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COMPARATIVE EFFECT OF VIRTUAL LABORATORY AND PHYSICAL LABORATORY PRACTICALS ON THE ACADEMIC ACHIEVEMENT AND THE ATTITUDE OF BIOLOGY STUDENTS IN SENIOR SECONDARY SCHOOL, ADAMAWA STATE, NIGERIA

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ABSTRACT

The study investigated comparative effects of virtual laboratory and physical laboratory practicals on the academic achievements and attitudes of biology students in senior secondary schools in Adamawa State. Two objectives, two research questions and two hypotheses tested at 0.05 level of significance guided the study. The study adopted quasi-experimental research pre-test, posttest, non-equivalent comparative group design consisting of 140 SS II Biology Students in Adamawa State. The instrument for data collection was Biology practical Achievement Test (BPAT adopted from WAEC past question and Biology Practical Attitudes Questionnaire (BPAQ) which was tested for reliability using Cronbach Alfa and Internal consistency of 0.71 was obtained. The data collected were analysed using Descriptive statistics Mean and Standard Deviation for research questions and one-way ANCOVA. The study revealed the following findings: - There is significant effects of virtual laboratory and physical laboratory on Students' Academic Achievement when taught Biology using virtual laboratory in senior secondary schools in Adamawa State in favour of physical laboratory $F = 119.124$ (df 1, 139), $P = 0.00$. There is significant effects of virtual laboratory and physical laboratory on students' attitude when taught Biology using virtual laboratory and physical laboratory in Senior Secondary School in Adamawa State in favour of physical laboratory $F = 6.867$ (df 1, 139), $P = 0.01$. it was recommended that, Adamawa State government should provide a well- equipped Physical Biology Laboratory for adequate teaching, learning and understanding Biology practical in Senior Secondary School in Adamawa State, capacity building, workshop trainings for biology teachers on laboratory techniques and usage. Incorporation of virtual and physical laboratory practical in the biology curriculum to enhance academic achievement and promote positive attitudes and clear learning objectives and guidelines for both virtual and physical laboratory experiences to ensure effective utilization of resources among others. Suggestions for further research and conclusions were drawn

KEYWORDS: Virtual, Laboratory, Students, Biology.

INTRODUCTION

Education is the key to unlimited achievement it is a dynamic instrument par excellence that can be used to improve economic, political and social development of people and their societies. Men and women live in a dynamic society in which social values, political movement and technological conditions are changing continuously. Therefore, educators should analyze and evaluate the trends in order to decide appropriate curricula and models of instruction which will motivate and make students ready for real life situation. Each society expects its education system to mold her individuals to become effective problem solvers in their lives. Education therefore, improves the productive capacity of societies and their political awareness, economics and scientific institutions. In line with this the Nigerian education system over the years has witnessed various forms of reforms from the government policies resulting to inappropriate education and training of the populace. There is indeed growing anxiety in Nigeria about the low level of scientific literacy and productivity of the economy as is being manifested in the manufacturing service, creativity, innovation in science and technology, public utilities and public service (Araoye & Araoye, 2011).

Nigerian educational system in the 21st century is characterized by lack of quality teaching materials, lack of adequate and uniform training and funding, high rate of student examination malpractice and strike actions, poor teaching methods, lack of motivation among teachers and students, resulting to poor academic achievement leading to low productivity in all its ramifications (Lawan & Usman, 2017). Sadly, also, Nigeria ranks last 136th of 136 countries surveyed by UNESCO with reference to public spending on education as a proportion of Gross Domestic Product (GDP). The proportion of public spending on education in Nigeria as a percentage of GDP is 0.89% and education expenditure as a proportion of Gross National Income (GNI) is not better 0.85% or 167% out of 168 countries (Araoye, 2011). Indeed, the policy for education as a generator of national development needs a fresh look by all interested people in the future of Nigeria. There is need to check our educational sector by finding better instructional strategies and methods that would enhance students' achievement and motivation in schools. Therefore, biology teachers need to find out ways to motivate biology students to enhance their interest towards learning biology and actualization of the need and relevance of education in achieving national objectives.

