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Effects of Guided-Inquiry, Virtual and Expository Laboratory Instructional Strategies on Students' Performance and Retention in Cell Biology in Uyo, Akwa Ibom State

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ABSTRACT

This study investigated the Effects of Guided-Inquiry, Virtual and Expository Laboratory Instructional Strategies on Students' Performance and Retention in Cell Biology in Uyo, Akwa Ibom State. Two research questions and two null hypotheses guided the study. The Quasi experimental design was adopted for the study. A sample 202 Senior Secondary one (SS1) Biology students from three (3) Urban and three (3) Rural secondary schools in the study area were selected using the purposive sampling technique. The instruments used for data collection were the Biology Performance Test on Cell Biology (BPTCB), and the Cognitive Ability Test on Biology (CATB). A reshuffled BPTCB was also used to measure retention. Kuder-Richardson's formular–20 was used to determine the reliability of the instrument with coefficient of 0.85. Data obtained were analyzed using mean, standard deviation and analysis of covariance (ANCOVA). ANCOVA was used to test the hypothesis at $p<0.05$ level of significance while Mean and standard deviation were used to answer the research questions raised. Findings on performance showed that students in the urban area performed significantly better than their rural counterparts when taught Cell Biology with Guided-Inquiry and Virtual Laboratories strategies while findings on retention showed a non-significant difference in the retention of students in both the urban and rural areas when taught cell biology with Guided-Inquiry and Virtual Laboratories strategies. Based on the findings of the study, it was recommended among others, that Biology teachers should be encouraged to adopt Guided-Inquiry and Virtual Laboratory strategies during biology practicals to facilitate students' performance and retention.

Keywords: Guided-Inquiry Laboratory, Virtual Laboratory, Expository Laboratory, Students' Academic Performance, retention, Biology, Cell Biology.

Introduction

Biology, the scientific study of life and living organisms, occupies a central role in the senior secondary school science curriculum. It encompasses a broad spectrum of sub-disciplines, including microbiology, botany, zoology, genetics, ecology, and physiology, each contributing to a holistic understanding of biological systems and processes. At this educational level, Biology serves not only as a gateway to advanced scientific inquiry but also as a critical platform for cultivating scientific literacy, environmental awareness and health consciousness among adolescents (Ahmad, 2022). It nurtures curiosity, critical thinking, and a deeper appreciation of life. Whether you are investigating microbes, dissecting a frog or exploring DNA, Biology invites you to explore the wonders of nature and the science behind it.

Cell Biology is the foundational discipline of the life sciences concerned with the structure, function, organization, and behavior of the cell, the fundamental unit of life (Hakan *et al,* 2023). Since the formulation of the cell theory by scientists such as Matthias Schleiden, Theodor Schwann, and Rudolf Virchow in the nineteenth century, the cell has been recognized as the basic structural and functional unit of all living organisms (Mirko *et al,* 2018).

Contemporary cell biology extends beyond descriptive morphology to encompass molecular mechanisms, biochemical pathways, intracellular communication systems, and dynamic interactions between cells and their environments (Charlotte *et al,* 2020).

Within the context of secondary education, cell biology represents a critical gateway topic in Biology. It provides learners with conceptual frameworks for understanding higher-level biological themes, including genetics, physiology, ecology, and evolution. However, the abstract and microscopic nature of cellular structures and processes often presents pedagogical challenges (Harrison and Waterhouse, 2021). Students may struggle to visualize organelles, comprehend dynamic molecular interactions, or integrate theoretical knowledge with practical laboratory experiences. Evidence of this shortfall is reflected in students deliberate avoidance of cell biology related questions in external examinations, as documented in the National Examination Council's annual reports (2020–2025). This persistent challenge underscores a pedagogical gap in how cell biology is taught at the senior secondary level. Consequently, the methods employed in teaching cell biology, particularly laboratory-based instruction, play a crucial role in shaping students' conceptual understanding, academic performance, and long-term retention (Haşiloğlu and Eminoğlu, 2017).

Accordingly, this study situates cell biology not merely as a body of scientific knowledge but as a pedagogical domain in which instructional design, learner engagement, and contextual realities intersect. By examining laboratory approaches within the teaching of cell biology in varying locations, this research seeks to advance evidence-based practices that enhance students' conceptual mastery, academic performance, and sustained understanding of one of biology's most fundamental and transformative fields.

