ISSN: 2578-7365

Research Article

Journal of Chemistry: Education Research and Practice

Comparative Effectiveness of Virtual Laboratory Instructional Package in Teaching Chemistry in Private and Public Secondary Schools

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Submitted: 07 Oct 2021; **Accepted:** 18 Oct 2021; **Published:** 04 Dec 2021

Citation: *Samuel Toyin Famuwagun, Folasade Busayo Ojobola (2021) Comparative Effectiveness of Virtual Laboratory Instructional Package in Teaching Chemistry in Private and Public Secondary Schools. J Chem Edu Res Prac 5(2): 131- 137.*

Abstract

The study investigated Comparative Effectiveness of Virtual Laboratory Instructional Package in Teaching Chemistry in Private and Public Secondary Schools in Ondo State, Nigeria. The purpose of the study was to compare the performance of students in chemistry in both private and public secondary schools in Ondo state using Virtual Laboratory Instructional Package. The study adopted the quasi-experimental pretest/posttest control group design. The sample for the study consisted of 183 senior secondary school two (SSSII) science students that were selected across the three senatorial districts of Ondo state using multistage sampling techniques. Two groups were involved in the study; the experimental group and the control group. The students in the experimental group were exposed to virtual laboratory instructional package while the control group was taught chemistry with the conventional method. One instrument; Chemistry Achievement Test was used to collect data for the study. The reliability of the instrument was ascertained through test-re-test method and the reliability index of 0.75 was obtained for the instrument. Hypotheses 1, 2 and 3 were tested with Analysis of Covariance (ANCOVA). However, Multiple Classifications Analysis (MCA) was used to identify the variable that contributed to the difference among groups. All the hypotheses were tested at 0.05 level of significance. The findings of the study showed that students exposed to Chemistry practical through virtual laboratory Instructional package in private secondary schools performed significantly better than their counterparts in public secondary schools. It was also found from the study that, gender has no effects on student's performance in public secondary schools meanwhile; there was gender difference in the performance of students in private secondary schools in favour of female students. Based on the findings, it was recommended that Government at all levels should endeavour to provide information and communication facilities like computer based instructional package in schools to teach chemistry and such must be made accessible to all students, so as to promote interactive and individualized learning among secondary school students.

Keywords: Virtual Laboratory, Chemistry Practical, Students Achievement, Multistage Sampling and Gender Difference

Introduction

The important position occupies in the development of nations today cannot be under estimated. Science has become such an indispensable tool that no nation developed or developing, wishing to progress in the social-economic sphere will afford to relegate its learning in schools. Science education is a distinct form of creative human activity which involves seeing, exploring and understanding reality [1].

Science and technology have long been recognized as instrument "par excellence for nations building and every country today craves for development [2]. Science is a field of human endeavor which seek to explain accurately the event and circumstance that exist in our natural environment. It produces laws which operates all over nature and when recognized, reduces events and circumstance in nature to orderly and predictable occurrence [3]. Nowadays, there had been observable level of development everywhere and all nations are striving to meet their needs through science and technology. Science and technology seem to be the factory that produces technologist technicians, craftsmen and skilled artisans who are required to change the economy of any nation. Science and technology skills acquisition are vital tools in coping with the present-day challenges.

However, with the level of science and technology contribution to the advancement of nation's science remain incomplete with-

out the knowledge of chemistry. Chemistry has become one of the important subjects in Nigeria secondary school curriculum to be offered at the senior secondary school level. Chemistry is the study of the properties and transformation of matter. It is also considered to be the study of substance that occur on earth and elsewhere in space Chemistry appeared to be very useful for its knowledge is required in the production of drugs, building materials, clothing material as well as food perseveration. It is making a great impact in the field of agriculture, engineering, pharmacy and medicine. Chemistry feature prominently in oil and gas, agriculture, health, solid material textiles, customer, water supply and sanitation crime detections, pulp and waste management, among others [3].

