Enhancing Students' Attitude in Physics through the Use of Combined Physical and Inquiry Virtual Laboratories in Secondary Schools in Enugu State

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Abstract

Research has revealed low enrolment and poor performance in Physics among secondary school students. This study compared the effects of enhancing students' attitude in Physics through the use of combined physical and inquiry virtual laboratories in Enugu State, Nigeria. The study adopted quasi experimental research design, specifically, pre-test, post-test non-equivalent control group design was used. Two research questions guided the study and three null hypotheses were tested at 0.05 alpha level. The population of the study consists 3,206 SS2 students. 220 SS2 physics students formed the sample size. The sample was composed using two stage sampling procedure. The research instrument used in this study is Test of Science-Related Attitude Scale (TOSRA). The instrument and lesson plan were validated by three experts. The reliability index was established using, Cronbach alpha technique which yielded reliability coefficient of 0.81. Experimental group was taught using combined physical and inquiry virtual laboratory while the control group was taught using physical laboratory only. Data were collected by administering TOSRA to the participants as pre-test and post-test. The research questions were answered using mean and standard deviation, while the null hypotheses were tested using Analysis of Covariance (ANCOVA). The findings showed that the use of combined Physical and Inquiry Virtual Laboratories had positive effect on students' attitude when compared to the use of only physical lab. The use of combined physical and IVL enhanced the attitude of male physics students more than their female counterparts taught the same way. Based on the findings it was recommended that teachers should expose physics students to inquiry virtual lab activities so as to promote meaningful learning, discovery learning and learning by experience among students. Also teachers should make teaching and learning of physics gender friendly by adopting the use of CPIVL in teaching physics concepts.

Keywords: Physical Laboratory, Inquiry Virtual Laboratory, Attitude

Introduction

The growth and development of most nations are dependent on science, technology and mathematics education. Science is that organized body of knowledge, which enhances the

ability to acquire skills. It is a search for meaning or exploration of events in nature (Ifeakor 2006).Science and technology related subjects that would enable students have a substantial understanding of science and be able to apply scientific knowledge in solving problems in their ever changing society are Mathematics, Physics, Biology, Health Science, Introductory technology and Chemistry. Science and technology would be incomplete without physics. Physics is applied to almost every human activity, as every profession involves some elements of physics. The significance of physics has made it imperative for its inclusion in the Nigerian senior secondary school curriculum for science-oriented students (FRN, 2004). In spite of the importance of physics as a requirement for many specialized science and engineering courses at the tertiary educational institutions, students' performance at the secondary school level (high school) in Nigeria is not encouraging (Adegoke, 2011, WAEC, 2012, Yusuf, Gambari & Olumorin, 2012).

The performances of students in physics as a subject in the Senior Secondary School Certificate Examinations (SSSCE) in Nigeria from 2010 to 2019 have been discouraging. The percentage of students that passed physics at credit levels (A1 - C6) had consistently been less than 50% (West African Examination Council [WAEC] Report, 2012). This can be traced to poor performance in physics practical which accounts for 40% of the total marks in SSCE physics examination.

Electricity, Simple Pendulum, Momentum, Mass of Spring, and Geometric Optics are among the major practical concepts that are problematic. Research findings have confirmed that these concepts among the abstract and complex aspects of physics, which the students find difficult to learn, and some teachers find difficult to teach (NERDC, 1993; WAEC, 2015, 2016, 2017, 2018 & 2019). Students need practical experiences to enable them understand some abstract concepts in physics, therefore, effective use of laboratory equipment and facilities will

improve the mastery of physics concepts. However, most of the public secondary schools in Nigeria are faced with insufficient of laboratory and equipment which limits the teacher to perform just simple laboratory activity (Adejoh & Ityokyaa, 2009).

Physical experiments are rarely performed in some public secondary schools in Nigeria due to lack of equipment, facilities and other logistic problems (Adekunle & Hussaini, 2010). In addition, the cost of carrying out experiments, arranging the equipment and laboratory activities are laborious and much time consuming. Checking students' performance during the laboratory activities can be tasking and laborious especially when dealing with large class (Yuysuz, 2010). When taking these challenges into consideration, looking for appropriate alternatives becomes inevitable, hence, the use of inquiry virtual laboratory in supporting the traditional laboratory method or adoption in the absence of physical laboratory can be a logical one.

