EFFECTS OF MATHEMATICS LABORATORY INSTRUCTION ON STUDENTS' GEOMETRY ACHIEVEMENT AND ATTITUDE AMONG SENIOR SECONDARY SCHOOLS IN FCT MUNICIPAL COUNCIL

UGADA P. R.[1]; RAMATU W. G.[2]; & ALFA, A. M.[2]
[1]Department of Science Education, School of Technology Education
[2]Federal University of Technology, Minna, Niger State, Nigeria
Mathematics Department, Government Secondary School, Karshi, Abuja, Nigeria
E-mail: ugada.paul@yahoo.com

Abstract
This study examined the effects of mathematics laboratory instruction on geometry achievement and attitude of secondary school students in FCT Municipal Council, Nigeria. A sample of n=232 students were drawn from 7,565 randomly selected from the secondary schools in FCT Municipal Council. The subjects were divided into two groups, the experimental group (120) and the control group (112). The study adopted the pretest, posttest experimental and control group design. A pretest was administered before the treatment to establish group equivalence in ability. The subjects in the experimental group were then exposed to the treatment using mathematics laboratory instruction, while the control group was exposed to the conventional lecture method for a period of five weeks. Two instruments were adopted and validated by experts for data collection. They are (i) Geometry Achievement Test (GAT), and (ii) Attitude Towards Geometry Inventory (ATGI). The reliability coefficients were established at 0.786 and 0.768 respectively. Two null hypotheses were tested. The data collected were subjected to statistical analysis. The t-test for independent sample statistic was used to test for the hypotheses on achievement. Mann-Whitney u-test was used to test the attitude of the subjects to the Mathematics laboratory instruction. The major findings from the study were that; students exposed to Mathematics laboratory instruction achieved the learnt concept and developed more positive attitude to geometry than their counterpart exposed to conventional method of teaching The Mathematics laboratory instruction was suitable for both male and female students in teaching and learning of geometry. On the basis of these findings, recommendations were made as follows: mathematics teachers should be encouraged to use mathematics laboratory instruction; school principals should provide all the materials needed for effective implementation. Students' attitude towards mathematics should be positively changed by involving them to participate actively in the learning process.

Keywords: Mathematics Laboratory, Instruction, Geometry, Achievement, Attitude

Introduction

Education is the primary agent of transformation towards sustainable development. It increases people's capacities to transform their visions for society into reality. All countries strive for quality education for their sustainable development. It is on this premise that it is believed that the quality of a nation's education is proportional to the level of its prosperity. Today, it is a reality to say that the standard of living of a nation is dependent on the level of science and technology of that nation. Science is the bedrock of technology while mathematics is the gate and key to sciences.

The inclusion of Mathematics as a core subject in the secondary school curriculum is due to the pivoted roles Mathematics plays in the achievement of the objectives of the secondary school education. Such pivoted roles includes promoting of science and technology, provision of trained manpower in the applied sciences, technology and commerce, acquisition of appropriate skills, abilities and competence (both mental and physical) as well as serving as equipment for the individual to live on and contribute to the development of his society (Federal Republic of Nigeria, FRN, 2014).

Esther (2015) noted that Mathematics is the foundation of science and technology and the functional role of mathematics to science and technology is multifaceted and multifarious that no area of science, technology and business enterprise escapes its application Mathematics according to Nwoke, Nnaji and Ebele (2011) is the study of quantity, structures, space and change. It developed through the use of abstraction and logical reasoning from counting, calculation, measurement, and the study of the shapes and motion of physical objects. The ingredient for the effective articulation of the abstract elements of science that gives impetus to the development of technologies of any nation is based on mathematics. The indispensability of mathematics in human day to day activities cannot be over emphasized; therefore it is considered as the bedrock of all scientific and technological breakthrough and advancement for all the activities of human development.

Mathematics involves thinking logically and reasonably so as to understand how formulae are derived and their applications. The study of mathematics has been and will continue to be of tremendous importance to humanity for its ability to explain natural phenomena and everyday occurrences as well as its central role in the world's technological development. Esther (2015) noted that the importance of mathematics does not only lie in its development but also in its utility in day to day interactions. Ogunkunle (2011) noted that the widespread utility of mathematics in scientific and technological applications has made mathematics education a key predictor of scientific competitiveness.

