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Effect of Biology Practical Activities on Academic Achievement of Secondary School Students in Ikwo Local Government Area, Ebonyi State, Nigeria

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ABSTRACT

This study investigated the effect of Biology practical activities on the academic achievement of Senior Secondary School II (SS II) students in Ikwo Local Government Area (LGA) of Ebonyi State, Nigeria. Four research questions and four corresponding null hypotheses guided the investigation. The study was anchored theoretically on Kolb's Experiential Learning Theory and Piagetian-Vygotskian Constructivist Learning Theory, both of which converge on the proposition that meaningful learning arises from active, hands-on engagement with concrete materials and phenomena rather than from passive reception of verbally transmitted information. A quasi-experimental, pretest-posttest, non-equivalent control group design was adopted. The target population comprised all the SS II Biology students in public secondary schools across Ikwo LGA, from which a sample of 150 students was drawn from five schools using simple random sampling and assigned to an experimental group (n = 75, taught using structured practical activities) and a control group (n = 75, taught using the conventional lecture method). Data were collected using a 30-item, five-option, multiple-choice Biology Achievement Test (BAT) covering Ecology, Plant and Animal Habitats, and Food Chains and Food Webs, validated by subject-matter and measurement experts and yielding a Kuder-Richardson Formula 20 (K-R20) internal-consistency coefficient of 0.77. Data were analysed using means and standard deviations to answer the research questions, while one-way Analysis of Variance (ANOVA) was used to test the null hypotheses at the 0.05 level of significance. Results showed that the experimental and control groups were statistically equivalent at pretest, $F(1, 148) = 0.15$, $p = .700$, but that students taught using practical activities achieved significantly higher posttest scores than those taught conventionally, $F(1, 148) = 63.46$, $p < .001$. No statistically significant gender difference was found among students in the experimental group, $F(1, 73) = 0.18$, $p = .675$, whereas students in urban schools significantly outperformed their rural counterparts, $F(1, 148) = 7.34$, $p = .008$. It was concluded that Biology practical activities significantly and gender-equitably enhance academic achievement, though achievement gains are moderated by school location and, by implication, differential access to laboratory infrastructure. It was recommended that Biology teachers adopt practical, activity-based instruction as the primary mode of Biology teaching, and that education authorities prioritise the equitable distribution of laboratory facilities between urban and rural secondary schools in Ebonyi State.

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INTRODUCTION

Science occupies a foundational position in the technological, economic, and social transformation of nations, functioning as a systematic process through which knowledge of the natural world is generated, tested, and applied (Ezeh, 2013). Among the science subjects offered in the Nigerian secondary school curriculum, Biology holds particular significance because of its direct relevance to human health, agriculture, and environmental sustainability, and because it serves as a gateway to numerous professional disciplines including medicine, nursing, pharmacy, and biotechnology (Campbell & Reece, 2018; Raven et al., 2020). The centrality of Biology to national development has led the Federal Government of Nigeria to prioritise science education at all levels, with the expectation that learners emerge from secondary education equipped with the scientific knowledge, laboratory skills, and inquiry-based dispositions required for further study and productive citizenship (Federal Ministry of Education, 2014).

Despite this policy emphasis, the practical dimension of Biology instruction, arguably the aspect most directly responsible for translating abstract biological concepts into durable, applicable understanding, remains inconsistently implemented across Nigerian secondary schools. Biology practical activities refer to structured, hands-on learning experiences in which students directly observe, manipulate, measure, and interpret biological phenomena and specimens, thereby developing the scientific process skills of observing, classifying, hypothesising, experimenting, and inferring (Nzewi, 2018; Opuh et al., 2018). Recent empirical work continues to affirm that such activities are indispensable rather than supplementary to effective Biology teaching (Chengere et al., 2025) found that guided inquiry-based laboratory instruction significantly enhanced secondary school students' science process skills relative to conventional laboratory-enriched instruction, while Chikendu & Okoli's (2025) investigation of hands-on laboratory practical activities similarly reported significant achievement gains attributable to structured practical engagement.

