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Influence of Five Phase Piagetian-Constructivism Model and Mathematics Laboratory on Senior School Students' Performance in Plane Geometry in Abuja, Nigeria

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ABSTRACT The study investigated the influence of five phase Piagetian-constructivism model and Mathematics laboratory on senior school students' performance in plane geometry in Abuja. The study adopted a non-randomized, pretest, post-test control group. The population for this study was drawn from four area council of Abuja. The sample consisted of 97 senior secondary school 2 students which were purposively selected. Plane Geometry Performance Test was used for data collection which was validated by three experience lecturers of Science Education Department University of Ilorin; a test retest approach was used to determine the reliability of 0.79 using Pearson moment correlation coefficient. Two research questions and two corresponding hypotheses were raised and tested for this study. ANCOVA and T-test was used to analyse the collected data and the findings of the study indicated that students taught plane geometry using five phase Piagetian-constructivism model and mathematics laboratory (PCML) performed significantly better than those in the control group and also the there is no significant difference in the performance of students on the basis of gender. Hence the study recommended that mathematics teachers should be encouraged to use five phase Piagetian-constructivism model to enhance students' performance in plane geometry.

Keywords: Piagetian-constructivism, Mathematics laboratory, Plane Geometry, Performance, Mathematics

Introduction

Mathematics can be described as the study of ordering, synthesis, analysis and investigation of one's environment in order to solve problems. These problems, which are multifaceted ranges from Health, Agriculture, Finance, Education, Religion, Transportation, Communication, Power, Housing among others. This is why mathematics is a strong force to be reckoned with in the scientific, social and technological development of any society.

According to Golade, et al. (2013) mathematics is the touchstone of wit and whetstone of intelligence, a tool that requires us to reason and then draw an inference that with such power of reasoning, our national problem such as economic, social, political and technological can be tackled and a virile nation erected. Mathematics is also seen as a universal language shared by human beings irrespective of culture, religion or gender (Uka, Iji & Ekweme, 2012). This implies that irrespective

of beliefs, religion divide or ethnic colouration the principle of mathematics still remains the same.

Accordingly, Brain (2016) submitted that mathematics is a key which opened the technological world, without which most modern applications would not even be conceivable. Its plays a very important role in industrial research and development, finance, and economics. Mathematics has been described as the science of finding patterns, which appear throughout nature in everything from ripples of pond water to the orbits of the planets which fueled the development of today's technologies (Zandonella, 2016).

Mathematics at the senior secondary school in Nigeria has four main themes which are: Numeration, Algebra, Statistics and Geometry. This study focused on geometry. Fajemidagba (1999) described geometry as a study of spatial relationships (position, shape, and size). Its study is carried out through observations, constructions, and description of shapes; and location of a point in two- or three-dimensional space. Teaching and learning of geometry are enjoyable because it is full of practical problems and theorems. It is an integral part of our cultural experience being a vital component of numerous aspects of life from architecture to design in all its manifestations.

The overall goals for learning geometry according to Fajemidagba(1999) are: (i) to analyze characteristics and properties of two- and three-dimensional geometric shapes; (ii) to develop mathematical arguments about geometric relationships; (iii) to specify locations and describe spatial relationships using coordinate geometry and other representational systems;(iv) apply transformations and use symmetry to analyze mathematical situations; (v) to use visualization, spatial reasoning, and geometric modeling to solve problems. Some geometry skills are used in many everyday tasks, such as reading a map, describing the shape of an object, arranging furniture so that it fits in a room, or determining the amount of fabric or construction materials needed for a project. Geometry is one of the most important themes of mathematics which dominate over 30% of the entire senior school mathematics curriculum content (Iheonunekwu, 2016).

Effective teaching and learning of geometry could mean enabling more students to find success in mathematics as it's now a theme in the Nigerian senior schools' mathematics curriculum with sub-topics such as plane geometry, solid geometry, trigonometry, coordinate geometry, integral and differential calculus (NERDC, 2013).

