

Research Article

COMPARATIVE ANALYSIS OF VIRTUAL AND OUTDOOR LABORATORY STRATEGIES ON ACADEMIC PERFORMANCE OF N.C.E BIOLOGY STUDENTS IN KATSINA AND KANO STATES, NIGERIA

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ABSTRACT

The study is a Comparative Analysis of Virtual and Conventional Indoor Laboratory Strategies on the Performance of N.C.E Biology Students in Katsina and Kano States, Nigeria. The study developed 4 Research Objectives one of which is to: Compare the effectiveness of virtual, and convectional indoor laboratory strategies in teaching biology concepts. The study was guided by 4 research questions and 4 null hypotheses. Quasi-experimental research using a test-retest method of pretest and posttest was adopted for the study. A sample of 156 N.C.E III biology students comprising 95 males and 61 females were randomly selected from the population of 357 students of which 213 are males and 114 are females. The instrument used to collect data was Biology Concept Performance Test (BCPT). At the end of the treatment data was collected and analyzed using Means and standard deviations to answer the research question while t-test and ANOVA Statistics were used to answer the null hypotheses. The results obtained showed that the use of the virtual laboratory strategy enhances the academic performance of students more than the conventional indoor laboratory strategy. From the findings recommendations were made one of which is: the use of virtual laboratories should be encouraged among biology teachers by organizing seminars, workshops, and talk shows on the importance of virtual laboratories as an innovative teaching and learning strategy to prepare learners to live and function in a society that relies on technology at every aspect, as working in virtual biology laboratory provide important ways of teaching biology concepts.

Keywords: biology, indoor, laboratory, performance, virtual.

INTRODUCTION

Biology as a subject is one of the natural science subjects taught at secondary schools and tertiary levels of education and serves as a prerequisite to the study of many science courses and plays a vital role in the economic development of the nation. Nwakonobi (2008) opined that recent advances in the field of biochemistry, physiology, ecology, genetics, and molecular biology have made the subject a central focus in most human activities including solutions to the problems of food scarcity, pollution, population explosion, radiation diseases, health, and hygiene, conservation of natural resources, family life, various social vices as well as biotechnology and ethics. Biology is a key subject in the curriculum of Nigerian colleges of education under the supervision of the National Commission for Colleges of Education (NCCE). The philosophy behind the subject is to produce knowledgeable, highly motivated, professional, and effective teachers of biology who will be able to develop in students, an appreciation and understanding of biological processes and principles. The program is also designed to develop confidence in the biology teacher and enhance his ability to adapt to the changing situations in a science and technological-oriented society. The subject is combined with chemistry, computer, physical and health education geography, mathematics, and physics (NCCE 2012). As a subject discipline, it is quite popular at all levels of Nigerian education. It has a large student enrollment than any other science subject especially at the upper basic level of Nigerian education (Ofoegbu 2003).

The teaching of biology is meant to expose the learners to biological nature (facts, principles, and concepts), processes, and attitudes as

well as equip them with the skills of a professional biology teacher (Muoneme 2016). All this can be achieved when students do biology instead of merely reading biology. Doing biology implies going into the laboratory to carry out specific investigations (Ezeaghasi 2014). The laboratory activity method is a method of teaching where tools, apparatus, and instructional materials are used to enhance, and stimulates the process of learning in a place known as a laboratory. Laboratory work in biology involves observation, description or drawing, microscopy, dissection, and experimental work (Ezeaghasi, 2014). In the teaching and learning of biology scholars (Ango 2000, Reid and Shahi 2004, Baruwa 2006) hold that laboratory work allows the student to experience science by using scientific research procedures and also encourages the development of analytical and critical thinking. It also strengthens theoretical knowledge, experiencing the pleasure of discovery and development of their psychomotor skills, increasing creative thinking skills, higher order thinking skills, developing manual dexterity by using tools and equipment, allowing students to apply skills instead of memorization (Ezeaghasi 2014)