Developing countries have struggled to adequately teach and train professionals as well as students in the science related fields primarily due to limited access to adequate laboratory facilities and consumables. Physical laboratory for practical is widely considered essential to learning science related subjects because laboratory provides students opportunity to develop hand-on experience with physical equipment and materials. The emphasis on hands-on laboratory experience as an indispensable part of proper and adequate training in the science disciplines such as Biology, this meant that developing countries have lagged far in terms of quality of training and research. However, providing students with high quality laboratory facilities can be very expensive, dangerous, difficult, or time-consuming. Educational institutions are not able to keep up-to-date laboratory and facilities with the rapidly

growing technology noted the fast development of technology had become an issue for educational institutions to keep up with the pace. Physical laboratory is however, also constrained, as it is only open at scheduled class hours. In most cases, access to scarce and expensive equipment is very restricted, leading to low students' utilization. Considering financial constraints, the need to finding and adopting a viable alternative(s) to the use of expensive equipment in Physical laboratory help developing countries to significantly improve the teaching and training of students to graduation has become necessary.

Currently, Information and Communication Technology has witnessed a rapid development in educational fields. The resources of knowledge became various and numerous. The course of science is obviously connected with the technology, both cognitively and practically. Yet educational professionals consider the importance of integrating information and communication technology in science learning, as to facilitate studying many scientific phenomena that cannot be studied extremely due to its danger, high cost or lack of time to complete the experiment (Dillon, 2007).

The field of internet –based learning are diverse, including virtual laboratories of science, which are considered the main underpinning in practical learning, seeing that virtual labs closely resemble real labs. Moreover, a technology-enriched environment would greatly enhance students' motivation and develop positive attitude towards the course. Subsequently, the academic achievement would be enhanced. Several studies emphasized the vital role of virtual laboratory in developing academic achievement, providing awareness of scientific concepts, and modifying misconceptions, (Al Sharhan, 2009).

Virtual Laboratory, being the third era in the Human Computer Interaction (HCI) exhibits a system that is able to create a virtual environment that entirely exists inside the computer. Virtual Laboratory manages to display elements of 3 dimensional in sight, i.e. all sides can be seen, hearing and the sense of touch (haptic) Virtual Laboratory in many ways has created a new window of opportunity towards assisting and also enhancing the educational processes and techniques. Also Virtual Laboratory characteristics support the theory of constructivism hence able to create a learning-by-doing' atmosphere.

As quoted by “computers are symbol-system manipulation tools (Winn and McClure, 2003). Advances in computer technology have allowed for the development of real-time three dimensional graphic, auditory and kinesthetic environments that students can be perceptually "immersed". Biology learning environment should be active, learning centre, engaging relevant and robust. Therefore, the characteristics of a three dimensional interactive environment have to be closely aligned with those of an optimal learning environment.

The characteristics of Virtual Laboratory are relevant in the three areas of 'Educational Theory' i.e. (a) experiential education, (b) constructivism and (c) social learning. The study examined whether

constructivist practices in the classroom or laboratory help students to make deeper, more meaningful knowledge constructions than those derived from traditional laboratory practices. It, therefore describes the relationship between the learning theory known as 'constructivism', the semiotic theory of signs and the use of three dimensional interactive environments as a constructivist learning tool.

Biology as a science subject deals with the organism and total environment, energy consumption, behavior and improvement of man's condition (Ramalingam, 2007). Oxford dictionary defined biology as a course divided into many specialize field that covers the following areas namely: morphology, physiology, anatomy, behaviour, origin and distribution. It is a natural science with broad scope but has several unifying branches that tied it together as a single, coherent field. For instance, all organisms are made up of cells that process hereditary information encoded in genes, which can be transmitted to future generation.