Hasheem, Mohammed and Moni (2014) in a study on identifying mathematics themes perceived difficult by secondary schools' students identified geometry particularly, plane geometry as the topic perceived to be most difficult to senior secondary schools' students' in Nigeria. The Authors further stated that the respondents were of the view that the reasons for this difficulty include: poor teaching technique by their mathematics teachers, poor utilization of instructional resources among others. Also, Jarret (20l0) submitted that geometry is the most difficult topic students' fear most than any other topic in mathematics.

However, the teaching and learning of mathematics specifically geometry in Nigeria is yet to give the desired outcome which could stimulate the required personnel needed for scientific and technological development for job creation, security, agriculture, transportation, power, health, commerce, and industry. It was due to the great importance of mathematics in our daily lives that makes the teaching and learning of mathematics compulsory from primary to secondary school in Nigeria (NERDC, 2013). Despite the high benefits derived from the knowledge of mathe-

matics, students' performances in the subject at senior schools' certificate examination have not been encouraging (Akanmu & Fajemidagba, 2013; Bot & Iliya, 2015).

Based on the West African Senior Schools Certificate Examination (WASSCE) Mathematics results from 2006- 2015, students' performance has not been consistent as indicated in Table 1 and Figure 1. In 2006 the percentage of students with credit pass which is the condition for securing admission into the university and other tertiary institutions in Nigeria was 41.12%, this increased to 57.28% in 2008. Subsequently, the percentage credit pass began to decrease persistently from 2009 until 2012 when the percentage began to increase and move up to 65.94% in 2015. The question one begin to ask is why these inconsistencies in this trends of students' performance? And when will the students' performance in WASSCE mathematics in Nigeria going to be 90% and above? Many reasons have been advocated for the unsatisfactory performance of students in mathematics in Nigeria.

Figure 1: Bar Chart Showing the Trends of Students Performance in WASSCE from 2006-2015.
Source: Statistic Section WAEC Office Lagos

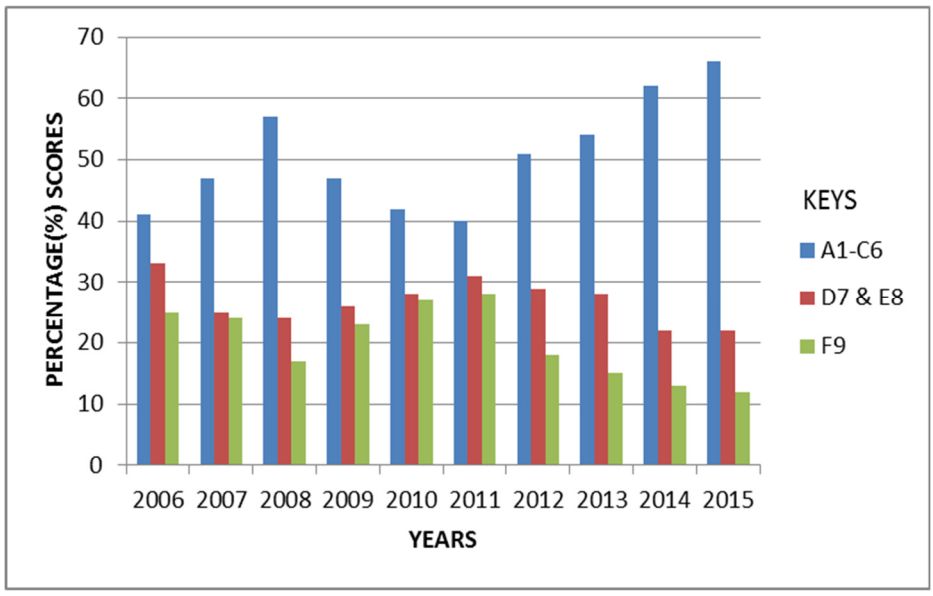

Table 1: Trends of Students Performance in WASSCE Mathematics in Nigeria from 2006-2015

