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Effect of Differentiated Instruction on Students' Achievement in Geometry

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ABSTRACT

This study determined the effect of differentiated instruction on students' achievement in geometry. Two research questions and two hypotheses tested at 0.05 alpha levels guided the study. The study employed pre-test post-test quasi-experimental research design. The population of the study consisted of 1603 Senior Secondary two (SSII) students in Onitsha North Local Government of Anambra State and a sample of 224 SSII students were randomly selected from two co-education secondary schools from the population. Geometry Achievement Test (GAT) which contained 30 items was face and content validated by three experts. Reliability of the instrument was estimated at 0.78 using split-half reliability method. Research questions were answered using mean and standard deviation, while the hypotheses were tested using z-test and t -test at 5% level of significance. The findings of the study showed that students that were taught geometry with differentiated instruction achieved better than those taught with conventional method. Both male and female students achieved high in geometry with the use of differentiated instruction. There is a statistically significant difference between the mean achievement scores of students taught geometry with differentiated instruction and those taught with conventional method. Again, there is no statistically significant difference between the mean achievement scores of male and female students taught geometry with differentiated instruction. It was recommended among others that Mathematics teachers and educators should adopt the use of differentiated instruction while teaching and learning mathematics. Also curriculum developers should incorporate the use of differentiated instruction in the mathematics curriculum.

Keywords- Differentiated instruction, Achievement, Geometry, Secondary school students

I. INTRODUCTION

Mathematics is a basic knowledge needed by students and others to face the daily life activities regardless of educational background and social life. The importance of mathematics to humanity accounts for its inclusion in the school curriculum as a compulsory subject for every child of school age and consistently generates interest among scholars because of its scientific discoveries and inventions (Salman, 2005). Secondary school mathematics consists of many topics of which according to Wikipedia Encyclopaedia (2010) include arithmetic, algebra, geometry, calculus, statistics topology, mathematical modeling.

Geometry being one of the branches of mathematics is the study of points, lines, planes, closed flat shapes, and solids. Hollebrands and Stohl Lee, (2011) opined that geometry has been a stable part of secondary school mathematics curricula whose tools have transformed from physical objects, such as a compass and straightedge (ruler), to technological tools such as computer, graphing calculators and iPad. Kilic (2010) posited that learning geometry involves visualization and constructions of images (shapes and patterns) of geometric concept. Kutluca (2013) and Özçakir (2013) also agreed that learners develop some basic skills in geometry, which comprise of logical thinking abilities, spatial intuition about the universe, comparing and generalising, reading and comprehending of geometrical concepts. Geometry is made up of plane (2- dimensional) shapes and solid (3-dimensional shape. Jones, (2002) opined that the reasons for including 3D geometry in the school mathematics curriculum is not only to develop spatial awareness but to develop knowledge and create ability to use geometrical properties and theorems. Solving problems in plan and solid shapes require students to find the areas and volumes of the shapes. French, (2004) defined area of plane shapes as the quantitative measure of the amount of two-dimensional surface contained within a boundary. He also defined volume as the amount of three-dimensional space in a solid shape that can be quantified in some manner. French, (2004) stated that area and volume are vital geometrical concepts, which underlie many aspects of mathematics.

Despite the relevance of geometry to national development, Hollebrands and Stohl Lee, (2011) stated that learners have difficulty in reasoning, interpreting and representing different geometric objects. Finding by, Marios, Mousoulides and Christou (2009) showed that understanding area and volume measurement requires reasoning multiplicatively which is not easy for students. Result by Owens & Outhred, (2006) showed that students focus only on the formulas and the numerical operations required to calculate the volume or surface

area of a solid and completely ignore the structure of the unit measures. Piaget and his colleagues had already found out that children could not fully comprehend the relation between two and three-dimensions of the same object until adolescence (Piaget, Inhelder, and Szeminska, 1960). The utmost worry is that the West African Examination Council (WAEC) 2007 Chief Examiner's report on students' areas of deficiency in school certificate examinations is geometrical questions, which most students avoid and haphazardly attempted due to poor teaching approach (WAEC, 2007; Olunloye, 2010). There is need to clarifies many of the shortcomings in traditional instructions and offer ways for appropriate teaching methods.

National Mathematical Center (NMC, 2009) reported that teaching and learning of mathematics has more to do with the teacher's method of teaching than the content of curricular of the school. The finding of Bolaji (2005) revealed that the teacher's method of teaching and teacher's personality greatly accounted for the students' positive achievement towards Mathematics. Arbain and Shukor (2015) admitted that teaching and learning of mathematics should not be focused purely on theory but on diversity of learning approaches that involve the use of teaching materials confirmed to stimulate learners' interest in mathematics. The fact that Mathematics teachers have shifted from conventional methods to innovative methods like inquiry method, demonstration method, constructivist method and problem-solving method did not stop students' poor achievement in mathematics.

