TIMBOU-AFRICA PUBLICATION INTERNATIONAL JOURNAL MAY, 2025 EDITIONS.

INTERNATIONAL JOURNAL OF EDUCATIONAL RESEARCH AND LIBRARY SCIENCE
VOL. 8 NO. 8 E-ISSN 3026-8478 P-ISSN 3027-186X

EFFECT OF ACTIVITY-BASED LEARNING ON BASIC SCIENCE STUDENTS' COGNITIVE SKILLS IN UPPER BASIC LEVEL IN MAKURDI, BENUE STATE, NIGERIA

OCHIGBO ADEBU CHARITY; & OMAJI REGINA

Department of Integrated Science, Federal College of Education Odugbo, Benue State

Corresponding Author: igomucharity2017@gmail.com

DOI: https://doi.org/10.70382/tijerls.v08i8.043

ABSTRACT

The study investigated the effect of Activity-Based Learning (ABL) on the cognitive abilities of Basic Science students at the Upper Basic level in Makurdi, Benue State, Nigeria. A sample of 120 Upper Basic Science II students was purposively selected, consisting of 51 males and 69 females, who were pre-tested and divided into experimental and control groups. The students in the experimental group were

INTRODUCTION

Science learning requires that students develop skills like logical thinking, problem-solving, and critical thinking to address real-world challenges. The foundation for these skills is laid in elementary science. In Nigeria, Basic Science (Years 1–6) and Upper Basic Science (Years 7–9) form the core of science education (Ogunleye, 2021; Federal Republic of Nigeria [FRN], 2020).

Having encountered science at the elementary level, these students should be able to consolidate their scientific process skills before studying it at the Senior Secondary level (ages ten to twelve). The revised Nigeria National Policy on Education (2022) emphasizes that a key objective of Junior Secondary Education is "*to provide the child with diverse*

instructed using the Activity-Based teaching method, and their performance was compared to that of the control group, who were taught the same concepts through traditional lecture methods. Pre-test and post-test results were analyzed to assess the equivalence of the groups and the academic performance of students in both the experimental and control groups. Two hypotheses were evaluated using t-test statistics at a significance level of 0.05, and the key findings were: Students who learned through Activity-Based methods (the Experimental group) performed significantly better than those taught through lectures. Additionally, no significant difference was found in academic performance between male and female students who experienced either the Activity-Based or lecture teaching methods. Based on these findings, several recommendations were proposed, one of which emphasizes that Basic Science teachers should implement Activity-Based instructional strategies in their teaching as it improves achievement among Upper Basic II students.

Keywords: Activity-Based Learning (ABL), Cognitive Skills Development, Basic Science Education, Problem-Solving Abilities, Gender-Inclusive Pedagogy.

basic knowledge and skills for entrepreneurship and educational advancement" (Federal Republic of Nigeria [FRN], 2022, p. 15). Recent studies confirm that this transition phase is critical for developing foundational STEM competencies (Ogunleye, 2021; UNESCO, 2023).

Basic Science serves as the foundation for other science courses at the senior secondary school (SSS) level. Its objective is to prepare students at the Upper Basic Level with essential knowledge, problem-solving skills, creative skills, and critical thinking skills needed to pursue core science subjects like Biology, Chemistry, and Physics at the SSS level (Achor et al., 2021; Ogunleye, 2022). To achieve this goal, teachers must focus on attaining the learning outcomes of their instruction. Learning outcomes represent specific knowledge or skills (including problem-solving, creative thinking, and critical thinking) that students are expected to demonstrate as a result of instruction (OECD, 2021; UNESCO, 2022).

Educational goals focus on instilling content knowledge and skills in today's learners to enhance their creativity and problem-solving abilities, equipping them for 21st-century demands and challenges (OECD, 2020; World Bank, 2021). Contemporary

researchers and national governments recognize that innovative pedagogical methods can significantly enhance intellectual development through diverse cognitive processes (UNESCO, 2022). Consequently, evidence-based pedagogical approaches have emerged, with most emphasizing active student engagement and participation in learning (Freeman et al., 2020). Student engagement represents "a state of emotional, social, and intellectual preparedness for learning, marked by curiosity, active involvement, and intrinsic motivation to acquire knowledge" (Wang et al., 2021, p. 45).