Nevertheless, the consistent and effective delivery of Biology practical activities in Nigerian secondary schools, and across much of Sub-Saharan Africa more broadly, is undermined by a cluster of interrelated structural constraints. A 2023 study of laboratory facility availability and utilisation, found that inadequate specimens, equipment, and insufficient weekly practical periods were directly associated with poorer Biology achievement, with the unavailability of laboratory facilities pushing students toward rote memorisation rather than genuine scientific understanding. Comparable patterns have been documented across the West African sub-region: Iweuno's (2024) assessment of practical work experience, found that many schools lacked dedicated science laboratories altogether, and that where laboratories existed, instructional emphasis was frequently oriented toward satisfying examination requirements rather than cultivating deep practical competence.

Beyond infrastructural constraints, the competence with which teachers organise, supervise, and deliver practical instruction has itself emerged as a critical determinant of practical work's effectiveness. Okoli & Nwosu (2020) and Uzoagulu & Eze (2021) both emphasise that teachers who are proficient in operating laboratory apparatus and integrating theory with hands-on demonstration create more stimulating and pedagogically productive practical environments than teachers who lack such competence, a finding corroborated by Adeyemi & Ogunleye (2019), who linked teacher competence in laboratory management directly to reductions in student error and improvements in the accuracy of scientific observation and interpretation. Equally important is the affective dimension of practical engagement: students' attitudes toward laboratory work meaningfully shape their willingness to participate, persist, and derive understanding from practical lessons, with Nworgu & Ugwuanyi (2020) and Eze & Nweke (2021) both reporting that favourable attitudes toward laboratory work correlate with higher Biology examination performance.

The question of gender further complicates the practical-achievement relationship. Historically, science education, and laboratory-based instruction specifically, has been characterised by a persistent, if empirically contested, presumption that male students derive greater benefit from hands-on scientific work than their female counterparts. Contemporary evidence increasingly challenges this presumption: Almasri's (2022) study of e-learning, gender groupings, and learning pedagogies among undergraduate Biology students found that pedagogical design, rather than gender per se, was the dominant predictor of attitude and achievement outcomes, a conclusion broadly consistent with Nwosu & Okeke's (2022) finding that gender differences in Biology achievement in Nigerian secondary schools are more plausibly attributable to differential instructional strategies and learning environments than to any inherent difference in scientific aptitude between male and female learners.

A further, comparatively under-examined dimension concerns the moderating influence of school location. Urban and rural secondary schools in Nigeria characteristically differ in the availability of qualified Biology teachers, functional laboratory infrastructure, and instructional resources, disparities that plausibly translate into differential capacity to implement practical activities with fidelity (Beaty & Woolnough, 2023). Within Ebonyi State specifically, and Ikwo Local Government Area in particular, concerns persist regarding students' consistently poor performance in Biology examinations, a pattern widely attributed to inadequate exposure to

practical activities and underutilisation of the limited laboratory facilities that do exist.

These converging strands of evidence, spanning teacher competence, student attitude, gender, and school location, collectively suggest that the effect of Biology practical activities on academic achievement cannot be adequately understood in isolation from the broader instructional and infrastructural context in which such activities are delivered. Yet, despite the accumulating body of Nigerian and international literature affirming the general value of practical, hands-on Biology instruction, remarkably few empirical studies have rigorously and experimentally examined this relationship specifically within Ikwo LGA, a predominantly rural and semi-urban educational context characterised by documented resource constraints. This represents a meaningful gap in the literature, both because generalised national or state-level findings may not accurately capture the specific dynamics of under-resourced local government areas, and because rigorous, quasi-experimental evidence, as opposed to purely descriptive or correlational evidence, is required to establish a credible causal link between practical instruction and achievement gains.

It is against this backdrop that the present study was designed. Rather than relying on descriptive survey methodology, as much of the existing Nigerian literature on this topic has done, this study adopts a quasi-experimental, pretest-posttest, non-equivalent control group design to rigorously compare the achievement of students exposed to structured Biology practical activities with that of students taught using the conventional lecture method, while simultaneously examining the moderating roles of gender and school location. By generating context-specific, experimentally grounded evidence from Ikwo LGA, this study aims to contribute both to the theoretical understanding of experiential and constructivist learning in resource-constrained settings and to the practical, policy-relevant evidence base needed to guide Biology instruction and resource allocation in Ebonyi State.

