Improving Students Attitude Towards Practical Chemistry Using Virtual Laboratory Package: Implications for Global Security Challenges

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Abstract

Problem: Among other things, the continuous failure of chemistry students in both internal and external examinations has been attributed to the students' negative views toward the subject. Using the virtual laboratory strategy may improve students' attitudes toward chemistry. In light of the possibility for virtual experiments to offer a solution for learning at home in an emergency situation made necessary by security concerns, it is necessary to investigate this element. There is, in fact, continuous discussion regarding the relative merits of the face-to-face laboratory approach vs the virtual laboratory strategy for improving students learning results. The key question is whether or not using a virtual laboratory can improve students' attitudes toward chemistry. Answering this question constitute the problem of this study. **Approach:** A quasi-experimental design pre-test, post-test control group was adopted for the study. The population of the study consists of all the public senior secondary school three (SSS III) students offering chemistry in Kogi State. One hundred and seventy-six (176) students were sampled from four co-educational schools using multi-stage sampling technique. A validated instrument titled: Test of Practical Chemistry Attitude Scale (TPCAS) was used for data collection with a reliability coefficient of 0.81 using Pearson Product Moment Correlation. Two research questions and two hypotheses guided the study. The two research questions raised were answered using mean and standard deviation while the two null hypotheses were tested using ANCOVA at 0.05 level of significance. **Findings:** the results of findings showed that there was significant difference between the mean attitude rating scores of students taught practical chemistry using virtual laboratory strategy and those taught using face-to-face laboratory, in favour of virtual laboratory strategy. Additionally, the results showed that gender difference exists when virtual laboratory strategy are applied in favour of male students that had higher positive attitude toward chemistry practicals. **Conclusion:** implications of the findings of this study in relation to global security challenges were discussed and the study concluded that government at various levels should provide all the necessary facilities for virtual experiments in order to encourage students to carry out virtual laboratory experiments at home, which in long run will help to address the barriers posed by the global security challenges.

Key words: attitude, practical chemistry, face-to-face laboratory, virtual laboratory, strategy, security challenges, students, homes, gender, schools

Introduction

Any country's progress and long-term development depend critically on security. Because of this, a sizable portion of the country's annual budget is typically set aside for security, yet sloppy management and application of security measures have led to problems with global security. Nigeria is not exempt from the aftershocks of international insecurity. Indeed, the nation is dealing with a number of security issues, including Boko Haram, terrorism, banditry, disputes between Fulani herders and farmers, attacks by ethnic militias, and

religious riots, among others. Due to the country's security issues, there has been an increase in rape, financial exploitation, emotional stress, depression, and other crimes[1]. The most common forms of insecurity include killings and kidnappings of schoolchildren, faculty members, and staff for ransom in primary, secondary, and higher institutions. To stop the kidnapping and ongoing murders of schoolchildren, many schools, particularly in Nigeria's north and northwest, have been closed for several months. While acknowledging the reality of the modern world, we must develop new ways to address our issues by implementing cutting edge teaching strategies that will enable students to learn science, particularly practical chemistry, at their convenience. This will therefore limit their movement to the school setting, where they are more readily kidnapped and killed. Fortunately, there is still controversy about the effectiveness of employing virtual experiments, particularly whether they can replace or improve students' positive attitudes toward chemistry when used in place of in person or physical laboratory instruction. This has created a window of opportunity for a robust rejuvenation of this field's chemistry education research.

Science is the methodical examination of the physical and natural world via close observation. According to [2], science is a systematic endeavor that creates and organizes information in the form of universe-related explanations and predictions that can be put to the test. Today, the advancement of any nation depends on its science and technology sectors as science is one of technology's fundamental building blocks. Because they have helped many nations become superpowers, saved lives, and cured terrible, incurable diseases, among other things, science and technology are crucial. One of the crucial science disciplines taught in Nigeria at the senior secondary and tertiary levels of education is chemistry.

