by both sexes in the society. Gender differentiation has also helped to moderate excesses in the society, whereby females are easily identified as emotional, non aggressive, slow in decision-making, dependent and gentle. Literature on students' activities and achievements in mathematics in relation to gender remains a focus of interest by many researchers due to the fact that gender issues cannot be conclusive. Males mostly exhibit characters that are dominated by risk taking. They do things that are opposite to the females' in all respects (Timayi, Ibrahim & Sirajo, 2016). The influence of gender in classroom situation is not totally different from what is common to the distinct characteristics of the two genders. Studies have shown that males are different from females in many respects. However, some studies reveal that female strengths has equal in achievements while some studies revealed that the males got upper hands in school achievements. This brings to us to the fact that gender reports are somehow inconclusive in terms of studies carried out.

Statement of the Problem

Mathematics educators are mostly concerned with how students' performance in mathematics examinations can be improved from time to time. This prompted the need to look into possible reasons why students' performance is poor and what can be done to salvage the situation. One of the topics in mathematics where students do not perform satisfactorily is geometry. Lack of understanding of some mathematical concepts, among which is the concept of geometry, was found to be responsible for the to misconceptions and the alternative conceptions from past classroom experiences. Identifying these incorrect conceptions could form the background for finding ways of correcting them. An attempt was made in this study to identify what was incorrect and where the problem arose from, whether from the definitions and meanings assigned to the concepts or as a result of a misunderstandings of the concepts. Hence, this study was conducted to assess the influence of gender on conceptions of geometry among senior secondary schools students in Ogun State, Nigeria.

Purpose of the Study

The purpose of this study was to investigate the following:

1. Differences in the number of senior secondary school students with correct conceptions of geometry concepts in Ogun State, Nigeria based on gender.
2. Differences in the number of senior secondary school students with misconceptions of geometry concepts in Ogun State, Nigeria based on gender.
3. Differences in the number of senior secondary school students with alternative conceptions of geometry concepts in Ogun State, Nigeria based on gender.

Research Questions

The following research questions guided the study:

1. What is the difference in the number of male and female senior secondary school students with correct conceptions of geometry in Ogun State, Nigeria?
2. What is the difference in the number of male and female senior secondary school students with misconceptions of geometry in Ogun State, Nigeria?
3. What is the difference in the number of male and female senior secondary school students with alternative conceptions of geometry in Ogun State, Nigeria?

Research Hypothesis

The following hypothesis was formulated and tested at 0.05 level of significance:

HO_1: There is no significant difference in the number of male and female senior secondary school students holding conceptions, misconceptions and alternative conceptions of concepts in geometry in Ogun State, Nigeria.

Methodology

A descriptive survey design was used for this study. The population for the study comprised senior secondary school II students in Ogun State, Nigeria. The sampling techniques used in this study were proportionate and stratified sampling techniques through which a sample of 757 senior secondary school students were selected from the 20 local government areas of Ogun State, Nigeria. A Geometry Conception Test (GCT) was developed and used as the research instrument in collecting the data for the study. The instrument was in two parts, A & B: Part A sought demographic data from the respondents while Part B consisted of 26, items on conceptions of concepts in geometry and a coding scale to guide the responses groupings into correct conception, misconceptions and alternative conception of the concepts in geometry was also developed by the researcher.

The instrument was validated for content and construct by experts in the fields of science education and mathematics and by experienced secondary school mathematics teachers in Ogun State, Nigeria. The reliability coefficient was computed, using the Pearson Product Moment Correlation statistics and 0.83 was obtained as the reliability coefficient of the instrument.

The responses were analysed qualitatively and quantitatively to identify the nature of conceptions and classified as correct conceptions, which are ideas that agree with scientific ideas; misconceptions, which are ideas that disagree with scientific ideas; or alternative conceptions, which are ideas that neither agree nor disagree with scientific ideas but express the learner's views about the phenomenon. The data collected were analysed statistically using frequency counts and percentages to answer the research questions and chi- square statistics to test the hypothesis formulated for the study at 0.05 level of significance.

Research Question 1: What is the difference in the number of male and female senior secondary school students holding correct conceptions of geometry concepts in Ogun State, Nigeria?

The percentage of female students who displayed correct conceptions of geometry concepts were higher than percentage of the male students in 23 out of the 26 items contained in the Geometry Conception Test (GCT). Male respondents had higher percentage on 3 items of the GCT which are the perimeter of a circle, an angle, and the edge of a shape. Hence, there were differences in the number of male and female students who held correct conceptions of geometry concepts in Ogun State, Nigeria in favour of the female students. The analysis is in Table 1.

Research Question 2: What is the difference in the number of male and female senior secondary school students holding misconceptions of geometry concepts in Ogun State, Nigeria?