Biology is needed to reform environmental challenges such as global warming, genetic disorder and also to make informed decisions concerning health. Biology has the potential of specific training and meeting the needs and challenges of the learners, in that the acquired literacy and scientific skills are immediately applied to improve learner's livelihood. Joda (2019) in Abel (2021) opined that human society has tapped biological knowledge since ancient times to provide food, biological welfare and other human needs for survival. This is because biology is an applied field of study built upon many disciplines for the purpose of achieving and maintaining the well-being of individuals in an ever-changing society.

Auwal (2014), opined that Biology Practical is a collection of experiment that demonstrate a wide range of biological concept and processes which exposes students to acquiring process skills in utilizing their knowledge and skills in real fields outside and within the laboratory. He mentioned that teaching practical biology as a subject in senior secondary schools is faced with many problems such as Poor preparation of teachers during practical, lack of well-equipped laboratory and unqualified teachers can affect students' academic achievement in Senior Secondary School Biology. Nevertheless, the knowledge acquired in Biology subject is applied in many fields as medicine, biochemistry, pharmacy, microbiology and agriculture. Students' achievement in Biology in Senior Secondary School has been unsatisfactory over many years. Various reasons have been attributed to this problem by scholars. Dinah (2013) concluded that unavailability of text books, laboratory apparatus and other learning resources contribute significantly to the poor performance of students in practical biology examination. Babateen (2011) stated the reason for emphasizing practical activities in biology like a realization of practical; work to be predecessor to real science knowledge. Practical work stimulates learner interest in the science subject they are studying, when they are made to personally engage in useful activities; knowledge obtained through practical; work and experience, promote long term memory that theory alone cannot do, from this reason, it becomes obvious that a learner acquired more in any science lesson, if giving the opportunity to do activities, ranging from manipulating apparatus, classifying, designing, experimenting, hypothesizing to make inferences and

verifying results. Hence, there is an urgent and serious need to justify the exposition of the student's biology practical activates as well as studying its effect on student's achievement in biology. Unfortunately, the ugly situation observed in the majority of our secondary school and students in lack of exposure of the students to practical activities.

Manalanga and Awelani (2014) concluded in their study that the possible factors responsible for the poor performance in practical Biology include lack of financial support, lack of equipped libraries, lack of well equipped laboratories, poor method of teaching and assessing Biology students' practicals activities. Teachers should be encouraged to assess learners regularly on practical skills. Perhaps, more practical lessons should be made and documented so that teachers should plan for regular inspection to ensure the actual order is adhered to (Wabuke, 2013).

STATEMENT OF THE PROBLEM

Sound theoretical and practical knowledge of biology is needed for the management of our natural resources, provision of good health facilities, adequate food supply and favourable life environment, but most public schools in Nigeria teaches biology as a subject in Senior Secondary School theoretically with little or no practical. Some teachers even skip or ignore topics with practicals in biology. As a result of lack or poor biology laboratory, unqualified teachers and lack of relevant resources and instructional materials, all these are resources requires large amount of funds to cater for it. These makes the availability and effectiveness difficult in many schools. (Al-Sharhen, 2005). Technological advancements have created opportunities for the augmentation and or complete replacement of physical science laboratories in the teaching of science students. However, the acceptability and suitability of these alternatives have remained contentious issues and only the bravest and most liberal institutions have so much as dared to discuss let alone try to incorporate them in their curricular. There is need, at this juncture, to explore the suitability and acceptability of virtual laboratories as potential alternatives or supplements to the expensive traditional physical laboratory facilities in Senior Secondary Schools in Adamawa State, Nigeria.

OBJECTIVES OF THE STUDY

The objectives of the study are to determine the Comparative Effect of Virtual Laboratory and Physical Laboratory Practical's on the Academic Achievement and the Attitude of Biology Students in Senior Secondary School, Adamawa State, Nigeria specifically the study sought to achieve the following objectives:

1. Determine the effect of Virtual and physical Laboratory on Students Academic Achievements in Biology in Senior Secondary Schools, Adamawa State.
2. Determine the effects of Virtual and physical Laboratory on student attitude on Biology in Senior Secondary Schools, Adamawa State

RESEARCH QUESTIONS

The study is guided by the following research questions:

Research Questions 1. What is the pre-test, post-test mean achievement scores of students taught Biology using Virtual and physical Laboratory in senior secondary schools in Adamawa State?

