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EFFECT OF VAN HIELE'S INSTRUCTIONAL MODEL ON STUDENTS' ACADEMIC PERFORMANCE AND ANXIETY IN GEOMETRY AMONG SENIOR SECONDARY SCHOOL IN KATSINA STATE, NIGERIA

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Abstract

This study effect of van Hiele's instructional model on students' academic performance and anxiety in Geometry among secondary senior school in Katsina State, Nigeria. Two Objectives and Research Question were generated to guide the investigation. Also, Two Hypotheses were postulated and tested at 0.05 level of significant. The study sample was 180 SSII students' which were selected from the population of (3072) students of all public senior secondary school Kankia zonal education quality assurance using intact classroom. The study was adopt quasi-experimental design and two instruments Geometry Performance Tests (GPT) and Mathematics Anxiety Questionnaire (MAQ) was developed and adopted which is valid and reliability coefficient obtained are 0.736 and 0.947 respectively using PPMC and Cronbach alpha. Descriptive statistics (mean, standard deviation and mean rank) were used to address the research questions and inferential statistic (independent samples t-test and Mann Whitney U-test) was used to test the hypotheses at $\alpha = 0.05$. The findings of the study led to the conclusion that, students taught Geometry using Van Hiele's Instructional Model performed significantly higher than their counterparts taught using lecture method. It was recommended that, the Van Hiele's Instructional Model should be incorporated into the teaching and learning of Mathematics at the Senior Secondary School level.

Keys: Van Hiele's Instructional Model, Geometry, Anxiety.

Introduction

The impacts of the development in Science, Technology and Mathematics Education on socio-economic status have become one of the factors influencing nations' development worldwide (Atebe, 2008). This impact of development in Science, Technology and Mathematics Education (STME) on the economy of Japan has made it to be the second largest economist in the world following United States of America (Wasagu & Rabi, 2007). In Nigeria (as a developing country) there is need for a strong emphasis on the provision of good and sound qualitative Science, Technology and Mathematics Education (STME). No doubt this may be the reason why in its educational policy, the Federal Government of Nigeria in its statement of National Policy on Education (FRN, 2013) has made mathematics a compulsory core subject both at the primary and secondary school levels. Today in Nigeria a candidate seeking for admission into tertiary institution must pass mathematics at a credit level before securing admission into the higher institution. This is due to the fact that mathematics remains the central player in the development of science and technology. Musa (2006) in his study article titled "Mathematics: The pivot of

Science and Technology for Sustainable Development", stressed that mathematics provides the laws, formula and the theories that empower the scientific and technological developments. This explained the fact that the study of mathematics by all individuals has become imperative because it serves as a catalyst for scientific thinking, technological advancement and provide problem solving skills.

Today, mathematics is used throughout the world in many field, including natural science, engineering, medicine and the social science such as economics, applied mathematics, the application of mathematics to such fields inspires and makes use of new mathematical discoveries and sometimes leads to entirely new disciplines (Madu & Hogan, 2010). The position of mathematics in our national curriculum and its role towards technological and industrial development put it in compulsory position in primary and secondary level of education. Despite the roles of mathematics in national development, its study has not been effective in meeting the demands of national development in Nigeria. Students' performance in mathematics on both internal and external examination from year to year has never been encouraging (Gimba, 2013).

There are so many issues proposed as the reasons for the students' poor performance state in mathematics generally and geometry in particular (which is an integral part of the mathematics curriculum). Unal in Hassan (2015) said one possible explanation why students are failing in geometry is that, mathematics teachers are failing to provide their students with appropriate learning opportunities in geometry. Faleye and Mogari (2012) discovered that the learners are unable to do basic arithmetic calculations without the use of calculators. Sadiki (2016) suggests that most students are lazy to think and geometry requires critical and creative thinking. Perhaps this may be the reason why students perform poorly in geometry in particular and mathematics in general.

The Van Hiele's instructional model is a phase-based instructional strategy that the teacher of mathematics can use to deliver classroom instruction appropriately and effectively because it

describes clearly what the teacher and the learners should be doing at each phase so as to promote learning of geometric concepts. The van Hiele leaning model takes into cognizance how learners progress in geometric cognitive thinking and hence prescribe a way to present classroom instruction to meet the thinking ability at each level of the learners. The prescribed method of instruction is named "van Hiele' Instructional model". These learning and instructional model is different from other learning or instruction models like the "Constructivism" learning theory.

