Effect of Virtual Laboratory-Based Instruction and Field Trip Method on Students' Performance and Retention in Basic Science in Bonny Local Government Area, Rivers State, Nigeria

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ABSTRACT

The study investigated the effect of Virtual Laboratory-based Instruction and Field Trip method on students' performance and retention in Basic Science concepts in Bonny Local Government Area, Rivers State. Two objectives guided the study, two research questions were answered and two hypotheses were tested at 0.05 level of significance. The Quasi-experimental research design was adopted for the study. The sample size comprised 89 Junior Secondary School 2 students drawn from intact classes in two selected public junior secondary schools. The purposive sampling technique was adopted to select the sample for this study. The instruments used for data collection were validated performance tests titled Basic Science Performance Test (BSPT) and Basic Science Retention Test (BSRT). The reliability of (BSPT) was determined using Kuder-Richardson Formula 21 which yielded a reliability coefficient of 0.91, while BSRT is a reshuffled version of BSPT. Data collected were analyzed using Mean and Standard deviation to answer the research questions while Analysis of Covariance was used to test the hypotheses at 0.05 level of significance. The findings revealed that Virtual laboratory-based Instruction significantly enhanced students' performance in Basic Science more than the Field Trip method. Also, there is a significant difference between the students taught using Virtual laboratory-based Instruction and those taught using the Field Trip method in their retention of Basic Science concepts, in favour of the students taught using Virtual laboratory-based Instruction. In conclusion, this study highlighted the efficacy of Virtual laboratory-based Instruction in improving students' performance and retention in Basic Science. It was recommended among others that educational institutions integrate virtual laboratory-based instruction into the Basic Science curriculum to enhance students' performance and retention. This approach provides a controlled learning environment that facilitates better understanding and long-term retention of scientific concepts.

Keywords: Virtual laboratory-based Instruction, Field Trip method, Students' Performance, Retention, Basic Science.

INTRODUCTION

Science is a fundamental part of the secondary school curriculum, introduced to cultivate scientific attitudes, critical thinking, active inquiry, and independent work (Mishra & Yadav, 2013). It serves as a systematic study based on verifiable knowledge through investigation, exploring nature and natural phenomena via observation and experimentation (Obafemi & Aderonmu, 2022). In the 21st century, science drives national wealth through advancements in various fields such as pharmaceuticals, technology, and health (Nnodim & Ndioho, 2023). Quality science education in secondary schools fosters scientific skills and literacy, promoting inquiry and a systematic approach to understanding society and the physical world. These skills are crucial for learners' intellectual development and their comprehension of the environment.

Research abounds on the factors militating against the academic performance and retention of junior secondary school students in Basic Science. The key factors contributing to the challenge include inadequate problem-

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solving skills, limited students' motivation, and the use of conventional lecture-focused instructional approaches. Having the 21st-century learners fill the classroom, the task for educators due to the learners' profile and characteristics has changed. These learners want to be challenged and engaged through a learning process that connects them to a different learning process. Educational institutions worldwide have recognized innovative teaching methods' salient roles in the learning process and environment. Hence, education in the developed world is highly hinged on innovation. With technological advancements, learning has changed; fun, engagement, and interaction are the keys to making learning interesting for 21st-century learners.

In the quest to discover new ways of enhancing the teaching and learning of Basic Science as a bedrock for successful technological development, there is a great need to foster innovative teaching strategies aimed at improving students' academic performance and retention in Basic Science. There is a need for practical, hands-on activities and active participation of students in the learning process to enhance their performance in the subject. Recently there has been an increasing interest in the adoption of innovative teaching and learning methods in Nigeria, especially about activity-based teaching strategies such as practical activity methods, inquiry-based, virtual laboratory, and field-trip instructional strategies.

Virtual laboratories are essentially simulated experiments conducted using computer software that offer numerous advantages for both student learning and the logistics of educational experiences. A virtual laboratory approach provides an interactive, practical environment in which students can conduct simulated scientific experiments (Redel-Macías et al., 2016). Virtual laboratory is one of the emerging technological-based interventions in science education. It remedies situations in which physical reality is not obtainable such as when conducting experiments that require materials that are expensive, volatile, or not available (Ndukwe & Obafemi, 2023). This approach not only enhances students' abilities, skills, and understanding of scientific concepts but also offers several benefits in science education. Akpan (2016) observed that the teacher-centered instructional strategies that have dominated educational processes since the advent of formal education are no longer adequate for preparing learners for effective participation in a knowledge-driven society. Virtual laboratory strategy, which incorporates theoretical material with graphics, animations, and videos, enables independent learning, particularly for students interested in computer-related topics (Eden, et al., 2023).