Activity--Based Learning (ABL) is an instructional approach that emphasizes student engagement through hands-on activities, experiments, and collaborative tasks rather than traditional lecture-based methods (Kumar & Sharma, 2020). In the context of basic science education at the upper basic level (Junior Secondary School, JSS), ABL has been recognized as a vital strategy for enhancing students' cognitive skills, including critical thinking, problem-solving, and conceptual understanding (Achor et al., 2019).

Activity-Based Learning (ABL) is an instructional approach where educators facilitate learning through task-oriented activities (Kumar & Sharma, 2022). This method requires learners' full participation, creating meaningful learning experiences through active mental and physical engagement (OECD, 2021). Grounded in constructivist principles, ABL emphasizes hands-on experimentation over passive listening, with "learning by doing" as its central tenet (Freeman et al., 2020). Research demonstrates that this approach leads to deeper knowledge retention and longer-lasting learning outcomes (Schneider & Preckel, 2021).

ABL incorporates multimodal techniques including reading, writing, discussions, practical applications, and problem-solving activities that develop analytical, synthetic, and evaluative skills (UNESCO, 2022). When implemented effectively, ABL transforms students' roles from passive recipients to active participants in the learning process (Wang et al., 2021). This pedagogical approach enhances cognitive development by providing multiple opportunities for application and performance (Achor et al., 2021). Through experiential learning and exploration, ABL creates impactful educational experiences by engaging multiple senses and promoting active knowledge construction (Hattie, 2023).

Contemporary psychologists define skills as the capacity to execute specific tasks, highlighting three essential characteristics: social determination, value creation potential, and trainability through targeted development (OECD, 2021; World Bank,

2022). Skills are broadly classified into cognitive and non-cognitive domains (UNESCO, 2023).

Cognitive skills represent the conscious intellectual processes involved in thinking, reasoning, and remembering. As defined by recent research, these encompass "the capacity to comprehend complex concepts, adapt to environmental demands, learn from experience, employ diverse reasoning strategies, and resolve challenges through cognitive effort" (Dumont & Istance, 2020, p. 47). These fundamental skills drive learning processes and include:

i. Memory: The cognitive system for encoding, storing, and retrieving information across both working memory (limited capacity) and long-term memory (virtually unlimited capacity) (Cowan, 2021).
ii. Reasoning: The capacity for logical thinking, systematic data analysis, and innovative solution generation (Halpern & Dunn, 2021).
iii. Perception: The neurocognitive processes of detecting, organizing, and interpreting sensory information (Goldstein & Brockmole, 2021).
iv. Creativity: The ability to generate novel and valuable ideas, approaches, or products through cognitive flexibility and imagination (Runco & Jaeger, 2022).
v. Problem-Solving: The systematic process of identifying challenges, analyzing root causes, and developing effective solutions (Greiff et al., 2021).

Contemporary research from the World Health Organization (WHO, 2021) underscores the critical role of cognitive skills in fostering mental well-being and adaptive competence in youth populations. WHO's current framework defines cognitive skills as "the neurocognitive capacities that enable individuals to demonstrate resilient, adaptive functioning when navigating complex life challenges" (WHO, 2021, p. 23). Complementing this perspective, UNICEF's (2022) Global Learning Strategy conceptualizes these competencies as "an integrated developmental process encompassing knowledge acquisition, mindset formation, and skill mastery to promote sustainable behavior change."

This evidence-based understanding highlights the necessity of comprehensive educational approaches that synergistically develop conceptual knowledge, growth mindsets, and applied competencies (OECD, 2022). WHO's (2021) updated guidelines identify ten essential cognitive skills for adolescent development:

1. Analytical problem-solving
2. Evidence-based decision making (incorporating strategic goal formulation)
3. Critical evaluation skills

4. Divergent creative thinking (including ethical reasoning)
5. Effective communication competencies
6. Relationship management skills (with emphasis on emotional intelligence)
7. Metacognitive self-awareness
8. Contextual empathy
9. Stress regulation capacities
10. Emotional self-regulation strategies

Pedagogical research demonstrates that students' cognitive potential remains frequently underdeveloped in traditional educational settings (Brookings Institution, 2023). This evidence base suggests targeted interventions are particularly crucial during the Upper Basic educational phase, where cognitive development shows heightened neuroplasticity (UNESCO, 2023). The Activity-Based Learning (ABL) approach, with its empirically validated engagement protocols and interactive methodologies, has demonstrated significant potential for optimizing students' cognitive skill development (Achor et al., 2022; Ogunleye, 2023).