Meanwhile, mathematics classroom setting contains students with varied means of expression, family background, knowledge, different learning styles and varying degrees of difficulty. There is possibility that all the students will not understand a given mathematics concept at the same time when taught with one instructional procedure. Again, no two students enter mathematics classroom with identical abilities, experiences and needs. This may be the reason Garba & Muhammad (2015) posited that students learn differently in building mathematical models because of individual differences. Buttressing this, Merchant, (2010) proposed that teachers should use teaching instructions that will ensure maximum participation of the students and provide knowledge at the understanding level of the students. Tomlinson, (2001) admonished that instruction can be differentiated based on student's readiness, learning profile and interest by varying the content, process or product.

Differentiated instruction is a philosophy of teaching the students by accommodating the differences in learning based on readiness, interest and learning profiles (Tomlinson, 2001). Tomlinson and Strickl (2005) define differentiated instruction as a systematic approach to planning curriculum and instruction for academically diverse learners. According to Nunley (2006), differentiated instruction is providing instruction in a variety of ways to meet the needs of learners. These expressions have shown that mathematics teachers are compelled to pro-actively respond to learners' characteristics and provide ideas effectively regardless of differences in ability. The model of differentiated instruction requires teachers to be flexible in teaching methods and adjust the curriculum rather than expecting students to modify themselves for the curriculum (Tomlinson, 2003). The theory of differentiated instruction is based on the theory of social constructivism (Vygotsky, 1978), which emphasises on the active participation of students in the learning process due to interaction with the environment. Tomlinson, (2003) posited that teachers are challenged to facilitate learning for students of different level of readiness, interest, learning profile, socio – economic background, cultural, psycho emotional characteristics and gender.

Distribution of mathematics instruction across gender will felicitate teaching and learning of mathematics. Gender refers to the socially constructed roles, behaviours, attitudes and attributes that a given society considers appropriate for men and women. Reid, (2003) posited that gender inequality in education has remained a perennial problem of global scope. No wonder Ogunseola - Bamidele (2004) stated that gender role expectation affected achievement at all levels of education, which promote access to education. Aremu and John (2005) posited that a lot of studies have been carried out to explain gender differences in students' learning outcomes especially in science subjects. This was confirmed by Okeke (2000) who concluded that gender differences existed in students' achievement in science.

Numerous studies conducted using differentiated instruction showed positive outcome on students' achievement in school subjects. For instance, the results by Koutselini and Gagatsis (2003) showed that differentiated instruction facilitated students' knowledge by maximizing motivation for cognitive and meta-cognitive growth that eventually improved academic outcomes of the students. The findings by Beecher and Sweeny (2008) showed that achievement gains occurred across student groups that used differentiated instruction. The results of Tieso (2002) showed that achievement gains are found across economic and achievement levels through pre/post-test results for students in effectively differentiated classrooms.

Few studies conducted in mathematics using differenced instruction on students' achievement did not consider geometry as an independent variable despite the inclusion of questions in geometry in senior secondary school examinations. Also there are inconsistence on the performance of students in mathematics among gender. Therefore, this study sought to determine the effect of differentiated instruction on students' achievement in geometry among the secondary school students. In

addition, studies on the effect of differentiated instruction in mathematics across gender are determined.

Purpose of the Study

The purpose of the study is to determine the effect of differentiated instruction on students' achievement in geometry among the secondary school students.

The study specifically determined the:

1. Mean achievement scores of mathematics students' taught geometry with differentiated instruction and those taught with conventional method.
2. Mean achievement scores of male and female students taught geometry with differentiated instruction.

Research Questions

The following research questions guided this study.

1. What are the mean achievement scores of mathematics students taught geometry with differentiated instruction and those taught with conventional method?
2. What are the mean achievement scores of male and female students taught geometry with differentiated instruction?

Hypotheses

The following null hypotheses were tested at 0.05 alpha levels.

Ho_1: There is no significant difference between the mean achievement scores of students taught geometry with differentiated instruction and those taught with conventional method.

Ho_2: There is no significant difference between the mean achievement scores of male and female students taught geometry with differentiated instruction.

II. METHOD

This study determined the effect of differentiated instruction on students' achievement in geometry among the secondary school students. Two research questions and two hypotheses tested at 0.05 alpha levels guided the study. The study employed pre-test post-test quasi-experimental research design. The population of the study consisted of 1603 Senior Secondary two (SSII) students in Onitsha North Local Government of Anambra State. A sample of 224 SSII students from two co-education secondary schools randomly selected from the population was used. Experimental group consisted of 129 students while the control group were 95 students.