Chemistry was described by [3] as the study of matter, including its constitution, applications, qualities, and physical and chemical changes. Chemistry explores the structure and transformations that matter goes through because our world is formed of matter. Any human being must understand chemistry since it is necessary to fulfill our fundamental needs for survival. According to [4], by meeting their fundamental requirements, such as food, clothing, housing, medical, and transportation, it has improved the quality of our lives. [5] made the point in their own contributions that the power of chemical research is what fosters an atmosphere that results in the food, medicines, and materials that are the trademarks of modern living.

Given the importance of chemistry, it is assumed that students will perform honorably well in the subject. However, evidence from the literature consistently shows that students perform poorly in chemistry [6, 7, 8]. The students' subpar chemistry performance is caused by a variety of variables. Some academics studying chemistry education have attributed it to students' attitudes, which are exhibited in their lack of enthusiasm in the topic [9,10]. Other chemistry education scholars attributed the declining performance to students' lack of proficiency with the use of laboratory instruments and their inadequate development of practical abilities in chemistry, which together make for 40% of the total marks for chemistry tests [11,12].

Other chemistry education researchers have concentrated on different aspects, but the researchers only looked at the two characteristics mentioned above because they were the main topics of this study. The success of any learner would, to a large part, depend on his or her attitude towards the learning materials, according to Fakeye in [13] described attitude as the positive or negative feelings that an individual feels about objects and ideas. This suggests that pupils' academic achievement will increase if their attitudes are favorable, but it will decrease if they have negative attitudes. This also implies that a positive attitude toward chemistry improves students' success in the subject, while a negative attitude produces poor academic results for the students in the subject. According to the aforementioned, a student's attitude greatly affects their study of chemistry and, as a result, their academic performance in the subject. Therefore, it is imperative for chemistry instructors to establish appropriate teaching techniques that can boost students' favorable attitudes toward chemistry. By using a laboratory teaching technique, it's possible to change how the students feel about chemistry.

Chemistry classes, like all science courses, must use the laboratory method of instruction. Practical laboratory courses in chemistry foster, among other things, student-centered learning, curiosity, and a favorable attitude toward chemistry. The face-to-face or in-person laboratory teaching strategy, however, has numerous difficulties. Some of the difficulties include the expensive cost of each piece of equipment, the lack of time to

complete practicals, the issues with crowded classrooms, security issues (such as kidnapping and assassination of schoolchildren), the Covid-19 situation, and other dangers. Given these obstacles, it is vital to examine suitable alternatives that will promote hands-on and mind-on activities in our classroom interaction pattern. The usage of instructional strategy packages for virtual laboratories is one of these options.

According to [13] a virtual laboratory is an online activity in which students use a computer interface to communicate with experimental equipment. A virtual laboratory is a web-based setting that includes films and simulations of experiments that let students do experiments remotely [14]. It is impossible to overstate the benefits of virtual experimentation, particularly in this day of computers. Students can conduct experiments in the comfort of their homes or anywhere else, better document the experimental procedure and results, actively participate in the experimental process, repeat failed experiments several times, and learn to overcome potential risks encountered in physical laboratories with the help of virtual experiments.

According to constructivist theory, knowledge is built on a foundation of prior experience. Constructivism learning theory, according to [15] is a type of learning method that emphasizes the active engagement of learners in the process of creating their own knowledge. The fundamental problem with constructivist theory is that it encourages students to create their own concepts in a given situation. The utilization of the visual laboratory instructional technique, which gives students full reign to engage with the visual world, fits in perfectly with this alluring aspect of constructivist theory.

In fact, it offers a suitable learning atmosphere in which the students can learn via experience. Constructivist learning theory supports the instructional technique of the visual laboratory in light of this. In the literature, there is ongoing discussion about how virtual laboratories compare to face-to-face laboratories in terms of the learning outcomes for students, particularly in the area of chemistry and whether or not virtual laboratories improve students' attitudes toward chemistry.

