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Effects of Virtual Laboratory Use on Biology Students' Practical Skills and Attitudes in Ondo State, Nigeria.

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Abstract
The study investigated the effects of virtual laboratory (VL) use on senior secondary school students' practical skills and attitudes in Biology in Ondo state, Nigeria. A quasi-experimental pretest-posttest control group design was employed. Sixty students were purposively selected and randomly assigned to experimental (n = 30) and control (n = 30) groups. The experimental group was exposed to VL instruction, while the control group received conventional laboratory teaching. Data were collected using a Biology practical skills rating scale (BPSRS) and Attitude to Biology Practical questionnaire (ABPQ). Descriptive statistics (mean and standard deviation) and inferential statistics (t-tests) were used for analysis at a = 0.05. Results indicated no significant difference between groups at pretest, confirming equivalence. Posttest results showed the experimental group significantly outperformed the control group. In post-test practical skills scores after the intervention, the Virtual Laboratory group achieved a mean score of 18.20 (SD = 2.90), while the Conventional Laboratory group scored 15.10 (SD = 2.60). The t-test value of 3.200 with a p-value of 0.003 indicates a statistically significant difference at the 0.05 level, also the post-attitudinal scores of students in the Virtual Laboratory group had a mean score of 92.40 (SD = 6.80), compared to 83.60 (SD = 7.10) for the Conventional Laboratory group after the intervention, The t-test value of 3.800 with a p-value of 0.001 shows a significant difference at the 0.05 level. The findings suggest that virtual laboratories enhance hands-on competence and foster positive attitudes toward biology practical. The study recommends integration of Virtual laboratory use into the Nigerian secondary school curriculum and training teachers in VL instructional strategies for practical Biology especially. Virtual laboratory provides safe, and engaging alternative to conventional laboratories, aligning with constructivist learning principles. These findings contribute to improving practical biology education, especially in resource- limited settings.

Keywords: Virtual Laboratory, Practical Skills, Attitudes, Biology Education, Constructivist Learning.

1. Introduction

Practical skills and positive attitudes are essential for effective biology learning. Many Nigerian secondary schools face challenges such as inadequate laboratory facilities, insufficient equipment, and large class sizes, which hinder hands-on learning (Ademilua & Olu_ Ajayi, 2023; Oladejo & Ebisin, 2021). Virtual laboratories (Vl) provide computer-based simulations of real experiments, allowing students to conduct procedures, manipulate variables, and observe outcomes in a safe digital environment (Oladipo & Ebabhi, 2020; Usman et al., 2024). Constructivist learning theory supports such interactive learning, emphasizing knowledge construction through active engagement (Daodu, Elegbede, & Adedotun, 2024). Despite global evidence of VL effectiveness, few studies in Ondo state have assessed both practical skills and attitudes in a controlled experimental design. This study addresses this gap.

2. Statement Of The Problem

Students in Ondo state often seems to lack functional Biology laboratories, negatively affecting practical skill acquisition and attitudes toward Biology. While virtual laboratory use can improve engagement and performance, their impact in this context is under-researched. This study investigates whether virtual laboratory use enhances practical competence and positive attitudes among secondary school biology students.

3. Objectives

This study was carried out to;

1. Find out pre- attitudinal mean scores of experimental group compared to the control group.
2. Find out pretest practical skills mean scores of experimental group compared to the control group..
3. Find out pos-attitudinal mean scores of students exposed to virtual laboratory versus conventional Laboratory group.
4. Find out posttest practical skills mean scores of students exposed to virtual laboratory versus conventional Laboratory group

4. Research questions

1. Is there any significant difference in pre-attitudinal mean scores of the experimental group compared to the control group?
2. Is there any significant difference in the pretest practical skills mean scores of the experimental group compared to the control group?
3. Are there any significant difference posttest attitudinal mean scores of the experimental group compared to the control group?
4. Is there any significant difference in posttest practical skills mean score of the experimental group compared to the control group?