The constructivism learning theory is about motivating or helping the learners to construct their own cognitive knowledge but van Hiele looks at how learners develop cognitive knowledge (in geometry) at their own pace and the instructional approach that will accommodate such level of thinking.

Based on this there is need for the mathematics teacher to identify and evaluate his/her students' level of geometric thinking based on the Van Hiele's Theory so as to make adequate preparation for the teaching of geometric concepts in his /her class. Van Hiele's instructional model has proved to be a useful framework for accessing and unraveling students' difficulties with school geometry (Wikipedia, 2010). Despite the popularity and wider usage of the model in many countries in the world like Netherland, United States of America (USA), Russia and Japan to improve the geometrical aspect of their curricula, there is little utilization of the model in African countries (Atebe, 2008). For example in Nigeria there is no single study (to my awareness) conducted on the usage of the model for teaching geometry at the secondary school level and only one study (Hassan, 2015) was conducted on the impact of the Van Hiele's model on pedagogical abilities of Nigeria certificate in education (NCE) mathematics teachers.

Since the lecture teaching method persistently used by teachers (Amaefule, 2004; Ezeliora, 2003) cannot permeate the difficult Mathematics concepts which manifests in perennial poor students' Performance, the researcher therefore deemed it necessary to study the effect of Van Hiele's instructional strategy on students' performance and retention in Geometry which is among the

perceived difficult Mathematics concepts (Sadiki, 2016). This instructional strategy has been found effective in overcoming other instructional problems such as large class size (Sani, 2014) and the poor performance of learners in mathematics (Igbo, 2004). It might therefore not be out of place to investigate the effect of this strategy on students' performance and retention in geometry in an attempt to improve on student's performance in Mathematics.

Mathematics anxiety (MA) is generally defined as a state of discomfort caused by performing mathematical tasks. Mathematics anxiety can be manifested as feelings of apprehension, dislike, tension, worry, frustration, and fear. Richardson and Suinn (1972) point out that: "Mathematics anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations". The impact of mathematics anxiety varies based on each individual student. Students who suffer from higher levels of mathematics anxiety typically develop negative attitudes and emotions toward mathematics.

Importantly, Mathematics Anxiety has several negative effects on children's and adult's mathematics education. For example, people who experience high levels of Mathematics Anxiety are likely to develop negative attitudes toward tasks involving mathematics, drop out of elective mathematics classes or avoid taking them altogether; in addition, those with high Mathematics Anxiety avoid pursuing careers that require quantitative skills (Ma & Xu, 2004).

Statement of the Problem

The problem of this study emerged as a result of the fact that students have difficulties in solving mathematics problems especially those that require mental manipulations, rearrangement of elements with a visual stimulus pattern like geometry (Hassan, 2015). Similarly the West African Examination Council and the chief examiners reports (2012, 2015, and 2017) shows that students have difficulties in answering questions on geometry and such problems have been traced to lack of knowledge of construction rubrics. According to this report, students find it difficult to

accurately measure, construct, draw and even rearrange objects which are processes involved in geometry.

Teachers' competencies and pedagogical abilities coupled with their abilities to employ appropriate instructional strategies and approaches will help the students of mathematics to learn and understand mathematical concepts better. Therefore there is need for the mathematics teachers to adopt and shift their teaching approaches from the traditional way of teaching to a more activity-based approach which gives the learners opportunity to actively participate in the teaching and learning process like the van Hiele's phase-based instructional approach.

This research work is going to investigate into the effect of using Van Hiele's instructional model on students' academic performance and anxiety in Mathematics (Geometry in particular) among senior secondary schools students in Kankia Zonal Quality assurance. This is with the view to improving the learners understanding of geometry in particular and mathematics in general and also to fill the existing gap in knowledge as some researches were conducted on the effect of using Van Hiele's instructional model in the teaching of some concepts such as congruence triangle (Sadiki, 2016) but to my search, no research was conducted on the effect of using the model in the teaching and learning of other geometric concepts among secondary schools students.

Objectives of the Study

The main objective of this study is to investigate the effect of van Hiele's instructional model on students' academic performance and anxiety in Geometry. In specific terms, the objectives of the study are to:

i- Determine the effect of Van Hiele's Instructional Model on the academic performance of students when taught circle geometry.

ii- Determine the level of students' Mathematics Anxiety when taught circle geometry using Van Hiele's Instructional Model.