Inquiry virtual laboratory (IVL) is an interactive environment without real laboratory tools meant for creating and conducting simulated experiments (Babateen, 2011; Harry & Edward, 2005). According to Babteen, IVL provides students with tools and materials set on computer in order to perform experiments saved on CDs or on web site. IVL is a learning environment in which students convert their theoretical knowledge into practical knowledge by conducting experiments (Woodfield, 2005). The potential benefits of virtual laboratory environment for physics practical cannot be underestimated in the contemporary world. Virtual laboratory makes students become active in their learning, provide opportunities for students to construct and understand difficult concepts more easily. Furthermore, it affords the learners some opportunities 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 the real laboratory conditions. Pyatt and Sims (2012) explain that using virtual

laboratory increases motivation and desire for the lectures in the process of learning. It also provides an affordable, safe, easy and ideal working environment.

In review of empirical studies on virtual laboratory, Tatli and Ayas (2012) and Shegog, Lazarus, Murray, Diamond, Sessions and Zsigmond (2012) found significant improvement in the performance of students exposed to virtual laboratory than their counterparts in the conventional laboratory method. Flint and Stewart (2010) reported that virtual laboratory was less expensive and ten times faster than a traditional laboratory exercise yet achieved the same learning outcomes for students who were already familiar with laboratory techniques.

Tuysuz (2010) found that virtual laboratory package made positive effects on students' achievements and attitude when compared to conventional laboratory method. Attitude of students towards school subjects however, could influence their academic achievement in the subjects either positively or negatively irrespective of gender.

Gender issues have been linked with attitude and performance of students in academic tasks in several studies but without any definite conclusion. Some studies revealed that male students performed better than the female in science courses. For instance, Kost, Pollock and Finkelstein (2009) found that male students performed better than female in interactive physics, while Anagbogu and Ezeliora (2007) found that girls performed better than boys using science process skills method of teaching. However, Adeyemi (2008), Gambari (2010) and Orabi (2007) reported that gender had no influence on academic performance of students. Therefore, part of this study examined the influence of female and male students exposed to the same amount and types of experiences in physics practical using virtual lab package in order to determine whether gender have any influence on students' attitude.

Attitude can be viewed as a predisposition to respond in a favourable or unfavourable manner with respect to a given subject (Okobia & Ogumogu, 2012). Several research in

developed nations reported that students liked to work with simulation program. For instance, Josephsen and Kristensen (2006) investigated undergraduate chemistry students' response to the SimLab computer-based learning environment, the results revealed that students enjoyed working with it; they found it motivating, and realized that it created a lot of experience, which they believed could be remembered more easily. Pyatt and Sims (2012) reported that students showed preference towards the chemistry virtual laboratory than physical laboratory. From the foregoing, most of the earlier studies from developed countries indicate that virtual laboratory could be an effective instructional tool for enhancing students' performance in sciences. However, there is very little research on the effectiveness of virtual laboratory for conducting physics practical at the senior secondary school level in Nigeria. Virtual laboratory is a new innovation in Nigerian education system particularly at secondary school level; therefore, this study examined the effect of researcher developed virtual laboratory on the performance of secondary school students in physics practical in Enugu State, Nigeria.

Purpose of the Study

The purpose of this study was to determine the effect of use of combined physical and inquiry virtual laboratories on attitude and achievement of secondary school students in electricity. Specifically, the study sought to determine the:

1. Difference in mean attitude rating scores of secondary school students taught electricity using combined physical and inquiry virtual laboratories (CPIVL) and those taught with only physical lab.
2. Difference between mean attitude rating scores of male and female secondary school students taught electricity using combined physical and inquiry virtual laboratories (CPIVL).
3. Interaction effect of teaching approaches and gender on attitude of secondary school students in electricity.

Research Questions

The following research questions guided this study:

1. What is the difference between the mean attitude rating scores of SS 2 students taught electricity using combined physical and inquiry virtual laboratories (CPIVL) and those taught using only physical laboratory?
2. What is the difference between the mean attitude rating scores of SS 2 male and female students taught electricity using combined physical and inquiry virtual laboratories (CPIVL)?

Hypotheses

The following null Hypotheses were tested at 0.05 level of significance.

1. There is no significant difference between the mean attitude rating scores of SS 2 students taught electricity using CPIVL and those taught using physical lab only.
2. There is no significant difference between the mean attitude rating scores of male and female of SS 2 students taught electricity using CPIVL and those taught using physical lab only.
3. There is no interaction effect of teaching approaches and gender on attitude of secondary school students in electricity.

Method

Research Design

The design for this study is quasi-experimental. Specifically pre-test, post-test non-equivalent control group design was used.