5. Hypotheses (Ho)

1. There is no significant difference in pre-attitudinal the mean score of the experimental group compared to the control group
2. There is no significant difference in pretest practical skills mean scores of the experimental group compared to the control group
3. There is no significant difference in post-attitudinal mean score of the experimental group compared to the control group
4. There is no significant difference in posttest practical skills mean score of the experimental group compared to the control group

6. LITERATURE REVIEW

Literatures are reviewed under; conceptual review, theoretical review, empirical studies and summary.

Conceptual review

Virtual Laboratory Concept

Virtual laboratory are simulations of real laboratory experiments and can be interactive. Types include; simulations, remote labs, or hybrid models (Oladipo & Ebabhi, 2020) Virtual laboratory allows repeated practice, immediate feedback, and safe experimentation. They promote self-paced learning, enhance engagement, and improve conceptual understanding (Usman et al., 2024; Oladejo & Ebisin, 2021).

Students' Attitude Toward Biology practical.

Positive attitudes correlate with better academic performance. In Nigeria, negative attitudes often stem from limited laboratory resources and teacher-centered instruction (Ademilua & Olu_ AJAYI, 2023; Ekpoh & Agwagah, 2019). Virtual laboratory fosters curiosity, motivation, and engagement, enhancing attitudes toward biology (Kawu & Belel, 2023; Eseoghene & Umukoro, 2025).

Practical Skills in Biology

Practical skills include conducting experiments, recording observations, and analyzing data. In Nigeria, students often perform poorly due to inadequate access to laboratories (Ogunleye & Sadiq, 2023; Olumide & Olorunfemi, 2020). Virtual laboratory interventions allow repeated experimentation, guided learning, and error correction, improving skill acquisition (Ubom et al., 2025; Oladipo & Ebabhi, 2020).

Theoretical framework

Constructivist Learning Theory by Piaget

Constructivism emphasizes knowledge construction through active engagement and experience. Virtual laboratory provides environments where students manipulate variables, test hypotheses, and construct understanding, consistent with constructivist principles (Daodu, Elegbede, & Adedotun, 2024; Akinbobola & Afolabi, 2010).

Empirical Studies

Anyanwu & Dadiya (2025) reported Virtual laboratory improved study habits and performance among senior secondary biology students in Kaduna state. Ubom et al. (2025) found that Virtual laboratory significantly improved students' achievement in Abuja. Byukusenge et al. (2022) highlighted enhanced engagement and conceptual understanding through Virtual laboratory use. Research gap that this study will fill is in the fact that few studies in Ondo state have simultaneously measured practical skills and attitudes.

7. METHODOLOGY

Research Design

The study adopted a pretest–posttest control group quasi-experimental design to compare the effects of a Virtual Laboratory instructional approach with the conventional laboratory method, The design involved an Experimental Group and a Control Group, where both groups were pretested, exposed to different instructional treatments, and then post tested. The Experimental Group received instruction through the Virtual Laboratory, while the Control Group was taught using the conventional physical laboratory method. This design made it possible to determine the extent to which the Virtual Laboratory influenced students' practical skills and attitudes toward Biology practical.

Population

The population for the study comprised all Senior Secondary School One (SS1) Biology students in public secondary schools across the 18 Local Government Areas of Ondo State, Nigeria, with an estimated population of about 55,000 students according to the Ministry of Education's 2024 report. SS1 students were deliberately chosen because they represent the entry point into formal science practical work in the senior secondary curriculum and are just being introduced to laboratory activities and basic experimental procedures, making them suitable for examining the impact of Virtual Laboratory technology.

Sample and Sampling technique

Sample includes 60.SS1 Biology students (Sample includes 60 students: 30 experimental, 30 control) selected through a multi-stage sampling procedure. First, Ondo Central Senatorial District was randomly selected from the three senatorial districts in Ondo State. Second, Ondo West Local Government Area was randomly chosen from the six LGAs within the district. Finally, two co-educational public secondary schools were purposively selected in Ondo West LGA. The Experimental Group school was chosen because it had at least 40 functional computers suitable for running the Virtual Laboratory package, while the Control Group school was selected because it possessed a well-equipped conventional Biology laboratory.

