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Effect of Virtual Mathematics Laboratory on Senior Secondary School Student's Achievement in Circle Geometry

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Abstract: This study investigated the effect of virtual mathematics laboratory on student's achievement in secondary school geometry in North-Central geopolitical zone of Nigeria. The influence of gender on student's academic achievement in circle geometry was also examined in the study. The study used a quasi-experimental research design specifically a non-equivalent pre-test, post-test control group design involving two intact classes. One intact class was taught with Virtual Mathematics Laboratory (VML) while the other was taught with Traditional Mathematics Laboratory (TML). Three research questions and three hypothesis guided the study. The population for this study consisted of 5657 students in SS2 from Co-educational Federal Government Colleges in the North-Central. The sample for the study consisted of 96 SS2 (55 males and 41 females) students. Purposive and simple random sampling techniques were used to produce the sample. The instrument for data collection was the Geometry Achievement Test (GAT) developed and validated by the researchers. The internal consistency of GAT section B (Objective Test) was established to be 0.99 using Kuder Richardson's Formula (K-R 20) while that of section C (Essay part) was determined using pearson's product moment correlation coefficient of two scorers and a correlation coefficient of 0.81 was established. GAT was administered to the experimental and control groups as a pre-test after which the treatment commenced and lasted for 3 weeks. Then, the same instrument with serial numbers rearranged was administered to the subjects to produce post-test scores. The data generated from the two sets of tests were used to answer research questions and test the hypothesis. The research questions were answered using mean and standard deviation while the hypothesis were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The results obtained indicated that students taught circle geometry using VML achieved significantly higher than those taught using TML but there was no influence of gender on student's achievement in circle geometry. The result also indicated that there was no significant interaction effect t of type of mathematics laboratory and gender on student's achievement in circle geometry. Based on the findings, it was recommended among others that, mathematics teachers and students should endeavour to use VML in teaching and learning circle geometry. Suggestions for further studies were made among which a study on other circle theorems and other topics in mathematics were suggested.

Key words: Virtual mathematics laboratory, traditional mathematics laboratory, geometry, achievement and gender, interaction, achievement

INTRODUCTION

Mathematics is an essential tool for development in any nation. It is a yardstick and a predictor of successful development and growth of any nation's economy. This is true because the knowledge of mathematics is needed in any nation for scientific discoveries and technological breakthrough which are indices of development in any nation (Anigbo, 2016). Research evidence has proved that mathematics is an essential tool for successful development and productivity in many nations (Kurumeh *et al*., 2012; Gambari *et al*., 2018). This means that for any nation to achieve economic development, that nation must at first achieve a tangible development in the area of mathematics which will lead to a scientific and technological breakthrough. It is in an attempt to achieve this economic development, according to Gimba and Angwagah (2012) that Nigeria as a nation repose implicit

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confidence in the power of science and technology to deliver her from poverty, ignorance and diseases which are the three indices of under development in any Nation. This is why the national policy on education for the FRN. (2008) prescribed mathematics as a core and compulsory subject for all students in primary and secondary schools. Consequently, this is why every student seeking entry into tertiary institutions in Nigeria is expected to be competent in mathematics and must also pass it at credit level. Mathematics has always been a core subject in the junior and senior secondary school curriculum right from the colonial and post colonial curriculum development in Nigeria due to its importance. The importance and the role of mathematics to science and technology for the attainment of economic development of any nation cannot be overemphasized.

Despite the importance and the role of mathematics in the economic development of any nation, there is a consistent poor achievement of students in mathematics in Nigeria. This poor achievement is evidenced in WAEC Chief Examiner's Reports over the years ranging from 2010-2016 in general mathematics. It has also been observed from a comparative analysis of WAEC report, according to geopolitical zones in Nigeria by Eze (2014) that student's achievement in Nigeria, especially, in the North-Central geopolitical zone has been very poor. Olagunju and Jimoh (2013) reported on poor achievement of students in mathematics and observed that WAEC Chief Examiner consistently reported candidate's lack of skills in answering questions in mathematics particularly in geometry.