Purpose of the Study

The main purpose of this study was to investigate the effect of Biology practical activities on the academic achievement of secondary school students in Ikwo Local Government Area, Ebonyi State, Nigeria. Specifically, the study sought to: (1) determine the pretest equivalence of students in the experimental and control groups; (2) determine the effect of Biology practical activities on students' posttest academic achievement in Biology; (3) examine the difference in posttest academic achievement between male and female students taught using practical activities; and (4) examine the difference in posttest academic achievement between students in urban and rural secondary schools.

Research Questions

1. What is the pretest academic achievement of students in the experimental and control groups before the commencement of treatment in Ikwo Local Government Area, Ebonyi State?
2. What is the effect of Biology practical activities on the academic achievement of secondary school students in Biology in Ikwo Local Government Area, Ebonyi State?
3. What is the difference in the posttest academic achievement of male and female students taught Biology using practical activities in Ikwo Local Government Area, Ebonyi State?
4. What is the difference in the posttest academic achievement of students in urban and rural secondary schools in Ikwo Local Government Area, Ebonyi State?

Hypotheses

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

$H0_1$. There is no significant difference in the pretest academic achievement scores of students in the experimental and control groups in Ikwo Local Government Area, Ebonyi State.

$H0_2$. There is no significant effect of Biology practical activities on the academic achievement of secondary school students in Biology in Ikwo Local Government Area, Ebonyi State.

$H0_3$. There is no significant difference in the academic achievement of male and female students taught Biology using practical activities in Ikwo Local Government Area, Ebonyi State.

$H0_4$. There is no significant difference in the academic achievement of students in urban and rural secondary schools in Ikwo Local Government Area, Ebonyi State.

METHODOLOGY

This study adopted a quasi-experimental research design, specifically the pretest-posttest non-equivalent control group design, which was considered appropriate because the use of intact SS II Biology classes avoided disruption of normal school activities while still permitting rigorous comparison of treatment effects. The study was conducted in Ikwo Local Government Area of Ebonyi State, an educational context comprising both urban and rural public secondary schools with varying levels of access to qualified Biology teachers and laboratory facilities. The target population comprised all the SS II Biology students in public secondary schools in Ikwo LGA, from which a sample of 150 students was drawn from five randomly selected schools using simple random sampling, with 30 students selected from each school. The sample was subsequently constituted into

an experimental group (n = 75; taught using structured Biology practical activities over a three-week period comprising two 40-minute periods per week) and a control group (n = 75; taught the same content over the same duration using the conventional lecture method), with the experimental group further comprising 38 male and 37 female students, and the overall sample comprising 70 students from urban schools and 80 from rural schools.

Data were collected using a researcher-developed, expert-validated Biology Achievement Test (BAT), comprising 30 five-option multiple-choice items covering Ecology, Plant and Animal Habitats, and Food Chains and Food Webs, topics selected because of their amenability to practical and field-based instructional treatment. Content validity was established through review by experts in Biology Education and Measurement and Evaluation at the Department of Science Education, Alex Ekwueme Federal University Ndufu-Alike, guided by a formally constructed table of specification. Internal consistency reliability, determined through a trial administration to 30 SS II students outside the study area and analysed using the Kuder-Richardson Formula 20 (K-R20), yielded a coefficient of 0.77, indicating satisfactory reliability. The BAT was administered as a pretest prior to treatment to establish baseline group equivalence, and again as a posttest following the three-week instructional intervention, with research-assistant teachers trained in advance to ensure uniform implementation across both groups and with standard threats to internal validity, including test familiarity, teacher variability, the Hawthorne effect, and novelty effects, explicitly controlled for. Data obtained were analysed using means and standard deviations to answer the four research questions, while one-way Analysis of Variance (ANOVA) was used to test the four null hypotheses at the 0.05 level of significance, with the decision rule that a null hypothesis was rejected where the computed probability value was less than or equal to .05 and retained otherwise.