Zhao et al. (2019) reported that the virtual laboratory approach complements physical laboratory experiences and enhances conceptual understanding. It has also been demonstrated to improve problem-solving skills (Gunawan et al., 2017), foster creativity (Gunawan et al., 2018), offer novel learning perspectives not possible in a traditional laboratory (Jiménez et al., 2021), and yield learning outcomes equivalent to those of hands-on laboratories (Stahre Wästberg, et al., 2019). Recognizing the importance of integrating Information and Communication Technology (ICT) in science education, Akpan (2016) advocated for the replacement of traditional instructional methods with activity-based, minds-on, hands-on, and student-centered strategies that enhance overall learning. This approach aims to help students from basic to senior secondary levels in science develop a more comprehensive conceptual understanding of science and technology relationships, as well as scientific procedures.

The implementation of a virtual laboratory approach in educational institutions is purported to expand access to a greater number of students compared to traditional brick-and-mortar schools. This approach not only facilitates the transformation of object properties but also revolutionizes the practical and theoretical aspects of science education. Furthermore, it is learner-centered and reinvigorates students' interest in the subject (Nwagbo & Ugwuanyi, 2015). Dyrberg et al. (2017) observed that students engage in higher-level discussions following the completion of lessons taught using the virtual laboratory approach, thereby potentially enhancing their preparedness for laboratory work.

The Field trip method is a teaching method that involves taking students outside the classroom to make relevant observations about living organisms in their natural habitats. These excursions may occur in various settings, such as nearby school farms, national parks, zoos, industrial sites, forests, or game reserves. Bajah (2002) recognized field trip as an essential component of science teaching. Furthermore, Obeka (2010) defined field trip as outdoor laboratory activities or fieldwork exercises undertaken by teachers and students in specific aspects of a subject, providing students with opportunities to acquire relevant knowledge of organisms in their natural habitats. It involves taking students out of the classroom to locations where they can witness concrete

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illustrations of classroom theories. Ecology is a topic that deals with nature and the environment and as such that the students have an experience of the concept in real life situation and study nature in their natural habitat. These experiences offer direct observation and interpretation in natural environments.

In the field, learners are required to utilize basic scientific skills, including participation in group activities, communication with others, cooperation, problem-solving, and manipulation of substances and organisms in their natural surroundings. Field trip is a critical component of science teaching, not a separate activity, but a direct extension of classroom instruction. That is why a quality science curriculum extends beyond the walls of the classroom. Field trips are fundamental to Basic Science concepts which derive much of their impetus from the interrelationships of living organisms with one another and their environment. Field trips are one of the most enjoyable and exciting experiences for students studying science-related courses which has a lot to do with living organisms and their environment. This is because it offers the learners firsthand experience of real things that cannot be brought into the classroom practically. When field trips are undertaken by students, the main objective is to gain additional knowledge through direct experience that will bring about active learning while dealing with concrete materials.

Field trip instruction includes field work, school excursions, and garden tours. Some positive benefits derived from field trips are hands-on, real-world experiences, quality education, positive attitudes to science, motivation towards the subject, development of rapport between teachers and students, and many more. Through field trips, students can witness a real-life location and view their subject of learning within the everyday context and these visits enable students to gain knowledge and perhaps a different perspective on their topic. It provides an opportunity for students to view information for themselves and use their senses to touch or feel materials that they had previously only heard about. This immediacy and accessibility are key features of field trips.

Leaving the school premises provides a social experience and offers a change of tempo and scenery for students. Field trips expose students to novel experiences and can increase interest and engagement in science, regardless of prior interest in a topic (Omeodu & Abara, 2018). During field trips, learners refine their skills of observation, perception, and objective reporting by utilizing all their senses (Shakil et al., 2011). This approach encourages students to become more imaginative and inquisitive observers. However, some disadvantages should be considered before planning a field trip. These include a lack of chaperones, potential students' misbehaviour, budget constraints, safety concerns, and time management challenges. While a field trip may be an exciting opportunity for students and teachers, these challenges may result in an unpleasant experience, potentially undermining the learning objectives if not properly managed by Basic Science teachers and the students.

