Effect of Inquiry-Based Learning on Biology Achievement of Senior Secondary School Students in Nigeria

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Abstract
Persistently poor achievement in Biology among Nigerian senior secondary school students has continued to attract the attention of science educators and examination bodies, and is frequently linked to over-reliance on the conventional lecture method. This study empirically examined the effect of inquiry-based learning on the Biology achievement of senior secondary school students in Nigeria, using ecology as the content area. A quasi-experimental, non-equivalent control group design with a pretest-posttest structure was adopted. A multi-stage sampling technique was used: one polytechnic was randomly selected from each of Nigeria's six geo-political zones; one senior secondary school was then randomly selected from each selected polytechnic's host community; and intact SS2 Biology classes within each school were randomly assigned to experimental (inquiry-based learning) and control (conventional lecture) groups, yielding a total sample of 360 students. Data were collected with a 25-item, expert-validated Biology Achievement Test (KR-21 = 0.83) and analysed using mean, standard deviation, and Analysis of Covariance (ANCOVA) at $p < .05$. Students taught with inquiry-based learning achieved significantly higher posttest scores than those taught conventionally, $F(1,357) = 48.62$, $p < .05$. Neither the main effect of gender, $F(1,357) = 0.68$, $p > .05$, nor the method-by-gender interaction, $F(1,357) = 1.14$, $p > .05$, was significant. The study concludes that inquiry-based learning significantly and equitably enhances Biology achievement among Nigerian senior secondary students, and recommends its wider adoption alongside targeted teacher training.

Keywords: *Inquiry-Based Learning; Biology Achievement; Senior Secondary School; Science Education; Ecology; Nigeria*

1. Introduction

Biology is central to Nigeria's senior secondary science curriculum, underpinning career pathways in medicine, agriculture, and environmental science (Federal Republic of Nigeria [FRN], 2014). Despite this importance, student achievement in Biology at the Senior School Certificate Examination level has remained persistently weak, with successive West African Examinations Council (WAEC) Chief Examiners' reports citing shallow conceptual understanding and poor application skills (WAEC, 2022). This weakness is widely attributed to the continued dominance of the teacher-centred conventional lecture method, which offers students little opportunity for investigation or collaborative problem-solving (Nwagbo, 2006; Okebukola, 1986).

Inquiry-based learning, in which students actively investigate questions, test hypotheses, and construct understanding under teacher facilitation, is theoretically and empirically associated with deeper conceptual learning (National Research Council [NRC], 2000; Minner, Levy, & Century, 2010). It draws on constructivist theory (Piaget, 1970; Vygotsky, 1978) and Bruner's (1961) discovery-learning theory, both of which predict superior retention and transfer from self-directed discovery relative to passive transmission. While international meta-analytic evidence broadly supports inquiry-based instruction's positive effect on science achievement (Furtak, Seidel, Iverson, & Briggs, 2012), Nigerian evidence spanning multiple geo-political zones remains limited, with most existing studies confined to a single state (Nwagbo, 2006; Bello, 2011).
This study addresses that gap by empirically examining inquiry-based learning's effect on Biology achievement using a sample drawn from schools located across all six of Nigeria's geo-political zones, anchored on a sampling frame of randomly selected polytechnics.

Objectives of the study

Specifically, the study determined:

1. the difference in Biology achievement between students taught ecology via inquiry-based learning and those taught conventionally
2. the achievement difference between male and female students within the inquiry-based group; and
3. the interaction effect of teaching method and gender on achievement. Three corresponding null hypotheses were tested at $p < .05$.

2. Literature Review and Theoretical Framework

2.1 Conceptual and Theoretical Framework

Inquiry-based learning spans a continuum from structured through guided to open inquiry (Minner et al., 2010); this study used guided inquiry, aligned to curriculum-prescribed ecology content (FRN, 2014). The conventional lecture method, by contrast, is teacher-centred, favouring recall over investigative skill (Okebukola, 1986). The study is anchored on Piaget's (1970) constructivist theory, which holds that learners actively construct knowledge through experience rather than passive transmission; Vygotsky's (1978) socio-cultural extension, which emphasizes guided social interaction; and Bruner's (1961) discovery-learning theory, which predicts deeper, more transferable understanding when learners discover principles for themselves. Jointly, these theories predict higher achievement for students engaged in inquiry-based ecology investigation than for those exposed only to lecture.

2.2 Empirical Review

Minner et al. (2010) and Furtak et al. (2012), in separate meta-analyses, found generally positive, though variable, effects of inquiry-oriented instruction on science achievement. Within Nigeria, Nwagbo (2006) found guided-discovery instruction significantly outperformed expository instruction in Biology, with no significant gender difference in the gain. Okebukola (1986) similarly favoured activity-based over lecture-based instruction, while Bello (2011) reported significantly higher achievement under inquiry teaching than conventional instruction. Akinbobola and Afolabi (2010) found that positive teacher attitudes toward constructivist pedagogy did not automatically translate into classroom practice, given large class sizes and resource constraints, an observation directly relevant to this study's implementation. Existing Nigerian evidence, however,

is overwhelmingly single-state in scope, leaving a national, multi-zone empirical gap that this study addresses.