Research Questions

Based on the stated objectives the following research questions were raised:

1. What is the mean difference between the academic performance scores of students taught circle Geometry using Van Hiele's Instructional Model and those taught using lecture teaching method?
2. What is the difference between the mean anxiety rating scores of students taught circle Geometry using Van Hiele's instructional Model and that of students taught using lecture method?

Research Hypotheses

Based on the stated research questions the following null hypotheses were formulated to guide this study and will be tested at 0.05 levels of significance:

$H_{o1:}$ There is no significant difference between the mean performance scores of students taught circle Geometry using Van Hiele's instructional Model and those taught using lecture teaching method.

$H_{o2:}$ There is no significant difference between the mean anxiety rating scores of students taught circle Geometry using Van Hiele's instructional Model and that of students taught using lecture method.

Methodology

The research design used in this study is quasi-experimental research design. Specifically a pre-test, post-test and post post-test non-equivalent group design was employed. According to Shuttleworth (2008) quasi-experimental research design is a research design that is used to estimate the causal impact of an intervention on its target population, it controls some but not all of the sources of internal validity. This design is appropriate because the intact classes and the rigid school timetable would not allow the researcher to fully randomize the subjects.

The table below gives the format of the research design

Table 3.1 the Research Design Format

EG: $\longrightarrow O_1 \longrightarrow X_1 \longrightarrow O_2$

CG: $\longrightarrow O_1 \longrightarrow X_0 \longrightarrow O_2$

Keys:

EG = Experimental Group

CG= Control Group

O_1 = Pre-test

O_2 = Post-test

X_1 = Intervention (Van Hiele's instructional model)

X_0 = No Intervention (lecture teaching method)

Both the Experimental and the Control groups were subjected to the Circle Geometry Performance Test (CGPT) as a pre-test and their performance recorded which served as the results for finding group equivalency. Then the Experimental group was taught circle geometry concepts for a period of six weeks based on the Van Hiele's instructional model of teaching geometry, the topics covered are in line with the curriculum content of Senior Secondary School II of mathematics curriculum while the Control group was taught circle geometry concepts using a lecture method for the same period of time. Again after the intervention, a Post-test (a re-shuffled version of the CGPT) was followed and both groups' performance recorded and compared.

The study sample of 180 SSII students' which were selected from the population of (3072) students of all public senior secondary school Kankia zonal education quality assurance using intact classroom. Two instruments Circle Geometry Performance Test (CGPT) which was developed by the researcher and Mathematics Anxiety Questionnaire (MAQ), which was adapted from Richardson and Suinn (1972) which is valid and the reliability coefficient obtained are 0.736 and 0.947 respectively using PPMC and Cronbach alpha. Descriptive statistics (mean, standard

deviation and mean rank) were used to address the research questions and inferential statistic (independent samples t-test and Mann Whitney U-test) was used to test the hypothesis at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Research Question 1: What is the mean difference between the academic performance scores of students taught circle Geometry using Van Hiele's Instructional Model and those taught using lecture teaching method?

Table 2: Mean and Standard Deviation of Geometry Performance Score between the Experimental Group and Control Group.

	Group	N	Mean	Std. Dev.	Mean difference
Performance	Experimental Group	98	22.64	4.844	7.240
	Control Group	82	15.40	5.130	

Table 2 shows the mean score of students' performance taught geometry using Van Hiele's Instructional Model is 22.64 and the standard deviation is 44.844 and that of lecture method is 15.40 and the standard deviation is 5.130, the difference between two mean scores is 7.240. This indicated that, the mean score of experimental group is higher than control group.

Research Question 2: What is the difference between the mean anxiety rating scores of students taught circle Geometry using Van Hiele's instructional Model and that of students taught using lecture method?

Table 2: Mean Ranks of students' Anxiety Scores toward Geometry between the Experimental Group and Control Group.

	Group	N	Mean Rank	Sum of Ranks	Mean Ranks Diff.
Anxiety	Experimental Group	98	125.16	12265.50	76.08
	Control Group	82	49.08	4024.50	
	Total	180			

Table 2 showed that the mean rank of students anxiety score of experimental group is (125.16) and that of control group is (49.08). The table indicates that, there is a difference between the mean ranks between the Experimental Group and the Control Group with mean rank difference of (76.08).