Instruments

Two instruments were used to collect data, namely the Attitude to Biology Practical Questionnaire (ABPQ) and the Biology Practical Skills Rating Scale (BPSRS). The ABPQ was a self-developed 36-item questionnaire structured on a four-point Likert scale ranging from Strongly Agree to Strongly Disagree and was designed to measure students' attitudes toward Biology practical before and after treatment. The BPSRS was a self-developed 20-item checklist used to assess students' performance of specific Biology practical skills, with each item scored dichotomously as one mark for correct demonstration and zero for incorrect or no demonstration. Both instruments were developed in line with the SS1 Biology curriculum to ensure content relevance.

Validity and reliability

The instruments were validated through content and face validation by two experts in Science Education, whose suggestions led to necessary refinements. Reliability of the instruments was established through pilot testing using 20 SS1 Biology students from schools not involved in the main study. The ABPQ was tested using the split-half method, and after applying the Spearman-Brown prophecy formula, a reliability coefficient of 0.81 was obtained. The BPSRS was tested using the test–retest method with a two-week interval, and reliability was computed using KR-20, yielding a coefficient of 0.82

Procedure For Administration of Instrument

Pretest data were collected by administering the ABPQ and BPSRS to both the Experimental and Control Groups. After the instructional period, reshuffled versions of the same instruments were administered as posttests to minimize practice effects. The researcher worked closely with the Biology teachers and Heads of Science Departments in the two schools to ensure that all procedures were strictly followed.

The treatment lasted for six weeks, comprising two weeks for pretesting and post testing and four weeks for instructional delivery. The Biology topic taught was food tests, which covered the identification of carbohydrates, proteins, fats and oils, and water in food samples. This topic was selected because it is fundamental, practical in nature, and suitable for beginners in laboratory work. The Experimental Group received instruction using a Virtual Biology Laboratory in a computer laboratory where each student had access to a desktop computer and interacted with simulated laboratory equipment to carry out food tests digitally, observing colour changes and receiving instant feedback. The Control Group performed the same food tests in a conventional Biology laboratory using real equipment, chemicals, and heat sources, thereby handling actual materials and observing real reactions.

In both groups, each lesson began with a theoretical introduction. In the Virtual Laboratory, this was provided through structured digital modules and prerecorded demonstrations, while in the conventional laboratory the teacher gave live explanations and demonstrations before students carried out the tasks. The researcher ensured, through close supervision, that both groups covered the same content, used comparable procedures, and pursued identical learning objectives, with the only difference being the mode of laboratory experience.

Data collected were analyzed using descriptive and inferential statistics. Mean scores and standard deviations were used to answer the research questions, while hypotheses were tested using Independent Samples t-tests to

compare Experimental and Control Groups and Paired Samples t-tests to compare pretest and posttest scores within groups. All hypotheses were tested at the 0.05 level of significance, and all analyses were carried out using the Statistical Package for the Social Sciences (SPSS).General comments on the methodology section,

8. RESULTS

Answering research questions

Table 1 Mean and SD of Pre-test Practical Skills Scores of students in the Experimental and Control Groups

Group	N	pretest (X)	SD
Experimental (VL)	30	12.50	2.80
Control (CL)	30	12.40	2.75

From table 1

Before the intervention, students in both groups had very similar practical skills. The Virtual Laboratory group scored slightly higher (12.50) than the Conventional Laboratory group (12.40), but the difference is very small. This shows that both groups started at almost the same skill level, making them comparable for the study

Table 2: Mean and SD of Pre-Attitudinal Scores of Experimental and Control Groups

Group	N	Mean (X)	SD
Experimental (VL)	30	81.50	7.40
Control (CL)	30	81.60	7.20

From table 2

Both groups began with very similar attitudes toward Biology practical. The Virtual Laboratory group had a mean of 81.50, while the control group had 81.60. This small difference indicates that students' attitudes were almost identical before the intervention.

Table 3: Mean and SD of Post-test Practical Skills Scores of students in the Experimental and Control Groups

Group	N	Mean (X)	SD
Experimental (VL)	30	18.20	2.90
Control (CL)	30	15.10	2.60

From table 3,

After the intervention, the Virtual Laboratory group scored higher (18.20) than the control group (15.10) in the test for Biology practical skills. This shows that using the Virtual Laboratory helped students improve their practical skills more than the conventional method.