Statement of the Problem

Despite the critical role of basic science in fostering scientific literacy and cognitive development among students at the upper basic education level (Junior Secondary School, JSS), academic performance in this subject remains persistently poor in Makurdi, Benue State, Nigeria (WAEC, 2020; Benue State Ministry of Education, 2021). Recent national assessment data reveal persistent challenges in science education, with many students demonstrating inadequate mastery of core scientific concepts, deficient problem-solving competencies, and subpar performance on standardized evaluations (NERDC, 2022; WAEC, 2023). Contemporary research attributes these learning gaps primarily to the continued prevalence of teacher-centered, didactic instructional approaches that constrain student participation, hinder critical thinking development, and limit opportunities for authentic scientific inquiry (Achor et al., 2022; Ogunleye, 2023; UNESCO, 2023). In response to these documented challenges, the present study investigates the effect of activity-based learning on Basic Science Students' Cognitive skills in Upper Basic Level in Makurdi, Benue state, Nigeria.

Objectives of the Study

This research aims to investigate the effect of Activity-Based Learning (ABL) on Basic Science students' cognitive skills at the Upper Basic level in Makurdi, Benue State, Nigeria. Specifically, the study has the following objectives:

i. To investigate the difference in cognitive skill development between students taught with Activity-Based strategy and those taught with conventional lecture methods.
ii. To find out whether the effect of Activity-Based strategy is appropriate for learning Basic Science concepts among male and female students.

Research Questions

The following questions guided the study:

1. What is the mean difference in the problem-solving abilities of Upper Basic Science students between those taught using Activity-based learning and those taught using traditional lecture-based learning methods?
2. What is the mean interaction effect between students' gender and instructional method (activity-based vs. traditional lecture) on students' intellectual development in Upper Basic Science classes?

Hypotheses

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

1. There is no significant mean difference in the problem-solving abilities of Upper Basic Science students between those taught using Activity-based learning and those taught using traditional lecture-based learning methods
2. There is no significant difference between male and female students mean cognitive skill in Basic Science for students who were exposed to Activity-Based Learning strategy and traditional lecture method

Methodology

The research employs a quasi-experimental design featuring both pre-test and post-test with experimental and control groups. Initially, both groups underwent pre-testing to confirm their equivalence, followed by a 6-week treatment period, after which a post-test was given to the students. The study's sample included 120 upper basic II students from four secondary schools in Makurdi metropolis. Two intact classes of Upper Basic Science II students were involved in the study utilizing a

purposive sampling to select these classes, ensuring they have similar academic performance and class sizes. The instrument used for this study is Basic Science Cognitive Skills Achievement Test which is specifically titled (BSCSAT) developed by the researchers. The topics are derived from the National Curriculum for junior secondary school Basic Science. The topics were selected because they feature in Basic Science curriculum and can be taught using the Activity-Based as well as Lecture teaching strategies. The reliability of the instrument for this research was determined by analyzing the responses from the pilot study with the Cronbach alpha method. As a result, a Cronbach reliability coefficient of 0.87 was achieved. Data collection was conducted with the assistance of four research aides; approval was obtained from the principals of the chosen schools to involve their teachers, educational institutions, and students. The students in the experimental group received instruction through activity-based learning approach, while the control group was taught using the lecture method for duration of six weeks. The assessment tool was administered to the students in the classroom setting as a post-test after the teaching sessions concluded. This approach was necessary as students needed to evaluate their perceived learning challenges only after the instructional period. The researchers and thier assistants gathered the completed answer sheets immediately after the assessment. Analysis was done using mean and standard deviation to answer research questions while t- test and ANOVA statistics were used to analyze data for testing the hypotheses at 0.05alpha level.

Results

This study examined the impact of Activity-Based Learning on Basic Science students' Cognitive skills in Upper Basic Level in Makurdi, Benue state, Nigeria.

Research Question 1

What is the mean difference in the problem-solving abilities of Upper Basic II Science students between those taught using Activity-based strategy and those taught using traditional lecture-based methods?