Practical activities are key to effective teaching and learning of chemistry, this is because during practical activities students tend to acquire various scientific skills, like the skill of manipulation, observations, calculation, discovery, inquiry and problem solving among others. Practical activities according to Osborne identified the following objective of each practical work in science (chemistry) teaching [4]:

- To enhance the learning of scientific knowledge
- To teach laboratory skill
- To give insight into scientific method and to develop expertise in using its
- To stimulate student interest and increasing motivation to study science
- To develop scientific attitude, such as open mindedness and objectivity
- To prepare student for practical examinations
- To develop scientific practical skill and problem-solving abilities

Practical knowledge helps students to understand complex, abstract ideas and give student opportunity to participate in the process and have an appreciation for the method of science. It constitutes also an integral part of chemistry.

The important of practical activities in the teaching and learning of chemistry cannot be underestimated, though there exist a lot of method involves in teaching of chemistry but the best method to be used at any given time is the method that teaches the necessary skills and abilities more than the others.

According to Ayegbusi most objective are better achieved through activities or experiment carried out by the student or demonstrated by the teacher after considering such factor as the facilities available on ground and the students attitude and ability [5]. The author or stressed further that, experiment as a matter of fact is a sensory aid that enriches the teaching and learning process through the use of human senses, he claimed that the term "chemical action" would have no meaning to a student who have never heard the sizzling in a test-tube or who has never seen precipitate form. Practical activities are needed in the teaching of science (chemistry) for its aid the acquisition of the basic scientific skills "investigation, discovery, observation, manipulation, calculation, inquiry and problem solving among others.

According to Omiko, when students are taught chemistry theoretically without actually carrying out practical in the laboratory, they are not likely to learn much [6]. The implication of this is that the students will lack scientific attitude, problem solving skills and inquiring skills, they will also learn chemistry poorly and may perform poorly in practical aspects of chemistry in both internal and external examinations.

The observation of the researcher and his personal interactions with the students revealed that students complain of lacks or inadequate practical engagement in school. Most of the topic that ought to have been taught practically are been attended to theoretically and their menace is unconnected with one or most of the following factors:

- α Lack of laboratory structure in school
- α Equipping laboratory is highly expensive
- α Fear of accident during practical session
- α Student are not familiar with simple laboratory apparatus
- α Student find it more difficult to link theoretical knowledge with practical knowledge
- α Checking student performance during practical can be tasking.

Furthermore, it had been part of the researcher observation that adequate teaching and learning are not taking place in the chemistry class because majority of chemistry teachers still engage the student with the traditional method of teaching which seems ineffective and do not allow students to participate actively in and interacts with their peers. The use of conventional laboratory is considered ineffective probably because it has some limitations especially in developing nations. Also, in a conventional laboratory, there is inadequate resources and where there are little at all they are not usually in good conditions while the few ones that are in good condition are not enough to go around the student who need them and these had reportedly hindered effective teaching and learning of chemistry and other science related subjects in secondary school in Nigeria [3]. Meanwhile, Omilani submitted that inadequacy and unavailability of material in conventional laboratory had led to students' poor performance in chemistry [7]. Adeyemi concluded that many schools do not have required laboratory facilities, hence students often fail to acquire science laboratory skill because their teachers were unable to conduct practical as they would like to and this always had inevitable consequences for students learning [8].

In the face of all these challenges militating against effective teaching of practical skills in chemistry, then it appears to look for an appropriate alternative and this bring into lime-light the use of virtual laboratory instructional package, virtual laboratory appeared to be a possible intervention through which the teaching and learning of chemistry can be improved. Virtual laboratory instructional package; a computer based application; is a learning environment in which student convert their theoretical knowledge into practical knowledge by conducting experiment. Virtual laboratory is one of the solutions provided by instructional technology that appeared to the teaching and learning of chemistry. It provides students with meaningful virtual experiences and present important concepts, principles and processes [9].