The instrument titled "Geometry Achievement Test (GAT)" contained 30 multiple choice items of which six (6) of knowledge, six (6) of comprehension, six (6) of application, six (6) of analysis and six (6) of synthesis levels sorted and adapted from geometry topics in senior secondary school mathematics curriculum. The instrument was face and content validated by three experts from Science Education (measurement and Evaluation and Mathematics Education). The corrections and suggestions made were incorporated in the final draft of the test items. Reliability of the instrument was estimated at 0.78 using split-half reliability method. The experiment was conducted during the normal school periods following the school timetable, which lasted for 4 weeks.

The class mathematics teachers who were trained by the researchers used the researchers' prepared lesson notes in areas of plane shapes, volume of solid shapes and surface areas for different groups respectively. The lesson note on differentiated instruction in geometry was used for the experimental group whereas lesson note on conventional method was used for the control group. The students in the experimental group were shared in four sub-groups according to their abilties. Instructional materials in geometric shapes were given to each group to see, touch, feel and identify. The mathematics teacher demonstrated and discussed how to differentiate plane shapes from the solid shapes, view the solid shapes from the side, front and top as the students observed. In finding the relationship between the surface area and volume of cylinder, the mathematics teacher asked the students to measure out two papers (15 cm x 7 cm) and they were directed to roll one paper along the long way (long cylinder) and the second paper along the short way (short cylinder) to make a cylinder. Then, students were directed to compare the volume of a short and long cylinder without using the formula. Teaching skills like use of examples, stimulus variations, set induction, verbal and non-verbal cues, questioning and planned repetitions were emphasized.

Students were allowed to demonstrate teacher's instructions in their deferent groups using different shapes as directed. Collaborative, cooperative and peer learning through active interactions and participation in groups were allowed. The mathematics teacher involved the students in problem solving skills by showing them the algorithms of using formula to calculate the areas of plane shapes, volumes of solid shapes and surface area. Students were given the opportunity to ask questions, answer questions and participate fully while solving giving examples. Individual questions were entertained and at the end of each lesson, students were given class work, which was marked by the researchers.

Before the geometry lesson, subjects in both the experimental and control groups were given the pre-test. At the end of the experiment, the researchers with the help of the class mathematics teacher administered the post-test to the subjects in the two groups. The contents of the questions in the pre-test and post-test are the same except that the post-test item numbers were reshuffled and marked with "X". The scripts were marked and recorded using the same marking guide. Scores from the instruments were collated and statistically analyzed using mean, standard deviation, z-test and t-test statistic at 0.05 level of significant.

III. RESULT

Research Questions 1

What are the mean achievement scores of mathematics students taught geometry with differentiated instruction and those taught with conventional method?

Table 1: Mean ratings and standard deviation of students taught geometry with differentiated instruction and those taught with conventional method.

Group	N	Mean	SD	Mean	SD	Mean gain
		Pre-test		Post-test		
Experimental	129	49.25	11.42	66.24	9.63	16.99
Control	95	48.13	11.14	50.18	11.12	2.05

Table 1 shows that the students taught geometry with differentiated instruction had a higher mean score of 66.24 with mean gain of 16.99 as against the students taught with conventional method whose mean score is 50.18 with mean gain of 2.05. This shows that differentiated instruction is more effective than conventional method in teaching geometry.

Research Question 2

What are the mean achievement scores of male and female students taught geometry with differentiated instruction?

Table 2: Mean ratings and standard deviation scores of male and female students taught geometry with differentiated instruction

Group	N	Mean	SD	Mean	SD	Mean gain
		Pre-test		Post-test		
Male	57	48.13	10.04	61.07	10.12	12.94
Female	72	47.75	10.18	65.18	10.03	17.43

Table 2 shows that the male students taught geometry with differentiated instruction had the mean score of 61.07 with mean gain of 12.94 while the female students taught geometry with differentiated instruction had the mean score of 65.18 with mean gain of 17.43. This shows that both male and female students taught achieve high in geometry with the use of differentiated instruction, although the mean scores of females are higher than their male counterparts.

Hypothesis 1

There is no significant difference between the mean achievement scores of students taught geometry with differentiated instruction and those taught with conventional method.

Table 3: z-Test difference in the mean achievement scores of students taught geometry with differentiated instruction and those taught with conventional method

Group	N	X	SD	df	α	t-crit	z– cal	Decision
Experimental	129	66.24	9.63	222	0.05	1.96	36.50	Reject H_o
Control	95	50.18	11.12					

The result in Table 3 shows that t- crit. value of 1.96 is less than the z-cal value of 36.50at 0.05 level of significance. Therefore, the null hypothesis is rejected. This means, there is a significant difference between the mean achievement scores of students taught geometry with differentiated instruction and those taught with conventional method.