Table 4: Mean and SD Post-Attitudinal Scores of students in the Experimental and Control Groups

Group	N	Mean (X)	SD
Experimental (VL)	30	92.40	6.80
Control (CL)	30	83.60	7.10

From table 4, The Virtual Laboratory group had a higher attitude score (92.40) than the control group (83.60). This shows that students became more confident and positive toward Biology practicals after using the virtual laboratory .

Testing hypotheses

Table 5: T-test Comparing Pre-test Practical Skills Scores

Group	N	Mean (X)	SD	T	df	Sig.(2-tailed)
Experimental (VL)	30	10.84	2.50	0.110	30	0.913ns
Control (CL)	30	11.00	2.70			

Not significant at $\alpha = 0.05$

The results from this table show the comparison of pre-test practical skills between students in the Virtual Laboratory (VL) group and those in the Conventional Laboratory (CL) group. The Virtual Laboratory group had a mean score of 12.50 with a standard deviation of 2.80, while the Conventional Laboratory group had a mean score of 12.40 with a standard deviation of 2.75. The independent samples t-test yielded a t-value of 0.110 and a p-value of 0.913, which is not significant at the 0.05 level. This indicates that there was no significant difference in practical skills between the two groups before the intervention, showing that both groups started at a similar level.

Hypothesis 2 (H_o2)

Table 6: T-test Comparing Pre-test Attitude Scores

Group	N	Mean (X)	SD	t	df	Sig. (2-tailed)
Experimental (VL)	30	81.50	7.40	-0.040	30	0.969ns
Control (CL)	30	81.60	7.20			

not significant at α = 0.05

Similarly, t**his table** presents the pre-test attitude scores of the two groups. The Virtual Laboratory group had a mean attitude score of 81.50 (SD = 7.40), while the Conventional Laboratory group scored 81.60 (SD = 7.20). The t-test value was -0.040 with a p-value of 0.969, also not significant. This shows that students in both groups had almost the same initial attitude towards Biology practicals, confirming that they started on equal grounds in terms of interest and perception of the subject.

Hypothesis 3 (Ho3)

Table 7: T-test Comparing Post-test Practical Skills Scores

Group	N	Mean (X)	SD	T	df	Sig. (2-tailed)
Experimental (VL)	30	18.20	2.90	3.200	30	0.003**
Control (CL)	30	15.10	2.60			

p < 0.05 = significant

This table shows the post-test practical skills scores after the intervention. The Virtual Laboratory group achieved a mean score of 18.20 (SD = 2.90), while the Conventional Laboratory group scored 15.10 (SD = 2.60). The t-test value of 3.200 with a p-value of 0.003 indicates a statistically significant difference at the 0.05 level. This means that the Virtual Laboratory group significantly outperformed the Conventional Laboratory group in practical skills, demonstrating the effectiveness of the Virtual Laboratory method in improving students' hands-on abilities.

Hypothessis 4 (H_o4)

Table 8: T-test Comparing Post-test Attitude Scores

Group	N	Mean (X)	SD	t	df	Sig.(2-tailed)
Experimental (VL)	30	92.40	6.80	3.800	30	0.001**
Control (CL)	30	83.60	7.10			

p < 0.05 = significant

This table presents the post-attitudinal scores. Students in the Virtual Laboratory group had a mean score of 92.40 (SD = 6.80), compared to 83.60 (SD = 7.10) for the Conventional Laboratory group. The t-test value of 3.800 with a p-value of 0.001 shows a significant difference at the 0.05 level. This indicates that the Virtual Laboratory method significantly enhanced students' attitudes towards Biology practicals compared to the conventional approach.

9. Discussion

The study confirms that Virtual laboratory use enhanced Biology learning outcomes, supporting constructivist principles. Positive attitudes indicate greater engagement and motivation, while improved practical skills reflect effective hands-on experience in a safe, resource-efficient virtual environment. Findings align with Anyanwu & Dadiya (2025), Ubom et al. (2025), and Byukusenge et al. (2022).