RESULTS

Results are presented in tables according to the research questions and null hypotheses that guided the study.

Research Question One:

What is the pretest academic achievement of students in the experimental and control groups before the commencement of treatment in Ikwo Local Government Area, Ebonyi State?

Table 1: Mean and Standard Deviation of Pretest Academic Achievement Scores of the Experimental and Control Groups (N = 150)

Group	*N*	*M*	*SD*
Experimental Group	75	12.50	3.20
Control Group	75	12.30	3.15

Note. M = Mean; SD = Standard Deviation. Maximum obtainable score = 30.

Table 1 shows that the Students in the experimental group obtained a pretest mean achievement score of 12.50 (SD = 3.20), while students in the control group obtained a pretest mean achievement score of 12.30 (SD = 3.15). The mean difference of 0.20 points was negligible, indicating that the two groups were approximately equivalent in prior Biology knowledge before treatment, thereby establishing valid pre-treatment equivalence.

Research Question Two: What is the effect of Biology practical activities on the academic achievement of secondary school students in Biology in Ikwo Local Government Area, Ebonyi State?

Table 2: Mean and Standard Deviation of Posttest Academic Achievement Scores of the Experimental and Control Groups (N = 150)

Group	*N*	*M*	*SD*
Experimental Group	75	22.40	4.10
Control Group	75	16.80	4.50

Note. M = Mean; SD = Standard Deviation. Maximum obtainable score = 30.

Table 2 revealed that the Students taught Biology using practical activities obtained a substantially higher posttest mean achievement score (M = 22.40, SD = 4.10) than students taught using the conventional method (M = 16.80, SD = 4.50). The mean difference of 5.60 points, compared with the negligible 0.20-point pretest difference, indicates a substantial achievement gain attributable to the practical activities intervention.

Research Question Three: What is the difference in the posttest academic achievement of male and female students taught Biology using practical activities in Ikwo Local Government Area, Ebonyi State?

Table 3: Mean and Standard Deviation of Posttest Academic Achievement Scores of Male and Female Students in the Experimental Group

Group	*N*	*M*	*SD*
Male	38	22.60	4.05
Female	37	22.20	4.18

Note. M = Mean; SD = Stand4rd Deviation. Maximum obtainable score = 30.

Table 5 shows that the Male students in the experimental group obtained a slightly higher posttest mean achievement score (M = 22.60, SD = 4.05) than their female counterparts (M = 22.20, SD = 4.18). The mean difference of 0.40 points was small, suggesting that male and female students benefited at a broadly similar level from Biology practical activities.

Research Question Four: What is the difference in the posttest academic achievement of students in urban and rural secondary schools in Ikwo Local Government Area, Ebonyi State?

Table 4: Mean and Standard Deviation of Posttest Academic Achievement Scores of Students in Urban and Rural Secondary Schools (N = 150)

Group	*N*	*M*	*SD*
Urban Schools	70	20.80	4.85
Rural Schools	80	18.60	5.05

Note. M = Mean; SD = Standard Deviation. Maximum obtainable score = 30.

The result analysis in Table 4 shows that the Students in urban secondary schools obtained a higher posttest mean achievement score (M = 20.80, SD = 4.85) than students in rural secondary schools (M = 18.60, SD = 5.05). The mean difference of 2.20 points suggests that differential access to laboratory facilities and instructional resources between urban and rural schools is associated with a moderate achievement gap.

Hypothesis One: There is no significant difference in the pretest academic achievement scores of students in the experimental and control groups in Ikwo Local Government Area, Ebonyi State.

Table 5: ANOVA Summary of Pretest Academic Achievement Scores of the Experimental and Control Groups

Source of Variation	SS	df	MS	F	p	Decision
Between Groups	1.50	1	1.50			
Within Groups	1489.68	148	10.07			
Total	1491.18	149		**0.149**	**.700**	**Not Significant**

Note. SS = Sum of Squares; df = Degrees of Freedom; MS = Mean Square. H_0 retained if p > .05.