The location of a student's school whether urban or rural plays a nuanced role in shaping academic achievement and retention of biology concepts. While some studies report no significant difference in achievement between students from different school locations when effective instructional strategies such as concept mapping or the 5E learning cycle are employed, others highlight that retention may be more sensitive to environmental disparities. Factors such as access to qualified teachers, availability of instructional materials, and infrastructural quality often vary by location, influencing the depth and durability of conceptual understanding (Khanal, 2019). In particular, rural schools may face challenges related to resource limitations and environmental stimulation, which can hinder long-term retention despite comparable initial performance. Therefore, while school location may not directly predict achievement under optimized teaching conditions, it remains a critical variable in educational equity and the sustained internalization of scientific knowledge.

Urban or Rural location of schools refers to the state classification of areas where schools are located. Urban areas are mainly the towns while the rural areas are the villages. The interaction of individuals with the habitats influences the rate of intellectual development in relation to academic performance and retention. The attainment of a high development level is not determined by differential geographical environment but by maturity and experience; hence, the understanding of a biology concept may be determined by school location (Ichipi-Ifukor, 2019). The performance of students in biology could be largely attributed to the location of the school: whether the school is in a rural or an urban area. Much of the reliable variance in student performance could be attributed to the learner's environment or location of learning. Urban students are said to be exposed to a good learning environment, appropriate methods of teaching, and consequently, perform better in solving biology problems than those in the rural schools Ebinum *et al.* (2017).

Academic performance refers to the measurable outcomes of learners in formal educational settings, typically assessed through standardized tests, examinations, coursework, and other evaluative instruments. It is the learner's actual record and level of accomplishment in a specific field of study (Chinda and Achigbe, 2024). It serves as a central metric for gauging student learning, instructional quality, and institutional effectiveness. In educational research, academic performance can be used to examine the impact of pedagogical strategies and environmental influences such as school location on student success. It is a measure of what students have learned using assessment techniques such as standardized tests, performance tests, and other measures. It can also describe the exhibition of knowledge, skills, and attitudes attained or developed by the students in a subject in relation to other factors like school location as determined by their test scores

assigned by their teacher (Abampa, 2021). Research by Ovat *et al* (2021) on the influence of school location on the academic performance of students showed that there was a significant influence of school location on students' academic performance: urban students performed significantly better than their rural counterparts in core subjects. Also, Adebisi and Ajoke (2018) investigated on the influence of school location on students' academic achievement and found that there was statistically significant difference in the achievement mean scores of students in urban and rural school located areas. However, other researchers opined differently as Effiom-Edem and Edoho (2017) showed that there was no significant difference in the mean performance scores between urban and rural school students.

Retention of Biology concepts refers to students' sustained ability to recall and apply learned scientific knowledge over time, serving as a key indicator of meaningful learning in science education (Brackett and Rivers, 2019). It is the ability to retain and subsequently remember things experienced or learned by an individual later (Kamarul, 2017). Research consistently shows that retention is significantly enhanced through the use of multimodal instructional strategies such as combining lectures, demonstrations, and laboratory activities as well as the integration of visual and interactive learning materials (Etiubon and Udoidiong, 2024). These approaches reduce cognitive overload, foster deeper conceptual understanding, and benefit learners across gender and ability levels. Empirical studies from various Nigerian education zones affirm that students exposed to diverse teaching methods and science learning aids demonstrate higher retention rates than those taught through conventional approaches (Michael *et al,* 2020). The rate of retention varies in individuals due to differences in abilities, skills, and storage capacity. Researchers have also studied the influence of location on the retention of students. In a study by Ekon and Nwankwo (2024), which focused on Biology achievement and retention, The result of the analysis showed a significant effect of school location on secondary school students' academic retention in biology. Also, Udeme-Obong (2023) and Wahab and Ileuma (2022) in their separate studies showed that school location is not a significant predictor of students' academic retention.