The most accepted types of laboratories include conventional indoor laboratories and outdoor laboratories. An indoor laboratory is the school building set aside for scientific discovery and inquiry in which students are brought in direct contact with materials, manipulating them through procedures that reflect scientific thinking while an outdoor laboratory is sited outside the school building which also provides a meaningful learning experience for the students (Fagbemi 2012). However, the colleges of education in Nigeria are faced with a lack of laboratory or equipment, or insufficient laboratory conditions which limits the teacher to performing simple laboratory activities (Adekunle and Hussaini 2011). Also, the cost of carrying out experiments, arranging the equipment, and laboratory activities are painstaking and time-consuming. Checking students' performance

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during laboratory activities can be tasking and laborious especially when dealing with a large number of students (Tuysuz, 2010). When considering these challenges makes the use of indoor and outdoor laboratories which are the most accepted types of laboratories to be avoided, therefore looking for appropriate alternatives is inevitable, and hence, the use of virtual laboratories in supporting the laboratory methods can be a logical one. A virtual laboratory is a virtual studying and learning environment that stimulates the real lab. It provides the students with tools, materials, and laboratory sets on a computer to perform experiments subjectively or within a group anywhere and anytime. According to Reese (2013), a virtual laboratory can be seen as a studying and learning environment that stimulates the real laboratory. It provides the students with tools, materials, and laboratory sets on a computer to perform experiments subjectively or within a group anywhere and anytime. These experiments are saved on CDS or web site. A virtual laboratory may sometimes be a preferable alternative, or simply a supportive learning environment, to real laboratories. A virtual laboratory provides students with opportunities such as: fostering students' interest and motivation; promoting student's commitment to learning; making lessons more exciting and interesting for both teachers and students; making students do science effectively and conducting experiments as viewed on screen; and facilitating the process of learning through interaction with drill and practice software and simulations. The most important feature of computerized instruction is that it permits a high degree of individualization. This means that students can proceed at their own pace, following a path through the curriculum as suited to their particular interests and talent (Egbodo, 2016). The virtual laboratory makes students active in their learning and provides opportunities for students to construct and understand difficult concepts more easily. Furthermore, it affords the learners to overcome mistakes that occur as a result of such laboratory conditions or misuse of the laboratory and enable them to easily overcome the possible dangers that can be seen in real laboratory conditions (Ozmen, 2005).

Gender is another important factor in this research, especially since it involves the use of virtual and conventional indoor laboratory activities, two areas that usually are stereotyped as male domains. Many researchers such as Wong and Hanafi (2007) believed that the usual assertion is that since boys are more predisposed to the use of technology, they may benefit more from the integration of technology for teaching and learning. Girls, on the other hand, may be limited in their learning when it involves technology. Though it was opposed by Muomene (2016) who found out that the use of computers and technology in teaching is gender friendly. The issue of gender is controversial, therefore, there is a need to carry out further investigations. In this study, there is a need, to compare the effectiveness of virtual, and conventional indoor laboratory strategies on N.C.E. students' performance in Katsina and Kano states, Nigeria.

Statement of the Problem

The problem encountered by many schools in north-western states such as Katsina and Kano states of Nigeria is biology practicals are rarely performed due to a lack of laboratories, even if the laboratory exists, sometimes due to the limitation of equipment, limited time allocated for the topic, or insufficient laboratory conditions, force teachers to perform laboratory activities in crowded groups, or sometimes a demonstrational activity. Also, there are few resources at all, they are not in good condition, while the few ones that are in good condition are not enough to go around, and also the few available materials are dysfunctional. Researchers such as Oladare, Abiodun, and Bajulaiye (2006); Adesoji (2008); and (2008) stated that there are inadequate resources for teaching and learning science

subjects in schools in Nigeria. When considering these challenges, looking for appropriate alternatives is inevitable, hence, the use of a virtual laboratory in supporting the laboratory methods can be a logical one.

Objectives of the Study

The study has the following objectives, to:

- Investigate the impact of virtual laboratory strategy on academic performance of N.C.E Biology students
- Investigate the impact of conventional indoor laboratory strategy on academic performance of N.C.E Biology students
- Investigate the difference in academic performance of male and female N.C.E Biology students exposed to virtual laboratory strategy
- Compare the effectiveness of virtual, and conventional indoor laboratory strategies in teaching Biology concepts

Research Questions

The study sought to answer the following research question:

1. What is the difference between the mean performance score of NCE biology students exposed to virtual laboratory strategy and those exposed to lecture method?
2. What is the difference between the mean performance score of NCE biology students exposed to conventional indoor laboratory strategy and those exposed to lecture methods?
3. What is the difference in the academic performance of male and female NCE Biology students exposed to virtual laboratory strategy?
4. What is the difference between the mean performance score of NCE biology students exposed to virtual laboratory strategy and those exposed to conventional indoor laboratory strategy?