[16] discovered, for instance, that students exposed to the chemistry practical through the virtual laboratory method strategically outperformed those exposed to the face-to-face laboratory method. Additionally, [17] discovered that students exposed to virtual laboratories outperformed their counterparts exposed to traditional face-to-face laboratories in terms of learning outcomes. When compared to a real laboratory, [18] showed that a virtual laboratory had a substantial impact on students' attitudes, among other things. Contrarily, numerous studies found no discernible difference in learning results between the virtual laboratory style and the traditional face-to-face laboratory model [19,20]. Further research is necessary to determine the relative impact of virtual and face-to-face laboratories on students' attitudes toward chemistry because the literature review shown above is conflicting and inconclusive. The significance of this study lies not only in bridging the gap left by conflicting findings regarding the impact of using a virtual laboratory on students' attitudes toward chemistry, but also in the fact that its findings will give students and their teachers the chance to prepare and conduct experiments at home with the necessary practical skills, offering solutions or an alternative to the ongoing attacks, killings, and other violent acts against students and teachers. Students in secondary schools will be able to continue their practical studies in the event of a pandemic like COVID-19 according to the results. Science education scholars have debated the impact of gender on students' learning results, but no clear conclusion has been reached. Female students exposed to power-point slide presentations fared better than their male counterparts, according to [21]. On the other hand, [22] found that male physics students' attitudes were improved by the use of integrated physical and inquiry virtual laboratories more than those of their female counterparts. [15,8] showed no statistically significant difference between male and female students in science disciplines subjected to innovative teaching methods in terms of learning outcomes. As a result of the aforementioned gender empirical research findings, the researcher decided to incorporate gender as a moderating variable in this study.

Purpose of the Study

The purpose of this study was to determine the effect of the use of virtual laboratory on attitude of students towards chemistry at the secondary school level. Specifically, the study would determine the:

(i) Difference in main attitude rating scores of secondary school students exposed to chemistry practical using virtual laboratory method and those exposed using face-to-face laboratory method.
(ii) Difference in mean attitude scores of male and female students exposed to practical chemistry using virtual laboratory method.

Research Questions

The following research questions guided the study.

(1)What are the mean attitude rating scores of students exposed to chemistry practical using virtual laboratory method and those exposed through to physical laboratory method?

(2)What are the mean attitude rating scores of male and female students exposed to virtual laboratory method?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significant.

1. There is no significant difference in the mean attitude rating scores of chemistry students exposed to virtual laboratory and those exposed to face-to-face laboratory.
2. There is no significant difference in man attitude rating score of male and female chemistry students' exposed to virtual laboratory.

Methods

The design of this study was the pre-test, post-test, non-equivalent control group, quasi experimental design. The virtual laboratory method was used as the experimental group while the physical laboratory was used as the control group. The population of this study comprised of 5,600 of senior secondary three (SS3) chemistry students of 257 public senior secondary schools in Kogi State ([23], 2022/2023 academics session). The sample size of this study is 176 students were selected using multistage sampling techniques. Firstly, purposive sampling was used to select all the public secondary schools in Kogi State that are co-educational. Secondly, simple random sampling technique by balloting was used to select four secondary schools. From the four schools sampled, two schools were randomly assigned to experimental and control groups.

The researcher's Test of Practical Chemistry Attitude Scale (TPAS) was the instrument utilized to gather data. Three specialists from Prince Abubakar Audu University in Anyigba, two in science education and one in measurement and evaluation, verified the TPAS. A test blueprint containing the dimensions and the number of tests from each dimension was used to develop the content validity. The three professionals approved the lesson plans for both the experimental and control groups. With a result of 0.81, the Pearson Product Moment Correlation Coefficient was used to assess the instrument's dependability. And this was deemed suitable for use in this investigation.

For this study, the researcher instructed the chemistry teachers on how to use both the traditional face-to-face laboratory method and virtual laboratory instructional tools. One week was allotted for the training. Both the experimental and control groups received a pre-test on the test of practical chemistry attitude scale following training and right before the start of the treatment. To ascertain the impact of the treatments on the chosen students, a post-test was given to the two groups after the exposure to the treatment groups for a period of four weeks. Both descriptive and inferential statistics were used to analyze the acquired data. Mean and standard deviation were used to answer the study questions, and analysis of covariance (ANCOVA) was used to evaluate the hypotheses at a 0.05 significant level.

Results

Table 1: Mean and Standard Deviation of attitude rating scores of students exposed to virtual and face-to face laboratory methods.