Mathematics is an excellent vehicle for the development and improvement of a person's intellectual competence in logical reasoning, spatial visualization, analysis and abstract thought (Curriculum Planning and Development Division (CPDD, 2007). Students who study Mathematics therefore, develop numeracy skill, reasoning, thinking skills and problem solving skills through the learning and application of Mathematics. Curriculum Planning and Development Division (CPDD, 2007) stipulated that the aims of Mathematics education are to enable students to: Acquire the necessary Mathematical concepts; skills for everyday life and for continuous learning in Mathematics and related disciplines.

Mathematics comprises of number and numeration, algebra, trigonometric, geometry, mensuration, statistics and probability. Geometry is a branch of Mathematics that deals with the study of lines, angles, triangles, polygons, circles and their properties (Olowofeso, 2012). Geometry is an aspect of mathematics which deals with the study of different shapes. These shapes may be plane or solid. A plane shape is a geometrical form such that the straight line that joins any two points on it wholly lies on the surface. A solid shape on the other hand is bounded by surfaces which may not wholly be represented on a plane surface. Godwin (2010) suggested the following broad objectives of teaching Geometry:

(i) An understanding of the basic facts about geometric figures in the plane and solid in space.
(ii) An understanding of the basic facts about geometric transformations such as reflection and translations.
(iii) An appreciation of the deductive method.
(iv) An introduction to imaginative thinking.
(v) An integration of geometric ideas into other parts of mathematics.

Geometry as a gateway to Mathematics should be studied because

(i) Geometry provides one or more points of views: or ways looking at nearly all three areas of mathematics.
(ii) Geometry interpretations; continue to provide insights leading to both the intuitive understanding of and advance in, most area of mathematics.
(iii) Geometric techniques provide effective tools for solving problems in most areas of mathematics.

Despite the importance placed on Geometry, researchers (Odili, 2006; Esther, 2015) had observed that students lack interest in Geometry and perform poorly. This research will examine the core topics in geometry where the problems of teaching and learning occurs most in mathematics. For a topic like geometry which is the bedrock of engineering and technological development, the issue of adequate physical facilities cannot be over emphasized. The physical facilities such as models will help grasp the idea of geometry which seems to be abstract. It is the facilities in terms of infrastructure, equipment and materials that afford the students the opportunity to acquire the necessary knowledge. Olatunde (2010) stated that the knowledge of mathematical concepts with the corresponding knowledge of their application to real life seems to be deteriorating. In view of the above, this study attempted to determine the effect of Mathematics Laboratory Instruction on students' Geometry achievement, retention and attitude among senior secondary schools in FCT Municipal Council.

The conventional instruction used all along had been found to be inadequate for effective teaching. According to Esther (2015); there are no enough instances when a teacher has tried to teach mathematics in an interesting way, say through activities that involves the use of mathematics laboratory instruction. Researchers Nnaji and Ogunkunle (2011); Esther (2015) had observed that lack of mathematics laboratory and mathematics teachers' non-use of laboratory technique in teaching mathematics is one of the major factors that contribute to poor achievement of secondary school students in Mathematics. Despite the importance placed on Geometry, researchers (Odili, 2006; Esther, 2015) had observed that students lack interest in Geometry and perform weakly. The West African Examination Council (WAEC) chief examiner (2016) reported candidates lack of skill in answering almost all the questions asked in Geometry. WAEC Chief Examiners (2014-2016) identified topics such as plane and solid shapes, measurement of plans and solid shapes, polygons, geometrical ratio, geometrical transformation, latitude and longitude and so on as the topics that are generally identified to be difficult by both students and teachers. Evidence of poor achievement in mathematics by secondary school students point to the fact that the most desired technological, scientific and business application of mathematics cannot be sustained. To this effect the study assessed the effect of Mathematics laboratory instruction on Geometry. It also assessed the effect of this instruction on students understanding of Geometry as when compared with those taught using the traditional strategy. In addition the effect of Mathematics laboratory instruction on students' attitude was determined. Any gender-related difference was also sought for.

Aim and Objectives of the Study

The aim of this study was to determine the effect of Mathematics laboratory instruction on students' geometry achievement and attitude among senior secondary schools in FCT Municipal Council.