Table 5 shows that the calculated F-value of 0.149 was not statistically significant, F(1, 148) = 0.15, p = .700. The null hypothesis was therefore retained, confirming the pre-treatment equivalence of the experimental and control groups.

Hypothesis Two: *There is no significant effect of Biology practical activities on the academic achievement of secondary school students in Biology in Ikwo Local Government Area, Ebonyi State.*

Table 6: ***ANOVA Summary of Posttest Academic Achievement Scores of the Experimental and Control Groups***

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	Decision
Between Groups	1176.00	1	1176.00			
Within Groups	2742.44	148	18.53			
Total	3918.44	149		**63.46**	**<.001**	**Significant**

Note. SS = Sum of Squares; df = Degrees of Freedom; MS = Mean Square. H_0 rejected if p < .05.

The result of the analysis in Table 6 indicated that the calculated F-value of 63.46 was statistically significant, F(1, 148) = 63.46, p < .001. The null hypothesis was therefore rejected, confirming that Biology practical activities significantly improved students' academic achievement, in favour of the experimental group.

Hypothesis Three: There is no significant difference in the academic achievement of male and female students taught Biology using practical activities in Ikwo Local Government Area, Ebonyi State.

Table 7: ANOVA Summary of Posttest Academic Achievement Scores of Male and Female Students in the Experimental Group

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	Decision
Between Groups	3.00	1	3.00			
Within Groups	1235.90	73	16.93			
Total	1238.90	74		**0.177**	**.675**	**Not Significant**

Note. SS = Sum of Squares; df = Degrees of Freedom; MS = Mean Square. H_0 retained if $p > .05$.

Table 7 shows the calculated F-value of 0.177 was not statistically significant, F(1, 73) = 0.18, p = .675. The null hypothesis was therefore retained, indicating that Biology practical activities benefit male and female students equally.

Hypothesis Four: There is no significant difference in the academic achievement of students in urban and rural secondary schools in Ikwo Local Government Area, Ebonyi State.

Table 8: A**NOVA Summary of Posttest Academic Achievement Scores of Students in Urban and Rural Secondary Schools**

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	Decision
Between Groups	193.60	1	193.60			
Within Groups	3908.44	148	26.41			
Total	4102.04	149		**7.34**	**.008**	**Significant**

Note. SS = Sum of Squares; df = Degrees of Freedom; MS = Mean Square. H_0 rejected if $p < .05$.

Table 8 revealed that the calculated F-value of 7.34 was statistically significant, F(1, 148) = 7.34, p = .008. The null hypothesis was therefore rejected, indicating a statistically significant achievement gap favouring urban over rural school students.

DISCUSSION OF FINDINGS

The finding of no significant pretest difference between the experimental and control groups, F(1, 148) = 0.15, p = .700, confirms that the two groups entered the study with statistically equivalent prior Biology knowledge, a methodologically essential precondition for validly attributing subsequent posttest differences to the treatment rather than to pre-existing group disparities. This baseline equivalence result is consistent with standard quasi-experimental practice and provides confidence that the substantial posttest gap subsequently observed reflects a genuine treatment effect rather than sampling artefact.

The finding that students exposed to Biology practical activities significantly outperformed those taught through the conventional lecture method, F(1, 148) = 63.46, p < .001, aligns closely with a substantial and growing body of recent empirical literature. Chengere et al. (2025), found that guided inquiry-based laboratory instruction significantly enhanced students' science process skills and achievement relative to conventional laboratory-enriched instruction, a result that mirrors the present study's finding despite differing national contexts. Similarly, Chikendu & Okoli (2025) reported that hands-on laboratory practical activities produced statistically significant achievement while in the study of laboratory facility availability and utilisation found that inadequate practical exposure was directly implicated in poor Biology achievement, a converse finding that lends further indirect support to the present result. Within the theoretical frameworks adopted for this study, this finding is consistent with the central proposition of Kolb's (1984) Experiential Learning Theory, that learning is most durable and meaningful when it proceeds through the cyclical engagement of concrete experience, reflective observation, abstract conceptualisation, and active experimentation, and with the Piagetian-Vygotskian constructivist position that learners construct rather than passively absorb knowledge through active interaction with their environment (Piaget, 1970; Vygotsky, 1978).