The laboratory method of teaching is activity-oriented, and it offers students the opportunity to interact with learning contents, teachers, laboratory specimens, and materials to develop scientific attitudes such as being objective, critical thinking, and careful handling of instruments. It also offers the learners the opportunity to develop scientific skills as they observe, measure, record, manipulate, experiment, and draw conclusions. (Ojelade, 2015) identified the objectives of using the laboratory method to include teaching and learning of skills, concepts, attitudes, cognitive abilities, and understanding of the nature of science. Through the laboratory method, students are actively involved in the process of learning, and retention is enhanced. Laboratory activities can also help students develop new interests, attitudes, and values so that they may learn to investigate and explore further into their environment (Hebebci and Usta,2022). Laboratories are integral to disciplines such as physics, chemistry, biology, and engineering, each tailored to the specific needs and methodologies of the field.

The biology laboratory is a unique subset of the general laboratory, dedicated to the study of living organisms and life processes. It provides a controlled environment for exploring concepts in anatomy, physiology, microbiology, genetics, ecology, and biotechnology. Typical biology laboratories are equipped with: Microscopes (compound, dissecting, digital), Glassware (test tubes, petri dishes, beakers), Specimens (preserved animals, plant samples, microbial cultures), Dissection tools (scalpels, forceps, pins), and Safety equipment (gloves, lab coats, eyewash stations) (Kambaila *et al,* 2019). Advanced biology labs may also include centrifuges, incubators, PCR machines, and electrophoresis apparatus for molecular biology experiments.

Laboratory work and proficiency are key components and a degree requirement in education for students in STEM (science, technology, engineering, and mathematics) higher education (Reeves & Crippen, 2021). However, recent developments in education like increased demands for students' independence and distance education have led to the emergence of more innovative laboratory strategies like the guided-inquiry and the virtual laboratories, providing students with hands-on learning experiences without the need for the excessive techer interferences or even physical lab equipment that is traditionally offered in teaching laboratories at schools (Rato *et al,* 2024).

Guided-Inquiry Laboratory provide a framework within which students explore scientific questions, formulate hypotheses, and design

experiments. It serves as a transitional model that prepares students for independent research by cultivating critical thinking, methodological competence, and epistemological awareness (Vassiliadou, 2020). Its integration into biology curricula represents a meaningful advancement in science education, bridging foundational instruction with authentic investigative practice. Pedagogically, Guided-Inquiry Laboratories promote active learning, enhance problem-solving abilities, and foster a deeper engagement with the scientific process (Kepul *et al*, 2019). They support differentiated instruction and accommodate diverse cognitive styles, making them suitable for a wide range of learners. Moreover, they align with contemporary educational frameworks that emphasize inquiry, collaboration, and real-world relevance.

The Virtual Laboratory platforms often incorporate multimedia elements such as animations, real-time feedback, and embedded assessments, allowing students to visualize complex processes and reinforce theoretical concepts (Rato, 2024). Virtual labs also support iterative experimentation, enabling learners to repeat procedures, test alternative hypotheses, and explore outcomes without resource limitations. Pedagogically, virtual laboratories offer several advantages. They democratize access to laboratory experiences, particularly in under-resourced institutions or remote learning contexts. They promote self-paced learning, accommodate diverse learning styles, and reduce logistical barriers associated with traditional labs. Moreover, they enhance conceptual understanding by integrating visual and interactive elements that support cognitive processing. However, virtual laboratories are not without limitations. They may lack the tactile experience and technical skill development associated with physical manipulation of equipment. Additionally, they require reliable digital infrastructure and may not fully replicate the unpredictability and complexity of real-world experimentation. Despite these constraints, virtual laboratories represent a significant advancement in science education. When integrated thoughtfully alongside physical lab experiences, they enrich the learning environment, foster scientific inquiry, and prepare students for the evolving landscape of digital research and remote collaboration. Their role in modern Biology instruction underscores the importance of adaptability, innovation, and inclusivity in educational design, placing it in an advantageous position when compared to other forms of laboratory, such as the guided-inquiry laboratory or the expository laboratory (Vassiliadou, 2020).

