



Effects of Laboratory-Based Instruction on Retention Among Chemistry Education Students in Universities in Rivers State

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Abstract

This study investigated the effect laboratory-based instruction on Chemistry education students' retention in universities in Rivers State. Two research questions and two corresponding hypotheses guided the study. The study adopted the pre-test, post-test control group quasi-experimental design. The population of the study comprised sixty five (65) first year (100 level) Chemistry students in two public universities in Rivers State. Purposive sampling technique was used to select two public universities, which were randomly assigned into the experimental group and control group with their intact classes used. Chemistry retention Test (CRT) was used for data collection. A reliability index of 0.77 was obtained using Kuder Richardson formula 21. The research questions were answered using mean and standard deviation while the hypotheses were tested using t-test at 0.05 level of significance. The findings of this study revealed that laboratory-based instruction significantly improves retention of Chemistry content in Universities; No difference was found between the male and female students taught with laboratory-based and their counterparts in lecture method; Students in laboratory-based instruction group significantly retained better than their peers in lecture method group; and that gender is not a determinant factor for students retention when taught using laboratory-based instruction. Based on these findings, it was recommended among others that educational institutions should integrate regular laboratory sessions within the Chemistry curriculum to enhance understanding and retention of materials. Government should regularly organize teachers' professional development and learning in laboratory-based instructional methods. Since familiarity and experience in conducting laboratory activities are crucial for maximizing the benefits of this approach; and that schools and universities should invest in equipping the Chemistry laboratories, since adequate resources and modern equipment are essential for effective laboratory-based learning.

Keywords: Laboratory Based Instruction, Retention, Chemistry, Education, Students

Introduction

Teaching from the time of old has been an aristocratic endeavor that shapes minds, inspires development, and promotes leaders of tomorrow. In Nigeria, science educators play a crucial role in building young talents and contributing to societal upliftingment. According to Adewumi (2019), it is the targeted use of one's knowledge, abilities, and character traits to fulfil one's own educational and societal requirements. So, it is up to the teaching profession to decide what kinds of learning activities will help students achieve the school's stated objectives. Teaching, according to Osuagwu (2019), does more than only help students understand the material and achieve the goals of the curriculum; it also helps them grow as people and as members of society. Therefore, the fact that educators use strategies to foster pupils' healthy sense of self-concept is integral to this definition. Even though most classroom instruction takes place in a structured environment, the most crucial part of any good lesson is the one-on-one time that instructors spend with their students. Teachers have a crucial role in making curriculum a reality in the classroom, which is why teacher training is so vital. According to Ibe (2018), chemistry education instructors are university students who have earned admission to a teacher preparation program but have not yet fulfilled all of the prerequisites to become certified teachers. Osuagwu (2019) stated that students majoring in chemistry education participate in supervised field-based teaching experiences under the supervision of university-qualified instructors as they progress towards teacher certification. This necessitates a course or program of study in chemistry that student instructors must finish prior to entering the teaching profession. Students accepted into a teacher education program who also major in chemistry are therefore students studying chemistry education. These individuals are currently enrolled in a bachelor's degree program in chemistry education at a university. Preparing future educators requires a solid

grounding in chemistry. Aspiring educators get a solid grounding in the subject matter and pedagogy of their chosen field during this phase of teacher training. It is also a time for aspiring educators to develop the professional ethics that will serve them well as they carry the torch for America's youth and its future into the classroom. According to Eyisi (2020), chemistry education training is a curriculum designed for future teachers rather than current ones, and it occurs before instructors begin teaching. Bayo (2020), asserted that chemistry education training programs for teachers cover all the bases when it comes to educating and developing student-teachers at different teacher preparation programs.