Year	Total Enrollment	No. of Candidates that sat for Exams	No. and % of (A1-C6) at credit level	No. and % (D7-E8) (Ordinary Pass)	No. and% of F9 (Failure)
2006	1,170,521	1,149,277 (98.18%)	472,674 (41.12%)	389,858 (33.36%)	286,745 (25.52%)
2007	1,270,523	1,249,028 (98.33%)	584,024 (46.75%)	333,844 (24.72%)	302,774 (24.24%)
2008	1,292,890	1,268,028 (98.09%)	726,398 (57.28%)	302,266 (23.83%)	218,618 (17.24%)
2009	1,373,009	1,348,528 (98.22%)	634,382 (47.04%)	344,635 (25.56%)	315,738 (23.41%)
2010	1,331,374	1,306,535 (98.13%)	548,065 (41.92%)	363,920 (27.85%)	355,382 (27.20%)
2011	1,540,141	1,508,965 (97.98%)	608,866 (40.35%)	474,664 (31.46%)	421,412 (27.93%)
2012	1,695,878	1,658,357 (97.79%)	838,879 (50.58%)	478,519 (28.86%)	298,742 (18.01%)
2013	1,688,700	1,658,357 (98.19%)	899,901 (54.27%)	463,676 (27.96%)	246,148 (14.84%)
2014	1,632,377	1,011,608 (98.58%)	1,011,608 (61.97%)	357,555 (21.90%)	211,941 (12.98%)
2015	1,605,248	1,532,252 (95.45%)	1,010,492 (65.94%)	342,423 (22.35%)	179,427 (11.71%)

Source: Statistics Section, WAEC Office, Yaba, Lagos (June, 2016)

Agwagah (2013); Ugwanyi(2014); Josiah and Etuk-iren (2015); Ajai and Imoko (2015) found out that the traditional methods of teaching mathematics still dominates mathematics instruction in Nigeria which implies that most of the students resort to memorization (rote learning) which cannot lead to any meaningful knowledge and success in mathematics examinations, poor interest in the subjects by the students, perceived difficult nature of mathematics as a subject by students, poor

mastery of subject-matter by teachers, poor use of instructional materials, lack of mathematics laboratory among others are majorly responsible for students' poor performance in mathematics.

Ale (2002) in a study rated some of these causes of poor performance as follows: Poor instructional strategies 67%;
Low interest by students 21%; and Difficulties of examinations 12%.

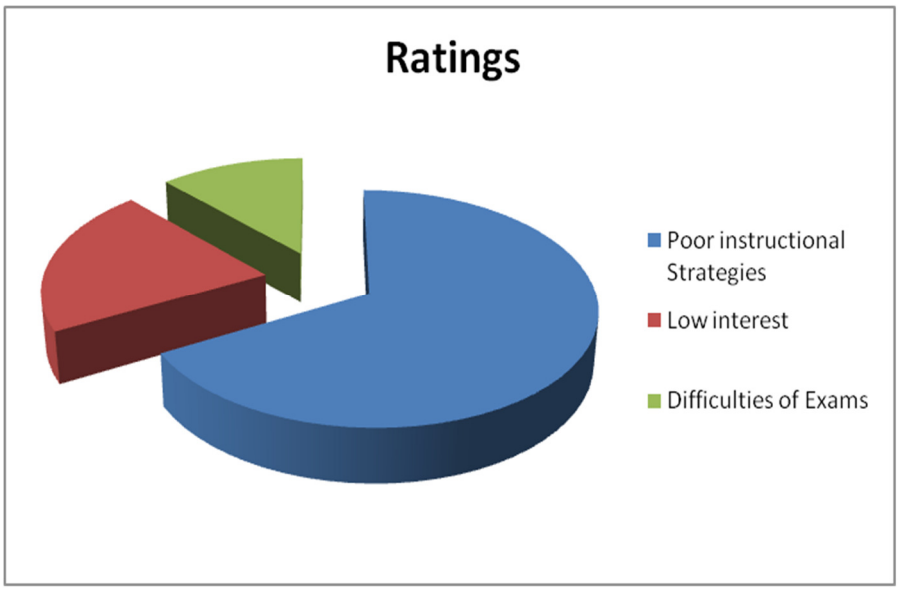

Figure 2: A Pie Chart Showing Causes of Poor Performance in Mathematics
Source: Ale (2002)