In Biology, Expository Laboratories are used to demonstrate key principles such as cell structure, physiological processes, and biochemical reactions. Activities like specimen dissection, microscopy, and chemical testing allow students to connect theory with observation in a controlled environment (Dedi and Ristina, 2020). These laboratories offer pedagogical benefits, including safety, efficiency, and consistency in assessment. They are especially effective for beginners, helping build confidence and competence in basic scientific techniques (Suaad, 2021). However, their rigid format may limit creativity and critical thinking if not complemented by reflective or inquiry-based elements. Overall, expository laboratories serve as essential stepping stones in science education, laying the groundwork for more advanced, investigative learning while ensuring foundational mastery of core concepts and methods as well as improved academic performance (Saul, 2024).

Statement of the Problem

The declining performance of students in Biology in recent West African Examinations Council (WAEC) examinations, particularly in questions relating to Cell Biology, further underscores the need for effective instructional interventions. Poor achievement in this area may reflect not only students' conceptual difficulties but also limitations in the instructional strategies employed in teaching complex biological concepts. Within the context of Uyo Local Government Area of Akwa Ibom State, there is therefore a need to establish empirically whether Guided-Inquiry, Virtual, and Expository Laboratory instructional strategies differ in their effectiveness in improving students' performance and retention in Cell Biology. Addressing this problem is important because sustained difficulties in Cell Biology may negatively affect students' overall achievement in Biology and their preparedness for further studies in science-related disciplines. Consequently, this study seeks to provide empirical evidence on the effects of Guided-Inquiry, Virtual, and Expository Laboratory strategies on senior secondary students' performance and retention in Cell Biology in Uyo, Akwa Ibom State. The findings are expected to provide evidence-based direction for improving laboratory pedagogy, informing teacher instructional practices, and

strengthening the teaching and learning of Biology in Nigerian secondary schools.

Research Questions

i. What differences exist among students in their mean performance scores in Cell Biology when taught with Guided-Inquiry, Virtual, and Expository laboratories based on school location?
ii. What differences exist among students in their mean retention scores in Cell Biology when taught with Guided-Inquiry, Virtual, and Expository Laboratories based on school location?

Null Hypotheses

i. There is no significant difference among the mean performance scores of Biology students taught Cell Biology in Guided-Inquiry, Virtual, and Expository Laboratories, based on school location.
ii. There is no significant difference among the mean retention scores of Biology students taught Cell Biology in Guided-Inquiry, Virtual, and Expository Laboratories, based on school location.

Research Methods

The research design adopted for this study was a quasi-experimental design with three groups, two experimental groups and a control group. Experimental group one was taught the concept of cell biology using Guided-Inquiry laboratory, experimental group two was taught the same concept using Virtual Laboratory and group three was the control group taught same concept using Expository Laboratory. The study was carried out in Uyo Local Government Area of Akwa Ibom State. The population of this study comprised of all the senior secondary one (SS1) Biology students in six co-educational secondary schools in Uyo Local Government Area of Akwa Ibom state estimated at seven thousand seven hundred and fifty (7,750), senior secondary one student. A sample of two hundred and two (202) Senior Secondary one (SS1) Biology students from three (3) classes in three Urban and three Rural secondary schools in Uyo Local Government Area of Akwa Ibom State will be selected for the study. The purposive sampling technique was used to select the three secondary schools for the study from the population. The instruments used for data collection were the Biology Performance Test on Cell Biology (BPTCB). The Biology Performance Test on Cell Biology (BPTCB) will however be reshuffled and presented as the Biology Retention Test on Cell Biology (BRTCB) to test for retention. BPTCB consisted of 50 multiple choices, items with four (4) options A, B, C, and D with only one correct answer. This generated a total of fifty (50) marks. While the BPTCB assesses students' academic performance after exposure to Guided-Enquiry, Virtual, and Expository Laboratory Methods, The BRTCB is intended to measure students' retention of Cell Biology concepts after a time interval, thereby assessing the durability and stability of learning achieved through the various laboratory methods. The instruments were subject to face, content, and construct validation by five experts, three science teachers and two educational research lecturers. For content validation, the test blue print was given to the validators to examine and ensure that the test content was representative of the area of interest and in line with the lower cognitive educational objective. In general, the comments and recommendations of the validators helped to modify the instrument. To establish reliability, the instrument was trial tested on a group of thirty (30) SS1 students from another school in Uyo LGA who were not selected for the main study but had the characteristics of the students used for the study. The Kuder-Richardson 20 (KR20) formula was used to measure the internal consistency with a reliability coefficient of 0.85. Guided-Inquiry laboratory was used to teach experimental group-one the concept of Cell Biology. The lesson lasted for three weeks. During the lesson, students were taught the concept of Cell Biology under the following headings: Cell structure, cell and its environment, and cell growth. Virtual laboratory was used to teach experimental group-Two the concept of Cell Biology. Expository laboratory was also used to teach group-three the concept of Cell Biology. At the end of the lessons, the three groups were administered the Biology Performance Test on Cell Biology (BPTCB), Finally, the scripts were retrieved, marked and the data collected were analyzed using Analysis of Covariance (ANCOVA) to test the research hypotheses at 0.05 while Mean(X) and standard deviation was used to answer the research questions raised. ANCOVA was considered suitable for this study because the sample size is large and the study is considering three groups of laboratories. All statistical analyses will be done using SPSS. After three weeks, the research assistants