Many factors could be responsible for this poor achievement of students in mathematics. Such factors include lack of mathematics laboratories in secondary schools in Nigeria, the predominant use of the traditional method of instruction. Other factors that could have led to poor achievement include mathematics phobia, gender disparity, lack of mathematics teachers, lack of lesson planning, the abstractness of the subject, student's poor background in mathematics among others (Gambari, 2010; Goolsby, 2013; Kurumeh and Onah, 2013; Anigbo, 2016). Investigations into these factors to arrest the problem of poor achievement in mathematics need prompt attention. If the situation is neglected, it may deny many Nigerian children admission opportunities into tertiary institutions. This effect will be disastrous not only to mathematics education but also to other disciplines. This is true because mathematics is a pre-requisite for admission into other disciplines. This may, in turn have a drastic effect on the economic development of Nigeria.

Despite the importance and the role of mathematics laboratories in teaching and learning, there is a lack of mathematics laboratories in Nigerian secondary schools and this may be among the causes of poor achievement in mathematics. The reason for its unavailability in secondary schools could be attributed to many factors among which include a high demand on space, cost of land and buildings, expensive or cost of apparatus or instruments and other experimental infrastructures (Kurumeh, 2008; Gambari, 2010). Other factors could be negligence on the part of the government to provide mathematics laboratory in Nigerian secondary schools as well as the school management.

There are two types of mathematics laboratories; traditional mathematics and virtual mathematics laboratories. Traditional mathematics laboratory refers to a room or building, real and physical environment equipped with instruments for teaching, learning or conducting research and experiments in mathematics. Mathematics laboratory, according to Kurumeh *et al*., (2012) is a special place in the school where students carry out demonstrations, constructions or practical mathematics instructions. Based on these definitions, mathematics laboratory can be defined as a special place designated for students to learn, explore and verify mathematical concepts, facts and theorems through a variety of activities using different materials.

On the other hand, virtual laboratory comes from two distinct words, virtual and laboratory. The word virtual simply refers to something that is not, in fact, a reality but imitated or simulated nearly or almost to a reality. While the word laboratory refers to a room, place, environment or building equipped with instruments for research and experiments. The fusion of the two words gave rise to the concept of a virtual laboratory which is referred to as an interactive environment with simulated tools meant for creating and conducting experiments. A virtual laboratory, according to Onyesolu and Eze (2011) is a computer-based learning environment where learners are able to simulate experiments that could be done in a traditional laboratory through the use of the computer. It is a digital or computer environment with real laboratory tools simulated for the conduct of experiments. materials saved on computers, CDs and websites to perform experiments (Babateen, 2011; Nunn, 2009). Virtual laboratory uses the power of computerized models and simulations to replace traditional laboratory activities. A virtual laboratory is an interactive simulation of a traditional laboratory. The roles of virtual laboratory in teaching and learning process cannot be over-emphasized. Therefore, based on the views of the researchers in this study, virtual mathematics laboratory can be defined as a computer-based learning environment where learners are able to simulate experiments that could

be done in a traditional mathematics laboratory. In other words, virtual mathematics laboratory is a simulated version of the traditional mathematics laboratory.