In a related development, Anaduaka and Okafor (2013) submitted that despite all the efforts by stakeholders to curb the failure of students in mathematics, the efforts seems not to be yielding the desired result. The authors attributed it to the following: poor methods of teaching by mathematics teachers, lack of passion for the teaching profession occasioned by poor pay, inadequate of quality and seasoned mathematics teachers, poor mastery of the subject matter by many mathematics teachers, politicizing training and retraining of mathematics teachers, research results not getting to the implementers of the findings among others.

According to Piaget (1969), human beings possess mental structures that assimilate external events and convert them to fit their mental structures. Moreover, mental structures accommodate themselves to new, unusual, and constantly changing aspects of the external environment. And the mind is organized in complex and integrated ways. Piaget's-constructivism key concepts that are applicable to learning at any age are Assimilation, Accommodation, Equilibration, Disequilibration and Schemas.

Ado (2014) define Piagetian-Constructivism as the philosophical position which holds that any so-called reality is the mental construction of those who believe they have discovered it. From this perspective, learning is said to be a self-regulated process of resolving inner conflicts that become apparent through concrete experi-

ence, discussion, and reflection. The basic idea of Piagetian-constructivism is that knowledge must be constructed by the learner and cannot be supplied by the teacher (Adaramola and Obamanu, 2013; Onwuka, 2015; Musa and Bolaji, 2015; Kajuru and Kaura, 2014).

From Piaget 's definition, knowledge is an interaction between subject and object. It is not a perpetual construction made by exchanges between thought and its object nor a copy of reality by the concepts of the subject that approaches the object without ever attaining it in itself (Abbs, Lai-Mei &Hairul, 2013). The task which the students will be involved in during the mathematics lessons will be numerous as each lesson will require a different activity from the previous once in order not to make the new lesson boring and uninteresting. This calls for the need for a very creative environment where numerous mathematics activities could be carried out conveniently and effectively to help the learner to construct their own knowledge which is what the mathematics laboratory provides.

Maschietto (2012) viewed mathematics laboratory as a self-contained centre devoted to the display, arrangement, and use of multi-sensory mathematics materials, activities and information. It is an individualized learning centre for mathematics remediation, reinforcement, and enrichment. It exists to foster mathematical awareness, skill building, positive attitudes and learning-by-doing experience in arithmetic, geometry, algebra, number theory, set theory, consumer mathematics, measurement, and other areas of mathematics. It provides a setting for individual or small groups of learners to explore, learn, and grow mathematically.

Mathematics laboratory is a place where learners are exposed to explaining difficult mathematical concepts and verify mathematical facts, formulae and theorems/results through a variety of activities and handling related projects using non-costly materials available in their environment. Mathematics laboratory can create mathematical awareness, skill-building, positive attitudes towards the subject and above all, ideas of learning by doing (Esangbedo, 2014). This implies, it is a very strong tool for effective mathematics teaching and learning.

The Central Board for Secondary Education (CBSE) (2011) identified ways by which mathematics laboratory can be useful to the learning of mathematics in secondary schools, viz:

i. it provides an opportunity to students to understand and internalize the basic mathematical concepts through concrete objects and situations;
ii. it provides greater scope for individual participation in the process of learning and becoming autonomous learners;
iii. its enables the students to verify or discover several geometrical properties and facts using models or by paper cutting and folding techniques; and
iv. helps the students to build interest and confidence in learning the subject since its provides an opportunity to exhibit the relatedness of mathematical concepts with everyday life.