Hypothesis 2

There is no significant difference between the mean achievement scores of male and female students taught geometry with differentiated instruction.

Table 4: t-Test difference in the mean achievement scores of male and female students taught geometry with differentiated instruction.

Group	N	X	SD	df	α	t-crit	z– cal	Decision
Male students	57	61.07	10.12	127	0.05	1.96	-7.21	H_o Upheld
Female students	72	65.18	10.03					

The result in Table 4 shows that t- crit value of 1.96 is greater than t-cal value of -7.21 at 0.05 level of significance. Therefore, the null hypothesis is upheld. This means, there is no significant difference between the mean achievement scores of male and female students taught geometry with differentiated instruction.

IV. DISCUSSIONS

The findings of this study showed that the students taught geometry with differentiated instruction had a higher mean score as against students taught with conventional method. This has shown that teaching

geometry with differentiated instruction is more effective than conventional method. This result is in line with Kim (2005) and Tieso (2005) whose research findings showed evidence for positive effects on students' achievement when exposed to differentiated instruction. This implies that differentiated instruction adversely widens the achievement gap between students in experiment group and control group. This finding is in consonant with the guiding principle report of Tomlinson (2000) and Anderson (2007) which indicated the efficacy of differentiated instruction in facilitating meaningful understanding of concepts and enhancing student's achievement. Finding of this result relates with the result of McAdamis (2001) which showed academic improvement from low academic outcomes after differentiated instruction was used. This result also agrees with the findings of Brimijoin (2001) which showed evidence of strong achievement gains on the standards test for students in the effectively differentiated elementary classroom.

There is a statistically significant difference between the mean achievement scores of students taught geometry with differentiated instruction and those taught with conventional method. This result is consistent with the findings of Brighton, Hertberg, Moon, Tomlinson and Callahan (2005) showed statistically significant different achievement outcome of students in differentiated middle school classrooms compared to students in control group. On contrary, the result of Adelabu, Makgat and Ramaligela (2019) showed that there was no significant difference between geometry achievement of learners in experimental and control group after the application of dynamic geometry computer software in terms of gender.

Result of the finding also showed that both male and female students that were taught geometry using differentiated instruction achieved high and there is no significant difference between the mean achievement scores of male and female students taught geometry with differentiated instruction. This result agrees with the result of Vale (2009) which showed that there is no gender difference when good teaching method is used. This finding is contrary to the result of Abiam and Odok (2006), Akinsola (2007) and Vale (2009) who reported that female students are weaker in geometry than the male students.

Implications

Based on the findings of the study, the following implications were drawn for students, mathematics teachers, policy makers, government and parents. The result which shows that students taught geometry with differentiated instruction had a higher mean score as against students taught with conventional method implies that mathematics teachers should actively respond to learners' characteristics and make teaching and learning of mathematics effective regardless of differences in abilities. They should thereby use more than one mathematics instructions in teaching a particular mathematics topic so as to accommodate the cognitive levels of the students. The curriculum planners and policy makers should plan mathematics curriculum in such a way that different mathematics instructions can be use to teach a particular mathematics topic.

The result shows that both male and female students achieved high in geometry with the use of differentiated instruction. This implies that use of differentiated instruction is very effective across gender. Male and female students have the same level of achievement when exposed to differentiate instruction while teaching geometry.

V. CONCLUSION

The findings of the study has shown that students taught geometry with differentiated instruction had a higher mean score as against students taught with conventional method. Both male and female students achieved high in geometry with the use of differentiated instruction. There is a significant difference in the mean achievement scores of students taught geometry with differentiated instruction and those taught with conventional method. Again, there is no significant difference between the mean achievement scores of male and female students taught geometry with differentiated instruction. This result has shown that differentiated instruction is an effective method of teaching and learning mathematics, geometric concepts in particular. This method gives the students hands-on learning and more opportunities to communicate with their classmates as compared to conventional method.

RECOMMENDATIONS

The following recommendations were made from the findings of the study:

1. Mathematics teachers and educators should adopt the use of differentiated instruction while teaching mathematics.
2. Mathematics teachers should master different instructional methods for effective use of differentiated instruction.
3. Curriculum developers should incorporate the use of differentiated instruction approach in the mathematics curriculum.
4. Publishers should produce mathematics text books using differentiated instruction format.
5. Government and other educational bodies should sponsor and organize technical workshops and seminars on the use of differentiated instruction.

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