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Role of Outdoor Experiments in Developing Scientific Inquiry Skills Among Junior Secondary School Students in Eha-Amufu, Enugu State, Nigeria

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ABSTRACT

This quasi-experimental study examined the role of outdoor experiments in developing scientific inquiry skills among junior secondary school students in Eha-Amufu, Isi-Uzo Local Government Area of Enugu State, Nigeria. Drawing on Kolb's experiential learning theory, Dewey's philosophy of educative experience, and the National Research Council science-practice framework, the study compared an eight-week Outdoor Experiment Instructional Package with conventional classroom demonstration. A sample of 236 intact-class Basic Science students (experimental n = 120; control n = 116) was drawn from four coeducational public junior secondary schools. Scientific inquiry skills were measured with a 50-item Scientific Inquiry Skills Test covering six constructs. Cronbach's alpha coefficients ranged from .78 to .85 for the constructs and .91 for the composite. After statistical control of pretest scores, students taught through outdoor experiments obtained substantially higher posttest inquiry-skill scores than students taught conventionally, $F(1, 233) = 198.42$, $p < .001$, partial $\eta^2 = .460$, Cohen's $d = 1.79$. Gender differences within the outdoor-experiment group were negligible, $t(118) = 0.62$, $p = .536$, $d = 0.11$, and the method-by-gender interaction was nonsignificant. Gains were largest for planning investigations and interpreting data. The findings support the use of locally available outdoor phenomena as a low-cost pathway for inquiry-skill development in resource-constrained Nigerian science classrooms.

Keywords: *outdoor experiments, scientific inquiry skills, science process skills, experiential learning, junior secondary school, Eha-Amufu, Enugu State*

1. INTRODUCTION

Scientific inquiry skills occupy a central place in contemporary science curricula because they enable learners to pose questions about natural phenomena, design investigations, collect and interpret evidence, and communicate warranted conclusions (National Research Council, 2012; Padilla, 1990). In Nigeria, the Basic Science curriculum for junior secondary school explicitly requires students to observe, measure, classify, hypothesize, experiment, and infer (NERDC, 2012). Despite this policy emphasis, classroom practice in many public schools continues to privilege recitation and chalkboard demonstration over authentic investigation (Ibe & Nwosu, 2017; Obodo & Ani, 2025). The result is a persistent gap between the inquiry ideals of the curriculum and the skills students actually display.

Eha-Amufu, a semi-urban town in Isi-Uzo Local Government Area of Enugu State, offers a distinctive setting. The community is the site of the Federal College of Education, Eha-Amufu, and is surrounded by farmlands, seasonal streams, school compounds with vegetation, and lateritic soils that can serve as readily accessible outdoor laboratories. At the same time, many public junior secondary schools operate with limited laboratory apparatus, irregular electricity, and large class sizes. Outdoor experiments that use the school compound, nearby farms, and local water sources may therefore constitute a realistic alternative for developing inquiry skills.

International evidence has accumulated that outdoor teaching can improve science learning, motivation, and process skills (Ayotte-Beaudet et al., 2025; Ting & Siew, 2014; Wells et al., 2015). Nigerian studies have shown related benefits of outdoor ecology lessons, ethnoscience activities, and inquiry-oriented practical work (Achor & Amadu, 2015; Ibe & Nwosu, 2017; Nwanne & Okoli, 2025). What remains comparatively scarce is a tightly designed quantitative test of a structured outdoor-experiment package against conventional instruction, with construct-level reliability, an a priori sample-size justification, and reported effect sizes, conducted specifically among junior secondary students in Eha-Amufu.

1.1 Problem, purpose and hypotheses

Junior secondary students in Eha-Amufu are expected to leave Basic Science with usable inquiry skills, yet observation is often unsystematic, measurement is approximate, hypotheses are rarely tested, and data interpretation is weak (Ejilibe et al., 2020; Ugwuanyi, 2019). The problem is not merely the absence of glassware. It is the absence of educative experience in which students transform encounters with phenomena into scientific reasoning (Dewey, 1938; Kolb, 1984). H01 stated no significant difference in adjusted posttest inquiry scores between outdoor experiments and conventional

demonstration. H02 stated no significant gender difference within the outdoor group. H03 stated no significant method-by-gender interaction.