The use of virtual mathematics laboratory for teaching and learning mathematics may bring about revolution in the world of mathematics because virtual mathematics laboratory has advantages over traditional mathematics laboratory on the basis of cost and accessibility. The cost of building and equipping the traditional mathematics laboratory is higher than the cost of developing virtual mathematics laboratory. The accessibility of virtual mathematics laboratory is more than traditional mathematics laboratory because virtual laboratories are available to students on CDs and on internet for use at home and in schools with the emergence of the new technological devices such as Palm tops, Laptops, Tablets, iPhones, Android phones among other devices at the student's disposal. The issue of cost and accessibility of virtual mathematics laboratories provide opportunities that are not possible with the use of traditional mathematics laboratory. Another issue with traditional mathematics laboratory is that facilities in traditional mathematics laboratories may only be available to learners during the school working hours but virtual mathematics laboratory will be available to learners at anytime and anywhere. This may help to supplement traditional mathematics laboratory learning because it affords learners opportunities to perform experiments and do revisions anywhere and at anytime as far as the user has access to computer with installed virtual mathematics laboratory or on internet. Akinoso (2011) suggested that the use of teaching methods that are good enough to train the mind and competencies which invariably eliminate mathematics anxiety and phobia thereby enhancing student's interest or motivation in learning of the mathematics are necessary. The use of mathematics laboratory is one of such methods of instruction. This may be true because the rapid increase in the use of educational computer in the classroom in the recent time has achieved a tangible change in the teaching and learning processes and virtual mathematics laboratory is a computer-based teaching device.

The use of virtual mathematics laboratory in teaching and learning mathematics is anchored on the information processing theory of learning propounded by Miller (1956). Miller provided two theoretical ideas of chunk and the capacity of short term memory to explain the theory. Miller observed that, short-term memory could only hold 7 chunks of information. Chunk is any meaningful unit. Test-Operate-Test-Exit (TOTE) proposed by Miller *et al*., (1960) was the second theoretical idea to information processing theory. TOTE refers to a learning situation where a learning task is tested to see, if the learning goal has been achieved and if not an operation will be performed to ensure that the goal is achieved. This theory is relevant to this study because, the practical activities in the virtual mathematics laboratory were designed to enable students to experience test-operate-test-exit (through rehearsal for the mastery of the knowledge) as proposed by Miller until the learning goal is achieved. The virtual mathematics laboratory was designed and developed with information in chunk that is circle theorems in the virtual laboratory were designed in chunk in a manner to enhance storage of the information in the short and long term memories without additional cost which may definitely enhance learning and achievement of students irrespective of gender, since, gender has been reported to be one of the factors affecting student's achievement in mathematics.

Gender is a construct that differentiates males from females based on the physical features endowed by nature to humans before birth. Mberekpe also refers to gender as a biological difference between male and female from nature or birth. Gender disparity in student's achievement has been a critical issue in mathematics over the years. Several studies in mathematics in the recent time have taken the issue of gender in relation to student's achievement as a serious variable of interest yet there is no definite and consensus result on the issue. The findings on the subject of gender and student's achievement in mathematics have been inconclusive and contradicting. Some studies discovered that male student's achieved better than their female counterparts in the same mathematics achievement test (Kurumeh and Onah, 2013; Olagunju and Jimoh, 2013). Other studies such as Gimba and Angwagah (2012) discovered contrary results where female students were found to achieve better than male student in the same test. Iwendi and Oyedum (2014) reported no significant difference in the achievement of male and female students in mathematics. This controversial report on gender could be attributed to nature and probably teaching methods exhibited by mathematics teachers. This may be true because some people believe that mathematics is male's subject and not female right from nature (Badmus, 2002). It is based on these contradictions from earlier studies that the researchers investigated the effect of virtual mathematics laboratory on student's achievement in circle geometry and determined the influence of gender on student's achievement in the study.

It has also been noted that teachers find it difficult to teach geometry in Nigerian secondary schools. This has been noted by several researchers such as Olagunju and Jimoh (2013) and Anigbo (2016). These researchers in

separate studies discovered that the teaching of geometry and student's achievement in it has been a very serious problem over the years in secondary schools in Nigeria. Geometry is one of the branches of mathematics that is taught in all classes at senior secondary school in Nigeria. It is the study of shapes and its properties. The shapes could be circles, rectangles, triangles, curves, planes and solid shapes, squares among others. While the properties could be size of angles, lengths and breathe, surface areas and others. The learning of geometry in secondary schools in Nigeria is very crucial to students because the knowledge of geometry helps students to understand other branches of mathematics such as Surds, Logarithms etcetera and also, due to its vast application to many fields of studies such as Arts, Architecture, Engineering, geography, Physics among others.