Variable		Pre-test		Post-test		Mean attitude gain	
Learning strategies	N	$\overline{X}$	SD	$\overline{X}$	SD		
Virtual laboratory	72	1.85	0.355	2.81	0.520	0.96	
Physical laboratory	104	1.92	0.367	2.53	0.458	0.62	

Where N = Number of respondents, $\overline{X}$ = Mean, SD = Standard deviation

Table1 showed that students exposed to chemistry practical through virtual laboratory had mean attitude rating pre-test scores of 1.85 with standard deviation of 0.335 and post-test of mean attitude scores of 2.81 and standard deviation of 0.520 with mean attitude gain of 0.96. On the other hand, students exposed to chemistry practical through face-to-face laboratory had pre-test and post-test mean attitude rating scores of 1.91 and 2.53 with standard deviation of 0.367 and 0.450 and mean attitude gain of 0.62 respectively. The difference in mean gain between virtual and physical laboratories is 0.96 – 0.62 = 0.34. This implies that students who were exposed to virtual laboratory had high positive attitude towards practical chemistry than their counterpart exposed to face-to-face laboratory.

Table 2: Mean and Standard Deviation of attitude scores of male and female chemistry students exposed to chemistry practical through virtual laboratory method.

Variable		Pre-test		Post-test		Mean attitude gain
Gender	N	$\overline{X}$	SD	$\overline{X}$	SD	
Male	30	1.83	0.84	2.91	1.26	1.08
Female	42	1.89	0.76	2.74	1.13	0.85

Where N = Number of respondents, $\overline{X}$ = Mean, SD = Standard deviation

Table1 showed that the mean attitude scores of male students exposed to virtual laboratory had mean scores and standard deviation of the pre-test and post-test of 1.83, 0.84, 2.91 and 1.26 respectively with mean attitude gain 1.08. On the other hand, their female counterpart exposed to virtual laboratory had mean scores and standard deviation of pre-test and post-test of 1.89, 0.76, 2.74 and 1.13 with mean gain of 0.85 respectively. The mean attitude gain difference between male and female is 0.23. The results showed that the male students exposed to virtual laboratory method mean attitude gain was higher their female counterparts. This result implies that the male students developed higher positive attitude towards chemistry practical than the female students exposed with virtual laboratory method.

Table 3: Analysis of Covariance of students mean attitude scores of students mean attitude scores of students exposed to virtual laboratory and those exposed to physical laboratory

Source	Type III sum of squares	Df	Mean square	F	Sig
Corrected model	738.869[a]	2	369.435	89.901	.000
Intercept	193.783	1	193.783	47.160	.000
Pre-test	111.087	1	111.087	27.035	.000
Strategies	610.555	1	610.555	148.590	.000
Error	710.97.064	173	4.109		

Total	14336.400	176			
Corrected total	**1449.837**	**175**			

The result in table 3 showed that an f-ratio of 148.590 was obtained with associated exact probability value of .0000. Since the associated probability (.000) was less than 0.05 level of significance, the null hypothesis (Ho_1) is rejected. Thus there was a significance difference in the mean attitude scores of students exposed to chemistry practical through virtual laboratory and those exposed to face-to-face laboratory method. Since those exposed to virtual laboratory had higher mean gain, this indicates that virtual laboratory improved students' attitude in chemistry practical than conventional face-to-face laboratory method.

Table 4: Analysis of Covariance of mean attitude scores of male and female chemistry students exposed to virtual laboratory

Source	Type III sum of squares	Df	Mean square	F	Sig
Corrected model	136.148[a]	2	68.074	12.519	.003
Intercept	209.834	1	209.834	38.590	.000
Pre-test	34.282	1	34.282	6.304	.080
Gender	104.348	1	104.348	19.280	.001
Error	375.190	69	5.438		
Total	10112.800	72			
Corrected total	**511.338**	**71**			

Table 4 shows that there was significant difference between the mean attitude scores of male and female students exposed to chemistry practical through virtual laboratory, an f-ratio of 19.280 was obtained with associated set probability value of (0.001) was less than 0.05 set as level of significance. That is to say null hypothesis (Ho_3) was rejected. The significance difference mean attitude score is in favour of the male with the highest mean attitude score.

