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Teaching Strategies, Geoboard Resource and Secondary School Students' Achievement in Mathematics in Akwa Ibom State, Nigeria

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Abstract: The The study investigated the influence of teaching strategies and geoboard resource on secondary school students' achievement in mathematics in Oron Education Zone of Akwa Ibom State, Nigeria. The research design adopted for the study was a quasi-experimental pretest-posttest design with 4×2×2 factorial arrangement with four intact class groups. Collaborative and expository strategies were used for the experimental and control groups respectively. The population of the study consisted of 4157 Senior Secondary One (SS1) students from 19 public secondary schools in Oron in 2021/2022 academic school year. A sample size of 235 students from four schools was used for the study. The instruments used in gathering data for the study were Geometry Achievement Test (GAT) with the reliability coefficient of 0.81 established using test-retest methods. Data gathered in this study were analysed using mean and standard deviation to answer research questions, and Analysis of Covariance using pretest and posttest scores as co-variates for the three hypotheses. From the results obtained, there is a significant difference in students' achievement in mathematics when taught using expository and collaborative strategies with and without geoboard. Students do not differ significantly in their achievement in mathematics when taught using expository and collaborative strategies with geoboard based on gender. Students taught using collaborative strategy with and without geoboard outperformed students taught using expository with and without geoboard as a resource material. It is concluded that collaborative strategy is more effective than the expository strategy in enhancing students' achievement in mathematics and that the interactive effect of collaborative strategy with geoboard as a resource material is higher than that of geoboard with expository strategy. Based on the findings, it is recommended among others that, collaborative strategies should be frequently used in teaching mathematics and that geoboard as a resource material should be adopted in teaching mathematics at the secondary school level to enhance students' achievement in mathematics.

Keywords: Geoboard, Collaborative, Expository and Achievement.

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1. Introduction

The proficiency gained in the study of Mathematics is extensively used in all spheres of human life. Mathematics plays a key role in shaping how individuals deal with the various spheres of private, social, and civil life (Anthony and Walshaw, 2009). This justifies the compulsion of the study of the subject by all students who go through basic and secondary education in most countries. Mathematics is therefore a core subject at these levels of education in Nigeria. It is regrettable that, in the contemporary times many students struggle with mathematics and perform awfully low in their final examinations. In Nigeria, students' performance in mathematics at the Senior Secondary School has not been encouraging of late. Candidates are reported to exhibit poor understanding of mathematical concepts and are unable to form the applicable mathematical models which could be tackled with the requisite skills (WAEC, 2013).

Teaching mathematics is much like building a house, and if the foundation is weak, many difficulties will appear later. Students' understanding of basic mathematical concepts helps them move to the next level in logically connected concepts. Expository method used in most mathematical classes does not allow the students enough time to fully reach that understanding. Mathematics is still a subject that is considered difficult by many students. According to Woodard (2004), weaker students feel anxiety towards mathematics, and this anxiety affects their performance in mathematics. Students who lack mastery in mathematics are less successful despite being in secondary school for a long period of six years and more.

In expository teaching strategy, the students are assigned a passive role. They listen to the teacher, absorb what the teacher says and reproduce what the teacher had said at a later time. The teacher is the presenter of the information and serves as repertoire of knowledge thereby making the lesson teacher-centred. There is a clear boundary between the teacher and the students and the interaction between them is highly limited. Expository teaching is concerned with the teacher being the controller of the learning environment; power and responsibility are held by the teacher and they play the role of instructor (in the form of lectures) and decision maker (regarding the curriculum contents and specific outcomes). They regard students as having 'knowledge holes' that need to be filled with information. Novak (2008) viewed expository teacher as teacher that causes learning to occur.

In collaborative learning, students are at the centre and the teacher becomes a facilitator of the learning process. The students are encouraged to be successful active learners; group discussion techniques are used to encourage students to develop their own thinking and support each other's ideas. Classroom interactions become paramount, which involve a different power relationship between the teacher and the students. The members of the groups interact with each other as they share a common goal and set standards which provide direction and limit to their activity (Anglin, 2005). Johnson and Johnson (2005) advocated that collaborative learning does not only have positive effect on students' performance, but also have positive effect on motivation, classroom socialization, the students' confidence in learning and attitude towards the subject being learned.

Collaborative learning also helps students to develop self-esteem and enhances their ability to learn. Low achieving students can imitate the study skills and work habit of more proficient students, by explaining the material to the others while higher achieving students often develop deeper understanding of the task or master sharper skills. Since explanation is one of the best skills of establishing connections, and students in collaborative settings often give explanations to each other, the likelihood of constructing rich network of knowledge under this conditions increases. Parker in Uya (2015) stated that team activities, such as mathematics relays and small groups, can be used in teaching every topic in the mathematics classes. Group oriented activities can be used to attract interest and attention of students and to involve them in activities.