The study of geometry is divided in into two broad types in Nigerian secondary school, namely solid and plane geometry. While solid geometry, according to Brown *et al*. (2010) deals with three dimensional shapes, plane geometry according to Page deals with the study of two dimensional shapes. The study of plane shapes covers flat shapes which include rectangle, squares, lines, triangles and circle. Circle geometry is the study of two dimensional shapes including circles in combination with other plane shapes. The study of circle geometry must involve a circle and other plane shapes. The other plane shapes are formed inside the circle or on the circumference. It means that, the study of plane shapes in conjunction with a circle is known as circle geometry. If the circle is excluded it will no longer be circle geometry. Despites the importance of geometry, it is observed that geometry is one of the branches of mathematics that is difficult for teachers to teach and students to learn.

It has been observed from the literatures reviewed in this study that, there is lack of mathematics laboratories in Nigerian secondary schools, geometry has also been identified as one of the branches of mathematics that is difficult for teachers to teach and students to learn; there is a consistent poor achievement of students in mathematics, especially, geometry, researchers have made serious efforts to identify factors that are responsible for student's poor achievement in mathematics but much has not been done on the use of virtual mathematics laboratory in Nigeria to the best knowledge of the researchers. Results from several studies have also shown inconclusive findings about the influence of gender on student's achievement in mathematics. Therefore, there is need to conduct a study on the effect of virtual mathematics laboratory on senior secondary school student's achievement in circle geometry in Nigeria. It is also important to determine the influence of gender on student's achievement in circle geometry in the study. The following research questions were formulated to guide this study

- What is the effect of virtual and traditional mathematics laboratory on mean achievement scores of students in circle geometry?
- What is the influence of gender on the mean achievement scores of students in circle geometry?
- What is the interaction effect of type of mathematics laboratory and gender on student's achievement in circle geometry?

Hypothesis: The following null hypothesis were formulated to guide the study:

- H_{o1}: there is no significant difference in the mean achievement scores of students taught circle geometry using virtual and traditional mathematics laboratories
- H_{o2}: there is no significant difference in the mean achievement scores of male and female students in circle geometry
- H_{o3}: there is no significant interaction effect of type of mathematics laboratory and gender on student's achievement in mathematics

MATERIALS AND METHODS

Study design: The study adopted a quasi-experimental research design. Specifically, a non-equivalent, pre-test, post test control group design. Kurumeh *et al*. (2012) and Egbe (2015) observed that quasi-experimental research design is the most appropriate research design to use where intact classes are involved in a study. This design was considered appropriate for this study because intact classes were involved in this study. The students that were used in this study were from intact classes and randomization of the research subject was not necessary. The study had two levels of independent primary variables (Traditional and Virtual mathematics laboratories), two levels of academic achievement (high and low) and two levels of gender (male and female). The pre-test and post test were administered to both groups experimental and control. Treatments in this study were virtual mathematics laboratory for experimental group and traditional mathematics laboratory for control group. Virtual and traditional mathematics laboratory were independent variables while the achievement test was dependent variable considered in the study. Gender was the moderating variable.

Sample and sampling techniques: The population for this study consisted of all senior secondary school students in the 24 Federal Government Colleges in the North-Central geopolitical zone in Nigeria and the target population was 5657 Senior Secondary School two (SSS2) student from all Co-Educational Federal Government colleges in the North-Central geopolitical zone of Nigeria. The sample size for this study consisted of 96 students (55 males and 41 females). To produce this sample, a purposive sampling technique was used to select 10 Co-Educational Federal Government Colleges from the North-Central geopolitical zone of Nigeria. A simple random sampling technique was then employed to select two schools and two intact classes from the selected Co-educational Federal Government Colleges using balloting otherwise called lucky dip (hand dip without replacement). The two schools were assigned to experimental and control groups. The experiment group was taught using VML and control group taught using TML.