3. Methodology

A quasi-experimental, non-equivalent control group design with a pretest-posttest structure was used, given the impracticality of individually randomizing students within intact Nigerian secondary school classes (Nwagbo, 2006; Bello, 2011). The population comprised SS2 Biology students in public senior secondary schools within polytechnic host communities across Nigeria's six geo-political zones. A multi-stage random sampling technique was applied: one polytechnic was randomly selected (by balloting from the National Board for Technical Education list) from each of the six geo-political zones; one senior secondary school offering SS2 Biology was then randomly selected from each polytechnic's host community; and within each school, two intact SS2 classes were randomly assigned by coin toss to experimental (inquiry-based) and control (conventional) groups. This yielded 360 students: 180 experimental and 180 control, 30 per condition per school. Data were collected with a researcher-developed, 25-item multiple-choice Biology Achievement Test (BAT) on ecology (energy flow, nutrient cycling, population dynamics, and ecological relationships), aligned to the SS2 curriculum (FRN, 2014). Content validity was established by three Biology educators and a measurement specialist; reliability, via Kuder-Richardson formula 21 on a 60-student pilot sample, yielded KR-21 = 0.83. The BAT was administered as pretest to both groups, followed by a six-week intervention in which experimental-group teachers, trained in a two-day workshop, facilitated guided-inquiry activities (field observation of school-compound ecosystems, food-web construction, and population-dynamics simulation), while control-group teachers continued conventional lecture delivery of the same content. The BAT, with re-ordered items, was then re-administered as posttest. Data were analyzed using means, standard deviations, and ANCOVA (pretest as covariate) at $p < .05$.

4. Results

Table 1: Mean and SD of Pretest and Posttest Biology Achievement Scores by Teaching Method

Group	N	Pretest M	Pretest SD	Posttest M	Posttest SD
Experimental (Inquiry)	180	10.42	2.87	18.65	3.21
Control (Lecture)	180	10.28	2.93	13.74	3.08

Pretest means were closely comparable across groups (10.42 vs 10.28), indicating baseline equivalence. Posttest means diverged substantially, with the experimental group (18.65) exceeding the control group (13.74).

Table 2: ANCOVA Summary — Effect of Teaching Method on Achievement (Posttest, Pretest as Covariate)

Source	SS	df	MS	F	p
Pretest (Covariate)	612.40	1	612.40	62.85	.000
Teaching Method	473.18	1	473.18	48.62	.000
Error	3472.55	357	9.73	—	—
Total	4558.13	359	—	—	—

$F(1,357) = 48.62$, $p = .000 < .05$: H01 was rejected. The posttest achievement advantage of the inquiry-based group over the control group is statistically significant.

Table 3: Mean and SD of Posttest Scores by Gender (Experimental Group)

Gender	N	Mean	SD
Male	92	18.51	3.34
Female	88	18.80	3.07

The 0.29-mark difference favouring females was not significant, $F(1,357) = 0.68$, $p = .411 > .05$: H02 was not rejected.

Table 4: ANCOVA Summary — Interaction Effect of Teaching Method and Gender

Source	df	MS	F	p
Method × Gender	1	11.09	1.14	.286

$F(1,357) = 1.14$, $p = .286 > .05$: H03 was not rejected. Inquiry-based learning's effectiveness did not differ significantly by gender.

5. Discussion of Findings

The significantly higher posttest achievement of the inquiry-based group is consistent with constructivist and discovery-learning theory (Piaget, 1970; Bruner, 1961) and aligns closely with Nigerian evidence favouring guided-discovery and activity-based instruction over lecture-based teaching (Nwagbo, 2006; Okebukola, 1986; Bello, 2011), as well as international meta-analytic findings (Minner et al., 2010; Furtak et al., 2012). The nearly five-mark gain on a 25-mark ecology test is notable given ecology's recurrent identification as a weak area in WAEC reports (WAEC, 2022), suggesting inquiry-based instruction as a promising response to this assessment concern.

The absence of a significant gender difference or interaction effect echoes Nwagbo's (2006) finding and carries an equity implication: inquiry-based learning benefited male and female students comparably, rather than disproportionately favouring either group (Akinbobola & Afolabi, 2010). Notably, successful implementation across all six geo-political zones depended on a structured teacher-training workshop, reinforcing Akinbobola and Afolabi's (2010) caution that favorable teacher attitudes toward constructivist pedagogy do not automatically translate into effective classroom practice without deliberate preparation and resource support.

6. Conclusion and Recommendations

This study found that inquiry-based learning significantly improved Biology achievement among Nigerian senior secondary students relative to the conventional lecture method, with no significant gender difference or method-by-gender interaction, using a sample spanning all six of Nigeria's geo-political zones. These findings support constructivist and discovery-learning theory and extend prior Nigerian and international evidence to a broader national scope. The study concludes that inquiry-based learning is an empirically validated, gender-equitable strategy for enhancing Biology achievement, contingent on adequate teacher training. Accordingly, it is recommended that:

1. Biology teachers adopt inquiry-based learning, particularly for ecology and other WAEC-flagged weak content areas;

2. State Ministries of Education and the National Teachers' Institute organise in-service training in inquiry-facilitation skills;
3. Colleges of Education and university education faculties strengthen inquiry-based pedagogy in pre-service training;
4. school administrators facilitate access to basic materials and field-observation sites for ecology instruction;
5. NERDC embed structured guided-inquiry activity guides within the official Biology curriculum and textbooks; and
6. future researchers extend this design to other Biology content areas and incorporate practical-skill and attitude measures.

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