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in experimental group one, two and three will administer BRTCB which will be a reshuffled version of BPT as another posttest to test for students' retention ability on the three laboratory methods used for the study. Thereafter, the scripts will be collected, marked, scored and used for data analysis.

Results

Research Question one:

What differences exist among students in their mean performance scores in Cell Biology when taught with Guided-Inquiry, Virtual, and Expository laboratories based on school location?

Table 1: Mean and standard deviation of students' pretest and post-test mean performance scores of students taught Cell Biology with Guided-Inquiry, Virtual, and Expository Laboratories based on school location

Laboratory Strategies	Location	N	Pre-test $\overline{X}$	SD	Post-test $\overline{X}$	SD	Mean Gain
Guided-Inquiry	Urban	41	17.02	4.80	40.56	4.01	23.54
	Rural	32	14.25	4.18	38.19	3.65	23.94
Virtual	Urban	34	16.35	5.99	38.21	5.34	21.86
	Rural	35	14.60	4.78	38.60	3.48	24.00
Expository	Rural	36	15.33	4.14	36.56	5.09	21.23
	Rural	24	14.63	3.59	32.50	4.53	17.87

Source: Field work (2026)

Results in Table 1 show the pre-test scores of urban students taught Cell Biology using Guided-Inquiry, Virtual, and Expository Laboratories strategies to be 17.02, 16.35 and 15.33 respectively with standard deviation scores as 4.80, 5.99 and 5.09 and 4.14 respectively, while their respective mean post-test scores are 40.56, 38.21 and 36.56 with standard deviation scores as 4.01, 5.34 and 5.09 respectively. This indicates that the mean performance scores of the three groups (Guided-Inquiry, Virtual, and Expository Laboratories strategies) increased from pre-test to post- test. The pre-test scores of rural students taught Cell Biology using Guided-Inquiry, Virtual, and Expository Laboratories strategies to be 14.25, 14.60 and 14.63 respectively with standard deviation scores as 4.18, 4.78 and 3.59 respectively, while their respective mean post-test scores are 38.19, 38.60 and 32.50 with standard deviation scores as 3.65, 3.48 and 4.53 respectively.

The table also shows mean gain scores of students taught Cell Biology using Guided-Inquiry, Virtual, and Expository Laboratories strategies for urban schools to be 23.54, 21.86 and 21.23, respectively and for rural students to be 23.94, 24.00 and 17.87 respectively. Comparing the mean gain scores of the three groups for the urban students, it indicates that Guided-Inquiry was the highest in enhancing students' academic performance with mean gain score of 23.54, followed by Virtual, with mean difference score of 21.86 and Expository Laboratory strategy as the least with the score of 21.23. In comparing the mean gain scores of the three groups for the rural schools, it still indicates that Guided-Inquiry was the highest in enhancing students' academic performance with mean gain score of 23.94 followed by Virtual with mean gain score of 24.00 The use of Expository Learning strategy was the least with mean gain score of 17.87 in enhancing students' academic perform in Cell Biology.

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Research Question two:

What differences exist among students in their mean retention scores in Cell Biology when taught with Guided-Inquiry, Virtual, and Expository Laboratories based on school location?