The use of Virtual laboratory in the teaching and learning of science is gaining the attention of researchers. In a study by Chado et al. (2021) a significant difference was found in the achievement of students taught balancing of chemical equations using the virtual laboratory strategy and those taught using the traditional method. In the study by Uwitonze and Nizeyimana (2022), the results revealed that the students in the experimental group who were administered virtual laboratory instructions achieved significantly higher mean scores than the students in the control group taught using the traditional lecturing method (chalk-talk method). In the study by Asiksoy (2023) the Virtual Lab Experiences significantly enhanced students' conceptual understanding in physics. In the study comparing the effects of real lab, virtual lab and lecture method, Bazie et al. (2024) found that the virtual laboratory group also performed significantly better than the lecture group in Chemistry. In the study by Byukusenge et al. (2024), the results indicated that virtual laboratories significantly improved students' performance in Biology. Ndukwe and Obafemi (2023) however found that guided inquiry significantly enhanced the performance of students better than the virtual laboratory, while Bazie et al. (2024) found that the real laboratory group had a higher performance than the virtual laboratory group.

Field trip method has been found to be effective in teaching and learning scientific concepts. In a study by Timothy and Apata (2014), it was found that Field Trip strategy was more effective in improving the academic achievement of Basic Science students. Nwala (2018) similarly, found that Field Trip method significantly improved students' scientific literacy and skills acquisition compared to conventional method. In the same vein, Adejoh et al. (2021) found a significant difference between the mean achievement scores of the students

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taught using field trip and those taught Biology with lecture in biology in favour of the students taught using field trip. Njoku & Mgbomo (2021) also, found that field trip teaching Method significantly enhanced students' achievement in Biology than demonstration method while Obineke and Nworgu (2024) found that that students in virtual field trip group achieved higher than those in real field trip group in Ecology concept. Concerning the retention of the knowledge of scientific concepts. Ogar and Effiong (2022) found that the students taught environmental hazards using field trip retained Basic science and technology concepts significantly higher than those taught with expository method, while Achor et al. (2014) found that there was a statistically significant difference in the mean retention scores of students taught using outdoor activities and lecture method, in favour of the students taught using outdoor activities.

Conventional teaching methods used over the years to teach Basic Science have not yielded the desired results. Despite the efforts of researchers to find more effective strategies, Basic Education Certificate Examination (BECE) results for Basic Science in Rivers State have remained poor over the years with consistent high failure rates. Could this be attributed to ineffective teaching methods? Effective teaching should elicit desirable changes in learners' behaviour, evidenced by improved performance and retention in the subject matter. To enhance students, learning outcomes, it is essential to implement more efficient teaching methodologies. Can virtual laboratory-based Instruction and field trip method remedy the poor performance problem? Hence, the aim of this study was to investigate the effects of virtual laboratory and field trip strategies on students' performance and retention in Basic Science in Bonny Local Government Area of Rivers State.

Aim and Objectives of the Study

This study was aimed at investigating the effect of Virtual Laboratory-based Instruction and Field Trip method on students' performance and retention in Basic Science concepts in Bonny Local Government Area of Rivers State. The specific objectives of the study include to:

1. Investigate the effect of virtual laboratory-based Instruction and field trip method on students' performance in Basic Science.
2. Investigate the effect of virtual laboratory-based Instruction and field trip method on students' retention of Basic Science concepts.

Research questions

Based on the stated objectives, the following research questions guided the study:

1. What is the effect of Instructional strategy (Virtual laboratory-based Instruction and Field Trip method) on students' performance in Basic Science?
2. What is the effect of Instructional strategy (Virtual laboratory-based Instruction and Field Trip method) on students' retention of Basic Science concepts?

Hypotheses

The following understated null hypotheses were tested at a 0.05 level of significance:

H_{01}: There is no significant difference between the performance of students taught Basic Science using Virtual laboratory-based Instruction and those taught using Field Trip method.

H_{02}: There is no significant difference between the students taught using Virtual laboratory-based Instruction and those taught using Field Trip method in their retention of Basic Science concepts.

MATERIALS AND METHODS

Research Design

This study investigated the effect of Virtual Laboratory-based instruction and Field Trip method on students' performance and retention in Basic Science concepts in Bonny Local Government Area, Rivers State.

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This study adopted a quasi-experimental design using a non-randomized, non-equivalent, pre-test and post-test experimental group design.

Sample

The population for this study comprised eight hundred and ninety-two (892) Junior Secondary School 2 students (JSS2) in all the six public junior secondary schools in Bonny Local Government Area of Rivers State. The sample for this study consisted of 89 Junior Secondary School 2 students (JSS2) drawn from two intact classes in each of the two selected public junior secondary schools in Bonny LGA. The two public junior secondary schools were purposively chosen from Bonny LGA for this study. The schools were chosen based on the following criteria: (a) they are co-educational; since gender is a moderating variable (b) they have at least one professional Basic Science teacher with either a B.Ed or B.Sc (Ed) qualification, (c) schools that are well-equipped with ICT facilities, (d) schools within Bonny town since it will be difficult to move students out of the creeks, (e) administrative consent.