As an essential and intriguing scientific discipline, chemistry is a must-study for all students. All matter is composed of atoms and molecules, and this branch of study focusses on their structure, behavior, and composition. When it comes to agriculture, health, and industry, among many other human pursuits, chemistry is the connecting tissue between the many branches of science. A good illustration would be the fact that many common home items include chemical byproducts. Chemistry lays the groundwork for the technologies that agriculture relies on for food production, processing, and preservation. Manufacturing, engineering, and capital goods all rely on operational methods that were first developed in industrial and analytical chemistry. At one end of the spectrum, Chemistry interacts with biochemistry and other branches of biological research; at the other end, it integrates with physical chemistry and chemical physics, further highlighting its prominent place in science. Concepts, established principles, rules, and theories, as well as extensive activity-oriented laboratory work, make up a chemistry student's curriculum. Some of the theoretical concepts covered in class will be put to the test in these lab experiments, which will also serve to show the characteristics of substances discussed in class and to evaluate the validity of certain empirical chemical laws. So, if we want a strong basis for technology and its advancement, chemistry education must be a top priority in schools (Arukoyu, 2018). Since the level of Chemistry instruction in a country's schools directly correlates to the level of scientific advancement in that country, it would seem that science can scarcely exist without from Chemistry. As a result of low enrolment in STEM fields, the government's goal of having 60% of university entrants major in sciences and applied mathematics and 40% in the arts and social sciences is often unfulfilled. Students' recent public exam performance in chemistry has been disheartening, despite the subject's inherent potential, its importance to humanity, and the efforts of researchers to enhance its teaching and learning, particularly at the secondary school level (Dike, 2018). The policy continues by outlining steps to accomplish the aforementioned goals via the creation of science and mathematics centers, workshops, and teachers' resource centers. The saying "what I hear, I forget" is based on this Chinese adage. Everything I do is clear to me. When the necessary resources are not available, students are unable to do. It is crucial to acknowledge that the goals of chemistry education may go unfulfilled unless this tendency is corrected. Students' dismal showing in the Science subjects, and notably Chemistry, on the SSCE is evidence that the subject is not being adequately taught or learnt. This shows that students aren't getting enough practice in the lab, which might be a cause of their failing to meet proficiency standards. It points to a problem with the way chemistry is taught and learnt in secondary schools, which needs to be looked into and fixed. Chemistry, according to Arukoyu (2018), is an experimental science that benefits from an activity-based approach taught in a properly-equipped laboratory. Students' enthusiasm, curiosity, attitude towards chemistry, creativity, and problem-solving skills in science, as well as their grasp of scientific principles and the scientific method, may be greatly enhanced by the use of labs, according to Azizoglu and Uzuntiryaki (2016), when it comes to teaching and studying chemistry, the laboratory is a crucial tool.

According to Crowther and Briant (2022), gender is a social construction that heavily involves the traditionally defined functions of men and women in any particular culture. Gender, according to this concept, dictates one's place in society's official political, cultural, social, and economic structures. The word "gender" refers to the set of traits that people in a given culture are expected to exhibit based on their biological sex. Gender may be seen as the contrast between the two extremes of the socially expected roles for men and women. As a result of culturally determined gender norms, women in most societies are unable to actively participate in or reap the benefits of development initiatives. For the female pupils, this has meant complete psychological estrangement. Consequently, girls tend to focus on language and art classes, while boys tend to perform well in STEM (science, technology, engineering, and mathematics) and ES (environmental studies) courses. Gender bias, in which patriarchal values and institutions work to disadvantage women, is present in Nigeria, as it is in many African countries (Akpochofo, 2019). The vast majority of elective posts that are open to both men and women exhibit this trait. As long as males are engaged, women will always be considered unfit for leadership roles. The harmful impact of the belief that women ought to be subservient to males permeated women's lives. As a result of historical and cultural shifts, males now have more power and authority over women in many African societies. Gender prejudices against women persist in certain countries despite efforts to disprove this view and establish a kind of gender equality via the creation of several possibilities favored by women. Despite the fact that men and women are fundamentally different, Akpochofo (2019) casts doubt on the idea that one sex may naturally possess superior intelligence. There is no fundamentally different level of intellect

between the sexes depending on biological factors. He went on to say that just because men are stereotypically seen as more artistically gifted does not mean they are. Despite this, researchers have found that the Nigerian curriculum does not adequately represent female students' needs since it focusses on male-dominated fields and promotes stereotypically masculine stereotypes about women's roles in the home.