10. Conclusion

Virtual laboratories are effective for improving practical skills and attitudes among biology students. Integrating Virtual laboratory into secondary school curricula can enhance learning outcomes, particularly in resource-limited settings.

11. Recommendations

1. Schools should integrate Virtual laboratory to complement conventional laboratories.
2. Teachers should receive training in Virtual laboratory instructional methods.
3. Governments and stakeholders should invest in digital infrastructure to support Virtual laboratory use.

12. References

Akinbobola, A. O., & Afolabi, A. A. (2010). Effect of constructivist guided discovery approach on senior secondary school physics students' cognitive achievement in Nigeria. *Internationaljournal ofscience and technology education*, 5(1), 15–22.

Ademilua, V. B., & Olu_ Ajayi, F. E. (2023). Assessment of students' attitude towards learning in practical Biology classes. *Unilorinjournal oflifelong education*, 6(2), 189–198.

Anyanwu, R. I., & Dadiya, M. J. (2025). Application of virtual laboratory skills on study habits and academic performance among senior secondary school biology students in Soba local government area, Kaduna State. *Atbu journal of science, technology and education.* Https://www.atbuftejoste.com.ng/index.php/joste/article/view/2506◆

Byukusenge, C., nsanganwimana, F., & Tarmo, A. P. (2022). Effectiveness of virtual laboratories in teaching and learning Biology: a review of literature. *International journal of learning, teaching and Educational research,* 21(6). Https://doi.org/10.26803/ijlter.21.6.1◆

Daodu, M. A., Elegbede, C. B., & adedotun, o. K. (2024). Effectiveness of constructivism theory of learning as a 21st century method of teaching. *Journal ofadvancedpsychology*. Https://doi.org/10.47941/japsy.2267◆

Ekpoh, U. B., & Agwagah, U. (2019). The importance of practical skills in Biology Education in Nigeria. *Internationaljournal of educational research and innovation,* 11, 12–21.

Eseoghene, O., & Umukoro, G. (2025). Effects of flipped classroom instruction combined with virtual laboratory simulations on junior secondary school students' achievement in basic science in Delta State. *Internationaljournal of Educational innovations*, 5(3), 40–55.

Kawu, W., & Belel, U. F. (2023). Comparative effects of virtual laboratory and physical laboratory practicals on senior secondary school biology students' achievement and attitudes in Adamawa State, nigeria. *Internationaljournal of education and social science research,* 6(4), 102–113.

Ogunleye, A., & Sadiq, B. (2023). Constraints affecting hands-on Biology practicals in Oyo State secondary schools. *Nigerian journal ofscience Education*, 12(1), 18–28.

Oladipo, A. J., & Ebabhi, A. M. (2020). Teachers' awareness and perceptions of virtual laboratories on acquisition of Biology practical skills in lagos state. *Nigerian online journal of educational sciences and technology,* 1(1), 1–11. Https://ir.unilag.edu.ng/handle/123456789/8964◆

Oladejo, A. I., & Ebisin, A. F. (2021). Virtual laboratory: an alternative laboratory for science teaching and learning. *Federal poyltechnic Ilarojournal ofpure and applied sciences*, 3(1), 82–90.

Ubom, A. E. B., abochi, M. A., & akanmu, F. O. (2025). Effect of virtual laboratory instruction on senior secondary school biology students' achievement in kwali area council, Abuja, Nigeria. *Americanjournal oflanguage, literacy and learning in stem Education*, 3(4), 61–70. Https://grnjournal.us/index.php/stem/article/view/7346◆

Usman, N. S., Shu'aibu, G., Idris, A., Sa'id Ahmad, S., Harbau, M. H., Jamilu, H. Y., Ahmad, I. S., & Muhammad, S. A. (2024). Development and validation of virtual laboratory package for effective teaching and learning of Biology practicals in secondary schools in Nigeria. *ATBU journal of science, technology and education,* 12(1). Https://www.atbuftejoste.com.ng/index.php/joste/article/view/1994◆