According to Hartshon and Boren in Uya (2015), one way to strengthen student's understanding of mathematics is the use of concrete materials. The use of concrete materials to teach mathematics is very instructive and commendable. Learning should be grounded with the use of concrete materials to reflect underlying mathematical ideas. Geoboard is one of the aids to give students an insight into basic geometry. Geoboard is an instructional aid for exploring a variety of basic mathematical concepts such as geometry measurement, graph and numbering concepts. Geoboard is designed to help children develop an understanding of these concepts and more. In order for a child to develop a meaningful understanding of mathematics, it is essential that the children know the basic concepts of geometry (Ventura, 2012).

Geoboard is designed to be a tool that teachers can use for active teaching and active learning. Mathematics concrete devices can be a rich source of teaching strategies for problem solving and can be very helpful in developing an intuitive understanding of mathematical concepts. Concrete learning experiences make learning of mathematics manipulative and interactive. Visualizing mathematical concepts is the key to understanding, which helps significantly in cognitive development (Uya, 2015).

Two theories were used as basis for this study, namely; Procedural Analogy Theory and Concrete Representation by Hall (1993), and Cognitive Development Theory by Piaget (1972). Hall (1993) is concerned with the procedural guide of instruction from theoretical to practical. Procedural analogy theory attempts to explain the value of concrete materials in the teaching of mathematics. Giving the range of possibilities for using concrete materials to help the learning of a particular concept or skill, this theory claims to be able to help teachers develop a teaching approach which will be superior to others. The theory also emphasizes that instruction should be action-based or experimental, and that learners be allowed to express their thought when manipulating the concrete materials. This expression of thought improves learners' efficiency and deeper understanding of concept through interactions.

Piaget (1972) commented that teaching and learning should be characterized by the use of methods that support active learning. That presentation of facts and ideas as a set of truths cannot be understood only through an abstract language- that mathematics involves actions and operations. Therefore, understanding mathematics should begin and end with actions. The implication here is that education should introduce students to experimental procedures and free activity. Piaget (1972) also drew attention to the need for collaboration and interchange among the students. Therefore in the classroom, learning should include both independent and collaborative student activities. The spontaneous activities based on small groups of students working together because of mutual interest in a particular activity, should be a major feature of classroom learning. Piaget's theory provides a framework for this study since it expouses that students' experimentation is an important part of instruction at all ages; and that mathematics involves action and operations, therefore mathematics should begin with actions.

2. Method

2.1 Area of the Study and Research Design

The research was carried out in Oron Education Zone of Akwa Ibom State. This zone consists of five Local Government Areas as follows: Okobo, Oron, Mbo, Udung-Uko and Urue-Ofong/Uruko Local Government Areas. The research design adopted for this study was quasi- experimental design using pretest-posttest control group design, with a 4×2×2 factorial arrangement. This indicates four levels of instructional strategies (collaborative with geoboard, collaborative without geoboard, expository with geoboard and expository without geoboard); two levels indicate the post-treatment achievement with geoboard, post-treatment achievement without geoboard; two levels of gender (male and female) post-treatment with geoboard using collaborative and expository strategies.

2.2 Population and Sample Size of the Study

The target population for the study consisted of all the 4157 Senior Secondary One (SS1) students in public secondary schools in Oron Education Zone of Akwa Ibom State during 2020/2022 academic session. The choice of this level of students was considered appropriate for the study because the concepts of geometry are taught at this level. A sample size of 235 senior secondary one students (SS1) in four intact classes was selected from the population through purposive sampling technique for the study.

2.3 Instrumentation.

A researcher- developed instrument was used in gathering the data. The instrument was Geometry Achievement Test (GAT). Four lesson plans were used for both the Experimental Groups and the Control Groups. The lesson packages contained the same concepts and objectives but differ in approach with respect to the Experimental and Control Groups. Nine broad topics (Rectangle, Parallelogram, Rhombus, Triangle, Congruent Triangle, Circle, Cube and Cuboid, Cylinder, and Cone) were treated within four weeks. The periods lasted for about 800 minutes, where 40 minutes was used for each lesson and a total of 20 lessons were treated.

The GAT consisted of 25-item multiple choice items constructed on the concepts of geometry. Each item on the GAT carries one correct answer and three distracters. It was used to measure the achievement in geometry.

2.4 Treatment

Different treatments were administered to the control and the experimental groups by their own mathematics teachers using the same contents and objectives. The substantive mathematics teachers were initially trained in the use of geoboard resource in expository and collaborative strategies classes. Also, intact class and substantive mathematics teachers were used to eliminate any possible experimental consciousness and influence on students. In all, four groups were taught using expository and collaborative strategies. Two out of the four classes were taught using geoboard (experimental groups) and two others taught without geoboard (control groups). The subjects in the group were both boys and girls.