The research instrument used for data collection was a researcher-developed and validated instrument titled Basic Science Performance Test (BSPT) which was restructured into the Basic Science Retention Test (BRPT) with reliability coefficients of 0.91 obtained using the Kuder Richardson-21 (KR-21) formula. BSPT has two sections: A and B. Section A was used to obtain the respondents' biodata, while section B contains 50 questions on Ecosystem and Biodiversity to be answered by the respondents. The questions have multiple options of A, B, C, and D. Each correct answer attracts 2 marks, while a wrong answer will attract zero mark. The maximum score obtainable is 100%, while the minimum score obtainable is 0%. BSRT was a reshuffled version of BSPT. It was used to measure the students' retention of the knowledge of Basic Science concepts.

Data Collection

The procedure for data collection was in stages. The researcher identified the sampled schools for the study and solicited permission from the principals of the selected public schools to use their students as well as some facilities. This was followed by the training of Basic Science teachers who were professional Basic Science teachers in the participating schools with either a B.Ed or B.Sc (Ed) qualification who served as the research assistants to the researcher. The research assistants administered the Basic Science Performance Test (BSPT) as a pre-test to the groups and handed over the scripts to the researcher for marking and grading. The students were subjected to a four-week teaching period after which BSPT was re-administered as the post-test to the students in the two groups. Retention test using the Basic Science Retention Test (BSRT) was administered as post-post test two weeks after the post-test. The research assistant in each school helped to collect the data under the supervision of the researcher. The researcher afterward marked the scripts followed by grading, recording, and analyses. The students' scores from the pretest, post-test, and post-post test constituted the data for this study.

Data Analysis

Descriptive statistics of Means and Standard Deviation were used to answer the research questions while Analysis of Co-variance (ANCOVA) was used to test the hypotheses at a 0.05 level of significance.

RESULTS

Research questions

Research question 1: What is the effect of Instructional strategy (Virtual laboratory-based Instruction and Field Trip method) on students’ performance in Basic Science?

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Table 1: Mean and Standard deviation values of students' performance classified by Instructional strategy

Instructional Strategy		Pretest Mean	Post Test Mean	Mean Gain (Performance)
Virtual Lab-based Instruction	Mean	43.8696	68.3696	24.5000
	Std. Deviation	11.91937	8.56182	12.76758
	N	46	46	46
Field Trip Method	Mean	42.5116	58.3721	15.8605
	Std. Deviation	8.66403	10.94363	13.03399
	N	43	43	43

Table 1 reveals that the students taught Basic Science using Virtual laboratory-based Instruction had a mean gain of 24.50 and standard deviation of 12.77 (Mg = 24.50, SD = 12.77), while the students taught Basic Science using the Field trip method had a mean gain of 15.86 and standard deviation of 13.03 (Mg = 15.86, SD = 13.03). These results show that the students taught Basic Science using Virtual laboratory-based Instruction had a better performance than the students taught Basic Science using the Field Trip method. This indicates that Virtual laboratory-based Instruction enhanced students' performance in Basic Science more than the Field Trip method.

Research question 2: What is the effect of Instructional strategy (Virtual laboratory-based Instruction and Field Trip method) on students' retention of Basic Science concepts?

Table 2: Mean and Standard deviation values of students' retention classified by Instructional strategy

Instructional Strategy		Post Test Mean	Post Post Test Mean	Mean Gain (Retention)
Virtual Lab-based Instruction	Mean	68.3696	71.9348	3.5652
	Std. Deviation	8.56182	6.98061	8.36302
	N	46	46	46
Field Trip Method	Mean	58.3721	61.9767	3.6047
	Std. Deviation	10.94363	11.69145	11.43749
	N	43	43	43

Table 2 reveals that the students taught Basic Science using Virtual laboratory-based Instruction had a mean gain of 3.57 and standard deviation of 8.36 (Mg = 3.57, SD = 8.36) while the students taught Basic Science using Field Trip method had a mean gain of 3.61 and standard deviation of 11.44 (Mg = 3.61, SD = 11.44). These results show that the students taught Basic Science using Field Trip method retained the knowledge of Basic Science concepts slightly more than the students taught Basic Science using Virtual laboratory-based Instruction. The mean gain values of the two groups are approximately equal. This indicates that Field Trip

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method slightly enhanced students' performance in Basic Science more than Virtual laboratory-based Instruction.