Validation of the instrument: Two instruments were used for this study namely; Virtual Mathematics Laboratory (VML) and Geometry Achievement Test (GAT). VML was used as a treatment and GAT was used for data collection.

The geometry achievement test was subjected to face and content validity using six experts. One of the experts was a specialist in measurement and evaluation; two were specialist in Educational Technology in the Faculty of Education, University of Nigeria, Nsukka, three of the experts were specialist in Mathematics, one of them was in Mathematics Education in the Faculty of Education, University of Nigeria, Nsukka, one was a mathematics teacher in the Secondary school, another was a specialist in a Mathematical Modeling and Simulation from Akparan Orshi College of Agriculture, Yandev, Benue State. In order to achieve the face and content validity, GAT was presented to the specialists to examine the test items generated in relation to the test blue/table of specification and the content scope for the study.

Virtual mathematics laboratory was also subjected to validation by the same experts. These experts were requested to validate the teaching and learning functions of the VML by vetting the content and manipulation of the virtual tools to determine the effectiveness and appropriateness of the program language, typographical errors, legibility of the virtual laboratory, navigations, the interface, animations and the general functionality of the package for effective teaching and learning of circle geometry in secondary schools.

Reliability of the instrument: To obtain the reliability of the instrument, GAT was subjected to a trial test using 40 SS3 students at Federal Government College, Enugu in the South-East geopolitical zone of Nigeria. These students were considered to be the most appropriate group of students for the trial test because they have learnt circle geometry recently in SS2 and were currently preparing for WAEC examination. These students are also outside the study area and they possess similar characteristics with the target population. In order to arrive at the internal consistency of GAT Section B (Objective Test), the data collected from the trial test were subjected to Kuder Richardson's Formula 20 (KR - 20). A reliability coefficient of 0.99 was obtained for section B. Section C (Essay Test) of GAT was photocopied and scored by two mathematics teachers. The two scores obtained from the two scorers were used to calculate the reliability coefficient (r) of Section C of GAT using Pearson's product moment correlation coefficient. A correlation coefficient of 0.81 was obtained. This shows that GAT instrument was reliable for the study.

Method of data collection: In order to collect data for this study, researchers first of all, visited the schools that were involved in the study to seek the cooperation of the principals to mount their research program in those schools. This was achieved after introducing the purpose and the significance of this study to the principals. This helps the researchers to gain the cooperation of those principals throughout the period of the study in those schools.

The researchers were introduced to the SS2 mathematics teachers in the two selected schools for the study by the principals. The mathematics teachers in those schools became the research assistants in the study, hence, the researchers were not directly involved in the administration of the treatments in the study. The researchers trained the research assistants (the mathematics teachers) on how to perform the experiment using VML for experimental group and TML for control group. The entire study lasted for a period of 4 weeks. The 1 week for the training of research assistants, 3 weeks for treatment and administration of the achievement test.

After the training of research assistants, the study commenced by the administration of GAT as a pre-test to both the experimental and control groups. The scripts were collected and given to the researchers for marking. The treatment for both groups started after the pre-test, where experimental group were taught using VML and control group taught using TML. Week 1: introduction to circle geometry and theorem one, a straight line drawn

from the centre of a circle to bisect a chord which is not a diameter, is at right angles to the chord. Week 2: the angle which an arc of a circle subtends at the centre is twice that which it subtends at any point on the remaining part of the circumference. Week 3: angles in the same segment of a circle are equal an angle in a semicircle is a right angle.

