



Laboratory-Based Instruction and Academic Performance of Chemistry Education Students in Universities in Rivers

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Abstract

This study investigated the effect laboratory-based instruction on Chemistry education students' academic performance 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 Performance Test (CPT) 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 those taught with laboratory-based instruction performed better than those taught with lecture teaching method; No difference was found between the male and female students taught with laboratory-based and their counterparts in lecture method; 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, Academic Performance, Chemistry, Education, Students

Introduction

Facilitating learning is the sole process of teaching. 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 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 maths 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, 2019). "Encouraging the implementation of educational policy and making learning experiences more meaningful for the student" is the stated goal of educational services, which are addressed in Section 11 of the National Policy on Education (NPE, 2013). The policy continues by outlining steps to accomplish the aforementioned goals via the creation of science and mathematics centers, workshops, and teachers' resource centers. Furthermore, the methodology used by teachers has shifted from being teacher-dominated to being student-centered, and current science curriculum place a strong emphasis on student participation in scientific activities. Research conducted both in and out of Nigeria has consistently shown that students' cognitive and psychomotor domain learning is enhanced when instructional materials are made use of (Ifeakor, 2020). 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 & 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 (Akpochofa, 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, Akpochafo (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, 2019). 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 (2019), 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 Ezeliara (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). These methods are important in scientific education.

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 purpose of this study is to examine the effect laboratory-based instruction on Chemistry education students' academic performance in universities in Rivers state. And the objectives were to:

1. determine the academic performance of students taught Chemistry using laboratory-based instruction and those taught using lecture method.

- ascertain the academic performance of the male and female students taught Chemistry with with laboratory based instruction.

Research Questions

The study was guided by the following research questions:

- Is there any difference in students' performance in Chemistry taught using the laboratory-based instruction and those taught with the lecture method?
- Is there any difference in male and female students' performance in chemistry taught using the laboratory-based instruction?

Hypotheses

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

- There is no significant difference between the mean performance score of students taught using laboratory-based instruction and those taught using the lecture method.
- There is no significant difference between the performance mean scores of male and female students taught Chemistry using laboratory-based instruction.

Material and Methods

This study adopted a pre-test post-test quasi experimental research design; sixty five year one Chemistry education student from the three public universities in Rivers state took part in the study (source: fieldwork). Two universities were purposively selected from the three public universities. These two selected universities with their intact classes were then randomly assigned into 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. 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: Is there any difference in students' performance in Chemistry taught using the laboratory-based instruction and those taught with the lecture method?

Effect of laboratory-based instruction on Chemistry students' academic performance in universities

Teaching Method	N	Pre-test		Post-test		Mean Diff.
		Mean	Std	Mean	Std	
Laboratory-Based	18	30.33	4.715	71.44	13.648	36.89
Lecture	47	25.74	6.920	34.55	8.158	

Table 1 depicts pre-test and post-test results of the two instructional methods: laboratory-based instruction and lecture method. For each method, the number of participants (N), mean scores (X) and standard deviations (SD) are reported for both the pre-test and post-test. Both laboratory based instruction and lecture method groups resulted in substantial improvement in mean scores from pre-test to post-test. Chemistry education students taught with laboratory based instruction had a pre-test mean of 30.26 which increased to 71.44 in the post-test. The students taught using the conventional lecture method had a lower pre-test mean of 25.74, which increased to 34.55 in the post-test. There was a broader spread of scores in the post-test results which was prompted by the increase of standard deviation of both groups from pre-test to post-test.

Research Question 2. Is there any difference in male and female students' performance in chemistry taught using the laboratory-based instruction?

Table 2: Effect of laboratory-based instruction on the performance of male and female Chemistry Education students.

Gender	N	Pre-test		Post-test		Mean Diff.
		Mean	Std	Mean	Std	
Male	8	30.75	3.694	74.50	14.803	5.50
Female	10	30.00	5.578	69.00	12.901	

Results in Table 2 showed that on the pre-test scores, the male and female groups were equal on the knowledge of the concepts taught before treatment by mere comparison of their means. On the post-test scores, Table 2 indicated that male students taught with Laboratory method scored slightly higher than their female counterparts with a mean difference of 5.50.

Hypothesis 1 (HO₁)

There is no significant difference between the mean performance score of students taught using laboratory-based instruction and those taught using the lecture method.

Table 3: ANOVA comparison of students' performance using laboratory-based instruction and lecture method.

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	17713.477	1	17713.477	179.181	.000
Within Groups	6228.061	63	98.858		
Total	23941.538	64			

Table 6, compared achievement test scores of students in the experimental (Laboratory-based) group and the control (lecture). Result showed an F-value of 179.181, with associated p-value of .000. Since the p-value of .000 is less than 0.05 level of significance, ($F = 179.181, p \geq 0.05$), we therefore rejected the null hypothesis (H_{01}). This indicated that there is a statistically significant difference between the mean performance scores of students taught using laboratory method and those taught using the lecture method. It also implies that students in the experiment group significantly outscored those in the control group.

Hypothesis 2 (HO₂)

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

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

Source of variation	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	134.444	1	134.444	.709	.412
Within Groups	3032.000	16	189.500		
Total	3166.444	17			

Table 4.7 showed the comparison of mean performance of male and female students taught using laboratory-based instruction. Result showed an F-value of .709, with associated p-value of .412. Since the p-value of .412 is greater than 0.05 level of significance ($F = .709, p \geq 0.05$), we then retained the null hypothesis (H_{02}). This implies that there is no significant difference between the performance mean scores of male and female students taught Chemistry using laboratory-based instruction.

Discussion

Findings from the study on the effect laboratory-based instruction on the academic performance of Chemistry education students in Universities in Rivers state revealed that the students taught using laboratory-based instruction has a higher mean performance 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. Okon (2017) also discovered that students taught mixture and compound via laboratory-based education fared better than those taught through lecture approach, therefore this results are in line with his findings. This conclusion is also in line with the research conducted by Ikutal (2019) on improving students' performance in Agricultural Science. The study indicated that the laboratory approach, followed by demonstration and field trips, was the most successful way for enhancing students' performance. Nsa (2021) also found that students taught using the laboratory method outperformed their project method counterparts cognitively when it came to soil testing.

Conclusion

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