Hypotheses

Hypothesis 1: There is no significant difference between the performance of students taught Basic Science using Virtual laboratory-based Instruction and those taught using Field Trip method.

Table 3: Summary of One –way Analysis of Covariance of students' performance classified by Instructional Strategy using Pretest as Covariate

Tests of Between-Subjects Effects						
Dependent Variable: Post Test						
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	2524.818[a]	2	1262.409	13.528	0.000	0.239
Intercept	14996.071	1	14996.071	160.700	0.000	0.651
Pretest	303.470	1	303.470	3.252	0.075	0.036
Instructional Strategy	2106.017	1	2106.017	22.568	0.000	0.208
Error	8025.294	86	93.317			
Total	369865.000	89				
Corrected Total	10550.112	88				
a. R Squared = 0.239 (Adjusted R Squared = 0.222)						

Table 3 reveals a value of $F_{1,86}$ = 22.57, p = 0.00 (p < 0.05), partial eta squared = 0.208 for the effect of instructional strategy on students' performance in Basic Science. The null hypothesis is therefore rejected, indicating that there is a significant difference between the performance of students taught Basic Science using Virtual laboratory-based Instruction and those taught using Field Trip method. The partial eta squared value shows that instructional strategy had a large effect on students' performance in Basic Science.

Table 4: Least Significant Difference Post Hoc Analysis of students' performance classified by Instructional strategy

Pairwise Comparisons						
Dependent Variable: Post Test						
(I) Instructional Strategy	**(J) Instructional Strategy**	**Mean Difference (I-J)**	**Std. Error**	**Sig.[b]**	**95% Confidence Interval For Difference[b]**	
					Lower Bound	**Upper Bound**
Virtual Lab-based Instruction	Field Trip Method	9.755*	2.053	0.000	5.673	13.838

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Field Trip Method	Virtual Lab-based Instruction	-9.755*	2.053	0.000	-13.838	-5.673
Based on estimated marginal means						
*. The mean difference is significant at the 0.05 level.						
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).						

Table 4, which shows the Least Significant Difference Post hoc analysis of students' performance classified by Instructional strategy, reveals a mean difference of 9.755 and a p-value of 0.000 ($p < 0.05$) between the effect of Virtual laboratory-based Instruction and Field Trip method on students' performance in Basic Science. This indicates that the students taught Basic Science using Virtual laboratory-based Instruction contributed more to the significant difference between the effects of the instructional strategies used on students' performance in Basic Science.

Hypotheses 2: There is no significant difference between the students taught using Virtual laboratory-based Instruction and those taught using Field Trip method in their retention of Basic Science concepts.

Table 5: Summary of One-way Analysis of Covariance of students' retention classified by Instructional Strategy using Posttest as Covariate

Tests of Between-Subjects Effects						
Dependent Variable: Post-Post-Test						
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	3947.187[a]	2	1973.593	27.418	0.000	0.389
Intercept	2920.847	1	2920.847	40.577	0.000	0.321
Posttest	1743.328	1	1743.328	24.219	0.000	0.220
Instructional Strategy	508.613	1	508.613	7.066	0.009	0.076
Error	6190.454	86	71.982			
Total	411134.000	89				
Corrected Total	10137.640	88				
a. R Squared = 0.389 (Adjusted R Squared = 0.375)						

Table 5 reveals a value of $F_{1,86} = 7.066$, $p = 0.009$ ($p < 0.05$), partial eta squared = 0.076 for the effect of instructional strategy on students' retention of Basic Science concepts. The null hypothesis is therefore rejected, indicating that there is a significant difference between the students taught using Virtual laboratory-based Instruction and those taught using Field Trip method in their retention of Basic Science concepts. The partial eta squared value shows that instructional strategy had a moderate effect on students' retention of Basic Science concepts.

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Table 6: Least Significant Difference Post Hoc Analysis of students' retention classified by Instructional strategy

Pairwise Comparisons						
Dependent Variable: Post-Post-Test						
(I) Instructional Strategy	**(J) Instructional Strategy**	**Mean Difference (I-J)**	**Std. Error**	**Sig.[b]**	**95% Confidence Interval For Difference[b]**	
					Lower Bound	**Upper Bound**
Virtual Lab-based Instruction	Field Trip Method	5.384*	2.025	0.009	1.358	9.411
Field Trip Method	Virtual Lab-based Instruction	-5.384*	2.025	0.009	-9.411	-1.358
Based on estimated marginal means						
*. The mean difference is significant at the 0.05 level.						
b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).						