Research Hypotheses

Based on the research questions stated the following null hypotheses are formulated for testing $p \leq 0.05$.

H01: There is no significant difference in the performance of NCE biology students taught with the virtual laboratory strategy and those taught with lecture method.

H02: There is no significant difference in the performance of NCE biology students taught with conventional indoor laboratory strategy and those taught with lecture method.

H03: There is no significant difference in the academic performance of male and female NCE Biology students exposed to the Virtual laboratory strategy.

H04: There is no significant difference in the mean performance scores of NCE biology students exposed to the virtual laboratory strategy and those exposed to the conventional indoor laboratory strategy.

METHODOLOGY

The research design adopted for the study is quasi-experimental, using pretest and posttest for all experimental and control groups. The control and experimental groups I and II were pre-tested (O1) before the administration of treatment. Treatment for experimental group I was teaching biology concepts using a virtual laboratory strategy and treatment for experimental group II was teaching biology concepts using an indoor laboratory. The control group was taught

the same concept using the lecture method, thus no treatment (X0) was administered. The population of the study comprised all N.C.E. III Biology students in Katsina and Kano states, Nigeria. A simple random sampling technique was used to select three colleges of education out of the 5 colleges of education in Katsina and Kano states Nigeria. The colleges were selected as experimental I, experimental II, and control groups using a simple random sampling technique of a balloting system (the first to be picked was tagged experimental I, the second to be picked was tagged experimental II, and the third to be picked was tagged control). A simple random sampling technique was used to obtain the number of students. Thus, a total number of 156 students comprising 95 male and 62 female students with an average age of 24 was used as the sample. Experimental Groups I, II, and Control group are made up of 52, 50 and 54 sample size each respectively. The instrument used for this study is Biology Concept Performance Test (BCPT) to determine the effect of virtual and conventional indoor laboratory strategies on the performance of N.C.E biology students. Due to the adaptation of the instrument, it was validated by experts who are Ph.D. holders with a minimum rank of senior lecturer in the field of science education. Its reliability was found to be $r=0.75$, the instrument is reliable and was used for the study. A total of 180 questionnaires were administered and 156 were collected back for analysis. Means and standard deviations were used to answer research questions, while t-test and ANOVA statistics were used to answer null hypotheses.

RESULTS

Research Question 1: What is the difference between the mean performance score of NCE biology students exposed to virtual laboratory strategy and those exposed to lecture method?

Table 1: Mean and Standard Deviation of Experimental I and Control Group

Variable	N	Mean	STD	Mean diff
Experimental I	52	20.23	3.96	5.76
Control	54	14.47	4.94	

From Table 1, the experimental group I exposed to the virtual laboratory strategy achieved a mean score of 20.23 while the control group who are taught using the lecture method scored 14.47 with a mean difference of 5.76. This finding answers research question 1 that students in the experimental group I performed higher than their counterparts in the control group.

Research Question 2: What is the difference between the mean performance score of NCE biology students exposed to conventional indoor laboratory strategy and those exposed to lecture method?

Table 2: Mean and Standard Deviation of Experimental II and Control Group

Variable	N	Mean	STD	Mean diff
Experimental II	50	20.00	4.15	5.53
Control	54	14.47	4.94	

The result in Table 2 revealed that, students in the experimental group II exposed to conventional indoor laboratory strategy achieved a mean score of 20.00 while the control group who are taught using the lecture method scored 14.47 with a mean difference of 5.53. This finding answers research question 2 that students in experimental group II who were exposed to indoor laboratory strategy performed

higher than their counterparts that were taught with the lecture method.

Research Question 3: What is the difference in the academic performance of male and female NCE Biology students exposed to virtual laboratory strategy?