The use of virtual laboratory instructional package is of immense benefits to the teaching and learning of chemistry. The use of virtual laboratory enables students to construct and understand difficult

concept more easily, gives the learners some opportunities to overcome mistakes that occur as a result of such laboratory conditions or misuse of laboratory, and as well make students to prevail possible dangers that do arises during practical session in the physical session in the physical laboratory [10].

According to Edward, the use of virtual laboratory instrumental package which is an interactive based computer simulation, with which students experiment with virtual manipulative rather than physical manipulative leads to better students' learning [11]. In a similar perspective, Natasa and Dajan asserted that, the use of virtual laboratory in the treating of chemical concepts, showed that, virtual laboratory gives students and the teachers the potential educational tools that allow them to introduce new strategies to support higher levels skills: communication and information literacy, self-management knowledge skills, problem solving, independent learning, cooperative learning among others [12]. The authors submitted that, the use of virtual laboratory represent an upgrade of the traditional teaching and from this point of view, student taught with virtual laboratory package had higher performance than their counterparts taught via the physical laboratory in the conventional teaching method.

Kerr, compared the achievement among students instructed using hand-on chemistry laboratory versus those instructed using virtual chemistry laboratory [e-lab] [13]. He found that there were no significant differences in the achievement gain scores for the traditional versus the on-line students. Similarly, Eli and Queen concluded that in their study that there was a significant difference in the achievement of students taught 'Biology" with video-based multimedia instructional package and those treated with the conventional teaching method.

One of the factors acclaimed to have influence the performance of students at any level of education is "school-type". School type as said above might also be a deferment factor contributing to students' performance in chemistry. According to Alimi, Ehinola and Alabi, secondary schools irrespective of ownership, are expected to function in compliance with the objectives of the national education curriculum [14]. Children who attended private primary schools generally came into secondary schools more readily for junior secondary school Mathematics than did their peers who attended public primary schools [15]. The authors stressed that about 10% of variance of the scores in Mathematics is uniquely accounted for by the type of school; after which the location effect had been statistically controlled.

Close to this is the submission of Oluwatosin and Bandele who found that students in private schools showed a higher performance of student in chemistry in private schools than did their counterpart in public secondary schools [16]. In contrary, the Oginni and Awobodu submitted that, school type made no significant relative contributions to students achievement in chemistry [2]. In the same vein, Musibau and Johnson acceded that the type of school did not make any contribution to academic performance just as Philias and Wanjobi reiterated that the type of school (single sex or mixed, private or public) has no effect on the academic performance of students in mathematics [17].

Meanwhile, Aderonke and Victoria submitted that, students in private schools are better in academic achievement than their counterpart in public schools because it is assumed that private schools are better and adequately equipped with human and physical resources and also those resources are channeled towards a purposeful educational objective [18]. A school without facilities be it private or public, may not be able to achieve the stated goals and objectives. The availability and skillful utilization of resources and facilities influences learning and as well makes learning more meaningful [3].

Gender issues have been linked with performance of student in academic task. Gender refers to the social meaning associated with being a male or a female including the construction of identity, expectation behavior and power relationship that derive from social interaction [19]. According to Ganbari, there is no-significant difference in the achievement of male and female students taught physics in virtual laboratory instructional package [10]. Similarly, Adeyemi and Gambari in their separate studies reported that gender had no effects on academics performance of the students in science subjects [8, 10]. In the same vein, Uduosoro asserted that the gender of students be it male or female does not affect the academic performance of the students. However, contrary to the views of the above authors is that of Ezeudu and Obi who found that there was a significant difference in the academic performance of male and female students in chemistry. Also, Pollock submitted that male students performed higher and better than their female counterpart in physics, while Wagbara, reported that female students had a better and academic achievement than did male.