Table 6, which shows the Least Significant Difference Post hoc analysis of students' retention classified by Instructional strategy, reveals a mean difference of 5.384 and a p-value of 0.009 ($p < 0.05$) between the effect of Virtual laboratory-based Instruction and Field Trip method on students' retention of Basic Science concepts. This indicates that the students taught using Virtual laboratory-based Instruction contributed more to the significant difference between the effects of the instructional strategies used on students' retention in Basic Science.

DISCUSSION

The findings of this study have revealed that Virtual laboratory-based Instruction enhanced students' performance in Basic Science more than the Field Trip method. There is a significant difference between the performance of students taught Basic Science using Virtual laboratory-based Instruction and those taught using the Field Trip method, in favour of the students taught Basic Science using Virtual laboratory-based Instruction. Also, the partial eta squared value shows that instructional strategy had a large effect on students' performance in Basic Science. This finding may be due to the benefits of controlled environments associated with virtual laboratories. This finding agrees with the finding of Chado et al. (2021), Uwitonze and Nizeyimana (2022), Asiksoy (2023), Bazie et al. (2024) and Byukusenge et al. (2024) who found that virtual laboratory enhanced students' performance in different scientific concepts. This finding aligns with Gunawan et al. (2019) who demonstrated the positive impacts of virtual laboratories, equating them to physical science laboratories in enhancing scientific process skills and students' motivation.

Similarly, the finding aligns with the finding of Harron et al. (2019) which highlighted the versatility and instructional utility of virtual field trips (VFTs), highlighting their positive cognitive and affective learning gains. Similarly, the finding aligns with the finding of Lawal (2023) who indicated that virtual field trip strategies significantly improved academic performance and motivation in biology concepts compared to traditional field trips. In the same vein, the finding is supported by the submission of Richardson (2011) that instructional strategies such as virtual laboratory-based instruction can have a significant impact on students'

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performance. This finding is however at variance with the finding of Ndukwe and Obafemi (2023) who found that guided inquiry significantly enhanced the performance of students better than the virtual laboratory.

Bazie et al. (2024) also found that the real laboratory group had a higher performance than the virtual laboratory group. This may be because of the challenges and limitations of virtual laboratories, highlighted by Reeves et al. (2021) suggesting that they may not always be as effective as traditional methods. This is further corroborated by the study of Lewis (2014) who raised concerns about the limitations of virtual laboratories, particularly in offering biological variation and the potential for complicating learning experiences. This finding is also at variance with the finding of Sunday (2021) that Field trip method significantly enhanced students' performance in Ecology more than Lecture method.

The findings of this study have revealed that the students taught using Field trip performed slightly higher than the students taught using the Virtual laboratory-based Instruction. However, there is a significant difference between the students taught using Virtual laboratory-based Instruction and those taught using the Field Trip method in their retention of Basic Science concepts, in favour of the students taught using Virtual laboratory-based Instruction. The partial eta squared value shows that instructional strategy had a moderate effect on students' retention of Basic Science concepts. The finding that the students taught using Field trip performed slightly higher than the students taught using the Virtual laboratory-based Instruction may have been because of the experiential nature of Field trip method. Seeing the concepts in real life and natural habitat by the students may have enabled them retained Basic Science concepts better. This finding aligns with the finding of Ogar and Effiong (2022) that the students taught environmental hazards using field trip retained Basic science and technology concepts significantly higher than those taught with expository method, while Achor et al. (2014) found that there was a statistically significant difference in the mean retention scores of students taught using outdoor activities and lecture method, in favour of the students taught using outdoor activities.

CONCLUSION

In conclusion, this study has highlighted the efficacy of Virtual laboratory-based Instruction in improving students' performance and retention in Basic Science. However, it also acknowledges the importance of addressing the limitations and challenges associated with virtual laboratories to maximize their benefits. The findings suggest that incorporating a mix of instructional strategies, tailored to the specific needs of students, may be the most effective approach to enhancing learning outcomes in Basic Science.