The percentages of female students who displayed misconceptions of geometry concepts were higher than the frequency counts and percentage of the male students in 14 out of the 26 items contained in the Geometry Conception Test (GCT). However, percentages of male students who displayed misconceptions were more than the percentages of the female students in only 12 out of the 26 items of the Geometry Conception Test. Differences existed in the number of male and female students who held misconceptions of geometry concepts in Ogun State, Nigeria in favour of the female students. The analysis is in Table 1.

Table 1: General Pettern of Senior School Students Holding Different Conceptions of Geometry

S/N	Concept	Correct Conceptions (Frequency & %)		Misconceptions (Frequency & %)		Alternative Conceptions (Frequency & %)	
		Male	Female	Male	Female	Male	Female
1	A plane	48 (6.34%)	49 (6.47%)	193 (25.50%)	235 (31.04%)	109 (14.40%)	123 (16.25%)
2	A triangle	205 (27.08%)	263 (34.74%)	61 (8.06%)	44 (5.81%)	84 (11.10%)	100 (13.21%)
3	A circle	88 (11.62%)	116 (15.32%)	126 (16.64%)	110 (14.53%)	136 (17.97%)	48 (6.34%)
4	Circumference of a circle	112 (14.80%)	157 (20.74%)	169 (22.32%)	143 (18.89%)	69 (9.11%)	107 (14.13%)
5	Diameter of a circle	207 (27.34%)	248 (32.76%)	72 (9.51%)	84 (11.10%)	71 (9.38%)	75 (9.91%)
6	Radius of a circle	197 (26.02%)	276 (36.46%)	92 (12.15%)	60 (7.93%)	61 (8.06%)	71 (9.38%)
7	Sector of a circle	128 (16.91%)	208 (27.48%)	164 (21.66%)	130 (17.17%)	58 (7.66%)	69 (9.11%)
8	Segment of a circle	50 (6.61%)	76 (10.04%)	220 (29.06%)	245 (32.36%)	80 (10.57%)	86 (11.36%)
9	Chord of a circle	185 (24.44%)	235 (31.04%)	119 (15.72%)	93(12.29 %)	46 (6.07%)	79 (10.44%)
10	A secant of a circle	14 (1.85%)	20 (2.62%)	318 (42.01%)	354(46.76 %)	18 (2.38%)	33 (4.36%)
11	A tangent to a circle	79 (10.44%)	144 (19.02%)	214 (28.27%)	177 (23.38%)	57 (7.53%)	86 (11.36%)
12	A quadrilateral	161 (21.27%)	236 (31.18%)	127 (16.78%)	113 (14.93%)	62 (8.19%)	58 (7.66%)
13	A quadrilateral with equal sides and equal angles	135 (17.83%)	201 (26.55%)	202 (26.68%)	189 (24.97%)	13 (1.72%)	17 (2.26%)
14	A polygon	106 (14.00%)	148 (19.55%)	202 (26.68%)	205 (27.08%)	42 (5.55%)	54 (7.13%)
15	Sum of the exterior angle of a polygon	130 (17.17%)	160 (21.13%)	206 (27.21%)	226 (29.85%)	14 (1.85%)	21 (2.77%)
16	Area of a plane shape	10 (1.32%)	19 (2.51%)	265 (35.01%)	306 (40.42%)	75 (9.91%)	82 (10.83%)
17	perimeter of a plane shape	43 (5.68%)	42 (5.55%)	243 (32.10%)	292 (38.97%)	64 (8.45%)	73 (9.64%)
18	An angle	75 (9.91%)	73 (9.64%)	200 (26.42%)	197 (26.02%)	75 (9.91%)	137 (18.10%)
19	A vertex	68 (8.98%)	95 (12.55%)	253 (33.42%)	276 (36.46%)	29 (3.83%)	36 (4.76%)
20	A solid shape	37 (4.89%)	71 (9.37%)	259 (34.21%)	283 (37.38%)	54 (7.13%)	53 (7.00%)
21	A cube	83 (10.96%)	135 (17.83%)	192 (25.36%)	186 (24.57%)	75 (9.91%)	86 (11.36%)
22	A cuboid	57 (7.53%)	79 (10.44%)	232 (30.65%)	237 (31.31%)	61 (8.06%)	91 (12.02%)
23	An edge of a shape	34 (4.49%)	29 (3.83%)	291 (38.44%)	342 (45.18%)	25 (3.30%)	36 (4.76%)
24	An irregular shape	38 (5.02%)	43 (5.68%)	259 (34.21%)	289 (39.37%)	53 (7.00%)	66 (8.72%)
25	A good example of an irregular shape	50 (6.61%)	66 (8.72%)	281 (37.12%)	257 (33.95%)	19 (2.51%)	24 (3.17%)
26	The difference between a regular shape and an irregular shape	30 (3.96%)	38 (5.02%)	26 4(34.87%)	304 (40.16%)	56 (7.40%)	65 (8.59%)

Research Question 3: What is the difference in the number of male and female senior secondary school students holding alternative conceptions of geometry in Ogun State, Nigeria?