Poripo experimented on the effects of simulation on male and female student's achievement in chemistry [20]. The research used two research questions and two null hypotheses and the instrument used was achievement test in simulation. The result of the study revealed that, the use of simulation method of teaching increased the achievement of students in chemistry with female and male not showing no significant difference in their mean response. Likewise, the study of Akinbobola and Afolabi reported that no significant difference between the achievement of male and female students taught physics with discovery, demonstration and expository teaching approaches and corresponding exposure to a Pretoria organizer [21]. Popoola posited that academic achievement is free of gender influences [22].

Purpose of the Study

The purpose of this study was to investigate the comparative effect of virtual laboratory instructional package in teaching chemistry in private and public secondary schools in Ondo State, Nigeria. The study also sought to find out the differential effects of (VLIP) on male and female students in public and private secondary schools in the state.

Research Hypotheses

The following hypotheses were formulated for the study.

1. There is no significant difference in the achievement mean score of students in private and public schools.
2. There is no significant difference in the achievement of mean scores of male and female students in public secondary schools exposed to chemistry through virtual laboratory instructional package.
3. There is no significant difference in the achievement mean scores of male and female students in private secondary schools exposed to chemistry through virtual laboratory instructional package.

Research Methodology

The study adopted the pretest-posttest quasi-experimental design. The paradigm for the design is represented diagrammatically as shown below:

$$\begin{matrix} O_I & X_I & O_2 \\ O_3 & C & O_4 \end{matrix}$$

Where

O_I, O_3 - pretests

O_2, O_4 - posttests

X_I - treatment (VIRTUAL LABORATORY INSTRUCTIONAL PACKAGE)

C - treatment (conventional method)

Population

The population for the study comprised all SS II science students in all the senior secondary schools in Ondo State. There exists 510 public secondary schools and 291 private secondary schools across all the eighteen local Government Areas of Ondo State, Nigeria (Source: Ondo State Ministry of Education, Akure).

Sample and Sampling Techniques

The sample for this study comprised of 183 Senior Secondary School two students (SSII) that were selected across the three senatorial districts in Ondo State using Multistage-stage sampling Techniques. The first stage involved the selection of one local Government from each of the senatorial districts using simple random sampling techniques after which Purposive sampling techniques was imployed in the selection of two schools that have functional computer laboratory from each of the local Government earlier selected. At the last stage, one intact class was selected from each of the sampled schools.

Research Instrument

The research instrument used in collecting data was Chemistry Practical Achievement Test (CPAT) composed of a standardized WAEC\NECO chemistry practical question on volumetric analysis. This instrument was used to determine the performance of students in practical chemistry.

Validity of the Instrument

Face and content validity of the instrument was ascertained by chemistry teachers and experts in science education. They examined and scrutinized the instrument, their comments and suggestions were effected and the corrected revision was used for data collection.

Reliability of the Instrument

The reliability of the instrument was determined through test-retest method. This was done by administering the instrument (CPAT) twice on 20 students who were not part of the actual sample within an interval of two weeks. The two sets of scores obtained from the separate sets of responses were later collated and correlated using Pearson's product correlation analysis, reliability index of 0.75 was obtained. This value was regarded as high enough to be used for the study at 0.05 level of significance.

Data Analysis

Data collected were collated and analyzed using descriptive statistics of mean, standard deviation and graph while the hypotheses were tested using inferential statistics of analysis of covariance (ANCOVA). Multiple classification analysis was used to identify the variable that contributed to the difference between groups.

Results and Discussions

Hypothesis 1: There is no significant difference in the achievement mean scores of students exposed to Chemistry practical through Virtual Laboratory Instructional Package in public and private secondary school.

Achievement mean scores of students exposed to Chemistry practical through Virtual Laboratory Instructional Package in public and private secondary schools were computed and subsequently compared for statistical significance using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The result is presented in Table 1.