The objectives of the study were as to:

(i) Assess the effect of Mathematics laboratory instruction on achievement of students' in geometry at senior secondary schools.

(ii) Determine the achievement of male and female students taught geometry with Mathematics laboratory instruction.

(iii) Determine the effect of Mathematics laboratory instruction on attitudinal change of students exposed to laboratory instructional strategy.

Research Questions

This study sought to answer the following questions:

(i) What is the difference in the mean achievement scores of students taught geometry

using Mathematics laboratory Instruction and those taught using the conventional Method?

(ii) What is the difference in the mean achievement scores of male and female students taught geometry using Mathematics laboratory Instruction?

(iii) How does the attitudinal change in the students taught geometry with Mathematics laboratory Instruction differ from those taught with conventional method?

Research Hypotheses

Based on the research questions, two hypotheses were formulated and tested at 0.05 level of significance to guide the study:

Ho_1: There is no significant difference between the mean achievement scores of students taught geometry using Mathematics laboratory Instruction and those taught using conventional method.

Ho_2: There is no significant difference between the mean achievement scores of male and female students taught geometry using Mathematics laboratory Instruction.

Ho_3: There is no significant difference between the attitude of students taught geometry with Mathematics laboratory Instruction and those taught with the conventional method.

Methodology

Quasi-experimental design was adopted for this study. Thus, this study used pre-test, post-test non-equivalent control group design. Two groups of students were used for data collection; the experimental group (EG) and the control group (CG). The experimental group was taught geometry using Mathematics laboratory Instruction which involves the use of earth globe, inclinator, protractor and tin of milo whereas the control group was taught geometry with conventional teaching method. A post-test was administered to both groups of students to evaluate the effectiveness of the treatment. A post post-test was administered two weeks after the post-test to test for the students' retention ability. The target population is made up of seven thousand five hundred and sixty five (7,565) students from secondary schools in FCT Municipal. This study considered only co-educational public schools in FCT Municipal Area because the facilities they share are common and co-educational in nature. Only the Senior Secondary School S.S.II Students were used for the study because the concept to be taught is in S.S.II scheme of work and S.S.II students will not be preparing for any Senior School Certificate Examination. A total of 232 students from intact classes were used from four selected public schools which were randomly assigned to experimental and control groups prior to the administration of treatment. Purposive sampling technique was used to select four co-educational secondary schools because the study adopted experimental design. These selected schools are believed to have and share common environmental conditions, staff, gender composition and status. The design entails the use of non - randomized samples. Hence, intact classes were used to administer the treatment because it would not be possible to randomize the subjects of the study without disrupting the school activities. Therefore, four intact classes chosen by simple random sampling (balloting with replacement) were used to administer the treatment to the experimental group and control group. Two intact classes were assigned to experimental group (Mathematics laboratory instruction) and the remaining two intact classes to conventional group (traditional lecture method).

Table 1: Distribution of sample size

S/N	School	No. of Boys	No. of Girls	Total
1	GSS Karshi	34	38	72
2	GSS Karu	28	22	50
3	GDSS Karu	27	30	57
4	GSS Jikwoyi	26	27	53
			Total	232

Two validated research instruments were used for the purpose of this study. These instruments were adopted by the researcher and used for data collection;

(i) Geometry Achievement Test (GAT): was used for pre-test, post-test and post post-test to determine the achievement of the students.

(ii) Attitudes Towards Geometry Inventory (ATGI): was used to assess students' attitude towards Geometry.

The GAT items made up of forty multiple-choice questions with four options based on students' misconceived ideas were constructed based on the topics to be taught. The items in the test constructed to test the subjects' achievement of the concepts taught covers the entire unit to be taught by the researcher on angles of elevation and depression, bearing and distances, three dimensional figures, and latitude and longitude. Attitude toward Geometry Inventory (ATGI) adopted from Martha and George (2003) is an attitudinal scale made up of statements relevant to Geometry teaching and learning. It consists of 20 items which were rated on five point likert scale of Strongly Agree (SA), Agree (A), Disagree (D), Uncertain (UN) and Strongly Disagree SD. The reliability of GAT and ATGI instruments obtained based on data collected from pilot study are 0.786 and 0.768 respectively.