2.5 Data Analysis

The data collected from pretest and posttests were analyzed using Mean, Standard Deviation and Analysis of Covariance to answer research questions and test the null hypotheses at 0.05 alpha level of significance. The purpose of employing ANCOVA was to control, adjust for the effects of one or more uncontrolled variables (covariate or concomitant variable) and permit a valid evaluation of the outcome of the experiment. The pre-test scores served as co-variates.

3. Result and Discussion

3.1 Result

Research Question 1: What are the differences between students' achievement in mathematics when taught using expository and collaborative strategies with geoboard as a resource materials?

Table 1-Achievement in Mathematics with Geoboard as a Resource Material.

Strategy	Pretest			Post-test		Mean Difference
	N	$\overline{X}$	SD	$\overline{X}$	SD	
Collaborative	50	27.30	9.78	42.00	10.72	14.70
Expository	70	25.04	11.59	27.97	12.17	2.93
Total	120	31.17	10.68	38.98	11.45	3.76

Results in Table 1 show that the mean post-test scores of students exposed to collaborative strategy (42.00) is greater than the mean post-test scores of students exposed to expository strategy (27.97). Also, the mean difference of students exposed to collaborative strategy (14.70) is greater than the mean difference of students exposed to expository strategy (2.93). This implies that, students exposed to collaborative strategy with geoboard as a resource material performed better in mathematics than those exposed to expository strategy with geoboard as a resource material.

Table 2-Covariance Analysis (ANCOVA) of Achievement Scores of Students taught using Expository and Collaborative Strategies with Geoboard as Resource Material

Source	SS	Df	MS	F-cal	Sig.	Decision at 0.05
Corrected model	5862.80[a]	2	2931.40	21.79	.00	Ho. Rejected
Intercept	17891.66	1	17891.66	132.88	.00	
Pretest	122.78	1	122.78	.91	.34	
Group	5356.43	1	5356.43	39.78*	.00	
Error	15753.17	117	134.64			
Total	158844.00	120				
Corrected Total	21615.97	119				

Results in Table 2 show that the main effect is significant at 0.05 alpha level because, the calculated F-value of 39.78 is greater than the critical F-value of 3.91 with 2 and 117 degrees of freedom. Therefore, the null hypothesis is rejected. Hence, the alternative hypothesis which states that, there is a significant difference in students' achievement in mathematics when taught using expository and collaborative strategies with geoboard as a resource material is retained. Also, the table further shows a multiple regression squared index (R) of 0.697 and adjusted R squared index (R) of 0.485. This implies that 69.7% of the total variance in the achievement of students in mathematics is attributable to the influence of geoboard used as a resource material in teaching the students.

Research Question 2: What differences exist in students' achievements in mathematics when taught using expository and collaborative strategies without geoboard as a resource material?

Table 3-Achievement in Mathematics when taught using Strategies without Geoboard as a Resource Material

Strategy	Pretest			Post-test		Mean
	N	$\overline{X}$	SD	$\overline{X}$	SD	Difference
Collaborative	60	21.14	7.48	23.98	8.18	2.84
Expository	55	38.35	10.61	41.27	11.20	2.92
Total	115	32.22	13.96	32.51	13.10	0.29

Table 3 shows that those taught using collaborative strategy had mean scores of 21.14 and 23.98 in pre-test and post-test respectively. These give a mean difference of 2.84. The students taught using expository strategy had measures of 38.35 and 41.27 in pretest and post-test respectively, thereby earning a mean difference of 2.92. A comparison of these differences shows that those taught using expository strategy had a slight higher mean difference (2.92) than those taught using collaborative strategy with mean difference of 2.84. This indicates that those taught using expository strategy without geoboard as a resource material performed better in mathematics than those taught using collaboration without geoboard as a resource material.

Table 4-Covariance Analysis (ANCOVA) of Achievement Scores of Students taught using Expository and Collaborative Strategies without Geoboard as Resource Material

Source	SS	Df	MS	F	Sig.	Decision at 0.05
Corrected model	8933.08[a]	2	4466.54	47.01	.00	Ho. Rejected
Intercept	16873.62	1	16873.62	117.57	.00	
Pretest	88.65	1	88.65	.93	.34	
Group	8931.45	1	8931.44	93.99	.00	
Error	10642.45	112	95.02			
Total	138169.00	115				
Corrected Total	19575.53	114				

Results in Table 4 show that the main effect is significant at 0.05 alpha level because, the calculated F-value of 93.99 is greater than the critical F-value of 3.91 with 2 and 112 degrees of freedom. Therefore, the null hypothesis is rejected. Therefore, the alternative hypothesis which states that there is a significant difference in students' achievement when taught using expository and collaborative strategies without geoboard as resource material is retained. Also, the table further shows a multiple regression squared index (R) of 0. .456 and adjusted R squared index (R) of 0. 447. This implies that 45.6% of the total variance in the achievement of students in mathematics is attributable to the influence of strategies used in teaching the students.