In addition, the mathematics laboratory provides scope for greater involvement of both the mind and the hand which facilitates cognition (Ugwuanyi, 2014; Farayola, 2014; Badru, 2015). The use of instructional strategies has varying implications for both teachers and students' characteristics which also influence the gender of the students and their academic performance in mathematics. Several studies have revealed contradictory results on the correlation between students' gender and their performance in mathematics. While some studies indicated that there is no statistically significant difference in the students' performance in mathematics based

on gender (Iheonunekwu, 2016; Sunday, Akanmu & Fajemidagba, 2014; Olasehinde & Olatoye,2014).

Some studies reveal that boys performed significantly better than their female counterparts in mathematics (Amogne, 2015; Jonah, Philip, Jackson, Benjamin & Too, 2013). Hence this paper investigated the influence of five phase Piagetian-constructivism model and Mathematics laboratory(PCML) on senior school students' performance in plane geometry and gender as moderating variable.

Research Questions

i. Will there be any difference in the students' performance when taught plane geometry using Five Phase Piagetian-constructivism model and Mathematics laboratory and those taught using the conventional method?

ii. Is there any difference in the students' performance when taught plane geometry using Five Phase Piagetian-constructivism model and Mathematics laboratory based on gender?

Research Hypotheses

H_{01}: there is no significant difference in the students' performance when taught plane geometry using Five Phase Piagetian-constructivism model and Mathematics laboratory and those taught using the conventional method

H_{02}: there is no significant difference in the students' performance when taught plane geometry using Five Phase Piagetian-constructivism model and Mathematics laboratory based on gender

Methodology

The study which lasted for 6 weeks adopted a non-randomized, pretest, post-test control group. The study was conducted in Abuja, Nigeria. The sample for this study was 97 students selected from two intact classes of senior secondary schools purposively selected based on schools that operate coeducational school and have a mathematics laboratory in their schools. There were 51(27 males and 24 female) students in the experimental group taught plane geometry using Five Phase Piagetian-constructivism model (E-Elicit, E-Engage, E-Explore, E-explain and E-Evaluate) and Mathematics laboratory while there are 46(28 males and 18 female) in the control group taught plane geometry using conventional method. Both the experimental group and control group were pre-tested. This is to establish the homogeneity of the two groups using Ballet's test (=0.86) which indicated that both groups are homogeneous.

Instrumentation

The instrument used for data collection was Plane Geometry Performance Test (PGPT), the instrument which was validated by 3 experienced lecturers of the Department of Science Education University of Ilorin, Ilorin, Nigeria comprises of two sections: section A gives the Bio data of the students while section B consist of twelve open ended questions on plane geometry. The instrument was administered twice between an interval of 3 weeks on a non-participating school using test re-test

method and Pearson product moment correlation was used to determine the reliability coefficient of 0.79.

Results

Research Question 1: Will there be any difference in the students' performance when taught plane geometry using Five Phase Piagetian-constructivism model and Mathematics laboratory and those taught using the conventional method?

Table 2 shows that students taught plane geometry using PCML had a mean performance score of 3.37 in the pre-test and 13.35 in the post test. The control group had a mean performance score of 3.38 and rose to 4.54 after the treatment. Thus there is a mean difference of 8.81 in favour of the experimental group.

Table 2: Mean scores of students' performance in experimental and control group

		Pre-test		Post-test		
Variable	N	Mean	Std. Devi	Mean	Std. Devi	Mean Gain
PCML	51	3.37	1.98	13.35	3.42	9.98
CONTROL	46	3.38	2.09	4.54	2.05	1.16
Mean Difference		0.01		8.81		

Table 3 shows that the mean gain for the male students was 9.48 and the female student was 10.54. There was a mean difference of 0.78 before the treatment but this reduced to 0.28 after the treatment.