For the purpose of data analysis, the null hypothesis is restated for testing at $P \leq 0.05$

Ho_1: There is no significant mean difference in the problem-solving abilities of Upper Basic II Science students between those taught using Activity-based strategy and those taught using traditional lecture-based methods

The data obtained from the Basic Science Cognitive Skills Achievement Test (BSCSAT) were analyzed using t-test statistics to find out if there was a significant difference in achievement between the experimental group and the control group. A summary of the analysis is presented in Table 1.

Table 1: t- test Analysis of Mean Scores of Post-test of the Experimental Groups (EG) taught using Activity-Based Method and the Control Group (CG) Taught Using Lecture Method

Group	N	Mean score	S.D	S.E	t-cal	t-crit.	df	P-value
Experimental	60	34.57	2.69	0.30				
Control	60	19.35	2.09	0.23				

Significant at p≤0.05

The data presented in Table 1 indicates that the experimental group has a mean score of 34.57, which surpasses the control group's mean score of 19.35. This outcome addresses research question 1. It is thus empirically confirmed that students who were taught using Activity-Based Teaching Strategy achieved higher mean scores compared to those in the control group. To evaluate the corresponding Ho_1, the following analysis is provided:

According to Table 1, the calculated t-value is 33.45. This value exceeds the critical t-value of 1.96 at $\alpha=0.05$ with 78 degrees of freedom. This suggests a significant difference exists between the mean scores of the experimental and control groups, favouring the experimental group. Consequently, the hypothesis is rejected. This signifies that the experimental group, which learned Basic Science concepts through the Activity-Based teaching strategy, performed significantly better than the control group, which was taught the same concepts using the Lecture teaching strategy. Hence, the null hypothesis, which posits no significant difference, is rejected.

Research Question 2

What is the mean interaction effect between students' gender and instructional method (activity-based vs. traditional lecture) on students' intellectual development in Upper Basic II Science classes?

Ho_2: There is no significant difference between male and female students' mean cognitive skill in Basic Science for students who were exposed to Activity-Based Learning strategy and traditional lecture method

In order to examine this hypothesis, the post-test results from the Basic Science Cognitive Skills Achievement Test (BSCSAT) were categorized by gender and analyzed using t-test statistics to assess whether there is a significant difference in the performance of male students compared to their female peers who were instructed on selected concepts through the Activity-Based learning strategy. The summary of the t-test is presented in Table 2.

Table 2: t- test Analysis of Post-Test Mean Scores of Male and Female Students Exposed to Activity-Based learning Strategy

Gender	N	Mean Score	S.D	S.E	t-cal	t-crit.	df	P-value
Male	51	33.22	2.76	0.46	1.01	1.96	78	0.31
Female	69	33.84	2.60	0.38				

Not significant at $p \leq 0.05$

According to Table 2, the mean scores for males and females are 33.22 and 33.84, respectively, indicating that they are essentially equivalent. This result addresses research question number 3, showing that there is no significant difference in academic performance between male and female students who have been exposed to an activity-based learning strategy. From Table 2, the calculated t-value is 1.01, which is lower than the critical t-value of 1.96 at $\alpha=0.05$ with 78 degrees of freedom. Additionally, the P-value of 0.31 exceeds $P \leq 0.05$. This indicates that there is no significant difference in the mean scores of male students compared to their female peers. Consequently, the academic achievement levels of male students exposed to the Activity-Based learning strategy are aligned with those of female students. Thus, null hypothesis number 2 is upheld, suggesting that the Activity-Based learning strategy is accommodating to both genders.

Discussion of Findings

The objective of this study is to investigate the impact of Activity-Based Learning (ABL) on the cognitive skills of Basic Science students at the Upper Basic level in

Makurdi, Benue State, Nigeria. In order to fulfil this objective, students in the Experimental Group (EG) received instruction in Basic Science concepts through the Activity-Based teaching strategy. Meanwhile, students in the Control Group (CG) were taught the same concepts using the traditional teaching method, which was limited to the conventional "talk and chalk" approach.

Following the instruction, both the Experimental Group (EG) and Control Group (CG) underwent post-testing allowing for a comparison of their achievements based on the variable being studied. It was observed that the students in the experimental group outperformed those in the control group significantly.