Research Questions 2. What are the mean attitude scores of students when taught Biology using virtual and physical laboratory in Adamawa State?

Hypotheses

Ho₁: There is no significant effects of Virtual Laboratory on Student Academic Achievement when taught Biology using virtual laboratory and those taught with physical laboratory in senior secondary schools in in Adamawa State.

Ho₂: There is no significant effects of virtual laboratory on students' attitude when taught Biology using virtual and physical laboratory in Senior Secondary School in Adamawa State.

METHODOLOGY

This study adopted quasi-experimental research design. Specifically, the pre-test, post-test, non-equivalent, comparative group design. The design was chosen because intact classes were used instead of randomly composed samples. The area of the study was Adamawa State. The population of the study consists of all SS 2 Biology Students which are about 18,259 in Adamawa State. A sample of the study will consist of 140 SS 2 Biology students in one intact class from two Senior Secondary School in Adamawa State. The instrument for data for data collection was Biology Practical Achievement Test (BPAT) and Biology Practical Attitude Questions (BPAQ) the biology practical achievement test contains five questions/item with multiple sub-questions. BPAT (Biology Practical Achievement Test) adopted from WAEC past questions, hence the face validity is assured. To ensure content validity the instrument was subjected to validation by three experts. To test the reliability of the instrument, a pilot study was conducted. The test instrument Biology Practical Attitude Questions (BPAQ) was administered to 20 SS 2 Biology Students. Cronbach's Alfa was used to determine the internal consistency of the instrument, a result of 0.71 was obtained for Attitude.

The researcher employed assistance of two research assistants, one from each school who are qualified and experienced biology teachers. The biology teachers will be trained for one week as research assistants to teach the students in the experimental groups using virtual laboratory. While for the control group the research assistants will be shown how to use the physical laboratory practical lesson plans. The experimental group was taught using virtual laboratory and while the other group was taught using physical laboratory. The exercise lasted for six weeks. In the first week, pre-test was administered to both groups to ascertain their entry behavior followed by training of the research assistants. In the second week, the treatment (instruction) starts which last for four (4) weeks. At the end of the treatment, post-test was administered in the sixth week to both groups using the same instrument Biology Practical Achievement Test (BPAT).

The data collected was analyzed using descriptive statistics (mean and standard deviation) to answer research questions. Analysis of Covariance (ANCOVA) was used to test null hypothesis at 0.05 level of significance.

RESULTS AND DISCUSSION

Research Question 1. What is the pre-test, post-test mean scores of students taught Biology using Virtual and Physical Laboratory in senior secondary schools in Adamawa State.

Table 1. Mean and Standard Deviation of pre-test and post-test mean achievement score of biology students when taught using Virtual and Physical Laboratory.

Teaching Method	n	Pretest		Post-test	
		Mean	SD	Mean	SD
Virtual Laboratory	70	13.56	0.50	43.54	1.62
Physical Laboratory	70	13.64	0.48	46.83	1.96

The descriptive statistics in Table 1 revealed that, the group taught with Virtual Laboratory with 70 students has a pretest mean score of 13.56 and standard deviation of 0.50. In the posttest, the Virtual Laboratory has the highest mean score of 43.73 with a standard deviation of 1.01. The group taught with Physical Laboratory has 70students with a mean score of 13.64 and standard deviation of 0.48 at pretest level and mean score of 46.83 with standard deviation of 1.96 at posttest level. In summary, there is mean difference between students taught with Virtual Laboratory and Physical laboratory is high.

Research Question 2. What is the pre-test, post –test mean of attitude of students when taught Biology using virtual laboratory in Adamawa State.