RECOMMENDATIONS

Based on the findings and conclusion of this study, the following recommendations are made:

1. Educational institutions should integrate virtual laboratory-based instruction into the Basic Science curriculum to enhance students' performance and retention.
2. It is also important for educational stakeholders and curriculum planners to address the challenges and limitations associated with virtual laboratories, such as the lack of biological variation and potential complexities in learning experiences.
3. Efforts should be made to improve virtual laboratory simulations to provide a more comprehensive and realistic learning experience.
4. Educators should receive continuous professional development and training on the effective use of virtual laboratory-based instruction and other innovative teaching methods. This will enable them to maximize the potential of these instructional strategies and improve students' outcomes in Basic Science.

REFERENCES

1. Achor, E. E., Ogbeba, J., & Samuel, A. O. (2014). Effects of school outdoor activities on senior secondary two (SSII) students' retention in ecology in Jalingo metropolis, Taraba, Nigeria. Nigeria Educational Forum, 22(2), 83-95.

2. Adejoh, M. J., Ochu, A.N. O., Egbe-Okpenge, E. G., & Uroko, E. G. (2021). Effects of field trip and discovery methods on senior secondary school students' achievement in biology in Benue state, Nigeria. International Journal of Multidisciplinary Research and Growth Evaluation, 2(4), 330-342. www.allmultidisciplinaryjournal.com
3. Akpan, I. F. (2016). New trends in science education curriculum for knowledge-based economic development in Nigeria. African Journal of Theory and Practice of Educational Research, 3, 106-116.
4. Asiksoy, G. (2023). Effects of Virtual Lab Experiences on Students' Achievement and Perceptions of Learning Physics. International Journal of Online and Biomedical Engineering (iJOE), 19(11), 31–41. https://doi.org/10.3991/ijoe.v19i11.39049
5. Bajah, S. T. (2002). Teaching science for scientific development. A keynote address to the NCE Conference at Federal College of Education, Zaria.
6. Bazie, H., Lemma, B., Workneh, A., & Estifanos, A. (2024). The effect of virtual laboratories on the academic achievement of undergraduate Chemistry students: Quasi-Experimental study. JMIR Formative Research, 1-14, 8:e64476 https://doi.org/10.2196/64476.
7. Byukusenge, C., Nsanganwimana, F., & Tarmo, A. P. (2024). Investigating the effect of virtual laboratories on students' academic performance and attitudes towards learning biology. Education and Information Technologies, 29, 1147-1171. https://doi.org/10.1007/s10639-023-12351-x
8. Chado, A., & Dalhatu, B., & Mohammed, S. (2021). Effects of virtual laboratory instructional strategy on students' achievement in Chemistry practical among Senior Secondary Schools in Minna Metropolis, Niger State. International Journal of Instructional Technology and Educational Studies (IJITES), 2(3), 1-5. https://doi.org/10.21608/ihites.2021.90629.1048
9. Dyrberg, N. R., Treusch, A. H., & Wiegand, C. (2017). Virtual laboratories in science education: Students' motivation and experiences in two tertiary biology courses. Journal of Biological Education, 51(4), 358-374.
10. Eden, M. I., Etiubon, R. U., Ekong, A. M., Sampson, E. M., & Umoetuk, E. U. (2023). Digital tools utilization and chemistry students' academic achievement in the teaching of soap production in secondary schools. Unizik Journal of STM Education, 6(1), 73-81.
11. Gunawan, G., Harjono, A., Sahidu, H., & Herayanti, L. (2017). Virtual laboratory to improve students' problem-solving skills on electricity concepts. Journal Pendidikan IPA Indonesia [Journal of Indonesian Science Education], 6(2), 257-264.
12. Gunawan, G., Suranti, N. M. Y., Ekasari, R., & Herayanti, L. (2018). The effect of virtual labs toward students' understanding of physics based on gender. In W. Strielkowski (Ed.), Advances in Social Science, Education and Humanities Research, 128-131. Atlantis Press.
13. Gunawan, H., Harjono, A., Gunarhadi, G., & Rohaeti, E. (2019). The effectiveness of virtual laboratory to improve students' scientific process skills and motivation in science learning. Jurnal Pendidikan IPA Indonesia (Indonesian Journal of Science Education), 8(1), 81-89.
14. Harron, J., Carter, J., Cheng, R., & Lazarus, R. (2019). Virtual field trips as a versatile educational technology for science learning. Science Scope, 42(6), 56-61.
15. Jiménez, C. F., Guadaño, L. H., & Muñoz, F. P. (2021). Virtual labs: A complement for traditional laboratories. http://oa.upm.es/41724/1/INVE_MEM_2014_219761.pdf
16. Lawal, A. A. (2023). The impact of virtual field trip strategies on academic performance and motivation in biology concepts. Journal of Science Education and Technology, 32(3), 194-208.
17. Lewis, D. (2014). Limitations of virtual laboratories in biology education. Journal of Biological Education, 48(2), 64-67.
18. Mishra, S. K., & Yadav, B. (2013). Effect of teacher and school variables on use of community resources in science teaching at middle level. Journal of Educational Sciences & Psychology, 3(2) 44-56.
19. Ndukwe, U. E., & Obafemi, D. T. A. (2023). Virtual laboratory and guided inquiry on students' performance in redox reaction in Rivers State. Faculty of Natural and Applied Sciences Journal of Mathematics, and Science Education, 4(2), 102-109.
20. Njoku, M. I. A., Mgbomo, T. (2021). Effect of Field Trip and Demonstration Methods on the Achievement of Secondary School Students in Biology. Rivers State University Journal of Education (RSUJOE), 24(2), 55-64. www.rsujoe.com.ng