There were differences in the number of male and female students who held alternative conceptions of geometry in Ogun State, Nigeria. The percentages of female students holding alternative conceptions were higher than the male students in 23 items out of the 26 items contained in the Geometry Conception Test. Meanwhile, the male students with alternative conceptions of geometry were higher in percentages than their female counterparts in only 3 items of the Geometry Conception Test. These are: circle; quadrilateral; and solid shape. The analysis is in Table 1.

Research Hypothesis (H_o): There is no significant difference in the number of male and female senior secondary school students holding conceptions, misconceptions and alternative conceptions of geometry in Ogun State, Nigeria.

The output of the Chi-square analysis in Table 2 shows that, there was a significant difference in the number of male and female students holding correct conceptions, misconceptions and alternative conceptions of geometry. The calculated Chi-square value, $\chi^2(2)=8.95$, $p < 0.05$ was obtained from the study. The null hypothesis was rejected. It was therefore, concluded that there is a significant difference in the number of male and female students holding correct conceptions, misconceptions and alternative conceptions of geometry in Ogun State, Nigeria.

Table 2: Chi-square Analysis on Frequency Counts of Number of Students Holding Various Conceptions of Geometry Based on Students' Gender

Gender			Conceptions		Df	Total	X^2-value	Sig.	Decision
		Correct	Misconception	Alterative					
Male	Observed	66	103	181		350			
	Expected	73.10	85.50	191.40		350			
					2		8.95	0.01	Reject H0
Female	Observed	92	82	233		407			
	Expected	84.90	99.50	22.60		407			
Total	Observed	158	185	414		757			
	Expected	158.00	185.0	414.00		757			

$P < 0.05$ Significant

Discussion

Findings revealed that there was a significant difference in the number of male and female students holding correct conception, misconception and alternative conception of geometry in Ogun State, Nigeria. This means that the proportion of male and female students holding correct conceptions, misconceptions and alternative conceptions of geometry was different from one another when the data was subjected to statistical analysis. The interpretation of the outcome of this hypothesis means that differences existed in the number of students holding conceptions of geometry based on gender. This finding was in line with the findings of Charles-Ogan (2014), Umoinyang (2005), Arleback (2009) Atebe (2008) who found that females had fewer misconceptions and higher mathematical attitudes and achievement than their male counterparts. Previous studies with other

views on gender include the study carried out by Ameen (2012) on gender in relation to students' academic performance in comparative effects of two problem solving models in mathematics word problems. The outcome of the study by Ameen (2015) was in favour of the female students. Also, Suleiman (2010) on the effects of three problem-solving models on students' performance in statistics concepts of mathematics curriculum. However in Abdulraheem (2012), Timayi, Ibrahim and Sirajo (2016), gender equality could be achieved when both male and female students are taught under the same condition and with the same strategies. These related studies submitted that gender did not have significant influence on the achievements of students as well as how students conceive various ideas in mathematics and geometry in particular. However the influence of gender on students' learning remains a topic with a continuous focus with an unending opinion.

Conclusion

It can be deduced from the results of this study that misconceptions and alternative conceptions held by students could affect their performance in geometry as well as in mathematics in general. The study also found that, gender differences existed in the number of students with various conceptions of geometry. Ability to identify these misconceptions and alternative conceptions would help both students and teachers to find ways of correcting them. The implications of the findings of this study is that, mathematics teachers need to first find out conceptions of geometry held by students when teaching geometry. It also implies that both students and their teachers in senior secondary schools have roles to play in reducing misconceptions and alternative conceptions in geometry. This can be achieved by mathematics teachers' first of all identifying these misconceptions and the alternative conceptions and finding ways of correcting them.

Recommendations

Based on the findings of this study, the following are recommended:

1. Mathematics teachers should first of all identify these misconceptions and the alternative conceptions and finding ways of correcting them before proceeding to teach new topics;
2. Mathematics teachers should attend regular workshops and in-service training to get current knowledge of the methods to be used in teaching correct concepts of geometry so as to remedy misconceptions and alternative conceptions of geometry and generally of mathematics.
3. Both male and female students of mathematics should endeavour to master geometrical concepts as much as possible to avoid wrong conceptions of them.
4. Authors of mathematics textbooks should guide against misconceptions and alternative conceptions in the textbooks they publish.

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