Table 2: Mean and standard deviation of students' post-test and retention mean performance scores of students taught Cell Biology with Guided-Inquiry, Virtual, and Expository Laboratories based on school location

Learning Strategies	Location	N	Post-test $\overline{X}$	SD	Retention $\overline{X}$	SD	Mean Loss
Guided-Inquiry	Urban	41	40.56	4.01	33.34	4.69	-7.22
	Rural	32	38.19	3.65	29.22	4.95	-8.97
Virtual	Urban	34	38.21	5.34	29.74	6.24	-8.47
	Rural	35	38.60	3.48	28.86	4.79	-9.74
Expository	Rural	36	36.56	5.09	25.28	4.44	-11.28
	Rural	24	32.50	4.53	24.67	4.47	-7.83

Source: Field work (2026)86

The table shows mean loss scores of students taught Cell Biology using Guided-Inquiry, Virtual, and Expository Laboratories strategies for urban students to be -7.22, -8.47 and -11.28, respectively and for rural students to be -8.97, -9.74 and -7.83 respectively. Comparing the mean loss scores of the three groups for the urban schools, it indicates that Guided-Inquiry was the highest in enhancing students' retention with mean loss score of -7.22, followed by Virtual, with mean retention score of -8.47 and Expository Laboratory strategy as the least with the score of -11.28. In comparing the mean loss scores of the three groups for the rural schools, it still indicates that Guided-Inquiry was the highest in enhancing students' retention with mean loss score of 23.94 followed by Virtual laboratory with mean loss score of -9.74. The use of Expository Laboratory strategy was the least with mean loss score of -7.83 in enhancing students' retention in Cell Biology.

Hypotheses

Hypothesis one:

There is no significant difference in the mean performance scores of students taught the concept of Cell Biology with Guided-Inquiry, Virtual, and Expository Laboratories based on school location

Table 3: 3x2 Factorial Analysis of Covariance (ANCOVA) of students' post-test performance scores on Cell Biology classified by treatment with pre-test as covariate

Source	Sum of Squares	df	Mean Square	F-value	P-value.
Corrected Model	1932.238[a]	23	84.010	5.08	.00[S]
Intercept	9827.302	1	9827.302	595.24	.00[S]
Pre-test (Covariate)	282.160	1	282.160	17.09	.00[S]
Strategies (Main Effect)	306.791	2	153.395	9.29	.00[S]
Location (Main Effect)	100.908	1	100.908	6.11	.01[S]
Error	2938.737	178	16.510		
Total	293149.000	202			
Corrected Total	4870.975	201			

a. R Squared = .397 (Adjusted R Squared = .319)

Where, NS = Not significant at .05 level of significance; S = Significant at .05 level of significance

Source: Field work (2026)

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The results on Table 3 show the analysis on the difference between the mean performance scores of students taught the concept of Cell Biology with Guided-Inquiry, Virtual, and Expository Laboratories with respect to location.

The table shows that the calculated F-value (6.11) having a p-value (.01) of location is less than the significant level (.05), therefore, the null hypothesis three is rejected. This implies that there exists a significant difference among the mean academic performance scores of students taught Cell Biology using Guided-Inquiry, Virtual, and Expository Laboratories with respect to location. In order to determine the direction of significance, the scores were subjected to post hoc analysis as shown in Table 4.

Table 4: Summary of LSD Post-hoc pair wise comparison of students' post- test performance classified by location

(I) Location	(J) Location	Mean Difference (I-J)	Std. Error	Sig.[d]
Urban	Rural	2.423*	.930	.010
Rural	Urban	-2.423*	.930	.010

The post-hoc result in Table 4 on the significant difference in the mean performance scores of students taught the concept of Cell Biology who were taught using Guided-Inquiry, Virtual, and Expository Laboratories strategies based on location shows that urban students taught using Guided-Inquiry strategy, Virtual strategy and Expository strategies performed better than rural students taught using Guided-Inquiry strategy, Virtual strategy and Expository strategies.

Hypothesis Two: There is no significant difference in the mean retention scores of students taught the concept of Cell Biology with Guided-Inquiry, Virtual, and Expository Laboratories based on school location.