After the treatment, the research assistants administered GAT as post-test to both the experimental group and control group. The post-test items were the same as the pre-test items. The only difference between the post-test and the pre-test items is that the pre-test items were reshuffled by changing their serial numbers only without any other alteration to obtain post test. At the end of the post-test, the scripts were marked by the researchers for data analysis.

Method of data analysis: Mean and standard deviation were used by the researchers to answer the research questions. These statistical tools were considered to be appropriate statistical tool for answering research questions because Nworgu (Neboh, 2009) stated that, mean is the most reliable measure of central tendency and standard deviation is the right statistics to estimate variability. While Analysis of Covariance (ANCOVA) was the statistical tool used for the testing of the hypothesis at 0.05 level of significance.

RESULTS AND DISCUSSION

The results of this study are presented, according to the research questions and hypothesis formulated for the study.

Research question one: What is the effect of virtual and traditional mathematics laboratory on the mean achievement scores of students in circle geometry?

Table 1 shows the result of experimental group (VML group) pre-test mean achievement score of 19.78 and standard deviation of 7.83 and the post test mean achievement score of 70.17 with 7.87 standard deviation. While the control group (TML group) pre-test mean achievement score is 18.58 with a standard deviation of 6.63 and a post test mean achievement score of 52.48 with 17.32 standard deviation. The data on Table 1 also shows an adjusted mean score of 69.94 for the experimental group against an adjusted mean score of 52.70 for the control group. The experimental group had a higher adjusted mean score of 17.24 than the control group. This result, therefore, shows that students taught circle geometry using virtual mathematics laboratory achieved higher than those taught with Traditional Mathematics Laboratory. Nevertheless, the experimental group had a post test standard deviation score of 7.87 and that of control group was 17.32. This shows that the experimental group individual scores of students clustered around the group mean than the control group.

Table 1: Pre and post test mean achievement scores and standard deviation of the experimental and the control groups

Groups	N	Pre-test $\bar{x}$	SD	Post-test $\bar{x}$	SD $\bar{x}$	Adjusted
Experimental (VML)	46	19.78	7.83	70.17	7.87	69.94
Control (TML)	50	1858	6.63	52.48	17.32	52.70

Table 2: Pre and post test mean achievement scores and standard deviation of male and female

Groups	N	Pre-test $\bar{x}$	SD	Post-test $\bar{x}$	SD $\bar{x}$	Adjusted
Male	55	19.75	8.09	62.31	15.95	61.62
Female	41	18.37	5.85	59.15	16.59	60.07

Research question two: What is the influence of gender on the mean achievement scores of students in circle geometry?

Table 2 shows the male students pre-test mean achievement score of 19.75 and standard deviation of 8.09 while female counterpart's pre-test mean achievement score was 18.37 with 5.85 standard deviation. Table 2 also shows male students post test mean achievement score of 62.31 along side with the standard deviation of 15.95 while the female students post test mean achievement score was 59.15 and standard deviation was 16.59. The table shows the adjusted mean score of male students to be 61.62 and adjusted mean score of 60.07 for female. There is a difference of 1.55 in the adjusted mean score of male against the female students. The difference in the adjusted mean scores shows that male students achieved higher than female students in the post test. The post test standard deviation of male of 15.95 and female of 16.59 shows that the male student's individual scores clustered around the group mean more than the female students.

Research question three: What is the interaction effect of type of mathematics laboratory and gender on student's achievement in circle geometry?

Table 3 shows that, male students taught circle geometry using VML had post test mean score of 69.39 and standard deviation of 8.72 while their female counterparts had a post test mean score of 71.39 and 6.35 standard deviation. Male students taught using TML on the other hand had 54.96 post-test mean scores with a standard deviation of 18.43 whereas female students achieved a post test mean score of 49.57 and 15.84 standard deviation. The data on Table 3 shows the

Table 3: Interaction effect of type of mathematics laboratory and gender on student's post mean achievement and standard deviation