Discussion of Findings

The result of the analysis showed that there was a significance difference in the mean attitude scores of students exposed to virtual laboratory package and those exposed to face-to-face laboratory strategy in favour of virtual laboratory strategy. That is to say that students exposed to virtual laboratory strategy had greater positive effect on attitudes of students toward chemistry than their counterpart exposed face to face. The relative effectiveness of virtual laboratory in enhancing students attitude toward chemistry may be attributed to the fact that virtual laboratory activities were carried out by students at the comforts in their own pace. Carrying out virtual laboratory strategy is more rewarding than regimented face to face laboratory activities which must often is dominated by the teacher. The finding of this study strengthens constructivist theory which emphasized that learning is enhanced through active participation of learners. This finding is in agreement with the findings of previous researchers such as [18] and [17] who reported in their separate findings that students exposed to science practicals through virtual laboratory instructional packages performed significantly better than their counterpart who were exposed to the face to face instructional practical chemistry. Regretably, students do not make good use of the approach because of lack of exposure of students to virtual experiment, lack of training of how to conduct experiment in virtual laboratory and lack of funds to purchase some gadgets [13]. Students have been called upon to go extra miles by being committed, creative and innovative in setting up and using virtual laboratory strategy.

The study further found significant difference in the mean attitude scores of male and female students exposed to virtual laboratory strategy in favour of the male. The present result may be as a result of the males having

more time at home to carry out the virtual laboratory experiment than their female counterpart. This finding is in line with the finding of [22] who reported that virtual laboratory package enhanced the attitude of male student more than their counterpart taught the same way. However, the finding disagrees with [19] and [20] found that no significant difference in the mean attitude scores of male and female students exposed to virtual laboratory method. The contradictions of the above two authors notwithstanding the present study has shown that virtual laboratory strategy depend on gender to be effective in favour males and this maybe as the result of the fact that most of the practical activities of virtual laboratory strategy are carried out at home and that the home environment put more pressure on female students to carry out domestic work, than their male counterparts.

The findings of this study have some educational and security implications. Firstly, in view of the fact that virtual laboratory strategy has proved more effective security in promoting students' attitude towards practical chemistry, chemistry students should retort to the use of virtual laboratory instructional strategy during any global security challenges. Secondly the use of virtual laboratory teaching strategy requires more efforts and commitment on the part of students to set up and use of virtual experiments, thus students must go extra mile in using this strategy to safeguard their lives during any global security crises. Thirdly, positive attitude builds into sustained interest and this contributes positively to achievement in chemistry, it is important that students adopt virtual laboratory strategy which keep them safe from any security challenges as well contribute to the positive achievement in practical chemistry.

Conclusion

Conclusively, the empirical evidence provided by this study showed that the virtual laboratory method had greater positive effect on the attitude of students toward practical chemistry than the face-to-face laboratory method. The researchers advocate the need for Kogi State Government to provide enabling environment that will promote the use of virtual laboratory method especially during the period of security challenges such killing and kidnapping of school children. This will give parents alternative of allowing their wards to remain at home and comfortably perform practical chemistry activities as well as other online lessons. Furthermore, this study has provided an empirical evidence to support the efficacy of virtual laboratory method in facilitating male students' positive attitude towards chemistry than the female students. Since, gender has significant positive effect on students' attitude towards chemistry in favour of male, there is the need to carry out further studies on the reasons for the superiority of the male over their female counterparts as well as possible ways motivation the female students to excel on their use of virtual laboratory strategy like their male counterparts.

References

1. Attah, F. & Fabetu, E. (2018). The incidences of kidnapping in an urban sprawl: Insights from white sand, Lagos State, Nigeria *Advances in Social Sciences Research Journal* 5(10), 132 – 148.
2. Achimugu, L. (2018). Effectiveness of enriched demonstration and lecture instructional strategies on senior school students' achievement in chemistry. *Journal Of Contemporary Educational Research* 1(1), 1 – 8.
3. Offiah, F.C. & Sammuel, N.N.C. (2018). The effect of teaching relevant mathematical topics before and during the teaching of selected topic in chemistry *49th Annual Conference Proceedings of Science Teachers Association of Nigeria (STAN)*, 110 – 115 STAN Place ltd.
4. Omiko, A. (2015). Impact of instructional scaffolding of students' performance in chemistry in secondary schools in Ebonyi State of Nigeria. *International Journal of Education, Learning and Development* 3(7), 74 – 83.
5. Seery, M.K. (2019). The role of prior knowledge in undergraduate performance in chemistry: A correlation prediction study. *Chemistry Education Research and Practices* 10 (3), 227 – 252.