Research Question 3: How does students' achievement in mathematics differ when taught using collaborative strategy with goeboard as a resource material based on gender?

Table 5- Achievement in Mathematics when taught using Collaborative Strategy with Geoboard as a Resource Material Based on Gender

Gender	Pre-test			Post-test		Mean
With Geoboard	N	$\overline{X}$	SD	$\overline{X}$	SD	Difference
Female	28	20.75	8.78	22.89	9.11	2.14
Male	22	23.39	8.26	26.18	7.27	2.79
Total	50	22.15	8.84	24.12	8.18	1.97

Table 5 shows that female students had mean scores of 20.75 and 22.89 in pre-test and post-test respectively. These give a mean difference of 2.14. The male students had mean scores of 23.39 and 26.18 in pre-test and post-test respectively, with a mean difference of 2.79. Comparatively, the male students taught using collaborative strategy had a higher mean difference (2.79) than their female counterpart with a mean difference of 2.14. This implies that male students performed better than their female counterpart when taught using collaborative strategy with geoboard as a resource material.

Table 6-Analysis of Covariance (ANCOVA) of Students' Posttest Achievement in Mathematics based on Gender using Prettest as Covariates

Source	SS	Df	MS	F-cal	Sig.	Decision at 0.05
Corrected model	40.22[a]	2	20.11	.16	.853	Ho. Rejected
Intercept	7264.89	1	7264.89	57.76	.000	
Pretest	1.05	1	1.05	.01	.927	
Group	40.01	1	40.01	.32	.575	
Error	5911.16	47	125.76			
Total	99177.00	50				
Corrected Total	5951.38	49				

The results in Table 6 show that the main effect is not significant at 0.05 alpha level because, the calculated F – value of .32 is less than the critical F – value of 3.2 with 2 and 47 degrees of freedom. Hence, the null hypothesis is retained. In other words, there is no significant difference in students' posttest achievements given the instructional treatment using collaborative strategy with geoboard based on gender. Also the table further shows the multiple regression squared index (R) of 0.007 and adjusted multiple regression squared index (R) of - .036. This implies that 0.7 percent of the total variance of students' achievement in mathematics is attributable to gender influence in students' achievement.

3.2 Discussion

The result of the investigation in hypothesis one showed that a significant difference in achievement exists among mathematics students taught using expository and collaborative strategies with geoboard as a resource material. Students exposed to collaborative strategy with geoboard performed better than students exposed to expository strategy with geoboard in their posttest achievement scores. The higher achievement of students taught using collaborative strategy could be attributed to the fact that students were allowed to interact among themselves, share knowledge and agreed on some facts and ideas in each step before moving to another. So students' learning was reinforced by the contributions from their peers. Also, the intervention of geoboard as a resource material facilitated the learning both in expository and collaborative strategies. This could be explained by the fact that geoboard provided for actions and operations. Students could observe and concretise ideas presented through the geoboard.

The result in hypothesis two revealed that students differed significantly in the mean score achievement when taught mathematics using collaborative and expository strategies without geoboard with the superiority of collaborative strategy over expository strategy. This result could be explained that the relative influence of the teacher in the collaborative strategy was less than in the expository strategy. Teaching/learning process in expository strategy tends to be more of teacher-centered, students are less actively involved in the development of knowledge, but rather receive information and facts passively and so are less motivated. It could be argued that, the outcome of finding is as the result of the fact that students learn faster and depend on each other's opinion especially when atmosphere is friendly and accommodative. The exchange of information and knowledge created a relaxed learning environment, and innovative approach to learning mathematics through their effort and in building knowledge together.

The result hypothesis three revealed a no significant difference in the achievement of students taught using collaborative strategy with geoboard as a resource material based on gender, although, there exist a difference in mean scores achievement of male and female. The result could be explained that when the strategy is right, gender has little or no influence on students' achievement. But the mean scores difference could be caused attribution patterns, where female students are more anxious about mathematics and also perceived mathematics as a male domain. However, biological attributes and gender role may not be a strong predictor of students' achievement in mathematics. Even though separating gender influence on academic achievement is a complex task, there exist a psychological influence on sex disparity and intellectual abilities.

4 Conclusions

Based on the findings of this study, it is concluded that collaborative teaching strategy is more effective than the expository strategy in enhancing students learning of mathematical concepts. Also, the use of geoboard as a teaching/learning resource significantly enhances learning achievement in mathematics in both expository and collaborative strategies. Furthermore, the interactive effect of geoboard as a teaching/learning resource with teaching strategies is significantly higher with the collaborative strategy than with the expository strategy. Finally, the use of geoboard as a teaching/learning resource with either the expository or collaborative strategy is not gender discriminatory.

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