Hypothesis 1

The findings supporting the first hypothesis demonstrate that students in the Experimental Group (EG) exposed to Activity-Based Learning (ABL) strategies achieved significantly higher scores ($M=34.57$) compared to the Control Group (CG) taught through traditional methods ($M=19.35$), with this difference being statistically significant ($p<0.05$). These results align with current meta-analytic research showing substantial learning gains from active learning approaches in science education (Freeman et al., 2020; Theobald et al., 2022). Contemporary studies in Nigerian contexts have similarly documented significant performance improvements when using activity-based methods, with effect sizes ranging from 0.5 to 1.2 standard deviations (Achor et al., 2022; Ogunleye, 2023).

This evidence base confirms the robust connection between constructivist pedagogies and enhanced learning outcomes in science education (OECD, 2022). Recent neurological research further explains these findings, showing that hands-on learning activates multiple brain regions associated with deeper cognitive processing and longer-term knowledge retention (Schwartz et al., 2021). As emphasized in current teacher education frameworks (UNESCO, 2023), the ABL approach enables learners to actively construct knowledge through carefully scaffolded experiences with authentic scientific materials and phenomena.

Modern pedagogical research underscores how ABL's multimodal engagement - combining tactile, visual, and verbal learning modalities - effectively reduces the abstraction barrier common in science education (Hattie, 2023). This aligns with current STEM education reforms emphasizing experiential learning as fundamental for developing scientific literacy and inquiry skills (National Research Council, 2022). The present findings contribute to growing empirical evidence that activity-based

approaches not only improve test scores but also foster the cognitive skills necessary for 21st-century scientific thinking (World Bank, 2023).

Hypothesis 2

The analysis of Hypothesis 2 revealed no statistically significant difference in post-test performance between male (M=33.22) and female (M=33.84) students in the activity-based learning condition ($p>0.05$), indicating gender-equitable outcomes from the intervention. These findings align with contemporary research demonstrating that well-designed active learning pedagogies can eliminate traditional gender gaps in science achievement (Theobald et al., 2020; UNESCO, 2022). Recent meta-analytic evidence confirms that when instructional strategies emphasize hands-on engagement and collaborative problem-solving - hallmarks of activity-based approaches - gender differences in STEM learning outcomes typically disappear (Ogunleye, 2023; Wang & Degol, 2020).

This gender parity in outcomes supports current theories of equitable pedagogy which posit that inclusive instructional designs can mitigate systemic biases in science education (OECD, 2021). The results particularly resonate with emerging findings from Sub-Saharan Africa showing that activity-based methods promote more equitable classroom dynamics and learning opportunities (Achor et al., 2022). Contemporary neuroscience research offers one explanation, suggesting that multisensory, experiential learning activates similar cognitive pathways across genders during science tasks (Gur et al., 2021).

The present findings contribute to growing international consensus that pedagogical quality, rather than student gender, remains the primary determinant of science learning success (World Bank, 2022). This evidence base has important implications for Nigeria's educational policy as it works toward SDG 4 targets for inclusive, equitable STEM education (NERDC, 2022).

Conclusion

Based on the results of this study, the following conclusions were reached:

1. The teaching strategies employed by educators in science instruction significantly influence students' performance.
2. Activity-Based strategies enhance the effective comprehension of Basic Science concepts.

3. There is no significant difference in performance between male and female students when Basic Science concepts are taught using either the Activity-Based Strategy or the conventional lecture method; both approaches seem to be equally conducive to both genders.
4. The lecture method of teaching science appears to be less effective than the Activity-Based strategy for imparting Basic Science concepts, as it negatively impacts students' academic performance.

Recommendations

Based on the results and conclusions of this study, the following suggestions are proposed:

1. The teaching of Basic Science should be executed in a manner that enables students to effectively understand and remember the concepts taught. Incorporating the Activity-Based strategy appears to be beneficial in achieving this objective and should therefore be integrated into the Basic Science curriculum at the secondary school level.
2. In-service training programs for Basic Science teachers should be organized in the form of seminars, workshops, and conferences to instruct them on how to implement the Activity-Based strategy for teaching Basic Science concepts.
3. The study revealed that gender does not significantly influence the learning of Basic Science concepts when using both the Activity-Based teaching strategy and the Lecture method. Curriculum developers should take this finding into account during curriculum design.

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