The finding of no statistically significant gender difference in achievement among students taught using practical activities, F(1, 73) = 0.18, p = .675, is consistent with an increasingly prominent strand of contemporary science education research that challenges the traditional presumption of male advantage in laboratory-based science learning. Almasri's (2022) investigation of e-learning, gender groupings, and learning pedagogies among undergraduate Biology students found that instructional design and pedagogical approach, rather than gender itself, were the dominant predictors of achievement and attitudinal outcomes, a conclusion that resonates directly with the present study's finding that gender exerted no meaningful influence once both male and female students were afforded equal access to

structured practical engagement. This finding also corroborates Nwosu & Okeke's (2022) contention that Nigerian gender-achievement gaps in Biology are more plausibly attributable to differential instructional strategies and learning environments than to any inherent difference in scientific aptitude, and lends empirical weight to the broader argument, advanced by Okoli, Iwuozor, & Obioma (2017), that equitable access to hands-on scientific engagement can substantially neutralise historically observed gender disparities in science achievement.

Finally, the finding that students in urban schools significantly outperformed their rural counterparts, $F(1, 148) = 7.34$, $p = .008$, corroborates a well-documented pattern in the Nigerian science education literature linking school location to differential access to laboratory infrastructure and qualified teaching personnel. Iweuno's (2024) study of practical work experience in Yenagoa similarly found that many schools, disproportionately those in less urbanised areas, lacked dedicated science laboratories or possessed only inadequately equipped facilities, a resource disparity directly consistent with the urban-rural achievement gap identified in the present study. This finding is further consistent with the broader infrastructural-access argument advanced by Beaty & Woolnough (2023), who cautioned that even highly competent Biology teachers cannot fully realise the pedagogical benefits of practical instruction where the biological equipment and materials required for such instruction remain obsolete or insufficient, a constraint that plausibly disadvantages rural schools in Ikwo LGA more acutely than their urban counterparts.

CONCLUSION

This study provides rigorous, quasi-experimental evidence that Biology practical activities significantly enhance the academic achievement of secondary school students in Ikwo Local Government Area, Ebonyi State, confirming the applicability of experiential and constructivist learning principles within a resource-constrained Nigerian educational context. The pre-treatment equivalence of the experimental and control groups lends methodological credibility to the substantial posttest achievement gap subsequently observed in favour of practical instruction. Furthermore, the absence of a statistically significant gender difference among students exposed to practical activities indicates that such instruction is gender-equitable, benefiting male and female students alike, and thereby challenging traditional assumptions of male advantage in laboratory-based science learning. However, the statistically significant achievement gap favouring urban over rural schools signals that the benefits of practical instruction are not uniformly realised across the study area, and that structural disparities in laboratory infrastructure and instructional resources continue to constrain the achievement of rural students. Taken together, these findings affirm that Biology practical activities constitute an effective and equitable pedagogical strategy, but one whose full potential in Ikwo LGA remains contingent on addressing the infrastructural inequities that continue to separate urban and rural secondary schools.

Recommendations

1. Biology teachers should adopt practical, activity-based instruction as the primary mode of Biology teaching rather than relying predominantly on the conventional lecture method.
2. The State Ministry of Education should organise regular workshops, seminars, and retraining programmes for Biology teachers on the improvisation and effective utilisation of practical instructional materials, particularly in rural schools.
3. The Government, through the Secondary Education Board, should prioritise the equitable distribution of laboratory apparatus, specimens, and reagents between urban and rural secondary schools to reduce the documented achievement gap associated with school location.
4. School principals should ensure that scheduled Biology practical periods are strictly observed and not substituted with additional theory lessons.
5. Given the demonstrated gender-equity of practical instruction, school administrators and teachers should actively encourage equal participation of male and female students in all Biology practical activities.

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