	Experimental			Control		
Groups	N	$\bar{X}$	SD	N	$\bar{X}$	SD
Pretest						
Male	28	20.86	9.08	27	18.59	6.90
Female	18	18.11	5.16	23	18.57	6.44
Posttest						
Male	28	69.39 (69.30)	8.72	27	54.96 (54.96)	18.43
Female	18	71.39 (71.54)	6.35	23	49.57(49.57)	15.84
Total						
Observed mean		70.17	7.87		52.48	17.32
Adjusted mean		69.94			52.70	

Adjusted mean are in parentheses

Table 4: Summary of Analysis of Covariance (ANCOVA) of student's post achievement scores in circle geometry by type of mathematics laboratory and gender

Source of variation	Type III sum of squares	F-values	df-Mean	Square at p<0.05	Sig.	Decision
Corrected model	8383.236[a]	4	2095.809	11.483	0.000	S
Intercept	35743.351	1	35743.351	195.841	0.000	S
Pre-test scores	476.974	1	476.974	2.613	0.109	NS
Group	7383.583	1	7383.583	40.455	0.000	S
Gender	36.928	1	36.928	0.202	0.654	NS
Group * gender	392.519	1	392.519	2.151	0.146	NS
Error	16608.598	91	182.512			
Total	381720.000	96				
Corrected total	24991.833	95				

[a]R^2 = 0.335 (Adjusted R^2 = 0.306), S = Significant at 0.05 level, NS = Not Significant

interaction effect that is not ordinal between type of mathematics laboratory and gender on student's achievement scores in circle geometry. This is because at all levels of gender, the post test mean achievement of the group taught using VML is higher than the group taught using TML. The higher achievement recorded in the experimental group could be as result of the effect of VML to the group or interaction effect of type of mathematics laboratory and gender. Going by the standard deviation of the experimental and control group, table shows that individual scores in the experimental group for both male and female clustered at the group mean score while that of the control group was extreme to the group mean.

Hypothesis one:

- H_{o1}: there is no significant difference in the mean achievement scores of students taught circle geometry using virtual and traditional mathematics laboratory

Table 4 shows that F(1, 91) = 40.455, p<0.05. This shows that, the group taught circle geometry using Virtual Mathematics Laboratory (VML) achieved better than the other group taught using Traditional Mathematics Laboratory (TML). The null hypothesis that, there is no significant difference in the mean achievement scores of students taught circle geometry using virtual and traditional mathematics laboratory is rejected. This means that a significant difference existed in the mean achievement scores of students that were taught circle geometry using virtual and traditional mathematics laboratory.

Hypothesis two:

- H_{o2}: there is no significant difference in the mean achievement scores of male and female students in circle geometry

Table 4 shows that F(1, 91) = 0.202, p>0.05 which means not significant. This shows that male and female students that were taught circle geometry using virtual mathematics laboratory and traditional mathematics almost the same in their post test. Thus, the null hypothesis that, there is no significant difference in the mean achievement scores of male and female students in circle geometry is upheld.

Hypothesis three:

- H_{o3}: there is no significant interaction effect of type of laboratory and gender on student's mean achievement in mathematics

Table 4 shows data on the interaction effect of type of mathematics laboratory and gender on student's achievement with F(1, 91), p>0.05. This result shows that, the interaction effect of type of mathematics laboratory and gender on student's mean achievement scores in circle geometry is statistically not significant. Therefore, the stated null hypothesis which says that there is no

significant interaction effect of type of laboratory and gender on student's mean achievement in mathematics is upheld.