Population of the Study

The population for this study consists of all senior secondary year two (SS2) physics students in all the 30 public senior secondary schools in Enugu Education Zone of Enugu

State. The population is 3,206 SS 2 physics students. This population comprises 1,648 males and 1,558 females.

Sample and Sampling Techniques

The sample for the study comprised 220 SS 2 physics students. For the selection, a two-stage sampling was adopted. First, a purposive sampling was used to obtain two secondary schools out of the 20 co-educational public schools in Enugu Education Zone. The schools was sampled based on equivalence in (laboratory facilities and manpower), school location (urban area, Enugu metropolis), school type (coeducational schools), and equipped computer laboratories (under the school net programme) (students and teachers' exposure to the use of computer in their schools). All the students offering physics in each of the two schools were used for the study.

Instrument for Data Collection

The instrument for data collection was Test of Science – Related Attitude (TOSRA). The TOSRA was used to collect data on student attitude in physics. The TOSRA consists of 30 items.

Validation of the Instrument

The TOSRA was subjected to face and content validation. The face and content validation was done by submitting the instrument together with the purpose of the study, scope, research questions and hypotheses to three experts.

Reliability of the Instrument

Trial testing of the TOSRA was done by administering the instrument to 30 SS2 physics students in Comprehensive Secondary School Akpasha, Nkanu West Local Government Area of Enugu State (school not in Enugu Education Zone). The data were used to estimate the reliability of the instrument using Cronbach alpha technique. An internal consistency

(reliability) of 0.81 for TOSRA was determined and this was considered high enough for the instrument to be used for data collection.

Method of Data Collection

The research instruments developed for this study was: Test of Science Related Attitude Scale. The TOSRA were given to the students by their regular physics class teacher before the commencement of the lesson and after the lesson, the TOSRA were collected back from the students by their class teacher and the scores were used for data analysis.

Method of Data Analysis

The data gathered from the administration of research instruments were analysed using quantitative statistics. The research questions were answered using mean and standard deviation. The null hypotheses for the study were tested using Analysis of Covariance (ANCOVA).

Results

Research Question One: What is the difference between the mean attitude rating scores of SS 2 students taught electricity using combined physical and inquiry virtual laboratories (CPIVL) and those a taught using only physical laboratory?

To answer research questions one; the attitude scores of students before and after treatment were analysed quantitatively using mean and standard deviation (SD).

Table 1: Mean attitude rating scores of students taught physics using CPIVL and physical lab only.

Group	N	Mean Pre-test	SD Pre-test	Mean Post-test	SD Post-test	Mean gain
Experimental	116	62.93	30.68	100.91	29.67	37.98
Control	104	66.23	44.67	86.11	35.54	19.88
Mean diff.		-3.30		14.80		18.10

Table 1 revealed that those taught physics with combined use of physical and inquiry virtual laboratories developed positive attitude towards the subject than their counterpart taught physics with physical lab only.

Research Question Two: What is the difference between the mean attitude rating scores of SS 2 male and female students taught electricity using combined physical and inquiry virtual laboratories (CPIVL)?

Table 2: Mean attitude rating scores of male and female physics student exposed to combined use of physical and inquiry virtual laboratories.

Group	N	Mean Pre-test	SD Pre-test	Mean Post-test	SD Post-test	Mean Gain
Male	64	63.84	30.68	108.95	14.12	45.11
Female	52	61.81	30.96	91.00	39.47	29.19
Mean Diff.		2.03		17.95		15.92

Table 2 shows that male students taught physics with use of combined physical and inquiry virtual laboratories developed higher positive attitude towards physics than their female counterpart exposed with the same treatment.

Hypothesis One: There is no significant difference between the mean attitude rating scores of SS 2 students taught electricity using CPIVL and those taught using physical lab only.

Table 3: Summary of ANCOVA test of difference in attitude rating scores of treatment groups

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	post-test attitude	189697.740[a]	5	37939.548	151.209	.001
Intercept	post-test attitude	30906.017	1	30906.017	123.176	.001
Pre attitude	post-test attitude	142505.001	1	142505.001	567.956	.001
	post-test attitude	66.315	1	66.315	.264	.608
Method	post-test attitude	15934.377	1	15934.377	63.507	.001
Sex	post-test attitude	22917.610	1	22917.610	91.338	.001
method * sex	post-test attitude	929.884	1	929.884	3.706	.056
Error	post-test attitude	53694.442	214	250.909		
Total	post-test attitude	2183554.000	220			
Corrected Total	post-test attitude	243392.182	219			

From Table 3, F (1,214) = 63.507; P = 0.001< 0.05; thus, hypothesis one is rejected showing that there is a significant difference between the mean attitude rating scores students taught electricity using CPIVL and those taught with only physical lab. This is in favour of CPIVL group.