Table 4.3: Mean and Standard Deviation of Post-test Scores of Male and Female Students in Experimental Group I

Variable	Gender	N	Mean	STD	Mean diff
Mean Performance	Male	35	25.19	3.47	0.17
	Female	27	25.02	3.85	

The result in Table 3 shows that the computed performance mean scores of male and female students exposed to virtual laboratory strategy are 25.19 and 25.02 respectively with a mean difference of 0.17 in favor of female students. This implies that there is no significant difference between the performance of male and female students when exposed to virtual laboratory strategy.

H01: There is no significant difference in the performance of NCE biology students taught with virtual laboratory strategy and those taught with lecture method.

Table 4: the result of t-test analysis on data for experimental group I and control group

Group	N	Mean	STD	Df	t-value	P	Remark
Experimental I	52	20.23	3.96	104	5.94	0.00	Sig.
Control Group	54	14.47	4.94				

Significant at $P \leq 0.05$

From Table 4, the p-value calculated is 0.00 which is lower than $P \leq 0.05$, as such null hypothesis one was rejected. This implies that the difference between the mean scores was significant in favor of experiment group I students who were exposed to the virtual laboratory strategy.

H02: There is no significant difference in the performance of NCE biology students taught with conventional indoor laboratory strategy and those taught with lecture method.

Table 5: the result of t-test analysis on data for experimental group II and control group

Group	N	Mean	STD	Df	t-value	p	Remark
Experimental II	50	20.00	4.15	102	5.51	0.00	Sig.
Control Group	54	14.47	4.94				

Significant at $P \leq 0.05$

From Table 5 presented, the t-value recorded is 5.51 while the p-value observed is 0.00 at 102 degrees of freedom. The p-value observed is less than the alpha value, hence, the null hypothesis which stated that, there is no significant difference in the performance of NCE biology students taught with conventional indoor laboratory strategy and those taught with lecture method is hereby rejected.

H03: There is no significant difference in the academic performance of male and female NCE Biology students exposed to the Virtual laboratory strategy.

Table 6: Summary of t-test Analysis of Post-test Sores of Male and Female Students in Experimental Group I

Variable	N	Mean	STD	Mean diff	Df	t computed	t critical	p	Remark
Male	35	25.19	3.47						
				0.17	50	0.17	1.96	0.86	Not Sig.
Female	17	25.02	3.86						

$P = 0.864 > 0.05$, $t_{\text{computed}} = 0.173 < 1.96$ at $df = 58$

The Independent t-test statistics above showed that there is no significant difference in the academic performance of male and female Biology students exposed to the virtual laboratory strategy. This is because the calculated p-value of 0.86 is greater than the 0.05 alpha level of significance and the computed t value of 0.17 is lower than the 1.96 t critical value at $df = 50$. Therefore, the null hypothesis which states that, there is no significant difference in the academic performance of male and female Biology students exposed to virtual laboratory strategy is hereby accepted and retained.

HO4: There is no significant difference in the mean performance scores of NCE biology students exposed to the virtual laboratory strategy and those exposed to the conventional indoor laboratory strategy.

Table 7: Result of ANOVA test on mean scores of experimental group I, II, and control group.

Source of variance	Sum of Squares	Df	Mean Square	F	Sig.	Remark
Between Groups	913.53	1	456.76			
Within Groups	2368.59	153	19.25	23.73	0.00	Sig.
Total	3282.13	154				

Table 7 presented the Summary of ANCOVA on significant differences in academic performance of NCE Biology students taught biology concepts using virtual laboratory strategy, indoor laboratory strategy, and those taught using lecture method. Results show that the f-value calculated is 23.73 at $P = 0.00$ which is lower than the 0.05 level of significance. The mean of virtual laboratory strategy recorded 20.23 while that of the indoor laboratory strategy and control group is 20.00 and 14.47 respectively. Therefore the null hypothesis which stated that, there is no significant difference in the mean performance scores of NCE biology students exposed to virtual laboratory strategy and those exposed to the conventional indoor laboratory strategy is hereby rejected. This implies that the use of a virtual laboratory strategy enhances the academic performance of students more than a conventional indoor laboratory strategy.