Effect of virtual mathematics laboratory on student's achievement in circle geometry: The result from this study shows that, experimental group students that were taught circle geometry using Virtual Mathematics Laboratory (VML) acquired higher mean achievement scorein the post test against the control group taught the same content of circle geometry using Traditional Mathematics Laboratory (TML). The result from the tested hypothesis in regards to the research question revealed that, the difference in the mean achievement scores of the two groups experimental and control is statistically significant. The group taught with VML achieved significantly higher than the group taught with TML. This result, therefore, shows that VML has significant effect on student's achievement in circle geometry because the higher achievement in experimental group could be attributed to the effect of VML. The result of this study is the same with the findings of some earlier studies which also discovered in their separate studies that students taught with virtual laboratories achieved higher than those taught with traditional (Swan and O'Donnell, 2009; Gambari *et al*., 2018). On the other the hand the finding of the study disagreed with Kerr *et al.* (2004), Abdulwahed and Nagy (2009), Tatli and Ayas (2012) and Falode (2014) that reported no significant difference in the student's mean achievement scores of those taught using virtual laboratory and traditional laboratory.

Influence of gender on student's achievement in circle geometry: The analysis from this study on the influence of gender on student's achievement in circle geometry was considered on the basis of males and the females from two groups, experiment and control. The result shows that the post test mean achievement scores of male was higher than their female counterparts. A mere look at the mean achievement scores of male and female for both groups appears that, the male students achieved higher than female counterparts but the test of hypothesis in relation to the difference in their mean achievement scores revealed that the difference in the mean achievement scores of male and female in circle geometry is not statistically significant. The result of this study is in agreement with Viann (Gambari *et al*., 2018). The result also supports the findings of Olagunju (2001), Gbodi and Laleye (2006) that discovered no gender influence on student's achievement in mathematics. Meanwhil, the findings of this study disagreed with some earlier findings that discovered a significant gender influence on student's achievement in mathematics (Iwend and Oyedum, 2014; Gambari *et al*., 2018). This study, therefore, opposed the assertion by some researchers that gender is a significant factor that influences student's achievement in mathematics (Alio and Harbor-Peters, 2000; Ezeugo and Agwagah, 2000; Jahun and Momoh, 2001; Amali *et al*., 2004).

Interaction effect of type of laboratory and gender on student's achievement in circle geometry: It is clearly established from the empirical data in this study that significant interaction effect of type of mathematics laboratory and gender on student's achievement in circle geometry does not exist. This simply means that the higher achievement scores of experimental group can only be attributed to the effect of VML which was the treatment on the group but not as result of interaction effect of mathematics laboratories and gender. The finding from this study is the same with that of Achor *et al.* (2010) that also discovered no significant group and gender interaction on student's mean achievement in geometry. The finding is also in agreement with Kurumeh (2004) and Ogunleye *et al.* (2014). The study, therefore, disagreed with some studies that discovered significant interaction effect of group and gender on student's academic achievement in mathematics such as Anyichie and Onedike (2012), Sani (2011) and Akinsola and Odeyemi (2014).

CONCLUSION

The following conclusions were made based on the findings from this study, there exist a significant effect of type of mathematics laboratory on student's achievement in circle geometry, type of mathematics laboratory has been found to improve student's achievement significantly in circle geometry, students that were taught circle geometry using VML were found to achieve significantly higher against those taught using TML. This implies that the use of VML has been found to be more effective over TML in improving student's achievement in circle geometry. There is no significant gender influence on student's achievement in circle geometry. Achievement of males and females in this study were almost the same. The interaction effect of type of mathematics laboratory and gender did not influence student's achievement in circle geometry.

RECOMMENDATIONS

Based on the conclusions drawn from this study, the following recommendations are made, the use of virtual

mathematics laboratory in teaching and learning circle geometry in senior secondary schools has been found to improve student's achievement. Therefore, mathematics teachers and students should endeavour to use VML in teaching and learning mathematics, respectively.

Gender disparity does not exist or link with student's achievement in circle geometry, therefore, both male and female student should endeavour to use VML to learn circle geometry.

Curriculum developer such as the Nigerian Educational Research and Development Council (NERDC) should incorporate the use of virtual mathematics laboratory as an effective and innovative method of teaching circle geometry in mathematics curriculum of secondary schools in Nigeria.

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