Hypothesis Two: There is no significant difference between the mean attitude rating scores of male and female of SS 2 students taught electricity using CPIVL.

From Table 3, F (1,214) =91.34; P = 0.001<0.05. Thus, hypothesis three is rejected. It was therefore concluded that there is significant difference in the mean attitude rating scores of male and female students exposed to CPIVL group. The male physics students had higher positive attitude than their female counterpart.

Hypothesis Three: There is no interaction effect of teaching approaches and gender on attitude of secondary school students in electricity.

From Table 5, F (1,214) = 3.706; P = 0.056 > 0.05. Hypothesis five is not rejected. This shows that there was no interaction effect between Teaching methods and gender on students' attitude towards physics.

Discussion of Findings

The results of hypothesis one shows that students taught physics with use of combined physical and inquiry virtual laboratories developed positive attitudes towards the course than those taught with physical lab only. This finding agrees with the earlier findings of Josephsen and Kristensen (2006), and Pyatt and Sims (2012) who reported that students enjoyed working with virtual laboratory, showed preference towards the virtual medium in their lab experiences, found it motivating, and gained a lot of experience, which they believed could be remembered more easily. The results also shows that there is gender effect on the attitude of male and female students exposed to use of combined physical and inquiry virtual laboratories. This finding agrees with earlier findings of Adeyemi (2008), Gambari (2010) and Orabi (2007).

On interaction effect of teaching methods and gender on mean attitude rating and achievement scores, the finding of this study showed that there was no significant interaction effect of teaching methods and gender on students' mean attitude rating and achievement scores in physics. This is because the difference in their performance was not significant. However, the performance of the male students was slightly higher than that of their female counterparts, even though it was not statistically significant. This slight difference in the performance of male students and their female counterparts could be as a result of the nature of instructions delivered to the students, which enabled both the male and female students to be actively involved during the teaching and learning process. However, the male students performed better than their female counterparts, even though it was not statistically significant. This difference in the score of male students and their female counterparts could be as a result of the student's disposition to learn, both male and female students had equal opportunity to participate actively, but maybe the male students were more determined to learn than their female counterparts. Though the female students made considerably good effort based on their results.

Conclusion

From the findings, it can be deduced that use of combined physical and inquiry virtual laboratories produced more positive effect on students learning outcomes. It is gender friendly and improves students' attitude towards physics. This package is therefore a better approach for teaching practical physics at senior secondary schools in Nigeria. Through the use of combined physical and inquiry virtual laboratories, practical content can be delivered in simplest, motivating and interactive manners. This could reduce the age long poor performance in physics practical in Enugu State.

Recommendations

Based on the findings of this study, and their implications, the following recommendations were made.

1. Physics teachers should be trained on how best to involve students in the use of combined physical and inquiry virtual group laboratories activity during physics practical instructions so as to facilitate students' attitude and achievement in the lesson. This could be achieved through seminars and workshops for teachers in secondary schools.
2. Teachers should make teaching and learning of physics gender friendly by adopting the use of CPIVL in teaching physics concepts especially electricity.

Educational Implications of the Findings

The findings of this study have implications for education particularly in teaching physics practical in secondary schools. The implications of this study border on development of more virile instructional approach for teaching physics practical. The study revealed that use of combined physical and inquiry virtual laboratories was more effective in enhancing students' attitude and achievement in physics than physical laboratory activity. This result implies that the current instructional approach used in teaching might have been partly responsible for student's poor performance in physics practical.

The finding of this study equally has implication for science teachers. The finding of the study showed that science teachers (physics teachers) may have been using methods that are not favourable to students' understanding of the subject, therefore they need to move from using teacher-centred to student-centred and co-operative instructional strategies like the inquiry virtual laboratory activity, since it can enhance students to understand practical

activities, this will make them to focus on the learning task and be able to cooperate well with their colleagues.

Furthermore, the findings of the study showed that male performed better than their female counterparts in physics practical. The implication of this finding is that most instructional approach used in teaching physics does take care of gender difference in students. Therefore gender has to be considered during instructional delivery so that both male and female students will have equal opportunity to learn.

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