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21. Nnodim, N. E. & Ndioho, O. F. (2023) Enhancing students' retention in genetics using 5E learning cycle and WebQuest in secondary schools in Rivers State. International Journal of Multidisciplinary Education and Research, 8(2), 1-6. www.multidisciplinaryjournals.in
22. Nwagbo, C. R., & Ugwuanyi, C. S. (2015). Assessment of science teachers' pedagogical beliefs and information and communication technology (ICT) classroom practices in secondary schools in Enugu State, Nigeria. Journal of Science Teachers Association of Nigeria, 50(1), 24-39.
23. Obafemi, D. T. A., & Aderonmu, T. S. (2022). Identification and sources of misconceptions held by secondary school physics students in heat energy in Rivers State, Nigeria. European Journal of Education Studies, 9(4), 120-133.
24. Obeka, S. S. (2010). Epodawalad and power stimulation games of geographical and environmental education. Ahmadu Bello University Press Limited.
25. Obineke, C. J., & Nworgu, L. N. (2024). Effect of Two Modes of Field Trip Method on Students' Achievement in Senior Secondary School Ecology in Nsukka Local Government Area, Enugu State. African Journal of Science, Technology and Mathematics Education (AJSTME), 10(3), 350-357. https://www.ajstme.com.ng
26. Ogar, M. E., & Effiong, O. E. (2022). Effects of field trip method on students' academic achievement and retention in Basic science and technology. IJRDO-Journal of Applied Science, 8(9), 20-27.
27. Omeodu, M. D., & Abara, J. F. (2018). Relevance of fieldtrips in teaching and learning of physics in secondary schools in Port Harcourt Metropolis, Rivers State. International Journal of Education and Evaluation, 4(4), 67-87.
28. Redel-Macías, M. D., Pinzi, S., Martínez-Jiménez, M. P., Dorado, G., & Dorado, M. P. (2016). Virtual laboratory on biomass for energy generation. Journal of Cleaner Production, 112, 3842-3851.
29. Reeves, T. C., McKenney, S., & Herrington, J. (2021). Challenges and limitations of virtual laboratories in science education. Educational Technology & Society, 24(2), 135-150.
30. Richardson, J. T. E. (2011). Eta squared and partial eta squared as measures of effect size in educational research. Educational Research Review, 6(2), 135-147.
31. Shakil, A. F., Faizi, W. N., & Hafeez, A. (2011). The need and importance of fieldtrips at higher level in Karachi, Pakistan. International Journal of Academic Research in Business and Social Sciences, 1(2), 1-16.
32. Stahre Wästberg, B., Eriksson, T., Karlsson, G., Sunnerstam, M., Axelsson, M., & Billger, M. (2019). Design considerations for virtual laboratories: A comparative study of two virtual laboratories for learning about gas solubility and colour appearance. Education and Information Technologies, 24, 2059-2080.
33. Sunday, B. E. (2021). Impact of field trip on academic performance of secondary school students in ecology concepts in Kaduna State. Journal of Science Technology and Education, 9(4), 101-108. www.atbuftejoste.com
34. Uwitonze, D., & Nizeyimana, G. (2022). Effects of virtual laboratories on students' understanding of biology in selected secondary schools of Rwamagana District, Rwanda. Journal of Research Innovation and Implications in Education, 6(4), 249 – 258. www.jriiejournal.com
35. Zhao, Y., Flanagan, E., Abbasi, H., Black, K., Wang, X., & Cardona, A. (2019). Development of a virtual lab in assistance of a fluid mechanics laboratory instruction. In Proceedings of the ASME 2019 International Mechanical Engineering Congress and Exposition. https://doi.org/10.1115/IMECE2019-10540