Hypothesis Testing

The hypotheses formulated are tested using t-test and U-test analysis between the variables involved. The null hypothesis is rejected when the p-value is less than the alpha value of 0.05 and otherwise is retained.

$H_0$1: There is no significant difference between the mean performance scores of students taught circle Geometry using Van Hiele's instructional Model and those taught using lecture teaching method.

Table 3: t-test Result on Performance in geometry between Experimental Group and Control Group.

Group	N	Mean	Std.	Df	t-value	p-value	Remark
Experimental Group	98	22.64	4.844	178	9.721	.000	Significant
Control Group	82	15.40	5.130				
Total	180						

** Significant at $\alpha \leq 0.05$*

Table 3 showed that p-value (observed) = 0.000 is less than α-value of 0.05 at df = 178. Since the observed p-value = 0.000 < 0.05 then the null hypothesis (HO1) which states that: "There is no significant difference between the mean performance scores of students taught circle Geometry using Van Hiele's instructional Model and those taught using lecture teaching method" is rejected. This means there exist statistically significant difference between Experimental Group (Van Hiele's instructional Model) and the Control Group (Lecture). Students taught circle Geometry using Van Hiele's instructional Model performed better than those taught same content using Lecture Method. Hence, there is significant difference between the mean performance scores of students taught circle Geometry using Van Hiele's instructional Model and those taught using lecture teaching method.

$H_0$2: There is no significant difference between the mean anxiety rating scores of students taught circle Geometry using Van Hiele's instructional Model and that of students taught using lecture method.

Table 4: Mann Whitney U-Test for Comparison of Mean Ranks of Anxiety Score toward geometry for Experimental Group and Control Group.

Group	N	Mean	Sum of rank	U-value	p-value	Remark
Experimental Group	98	125.16	12265.5	Z = -9.776*	0.000	Significant
Control Group	82	49.08	4024.5			
	180					

** Significant at $\alpha \leq 0.05$*

Result in Table 4 showed that there exists a statistically significant difference in the mean ranks between the Experimental Group and Control Group with Mann-Whitney U test (Z = -9.776) and mean rank difference of . Since the p-value = 0.000 < 0.05 significant level, the H05 which states that: "There is no significant difference between the mean anxiety rating scores of students taught circle Geometry using Van Hiele's instructional Model and that of students taught using lecture method" is rejected. Hence, there is significant difference between the mean anxiety rating scores of students taught circle Geometry using Van Hiele's instructional Model and that of students taught using lecture method.

Discussion

The findings of research question one and hypothesis one revealed that Mathematics students taught geometry using Van Hiele's instructional strategy had higher mean academic performance scores than those taught using conventional lecture method. This implies that the use of Van Hiele's instructional strategy in teaching geometry concepts enhances students' academic performance in Mathematics. This study is in line with Armah, Cofie & Okpoti (2018) which revealed that the experimental group performed better than the control group which means that the Van Hiele's phase-based instructional strategy can improve the performance of learners. The finding also agree with the finding of Sadiki (2016) The results of his study showed that the use of the intervention (Van Hiele's Instructional Model) improves the achievement scores in the experimental groups and also it facilitated the learning of the concept of congruent triangles.

Results of the findings of research question two and hypotheses two indicate that there is a significant difference in the students' mathematics anxiety rating scores with the students in the control group having higher mathematics anxiety than their counterpart in the experimental group. This asserted that the Van Hiele's instructional model of teaching has reduced the students fear and feeling of uneasiness when it comes to Mathematics learning.

Conclusions

Based on the findings of this research, the following conclusions were drawn:

1. Van Hiele's Instructional Model enhances the student's academic performance in geometry among senior secondary school students under study.
2. This asserted that the Van Hiele's instructional model of teaching has reduced the students fear and feeling of uneasiness when it comes to Mathematics learning.

Recommendations

Based on the major findings and concluded issues, the following recommendations are made:

1. Mathematics Teachers of senior secondary schools in Kankia Zonal Education Quality Assurance should expose Mathematics students to the Van Hiele's instructional model, so as to promote their academic performance and retention in geometry concepts and as well reduces the anxiety level of the students.

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