Table 1: ANCOVA Showing Achievements Exposed Virtual Laboratory Instructional Package in Chemistry Practical by School Type and Treatment

Source	SS	Df	MS	F	P
Corrected Model	791.926	2	395.963	51.006	.000
Covariate (Pretest)	4.279	1	4.279	.551	.460
School Type	730.384	1	730.384	94.084	.000
Error	512.363	66	7.763		
Total	15025.000	69			
Corrected Total	1304.290	68			

*p<0.05

Table 1 shows that F1,66= 94.084, p<0.05. The null hypothesis is rejected. This implies that, there was significant difference in the achievement mean scores of students exposed to Chemistry practical through Virtual Laboratory Instructional Package in public and private Secondary Schools.

In order to determine the effect of school type on the achievement mean scores of students exposed to Chemistry practical through Virtual Laboratory Instructional Package, Multiple Classification Analysis (MCA) was carried out. The result is presented in Table 2.

Table 2: Multiple Classification Analysis (MCA) of Students' Achievement in Chemistry Practical Through Virtual Laboratory Instructional Package by School Type

Grand mean =14.10					
Variable + Category	**N**	**Unadjusted Devn'**	**Eta²**	**Adjusted for Independent + Covariate**	**Beta**
Private	34	3.43	.61	3.10	.22
Public	35	-3.33		-3.00	
Multiple R 0.217 Multiple R^2 0.047					

The result in Table 2 shows that with a grand mean of 14.10, students exposed to Virtual Laboratory Instructional Package in private schools had higher adjusted mean score of 17.20 (14.10+3.10) on achievement in Chemistry practical than their counterpart in public schools 11.10 (14.10+(-3.00). This implies that school type had effect on the achievement of students in Chemistry Practical through Virtual Laboratory Instructional Package. About 61% (Eta2=0.607) of the observed variance in students' achievement in Chemistry practical on exposure Virtual Laboratory Instructional Package is explained by school type.

Hypothesis 2: There is no significant difference in the achievements mean scores of male and female students exposed to Chemistry practical through Virtual Laboratory Instructional Package in public Secondary Schools.

Achievements mean scores of male and female students exposed to Chemistry practical through Virtual Laboratory Instructional Package in public Secondary Schools were computed and subsequently compared for statistical significance using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The result is presented in Table 3.

Table 3: ANCOVA Showing Students Achievement in Chemistry Practical Exposed to Virtual Laboratory Instructional Package in Public Secondary by Gender

Source	SS	Df	MS	F	P
Corrected Model	19.186	2	9.593	1.981	.155
Covariate (Pretest)	6.800	1	6.800	1.404	.245
Gender	14.463	1	14.463	2.986	.094
Error	154.985	32	4.843		
Total	4235.000	35			
Corrected Total	174.171	34			

p>0.05

Table 3 shows that $F_{1,32}$= 2.986; p>0.05. The null hypothesis is not rejected. This implies that, there was no significant difference in the achievement mean scores of male and female students exposed to Chemistry practical through Virtual Laboratory Instructional Package in public Secondary Schools.

Hypothesis 3: There is no significant difference in the achievement mean scores of male and female students exposed to Chemistry practical through Virtual Laboratory Instructional Package in private secondary schools.

Achievement mean scores of male and female students exposed to Chemistry practical through Virtual Laboratory Instructional Package in private Secondary Schools were computed and subsequently compared for statistical significance using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The result is presented in Table 4.

Table 4: ANCOVA Showing Students Achievement in Chemistry Practical Exposed to Virtual Laboratory Instructional Package in Private Secondary School by Gender

Source	SS	Df	MS	F	P
Corrected Model	42.940	2	21.470	2.222	.125
Covariate (Pretest)	.469	1	.469	.049	.827
Gender	42.269	1	42.269	4.375*	.045
Error	299.531	31	9.662		
Total	10790.000	34			
Corrected Total	342.471	33			

*p<0.05

Table 4 shows that F1,32= 4.375; p<0.05. The null hypothesis is rejected. This implies that, there was significant difference in the achievement mean scores of male and female students exposed to Chemistry practical through Virtual Laboratory Instructional Package in private secondary schools.