The GAT and ATGI were administered to the students before starting treatment to ascertain the academic equivalence of the students and from this pre-test, results were obtained. The instruments were also administered as post- test to the same students of each group under the same classroom conditions but this time, the test items were re-arranged. The same GAT was administered as post post-test, after two weeks from the date of the last test to determine the retention of the students. The different scores obtained during pretest, post-test and post post-test will be used for data analysis. Statistically, independent t-test and Mann-Whitney U-test were used to analyze the hypotheses at 0.05 level of significance.

Results

Table 2: Mean, standard deviation and independent t-test result of pre-test of experimental and control group.

Variable	N	df	$\bar{x}$	SD	t-value	p-value	Remark
Experimental Group	129		19.06	2.83	1.066	0.288	N/Significant
		230					
Control Group	103		18.70	2.21			

Ns: Significant at $p > 0.05$

The result in table 2 indicates that there was no significant difference at 0.05 level of significance between the pre- test mean scores of the experimental and control groups ($t = 1.066$, $df = 230$, $p > 0.05$). This means that subject in the experimental and control groups were at the same entry level with regards to academic ability before the study began.

Research Question One: What is the difference in the mean achievement scores of students taught geometry using Mathematics laboratory Instruction and those taught using the conventional Method?

Table 3: Mean, standard deviation of achievement of experimental and control groups

Groups	N	Mean (x)	SD	MD
Experimental	129	49.31	8.05	1.99
Control	103	44.23	11.27	

Table 3 shows the posttest comparison between the mean achievement scores of students in both experimental group and control groups. The table shows the mean score of 49.31 for the experimental group and standard deviation of 8.05, which is greater than mean of control group 44.23 with standard deviation of 11.27. This shows that students exposed to geometry using Mathematics laboratory Instruction achieved higher mean score than those taught using the conventional Method.

Research Question Two: What is the difference in the mean achievement scores of male and female students taught geometry using Mathematics laboratory Instruction?

Table 4: Mean, Standard deviation of achievement by gender of experimental group

Variable	N	Mean ($\bar{X}$)	SD
Male	61	48.26	7.48
Female	68	50.25	8.48

Table 4 shows that male has ($\bar{x}$ = 48.26 and SD = 7.48); and Female ($\bar{x}$ = 50.25 and SD = 8.48). This shows the performance of Female students was better than Male students after treatment with a mean difference of 1.99.

Research Question Three: How does the attitudinal change in the students taught geometry with Mathematics laboratory Instruction differ from those taught with conventional method?

Table 5: Mean rank and standard deviation of experimental and control groups attitude towards geometry

Groups	N	Mean Rank	S.D
Experimental	129	132.36	13.79
Control	103	96.64	13.55

Table 5 reveals that experimental group has (Mean Rank = 132.36 and S.D= 13.79); and Control (Mean Rank = 96.55 and S.D = 13.55), after being taught geometry. This indicates that experimental group had better attitude towards Mathematics when taught geometry than control group with a mean rank difference of 35.72.

Hypothesis One: There is no significant difference between the mean achievement scores of students taught geometry using Mathematics laboratory Instruction and those taught using conventional method.

Table 6: Summary of independent t-test analysis of achievement score of experimental and control groups at post- test

Group	N	df	$\bar{x}$	S.D	t - value	p-value	Remark
Experimental	129	230	49.31	8.05	3.997*	0.000	Significant
Control	103		44.23	11.27			

*: Significant at $p < 0.05$

Table 6 Shows the t-test comparison of mean achievement scores of students in both the experimental and control group at posttest, the t– value ($t = 3.997$ $df = 230$, $p = 0.000$) and since $p < 0.05$ Ho_1 was rejected. Therefore, this indicates that students taught geometry using Mathematics laboratory Instruction significantly performed better than those taught through lecture method.

Hypothesis Two: There is no significant difference between the mean achievement scores of male and female students taught geometry using Mathematics laboratory Instruction.