Table 2. Mean and Standard Deviation of pre-attitude and post-attitude mean of biology students when taught using Virtual and Physical Laboratory.

Teaching Method	n	Pre-attitude		Post-attitude	
		Mean	SD	Mean	SD
Virtual Laboratory	70	3.74	1.07	4.13	0.86
Physical Laboratory	70	3.64	1.12	4.27	0.72

The descriptive statistics in Table 2 revealed that, the group taught with Virtual Laboratory with 70 students has a pre-attitude mean score of 3.74 and standard deviation of 1.07. In the posttest, the Virtual Laboratory has the highest mean attitude of 4.13 with a standard deviation of 0.86. The group taught with Physical Laboratory has 70 students with an attitude mean score of 3.64 and standard deviation of 1.12 at pretest level and mean score of 4.27 with standard deviation of 0.72 at posttest level. In summary, there is mean difference in attitude between students taught with Virtual Laboratory and Physical laboratory is high.

Testing Hypotheses

H0₁: There is no significant effects of virtual laboratory and physical laboratory on Students’ Academic Achievement of students when taught Biology using virtual laboratory in senior secondary schools in in Adamawa State.

Table 3. Ancova of effect of virtual laboratory and physical laboratory on Students’ Academic Achievement of students when taught Biology using virtual laboratory in senior secondary schools in in Adamawa State.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	384.126 ^a	2	192.063	59.660	.000	.466
Intercept	469.798	1	469.798	145.931	.000	.516
PRETEST	6.268	1	6.268	1.947	.165	.014
PRACTICAL_MET HOD	383.496	1	383.496	119.124	.000	.465
Error	441.046	137	3.219			
Total	286670.000	140				
Corrected Total	825.171	139				

a. R Squared = .466 (Adjusted R Squared = .458)

The results of the analysis in Table 3 shows that, there is significant effect of virtual laboratory and physical laboratory on Students’ Academic Achievement of students when taught Biology using virtual laboratory and physical laboratory in senior secondary schools in in Adamawa State $F = 119.124$ (df 1, 139), $P = 0.00$. Since the computed p-value (0.00) is less than 0.05 level of significant, therefore, the null hypothesis of no significant effect is rejected, and concluded that there is significant effect of virtual laboratory and physical laboratory on Students’ Academic Achievement of when taught Biology using virtual laboratory and physical laboratory in senior secondary schools in Adamawa State in favour of physical laboratory. The partial eta square of 0.465 indicates that, 47% of students’ performance in this study was as result of physical laboratory.

H02: There is no significant effects of virtual laboratory and physical laboratory on students attitude when taught Biology using virtual laboratory in Senior Secondary School in Adamawa State.

Table 4. Ancova of effect of virtual laboratory and physical laboratory on Students’ attitude when taught Biology using virtual laboratory and physical laboratory in senior secondary schools in in Adamawa State.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	44.786 ^a	2	22.393	70.342	.000	.507
Intercept	66.820	1	66.820	209.897	.000	.605
PRE_ATTITUDE	44.072	1	44.072	138.441	.000	.503
PRACTICAL_METHO D	2.186	1	2.186	6.867	.010	.048
Error	43.614	137	.318			
Total	2558.000	140				
Corrected Total	88.400	139				

a. R Squared = .507 (Adjusted R Squared = .499)

The results of the analysis in Table 4 shows that, there is significant effect of virtual laboratory and physical laboratory on students’ attitude when taught Biology using virtual laboratory and physical laboratory in senior secondary schools in in Adamawa State $F = 6.867$ (df 1, 139), $P = 0.01$. Since the computed p-value (0.01) is less than 0.05 level of significant, therefore, the null hypothesis of no significant effect is rejected, and concluded that there is significant effect of virtual laboratory and physical laboratory on Students’ attitude when taught Biology using virtual laboratory and physical laboratory in senior secondary schools in Adamawa State. The partial eta square of 0.048 indicates that, 5% of students’ attitude in this study was as result of physical laboratory.