DISCUSSION

The result of analyses presented in Tables 1 and 4 showed that the experimental group I who taught biology concepts through the virtual laboratory strategy performed significantly better than the control group students taught with the lecture method. This finding conforms to that of Gambari *et al.*, (2013) who found out that students exposed to physics practicals using a virtual laboratory package performed better than those with conventional laboratory methods. Similarly, the findings of Yustina (2010) state that, the use of computers in learning provides opportunities that are interactive, effective, and can improve a variety of skills and achievement among students. On the same note, Murniza, Halimah, and Azlina (2010) revealed that a virtual laboratory for biology can support students to explore and visualize

the abstract concepts in learning biology especially in "Describing the application of knowledge on mitosis in cloning". The findings in Tables 2 and 5 revealed that students taught biology concepts in conventional indoor laboratories performed better than their counterparts taught the same concept with the lecture method. This is in line with the work of Ude and Saidu (2020) who revealed that, students taught biology concepts using an indoor laboratory instructional strategy achieved higher than those taught the same concepts using the lecture method. So also, the research of Aliyu and Osiakije (2020) revealed that the use of an indoor laboratory strategy improves academic performance better than the conventional lecture method. On the issue of gender concerning academic performance when exposed to virtual laboratory strategy, the result presented in Tables 3 and 6 reported that, in which the null hypothesis which says, there is no significant difference in the academic performance of male and female NCE Biology students exposed to virtual laboratory strategy. The hypothesis here is retained and accepted though the mean score of females is slightly higher than that of males but the difference is not significant. This agrees with the result of Lawal (2017) showed that there is no significant difference in the performance between male and female experimental groups showing that laboratory strategy is gender friendly. This also agrees with Usman, Alibi, Falode, and Muhammad (2019) who revealed that there was no significant difference between male and female students taught Geography using a virtual laboratory. Therefore, the explanation for this could be because biological sciences are not considered a field in which a dire gender gap is present, and also since both students (males and females) are given equal opportunities to participate actively in the learning process by interacting among themselves and the teacher in a virtual laboratory setting. The process could have helped to improve the student's achievement irrespective of gender.

The result of the analysis presented in Table 7 revealed that the use of a virtual laboratory strategy in teaching biology concepts improves the performance of students more than conventional indoor laboratory and lecture methods. This conforms to the finding of Flowers (2011) which indicated that students perform better when they participate in virtual laboratories compared to traditional (e.g., face-to-face) laboratories, she also indicated that students perceived higher learning gains as a result of participating in virtual settings compared to traditional hands-on laboratories. The general explanation for this could be that the virtual laboratory package is more conducive than the traditional laboratories (indoor and outdoor) method because they are task structured (i.e. going through the pre-laboratory instruction; watching the video demonstration on computers; and practicing as many times as possible by varying the parameters in a simulated platform at the same time achieving the objective of the concept taught). Overall studies indicated that the virtual laboratory demonstrations were a new venture in the field of Biology education, as they make a new dimension in visual learning so also virtual laboratory package is an activity based which arouses students' interest; it is stress-free because virtual materials, facilities, and equipment are readily available.

CONCLUSIONS

Based on this study, the following conclusions were made:

- Exposure to virtual laboratory strategy enhances the academic performance of NCE biology students
- Exposure to conventional indoor laboratories enhances the academic performance of NCE biology students
- Virtual laboratory strategy enhances students' academic performance equally despite gender difference
- Virtual laboratory strategy enhances academic performance more than the conventional indoor laboratory strategy.

RECOMMENDATIONS

The following are the recommendations put forward as a result of the outcome of the study:

1. The use of virtual laboratories should be encouraged among biology teachers by organizing seminars, workshops, and talk shows on the importance of virtual laboratories as an innovative teaching and learning strategy to prepare learners to live and function in a society that relies on technology in every aspect, as working in virtual biology laboratory provide important ways of teaching biology concepts.
2. The Ministry of Education should provide a biology Virtual Laboratory to serve each school in the region to overcome problems faced by teachers from a lack of real laboratories which leads to ignorance of practicals in many biological concepts.
3. Heads of Departments in the School of Sciences should encourage the use of a virtual laboratory strategy since it has a visualization and reorganization of science facts in handling abstract courses in biology.
4. Professional bodies like the Science Teachers Association (STAN), Mathematics Association of Nigeria (MAN), Colleges of Education Examination bodies like NCCE, and Research centers like the Nigerian Educational and Research Development Council (NERDC) should incorporate virtual laboratory strategy in their science curricula in Colleges of Education to encourage the use of that by teachers.

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