2. THEORETICAL FRAMEWORK AND RELATED STUDIES

Dewey (1938) argued that an experience educates when it is continuous with prior experience and when it interacts with the environment in a way that reconstructs the learner's capacity to meet subsequent problems. Outdoor experiments were designed as problematic encounters, for example unexplained variation in soil moisture, differential growth of seedlings under shade and sun, or unexpected turbidity in a stream after rainfall, rather than as nature walks. Kolb (1984) defined learning as the process whereby knowledge is created through the transformation of experience. The cycle moves through concrete experience, reflective observation, abstract conceptualization, and active experimentation. The NRC (2012) framework recast the scientific method as a set of practices. For measurement the study operationalized scientific inquiry skills as six constructs: observing and classifying; measuring and using numbers; formulating questions and hypotheses; planning and conducting investigations; interpreting data and inferring; and communicating findings. The 5E instructional model (Bybee, 2014) supplied the lesson architecture.

Ayotte-Beaudet et al. (2025) scoped 41 studies involving 10,453 learners and concluded that outdoor teaching improves learning most consistently in the sciences. Ting and Siew (2014) found that school-ground lessons produced higher science-process-skill scores among Malaysian Year Five students. Achor and Amadu (2015) reported a significant ecology-achievement advantage for outdoor activities among SS II students in Taraba State, with no significant gender difference. Ibe and Nwosu (2017) showed that ethnoscience practicals drawn from the local environment outperformed traditional laboratory work on process-skill acquisition in Nsukka. Ejilibe et al. (2020), working from the Federal

College of Education, Eha-Amufu, found that game-based teaching raised process-skill scores among JSS 1 Basic Science students. The present study extends that Eha-Amufu-linked programme of work from games to outdoor experiments.

3. METHODOLOGY

The study adopted a pretest, posttest nonequivalent control-group quasi-experimental design. Intact classes were assigned to conditions. Pretest scores served as the covariate in ANCOVA. The population comprised JSS 2 Basic Science students in public coeducational junior secondary schools in Eha-Amufu during the 2025/2026 academic session. A sample of 236 students from four schools was used (experimental n = 120; control n = 116). Sample size was justified with an a priori G*Power analysis for ANCOVA targeting 80% power to detect a medium effect (f = 0.25) at α = .05, then inflated for clustering.

Scientific inquiry skills were measured with a 50-item Scientific Inquiry Skills Test covering six constructs. Cronbach's alpha coefficients ranged from .78 to .85 for the constructs and .91 for the composite. The experimental group received an eight-week Outdoor Experiment Instructional Package using the school compound, nearby farms and local water sources, nested in the 5E model. The control group received conventional classroom demonstration of the same Basic Science topics. Regular teachers implemented the treatments after short task-level training. ANCOVA, independent samples t tests and construct-level contrasts were computed in SPSS.

4. RESULTS

Table 1. Posttest construct means by instructional method

Construct	Exp. M (SD)	Ctrl M (SD)	t	d
Observing and classifying	6.42 (1.18)	5.21 (1.32)	7.46	0.96

Measuring and using numbers	5.28 (1.09)	3.86 (1.21)	9.47	1.23
Questions and hypotheses	5.51 (1.24)	3.74 (1.19)	11.19	1.46
Planning investigations	6.14 (1.37)	3.92 (1.38)	12.38	1.61
Interpreting and inferring	6.73 (1.52)	4.41 (1.48)	11.86	1.54
Communicating findings	4.78 (1.21)	3.04 (1.16)	11.28	1.47

After control of pretest scores, students taught through outdoor experiments obtained substantially higher composite posttest scores than students taught conventionally, $F(1, 233) = 198.42$, $p < .001$, partial $\eta^2 = .460$, Cohen's $d = 1.79$. H01 was rejected. Gains were largest for planning investigations and interpreting data. All construct contrasts survived Holm correction.

Table 2. Posttest composite scores by gender in the experimental group

Gender	n	M (SD)	t	p	d
Boys	58	35.21 (5.88)	0.62	.536	0.11
Girls	62	34.53 (6.21)	,	,	,

H02 was not rejected. In two-way ANCOVA the method main effect remained large, $F(1, 231) = 196.08$, $p < .001$, partial $\eta^2 = .459$. The gender main effect was trivial and the method-by-gender interaction was nonsignificant, $F(1, 231) = 1.14$, $p = .287$, partial $\eta^2 = .005$. H03 was not rejected. The method gap was 11.28 points for boys and 10.54 points for girls.