There is significant effects of virtual laboratory and physical laboratory on Students’ Academic Achievement when taught Biology using virtual laboratory in senior secondary schools in Adamawa State in favour of physical laboratory $F = 119.124$ (df 1, 139), $P = 0.00$. The followings study contradicts the findings; Gambari (2017) which opined that the urgent need for Nigeria to shift steadily and progressively from the traditional time tested methods and techniques of instructions as expository, teacher-centred demonstration, and laboratory exercises to demonstrate, visualize or verify known information to those based on Information Communication Technology (ICT) requires a fundamental shift of focus from the teacher to the learner as the centre of education, and a progressive adoption of new method of virtual laboratory. Unfortunately, Nigeria is yet to embrace the concept fully and adopt ICT based methods in teaching, especially at the primary and secondary school levels. Murniza, Halimah and Azlina (2010), carried out an investigation on virtual laboratory for learning biology – a preliminary investigation to determine the topic to be focused in developing Virtual Laboratory for

Biology (VLab-Bio). Thus, it is hoped that the proposed virtual laboratory will help students to learn the abstract concepts in biology. Findings show that the difficult topic chosen in Cell Division and the learning objectives to be focused in developing the virtual lab is describe the application of knowledge on mitosis in cloning. Nataza Herga, Milena and Dejan (2014) conducted a study on Virtual Laboratory as an Element of Visualization when Teaching Chemical Contents in Science Class. The results from the didactic experiment showed that in terms of knowledge acquisition, the use of a virtual laboratory was more effective than classes without the use of dynamic visualization elements. Tatli and Ayas (2013) which Investigated the Effects of Virtual Chemistry Laboratory on Students Achievements among 90 students from three different ninth-grade classrooms (an experimental and control group). It was concluded that the developed virtual chemistry laboratory software is at least as effective as the real laboratory.

On the other hand, the followings studies agree with these findings, Tracy, and Bridget (2007) conducted research on virtual laboratory in the online Biology course: Student's perceptions of effectiveness and Usability. Findings indicated that though most students (86.9%) perceived the F2F laboratories as more effective than the virtual laboratories across several criteria.

The second findings of the study show there is significant effects of virtual laboratory and physical laboratory on students' attitude when taught Biology using virtual laboratory and physical laboratory in Senior Secondary School in Adamawa State in favour of physical laboratory $F = 6.867$ (df 1, 139), $P = 0.01$. This finding concurs with the following studies Miro, Matej and Sorgo (2011). Conducted a study on Students Perceptions of Real and Virtual Field Work in Biology, the study aims to find out students Perceptions of Real and Virtual Field Work the results of 192 students' point of view on the importance of field work, obstacle of that kind of work and the ICT as a solution to support or replace the real field works are presented. All questioned students were prospective teachers, so sooner or later majority of them will face issues connected to the field work and possibilities to solve them with the help of ICT. (Virtual). Gambari, Shittu and Adegunna (2016) investigated the effects of computer-self interactive package (CSIP) on Student's performance, achievements level and attitude toward mathematics at secondary schools in Nigeria the result shows positive attitude towards learning biology. Similarly, Cengiz Tuysuz (2010). Conducted a study on the Effect of the Virtual Laboratory on Student' Achievement and Attitude in Chemistry. In the study, a virtual laboratory related to "Separation of Matter" unit for 9th grade students was prepared and its effects on student's achievements and attitudes were investigated. For this aim 16 virtual experiments prepared by using flash program and used in the experimental group. Result of this study showed that virtual laboratory applications made positive effects on students' achievements and attitudes when compared to traditional teaching methods.

The study recommended that, Adamawa State government should provide a well- equipped Physical Biology Laboratory for adequate teaching, learning and understanding Biology practical in Senior Secondary School in Adamawa State, incorporation of virtual and physical laboratory practical in the

biology curriculum to enhance academic achievement and promote positive attitudes and clear learning objectives and guidelines for both virtual and physical laboratory experiences to ensure effective utilization of resources.

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