Subjects like chemistry and other fundamental sciences, which rely heavily on experimentation and empirical evidence, are ideal candidates for laboratory-based learning. For scientists and engineers, laboratory-based instruction is more than just a means to an end, it's a pedagogy that can help them develop professional competencies like scientific method, project management, technical communication and presentation, and more (Dike, 2018). Students have access to a wide variety of specialized tools in the Chemistry laboratory, which serves a crucial purpose. Several writers have offered varying definitions of the school lab. According to Dike (2018), a laboratory is a setting where science instructors carry out practical experiments for the benefit of their pupils. Experiments and other activities that aid students in developing scientific abilities are part of the laboratory exercises, often known as laboratory practical. The science laboratory was described by Ezeliiora (2017) as a place where scientific activity is done in an ideal setting. Furthermore, in her mind, the laboratory is the secure haven for all of the scientific tools, materials, and instruments. According to Igwe (2017), a laboratory may be either an indoor space, like the well-appointed classrooms in most institutions, or an outdoor space, like a riverbank, workshop, field, or even a market, where scientific investigations can be conducted. He went on to say that students should have the same laboratory experience regardless of the kind of lab that is used to teach science. Students will have the chance to learn both theoretical and practical principles via solving issues, which necessitates their active involvement in a variety of activities that combine observation, experimentation, and demonstration. An activity including a two-way approach carried out by one or more individuals via exercise and experimental procedures is the laboratory-based method of teaching, as noted by (Dienye, 2017).

Retention is the ability to store and remember information or content gotten after learning. One of the factors for the poor achievement in science is lack of retention (Ephraim, 2022). Aminu (2011) defined several variables that affect retention to include; the content or tasks to be performed, learners past experiences, the space between lesson and assessment and instructional strategies employed. Dike (2018) however, noted that the imperative factor influencing retention of students is the scope of learning experience given in the lesson which is also a factor of the instructional method applied. When the learning process engages more of the human senses, rich learning clime and atmosphere is created. To meaningfully engage the students in the learning process in the Chemistry subject, the teacher must have to adopt new and innovative teaching methods such as laboratory based instruction.

Learning in a scientific laboratory gives students invaluable experience that they may take with them into the workforce and into society at large. Giving pupils real-world experience in the scientific method is a great way to help them become scientists themselves. For laboratory education to be successful, students must grasp not just the steps to conduct the experiment, but also its value and purpose in enhancing their comprehension of a scientific idea, connection, or process. Schools lacking laboratories to conduct biology, chemistry, and physics practical would likely produce or graduate students lacking the practical knowledge needed to pass the senior school certificate examinations administered by the West African Examination Council (WAEC) and the National Examination Council (NECO), according to the roles of the science laboratory in science teaching and learning.

The circumstances in which low performance in Chemistry is experienced must be reconsidered if this issue is to be solved. Finding out how well students do in a lab setting should be the current emphasis of such a re-examination. Students' ability to take charge of their own education and reach their full potential is enhanced in classrooms where they are encouraged to actively engage in the learning process. Schools' inadequate laboratory learning conditions can be the root cause of students' low performance in Chemistry and related courses. Furthermore, it seems from the literature study that there has not been a lot of research on the impact of the laboratory learning environment on students' learning outcomes in Nigerian secondary school chemistry classes. Due to the dearth of relevant material, a rigorous scientific investigation into the laboratory setting is warranted. Examining the relationship between laboratory-based teaching and chemistry student retention at Rivers state institutions is, hence, central to this research.

Statement of the Problem

People in developing countries, and Nigeria in particular, do not have faith in the educational system because of its current condition. There are still issues with the Nigerian educational system at the university level, including overcrowding in classrooms, a lack of resources to help students learn, an excessive number of students per instructor, and insufficient professional development opportunities for faculty. None of these things are good for

students' grades, and they all have major consequences for how teachers present their lessons in the classroom. Educators in the scientific fields generally agree that students' ability to learn and retain information is a key component in helping them reach their maximum potential in chemistry classes. The majority of secondary school teachers in Nigeria are graduates of teacher preparation programs who struggle in the classroom.

Likewise, the JAMB examiner's report for many universities (2015–2022) drew attention to students' shortcomings, which had a negative impact on their performance, and emphasized the need of professors and students working together to improve. Finding answers to problems like low motivation and underwhelming performance is the meat and potatoes of annual reports. In an effort to tackle these recognized issues, research has been conducted to enhance chemistry education by using well-thought-out instructional methodologies and models. Even with all of these initiatives, students' chemistry scores on the SSC and in college have been persistently low. All of these methods improved upon the traditional approach to education that is still in use in our secondary and tertiary institutions. On the other hand, laboratory-based training seems to be overlooked, which is why this research was conducted.