6. Achimugu, L. (2020). Comparative effects of improved and standard science equipment on students achievement in senior Secondary Schools. *Kogi Journal of education and Padagogy,* 2(1), 49 – 58.
7. Pyatt, K. & Sims, R. (2012). Virtual and physical experimentation in inquiry based science labs: Attitudes, performance and access. *Journal of Science Education and Technology* 21(1), 133 – 149.
8. Adesoji, F.A.A. & Olatunbosun, S.M. (2018). StudeFnt teacher and school environment factors as determinants of performance in senior secondary school chemistry in Oyo State, Nigeria *The Journal of International Social Research* 1 (2), 14 – 34.
9. Tuysuz C. (2010). The effect of virtual laboratory on students' achievement and attitude in chemistry *International Online Journal of Educational Sciences* 2 (1), 37 – 53.
10. Famuwagun S.T. & Mohammed, N.N. (2020). Effects of virtual laboratory instructional package on senior secondary school students' performance in chemistry in Ondo State, Nigeria, *Kashere Journal of Education*, 1 (2), 55 – 63.
11. Ojo, M.O. & Owolabi, T.O. (2020). Effects of virtual laboratory instructional strategy on secondary school students' learning outcomes in physics practical. *International Journal of Scientific and Research Publications* 10 (4), 406 – 413.
12. Bajpai, M. (2013). Developing concepts in physics through virtual lab experiment: An effectiveness study *Tech-noleard* 3(1), 43 – 50.
13. Nwafor, C.E. & Aja, L. (2017). Effects of constructivist based teaching strategy on junior secondary school students' achievement in basic science *Journal of Science Teachers Association of Nigeria* 52 (1), 33 – 42.
14. Oloruntegbe, K.O. & Alam, G.M.C. (2010). Evaluation of 3D environment and virtual realities in science teaching and learning: The need to go beyond perception referents, *Scientific Research and Essays* 5(9), 948 – 954.
15. Famuwagun, S. T. (2019). Effect of virtual laboratory institutional package on students' learning outcome in chemistry Ondo State, Nigeria *Unpublished Ph.D Thesis of Department of Science Education, Ekiti State University, Nigeria*.
16. Alneyadi, S.S. (2019). Virtual laboratory implementation in science literature: Emirati science teachers' perspective. *EURASIA Journal of Mathematics Science and Technology Education* 15 (12), 1 – 10.
17. Crandall, P.G., O'Bryan, C.A., Killian, S.A., Beek, D.E., Jarvis, N & Clausen, E. (2015). Comparison of the degree of student satisfaction using simulation or a traditional net lab to teach properties of ice *Journal of Food Science Education* 14(1), 24 – 29.
18. Ambusaidi, A., Almusawi, A., Al-Bulushi, S. & Al-Balushi, K. (2018). The impact of virtual lab experience on 9th grade students' achievement and their attitudes toward science and learning by virtual lab. *Journal of Turkish Science Education* 15(2), 13 – 19.
19. Ihechu, P.J.K., Ugwuoji, J.N., Akwah, C.P. & Nwachukwu, D.C. (2019). Effect of power point innovative teaching technique and chalkboard instructional delivery on secondary school agricultural science students' achievement in Okigwe Education Zone II, Imo State *Nigerian Journal of Educational Research* 18(2), 249 – 262.
20. Onuh, C.C. & Okigbo, E.C., (2019). Enhancing shading attitude in physics through the use of combined physical and inquiry virtual laboratory in secondary schools in Enugu State. *Journal of Science, Technology and Mathematics Edducation 3(1), 141 - 154.*