Table 5: 3x2 Analysis of Covariance (ANCOVA) of students' retention performance scores on Cell Biology classified by treatment, with post-test as covariate

Source	Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4267.774[a]	23	185.555	14.152	.000
Intercept	15.415	1	15.415	1.176	.280
Post-test (Covariate)	1473.805	1	1473.805	112.406	.000
Strategies (Main Effect)	114.428	2	57.214	4.364	.014
Location (Main Effect)	.406	1	.406	.031	.860
Error	2333.835	178	13.111		
Total	174575.000	202			
Corrected Total	6601.609	201			

a. R Squared = .646 (Adjusted R Squared = .601)
Field work (2026)

The results on Table 5 show the analysis on the difference between the mean retention scores of students taught the concept of Cell Biology with Guided-Inquiry, Virtual, and Expository Laboratories with respect to location.

The table shows that the calculated F-value (.031) having a p-value (.86) of location is greater than the significant level (.05), therefore, the null hypothesis four is retained. This implies that there exists no significant difference among the mean retention scores of students taught Cell Biology using Guided-Inquiry, Virtual, and Expository Laboratories with respect to location.

Discussions of the Findings

The findings on the difference between the performance mean scores of Biology students in Urban and Rural schools taught Cell Biology with the Guided-Inquiry, Virtual and Expository Laboratory strategies indicated a significant difference. Urban Students taught the concept of Cell Biology with the Guided-Inquiry, and the Expository Laboratories strategies performed significantly better than their

Rural counterparts taught the same concept using Guided-Inquiry, and Expository Laboratories strategies. Urban Students taught the concept of Cell Biology with the Virtual, and the Expository Laboratories strategies performed significantly better than their Rural counterparts taught the same concept using Virtual, and Expository Laboratories strategies. The findings can be attributed to the fact that student in the urban areas may already have been exposed to other innovative strategies earlier hence the ease of understanding. The findings of the study are in line with that of Ovat *et al* (2021) who conducted a study to assess the influence of school location and class size on the academic performance of upper basic nine students in Cross River State, Nigeria and found out that urban students performed significantly better than their rural counterparts in core subjects like Mathematics and Basic Science. It is also in line with a study by Adebisi and Ajoke (2018) who investigated the influence of school location on students' academic achievement in Junior Secondary School Basic Science in Ekiti Stat, Nigeria and results shows that there was statistically significant difference in the achievement mean scores of students in urban and rural school located areas. The findings of this study further align with the study by Effiom-Edem and Edoho (2017) on "influence of school location on student's attitude towards mathematics and basic science," which also showed that there was no significant difference in the mean performance scores between urban and rural school students with positive attitude towards mathematics and basic science using the independent t-test analysis.

The findings on the difference between the retention mean scores of Biology students in Urban and Rural schools taught Cell Biology with the Guided-Inquiry, Virtual, and Expository Laboratory strategies indicated a non-significant difference. This may have been due to students in both locations being able to effectively interact and understand the concept of Cell biology when the various laboratory strategies were used, hence equally enhancing their retention. The findings of the study are in line with the study of Udeme-Obong (2023), who investigated the school location and teaching methods as determinants of students' performance and retention in biology in Ikot Ekpene Local Government Area and found that school location is not a significant predictor of students' academic retention. The findings are also in line with the study by Wahab and Ileuma (2022) who investigated school location as a correlate of learners' motivation towards learning and achievement of Universal Basic Education Goals in Public Basic Schools, Ogun State and concluded that school location is not an essential determinant of the achievement of Universal Basic Education goals and learners' motivation towards learning in public basic schools. The findings of the study are however contrary to the findings of a study by Ekon and Nwankwo (2024), on Biology achievement and retention which showed a significant effect of school location on secondary school students' academic achievement in biology in Calabar Education Zone, Cross River State.

Conclusion

Based on the Findings of the study, it is concluded that the Guided-Inquiry and the Virtual laboratory strategies were most significant in the performance of students in the urban schools, while they had no significant effects on students' retention irrespective of location.

Recommendations

i. Biology teachers and educators should be encouraged to adopt Guided-Inquiry and the Virtual laboratory strategies for laboratory instruction.
ii. Guided-Inquiry and the Virtual laboratory strategies which are purposive and efficient should be used in teaching Cell biology so that the students can reap the full benefits of the lesson.
iii. Strengthening the use of Guided-Inquiry and the Virtual laboratory strategies through in-service course could help science teachers to adopt proper use of good laboratory strategies.

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