Table 3: Mean score of students' performance on the bases of Gender

		Pre-test		Posttest	
Variable	N	Mean	Std. Devi	Mean	Std. Devi
MALE	27	3.74	1.98	13.22	3.45
FEMALE	24	2.96	1.51	13.5	3.64
Mean Diff.		0.78		0.28	

$H0_1$: there is no significant difference in the students' performance when taught plane geometry using Five Phase Piagetian-constructivism model and Mathematics laboratory and those taught using the conventional method.

Table 4 shows that F-value (1, 96) = 11.93 with P = .003, P<0.05. This indicates that there is a significant difference in the mean performance scores of students taught plane geometry in the experimental group. Hence the null hypothesis is rejected. There is a significant difference in the performance of students taught plane geometry using PCML and the conventional group in favour of PCML

Table 4: Two way ANCOVA test for performance scores of students in the experimental and control group

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	152.9229[a]	31	4.933	2.180	.039
Intercept	410.713	1	410.713	181.478	.000
Pre-test	31.288	1	31.288	2.766	.103
Gender	43.26	1	43.26	.78	.213
Treatment	1855.794	1	1855.794	11.93	.003
Gender*Treatment	21.52	1	21.52	.19	.342
Error	554.359	95	11.313		
Total	9679.00	96			
Corrected total	585.64	95			

R^2=0.54

$H0_2$: there is no significant difference in the students' performance when taught plane geometry using Five Phase Piagetian-constructivism model and Mathematics laboratory based on gender.

Table 4 shows that F (1, 96) = 0.19 with P = 0.342; P>0.05. This implies that there is no significant difference in the students' performance on the basis of gender. Hence the null hypothesis is retained which indicated no significant difference in the students' performance when plane geometry using PCML on the basis of gender.

Discussion of Findings

The finding of this study showed that students taught plane geometry using PCML performed significantly better than those taught using the conventional method. This might be as a result of PCML been more students centered and activity based learning approach where students construct knowledge by themselves. This finding is corroborated by Onwuka (2015) and Kaura and Sodangi 2016 whose findings reveal that students performed significantly better when taught geometry and trigonometry

respectively using Piagetian-constructivism models. The finding of this study is also supported by the findings of Ugwuanyi, (2014); Farayola (2014); Badru, (2015) whose separate findings indicated that students taught mathematics using mathematics laboratory performed significantly better than those taught using the conventional methods.

Furthermore, the findings of this study revealed that PCML improved students' performance significantly without gender bias. This might be because the PCML engaged all the students during teaching and learning of plane geometry so much that the students all performed significantly well. This finding is confirmed by the findings of Iheonunekwu, (2016) John & Benjamin, (2015) whose findings showed that both male and female benefitted equally when taught mathematics using innovative teaching strategies.

Recommendations

Based on the findings of this study, the following recommendations were made:

i. Mathematics teachers should be encouraged to use PCML in the teaching of mathematics specifically plane geometry as it will enhance their performance in the topic for a while.
ii. Government should organize workshops for mathematics teachers on how to use PCML since it will help both male and female students to learn and perform well in plane geometry which studies have shown is the most difficult topic in mathematics.

Conclusion

It could be concluded that the use of Five Phase Piagetian-constructivism model will improve students' performance in Plane geometry significantly irrespective of their gender. If the mathematics teachers could use this innovative approach the issue of poor performance yearly in mathematics and specifically plane geometry will be a thing of the past. The implication of this is that senior school students will be the architect of their own learning in plane geometry while the teacher plays the role of a coach and facilitator. The learning of plane geometry will be exciting and this will boast the overall performance of students in mathematics. This might also lead to the inculcation of the Piagetian-constructivism model in the senior school mathematics curriculum.

Limitation of the Study

This study is limited to the use of Five Phase Piagetian-constructivism model and mathematics laboratory on senior school students' performance in plane geometry. Only SS 2 students participated in the study in two out of the six area councils of Abuja. Other aspect of geometry was not investigated and other arms of the classes did not participate in the study.

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