In order to determine the effect of the gender on the achievement of students exposed to Chemistry practical through Virtual Laboratory Instructional Package in private secondary schools, Multiple Classification Analysis (MCA) was carried out. The result is presented in Table 5.

Table 5: Multiple Classification Analysis (MCA) Showing the Achievement of Private Secondary School Students Exposed to Virtual Laboratory Instructional Package by Gender

Grand Mean=17.53					
Variable + Category	**N**	**Unadjusted Devn'**	**Eta²**	**Adjusted for Independent + Covariate**	**Beta**
Male	17	-1.12	.13	-1.12	.04
Female	17	1.12		1.12	
Multiple R 0.044 Multiple R^2 0.002					

Table 5 shows that with a grand mean of 17.53, female students exposed to Virtual Laboratory Instructional Package in private schools had higher adjusted mean score of 18.65 (17.53+1.12) on achievement in Chemistry practical than their male counterparts 16.41(17.53+(-1.12). About 13% (Eta2=0.13) of the observed variance in students' achievement in Chemistry practical exposed to Virtual Laboratory Instructional Package in private schools is explained by gender.

Discussion

Effect of Treatment on Students'Achievement by School Type (Private & Public): The finding of this study showed that there was significant difference in the achievement means scores of students exposed to Chemistry practical through Virtual Laboratory Instructional Package in public and private secondary schools in favour of private schools. This finding corroborates the findings of Alimi et al. who reported that private schools are better than public schools in terms of the availability of human and physical facilities and consequently, students' performance is better in private schools than in public schools [14]. However, the submission of Oginni and Awobudu is in constrains to the finding of this study in that, they reported that school type made no significant relative contributions to students' achievement in Chemistry [2]. Also, the reports of Musibau and Johnson disagree with the findings of this study for they had found in their studies that the type of school did not make any contribution to the achievement of the students

Effect of Treatment on Achievement of Students'in Public School by Gender: Further analysis however revealed that there was no significant difference in the achievement mean scores of male and female students exposed to Chemistry practical through Virtual Laboratory Instructional Package in public Secondary Schools. This finding equally agreed with the findings of Philias and Wanjobi who concluded that sex had no effects on the academic achievement of students in Mathematics [17].

Conclusion

From the findings of this study, it was concluded that Virtual Laboratory Instructional Package was more effective and reliable in teaching practical Chemistry than the conventional laboratory method, (since students in private secondary schools who were exposed to Virtual Laboratory Instructional Package performed better than those taught with conventional laboratory teaching method in the achievement test. It could also be concluded that Virtual Laboratory Instructional Package is not gender biased.

Recommendations

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

1. Virtual Laboratory Instructional Package should be adopted

in teaching the laboratory skills like observation and manipulation.

2. Government should provide secondary schools with viable and functional computer laboratories and internet accessary so as to aid computer-based learning of Chemistry and other science related subjects.
3. Students should familiarize themselves more with the use of Information and Communication Technology (ICT) like Virtual Laboratory Instructional Package because of its numerous advantages (like, interactiveness, repetitiveness, individualized learning among others).
4. The use of Computer in Chemistry lesson should be encouraged for it enhances social interaction among the students and also boost the attitudes of students towards Chemistry in a positive way.
5. Science Teachers should be exposed to workshops and training on the use of Computer based Educational Packages in their instructional processes.
6. Curriculum planners should endeavour to incorporate the use of educational packages into the Chemistry Curriculum of Senior Secondary Schools.
7. Parents and guardians should encourage their children to be computer literate for the use of computer will enhance their individualized learning of concepts in science in general and Chemistry in particular.
8. Computer facilities should be made available to all students at the senior secondary school level to encourage learning at pace through interactive simulation and animation among others.

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