Table 7: Summary of independent t-test analysis of achievement score of male and female students taught geometry using Mathematics laboratory Instruction

Group	N	df	$\bar{x}$	S.D	t - value	p-value	Remark
Male	61	127	48.26	7.48	-1.406^{ns}	0.162	N/Significant
Female	68		50.25	8.48			

^{ns}: Significant at $p > 0.05$

Table 7 above shows the comparison of independent sample t-test of mean achievement scores of male and female students in experimental group taught Mathematics using Mathematical modeling. It reveals that the calculated t–value ($t = -1.406$, $df = 127$, $p = 0.162$). $P > 0.05$. Hence, HO_2 was retained. This mean, there was no significant difference in the mean achievement scores of male and female students taught geometry using laboratory instruction.

Hypothesis three: There is no significant difference between the attitude of students taught geometry with Mathematics laboratory Instruction and those taught with the conventional method.

Table 8: Summary of Mann Whitney U-test analysis of Attitude of students taught geometry with Mathematics laboratory Instruction and those taught with the conventional method

Experimental Group	**N**	**df**	**$\bar{x}$-Rank**	**U-value**	**P-value**	**Remark**
Experimental	129	230	132.36	4598.00	0.000	Significant
Control	103		96.64			

*: Significant at $p < 0.05$

Table 8 shows the comparison of Mann Whitney U-test of the attitude of students taught geometry with laboratory instruction and those taught with the conventional method. The table reveals that the calculated U-value ($U = 4598.00$, $df = 230$, $p = 0.000$). $p < 0.05$. Hence, HO_5 was rejected. Hence, there is significant difference in the mean attitude scores of students taught geometry with Mathematics laboratory Instruction and those taught with the conventional method. This implies that students taught geometry using Mathematics laboratory instruction has better attitude towards mathematics than those taught using lecture method.

Discussion

The finding revealed that using Mathematics laboratory Instruction enhanced students' geometry achievement better than using conventional teaching method. The finding agreed with that of Esther (2015) where she discovered that students taught with mathematical laboratory instruction achieved significantly better than the control group in geometry. Nwoke and Nnaji (2011) showed that the use of Mathematics Laboratory Instruction was more effective than the lecture method in teaching and learning mathematics with respect to students' achievement. The superiority of the method over conventional teaching method has also been reported by Etukudo (2006), who carried out a study on the effect of laboratory and discussion method of teaching on students' achievement in geometry at the secondary school level.

The finding revealed that there is no significant differences in the mean scores of male and female students taught Geometry concept using Mathematics laboratory Instruction. The implication of this result is that the use of Mathematics Laboratory Instruction is good for both male and female students alike. It is not gender selective. This outcome is not surprising as both male and female students were exposed to the treatment. The finding is in line with Janet (2008), Okigbo and Osuafor (2008) which showed that mathematics laboratory instruction enhance both male and female achievement in geometry. The fact that neither the male nor the female achieved significantly better than the other seem to make the method gender friendly.

The finding revealed that significant differences exist between students exposed to Mathematics laboratory Instruction and those exposed to conventional method (control group) in their level of attitude towards Geometry. This showed that experimental group of students had significantly higher mean level of attitude towards Geometry than their counterparts in control group that were not exposed to the treatment. For instance majority of the control students have difficulty in understanding the language used in teaching geometry as compared to that of experimental students. This finding is in conformity with Esther (2015), Akinsola and Olowojeye (2008) who found that teacher methods of mathematics teaching with the use of mathematics laboratory instruction accounted for the students positive attitude towards geometry.

Conclusion

Students exposed to Mathematics laboratory Instruction had significantly higher academic achievement than their counterparts that were exposed only to the conventional method. The Mathematics laboratory instruction is suitable for both male and female students in the teaching and learning of geometry. Geometry concepts were retained when Mathematics laboratory Instruction was used as a medium of instruction for senior secondary mathematics students, thus, the attitude of students towards geometry was also improved.

Recommendations

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

(i) Mathematics teachers should incorporate Mathematics laboratory Instruction in the teaching of concepts in geometry, and all other concepts in mathematics.

(ii) Mathematics teachers should be motivated by sponsoring them to attend seminars, workshops and paper presentations in modern techniques of teaching mathematics.

(iii) Curriculum planners should emphasize on the use Mathematics laboratory Instruction as they plan mathematics curriculum.

References

Abiami, P. O., & Odok, J. K. (2006). Factors in students achievement in different branch branches of secondary school mathematics. *Journal of Education and Technology, 1*(1), 161-168.