5. DISCUSSION

The magnitude of the method effect is consistent with the upper range of outdoor-science findings rather than with a modest novelty bump (Ting & Siew, 2014; Achor & Amadu, 2015; Berandoy & Villonez, 2024; Ayotte-Beaudet et al., 2025). Three design features help explain the size of the effect: eight weeks of treatment rather than a single field day, tasks that completed Kolb's full cycle rather

than stopping at concrete experience, and an outcome measure aligned to the practices students rehearsed outdoors.

The larger gaps on planning and interpretation indicate that the package did more than increase time on phenomena. Students had to decide what to measure, how to keep one variable reasonably constant on a sloping compound, and what a messy data table would and would not support. Those decisions are the integrated process skills that Ugwuanyi (2019) found weak among Enugu chemistry students. Ibe and Nwosu (2017) showed that environment-sourced practicals can outperform traditional laboratory work. The near-zero gender effect ($d = 0.11$) replicates Achor and Amadu (2015). In coeducational Eha-Amufu classrooms, outdoor group work mixed boys and girls at every station and no task required physical strength as a gatekeeper.

Limitations include intact-class assignment, a researcher-developed test without confirmatory factor analysis on a larger sample, an immediate posttest without delayed retention, restriction to public coeducational JSS 2 classes in one town, dependence on a dry-season window, and a paper-and-pencil criterion that only approximates field procedural fluency.

Fägerstam and Blom (2013) compared outdoor and indoor ecology lessons among Swedish secondary students and found that outdoor lessons supported more durable conceptual talk and better long-term retention of ecological content. Sellmann and Bogner (2013) evaluated a one-day outreach project at a botanical garden and reported significant cognitive achievement and a shift toward more informed views of the nature of science. Wells et al. (2015) found that a school-garden intervention improved science knowledge among elementary students in the United States. Collectively these studies support the claim that structured outdoor encounters, not mere time outdoors, drive the cognitive effect.

Berandoy and Villonez (2024) examined outdoor learning inquiry-based activities among 180 Grade 5 students in three Philippine divisions. Experimental groups reached outstanding posttest science performance, whereas comparison groups taught traditionally reached only very satisfactory performance. Related work on outdoor problem-based learning in Indonesian elementary science reported a large advantage in critical thinking. Nwanne and Okoli (2025) reported that outdoor learning significantly improved SS II biology students' achievement in ecology across South-East Nigeria. Onyia and Udu (2025) found that guided inquiry improved chemistry achievement and interest among SS II students sampled across the six education zones of Enugu State.

Obodo and Ani (2025) documented that facility quality and classroom environment predict Basic Science performance in Enugu public schools. The present package did not deny that indoor laboratories matter. It asked whether the compound, farm edge, and stream bank can function as a parallel laboratory when glassware is scarce. Fidelity data suggest that they can, provided teachers receive short, task-level training. Embedding outdoor-experiment modules in the Federal College of Education, Eha-Amufu, preservice curriculum would convert the present efficacy finding into a scalable local routine.

Theoretically, the results support a practice-based reading of inquiry. Skills such as planning and interpreting did not transfer automatically from teacher talk. They grew where students repeatedly enacted them on recalcitrant materials. That pattern fits the NRC (2012) emphasis on practices over a single scientific method and fits Driver and colleagues' account of knowledge construction through encounter with phenomena.

6. CONCLUSION AND RECOMMENDATIONS

Outdoor experiments developed scientific inquiry skills among junior secondary students in Eha-Amufu more effectively than conventional demonstration. The advantage was large, consistent across six constructs, and statistically indistinguishable for boys and girls. Inquiry skills are not waiting for imported kits. They can be grown where students already walk, provided lessons complete an experiential cycle and demand that students plan, measure, interpret and explain.

Basic Science schemes of work in Isi-Uzo should schedule at least one outdoor investigation per fortnight. Teacher education at the Federal College of Education, Eha-Amufu, should treat the school compound as a required practicum site. Quality-assurance instruments used by the Enugu State Ministry of Education should count documented outdoor investigations as legitimate practical work. Community assets already mapped in local farmland and water-security projects can double as teaching sites if principals and village heads agree simple access protocols before each term.

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Taken together, the evidence presented in this article is intended to inform classroom practice, teacher education and education-office supervision in Enugu State. The recommended actions are feasible with existing staff, existing compounds or devices, and existing scheme-of-work time, provided that school leaders protect the instructional routine long enough for teachers and students to internalize it.

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