Aims and Objectives of the Study

The aim of this study was to examine the effect laboratory-based instruction on Chemistry education students' retention in universities in Rivers state. The objectives were to:

1. examine chemistry students' retention taught using laboratory-based instruction and lecture method.
2. determine male and female students' retention taught Chemistry with laboratory-based instruction

Research Questions

The study was guided by the following research questions:

1. What is the mean retention score of students taught Chemistry using laboratory-based instruction and lecture method?
2. What is the mean retention score of male and female students taught Chemistry using laboratory-based instruction?

Hypotheses

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

Ho₁: There is no significant difference between the mean retention scores of students taught Chemistry using laboratory-based instruction and those taught with lecture method.

Ho₂: There is no significant difference between the mean retention scores of male and female students taught Chemistry using laboratory-based instruction.

Methods and Materials

This study adopted a pre-test post-test quasi experimental research design; sixty five year one Chemistry education student from two universities in Rivers state took part in the study. These two universities with their intact classes were then randomly assigned in experimental group consisting of 18 students and the control group having 47 students. Using the various teaching resources that followed laboratory based instruction, the experimental group got lesson on Chemistry with thorough practical activities carried out in the laboratory on the topic of interest. The same lessons on the subject were given to the control group with the conventional lecture method as obtainable in the university settings. Before the experiment, a pre-test was administered to both control and experimental group to ascertain their baseline knowledge. The two groups received instruction for four weeks. Upon conclusion of the instructional phase, a post-test was given to determine the level of performance and after two weeks, another post-test was issued to test students' retention. The mean and standard deviation was applied to answer research questions while ANOVA was employed to test hypotheses at 0.05 level of significance.

Results

Research Question 1: What is the mean retention score of students taught Chemistry using laboratory-based instruction and lecture method?

Table 1: Mean and standard deviation statistics showing the mean retention scores of students taught Chemistry using laboratory-based instruction and lecture method.

Method	n	Post-test		Retention-test		Mean Diff.
		Mean	Std	Mean	Std	
Laboratory-Based	18	71.44	13.648	60.67	10.716	10.77
Lecture method	47	34.55	8.158	32.60	6.056	1.95

Table 1 showed the post-test and mean retention scores of students in experimental group (Laboratory-Based) were 71.44 and 60.67, with standard deviation of 13.648 and 10.716 respectively. While the mean difference was calculated at 10.77 when compared with both the post-test and retention mean scores. Table 1 also show that those taught with lecture method had post-test mean scores and mean retention scores of 34.55 and 32.60 respectively, with standard deviation of 8.158 and 6.056. However, mean difference of 1.95 was obtained for the lecture method when compared with both the post-test and retention mean scores.

Research Question 2: What is the mean retention score of male and female students taught Chemistry using laboratory-based instruction?

Table 2: Mean and standard deviation showing the mean retention scores of male and female students taught Chemistry using laboratory-based instruction.

Gender	n	Post-test		Retention-test		Mean Diff.
		Mean	Std	Mean	Std	
Male	8	74.50	14.803	61.50	10.889	13.00
Female	10	69.00	12.901	60.00	11.116	9.00

Table 2 showed the post-test and mean retention scores of male students in experimental group (Laboratory-Based) as 74.50 and 61.50 with SD of 14.803 and 10.889 respectively. While the mean difference was calculated at 13.00 when compared with both the post-test and retention mean scores. Table 2 also show that the female counterparts had post-test mean scores and mean retention scores of 69.00 and 60.00 respectively, with SD of 12.901 and 11.116. However, mean difference of 9.00 was obtained when compared with both the post-test and retention mean scores.

Testing of Hypotheses

H₀₁: There is no significant difference between the mean retention scores of students taught Chemistry using laboratory-based instruction and those taught with lecture method.

Table 3: ANOVA comparison of mean retention scores of students taught using laboratory and lecture method.

Source variation	of Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	10255.819	1	10255.819	177.538	.000
Within Groups	3639.319	63	57.767		
Total	13895.138	64			

The result in Table 3 show an F-value of 177.538, with an associated p-value of .000 (which is less than the .05 alpha level). With this result, we then reject H_{01} , and conclude that students taught with laboratory method retained chemistry concepts better than those taught with lecture method.