Achor, E. E., Otor, E. E., & Umoru, W. (2013). Effects of computer-based instruction (CBI) on students' retention in biology in Olamaboro. *Journal of Science, Technology Mathematics and Education (JOSTMED), 9*(3), 148-158.

Akuezuilo, E. O., & Chinweoke, F. U. (2009). Effectiveness of prior knowledge of behavioural objectives and study questions on female studies. *Mathematics Achievement. UNIZIK Journal of STM Education, 1*(1), 1-7.

Anyamene, A., & Anyachebelu, F. U. (2009). Effects of use of advance organizer of students' achievement and retention in mathematics. *Unizik Journal of STM Education, 1*(1), 58-64.

Anyanwu, C. R., Ezenwa, V. I., & Gambari, A. I. (2014). Bridging the gap between low, medium, high ability students through the use of computer-Based multimedia instruction, *Journal of Information, Education, Science and Technology, 1*,(1), 105-115.

Ball, D. (2010). Magical hopes: Mathematics laboratory and the reform of math education. *American Educator*, 16, 14-18.

Erickson, G. L. (2009). Females and science achievement. *Journal of Science Education, 6*(92), 63-89.

Ezendu, F. O., & Ezinwance, O. P. (2013). Effects of simulation on students' achievement in senior secondary school chemistry in Enugu East Local Government Area of Enugu State, Nigeria. *Journal of Educational Practice*, 4(19).

Fuys, D., Geddes, D., & Tischler, R. (2008). *The Van Hiele model of thinking in geometry among adolescent.* Reston: VANCTIM

Gambari, A. I., Falode, C. O., & Adegbenro, D. A. (2014). Effectiveness of computer animation and geometrical instructional model on mathematics achievement and retention among junior secondary students, *European Journal of Science and Mathematics Education* 2 (2).

Garu, S. S. (2009). Mathematics laboratory. Cosmed 2009 International Conference on Science Mathematics Education Pencing Malaysia.

Hyde, J. S., & Mertz, J. E. (2009). Gender, culture, and mathematics performance. Proceedings of the National Academy of Science, 106(22), 8801- 8807.

Kurumeh, M. S., & Eniayeju, A. A. (2008). Cuisenaire rods' approach to teaching and learning of fractions in senior secondary schools. *Journal of Issues on Mathematics, 11*(1), 21-29.

Manjunath, D. (2008). Mathematics laboratory: An alternative method of instruction. *Educational Research*, 2(5).

Nwoke, E., & Nnaji, C. O. (2011). Effect of using mathematics laboratory in teaching mathematics on the achievement of mathematics students. *Educational Research and Review, 13*(8).

Nworgu, L. N. (2009). Effect of gender sanitization package (GSP) on students' achievement in integrated science. *JSTAN, 40*(1&2), 74-79.

Obeka, S. S. (2010). Effect of inquiry and demonstration methods on students achievement and retention in some environmental education concepts of education. *Journal of Studies in Science and Mathematics Education*, 1(1), 52-58.

Ogunkunle, R. A. (2011). Teaching of mathematics in schools: The laboratory approach. *The Nigeria Teacher Today*, 8(1&2), 80-184.

Okereke, S. C. (2011). Effect of prior knowledge of implementing of mathematics tasks/concepts to career types and gender on students' achievement, interest and retention. STAN Proceedings of the 47th Annual Conference, 253-259.

Okigbo, E. C., & Osuafor, A. M. (2008). Effects of using mathematics laboratory in teaching mathematics on the achievement of mathematics students. *Educational Research Review, 3*(8), 257-261.

Olatunde, Y. P. (2010). Adequacy of resource materials and students' mathematics achievement of senior secondary schools in South Western Nigeria. *Educational Research and Review 3*(3), 103-107.

Orialfo, S. O. (2008). Strategies for teaching science, technology, and mathematics for learners' gain. *A Publication for STAN, Pp. 1-13.*

West African examination council (2005, 2014-2016). Senior school certificate examination chief examiners reports Lagos.

Yadar, R. F. (2009). A vision for what science education should be like for the first 25 years of a new millennium. *School Science and Mathematics*, 100(82), 327-341.