H₀₂: There is no significant difference between the mean retention scores of male and female students taught Chemistry using laboratory-based instruction.

Table 4: ANOVA comparison of mean retention scores of male and female students taught using laboratory-based instruction

Source of variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	10.000	1	10.000	.082	.778
Within Groups	1942.000	16	121.375		
Total	1952.000	17			

The result in Table 4 show an F-value of .082 with associated p-value of .082. Since the p-value of .778 is greater than 0.05 level of significance ($F=.082$, $p \geq 0.05$), we then retained the null hypothesis (H_{02}), which states that there is no significant difference between the mean retention scores of male and female students taught Chemistry using laboratory-based instruction. This suggest that gender is not a statistically significant factor in determining students' performance in Chemistry using laboratory-based instruction.

Discussion

Findings from the study on the effect laboratory-based instruction on the retention of Chemistry education students in Universities in Rivers state revealed that the students taught using laboratory-based instruction has a higher mean retention score when compared when compared to the students taught using the conventional lecture method. Further investigation using ANOVA revealed the difference between students taught with Laboratory-based instruction and those instructed using lecture method is statistically significant, while the difference between male and female students taught using laboratory-based instruction was found to be not statistically significant in terms of their retention. Students who learnt chemistry in a laboratory setting had much higher mean retention scores than those who learnt the subject via a lecture-based approach, according to the study's conclusion. Ogiga and Alu (2025) on their study of laboratory based instruction and its effect on Chemistry education students in Universities discovered that Chemistry education students taught with Laboratory based instruction significant performed better than those taught using lecture method and they further suggested that Chemistry education students tutored with Laboratory based instruction may retain content better too. Emah and Noye (2018) found that comparison of chemistry students taught using lecture and demonstration approaches, those taught using laboratory-based education recalled concepts far more quickly and effectively. Our findings are in line with theirs. This conclusion is in line with the research of Imoniwe (2023), who found that compared to students taught using the lecture approach, those whose chemistry classes used computer simulation models recalled more of the material. These results corroborate those of Okoye (2016), who studied the impact of using computer simulations as an educational technique on the DNA replication and transcription performance of Biology students. When compared to students taught using the lecture technique, those whose chemistry classes included computer simulation models performed far better on measures of accomplishment and retention. This finding is in line with the research of Arum (2017), which examined the impact of an interactive computer simulation package on the achievement and retention of genetics concepts by students in senior secondary school. The study found that students taught chemistry using the simulation method outperformed those exposed to the lecture method in terms of achievement and retention. Also, when comparing the average retention scores of male and female students in chemistry classes that included laboratory work, no statistically significant difference was found. Abamba (2021) also found no significant influence of gender on students' performance or retention in Physics, and our results are in line with that. Arokoyu and Nenalebari (2018) found no significant interaction impact on gender and learning methodologies on students' performance and retention in organic chemistry, which is in agreement with our findings.

Conclusion

The study concludes that laboratory-based instruction improves students' retention in Chemistry more than lecture method in universities. Laboratory-based instruction enhances both male and female students' retention in

Chemistry. Gender is not a determinant factor for students' performance in both laboratory-based instruction and lecture method.

Recommendations

1. Educational institutions should integrate regular laboratory sessions within the chemistry laboratory sessions within the chemistry curriculum to enhance understanding and retention of material. This requires a balance approach combining both theoretical lectures and hands-on laboratory activities.
2. Government should regularly organize teachers' professional development and training in laboratory-based instructional methods. Since familiarity and experience in conducting laboratory activities are crucial for maximizing the benefits of this approach.
3. Schools and universities should invest in well-equipped chemistry laboratories. Adequate resources and modern equipment are essential for effective laboratory-based learning.
4. Chemistry teacher should encourage group work and collaborative experiments in laboratory settings to enhance peer learning. This approach can build communication and teamwork skills, as well as reinforce learning through discussion and shared problem-solving.
5. Implement continuous assessment techniques within laboratory sessions to monitor and support students' progress. Frequent, formative assessments help identify areas where students may struggle, allowing for timely intervention and support.

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