EFFECTS OF GUIDED- INQUIRY AND PROBLEM-SOLVING INSTRUCTIONAL APPROACHES ON BASIC- SCIENCE AND TECHNOLOGY STUDENTS'ACHIEVEMENT AND RETENTION AMONG UNITY COLLEGES IN NORTH CENTRAL NIGERIA

***OLAWUWO, ADEBOOLA FALILAT; **BELLO, RABIU M (PhD); **BABAGANA MOHAMMED. (PhD); & ***ZUBAIRU, ADAMU (PhD)**

*Integrated Science Department, FCT College of Education, Zuba Abuja
**Department of Science Education, School of Science and Technology Education, Federal University of Technology, Minna. ***Department of Animal Biology, School of Life Sciences, Federal University of Technology, Minna.
Corresponding Author: *bolaoawuwo.2016@gmail.com*

Abstract

The study investigated Effects of Guided- Inquiry and Problem-solving instructional Approaches on Basic-Science and Technology Students' Achievement and Retention among Unity Colleges in North Central Nigeria. Factorial 2x2x3 Experimental design was adopted for the study. The population of the study consisting of Sixteen thousand two hundred and forty (16240) Basic science and Technology students 111 (JSS3) from twenty four (24) Unity Colleges in North central, Nigeria. The sample size of 373 (198 male and 175 female) Junior Secondary School Basic Science and Technology Students of class 3 (JSS III) were randomly drawn from three states of North Central (FCT, Niger & Nassarawa) Nigeria. The research instrument used was Basic Science and Technology Students' Achievement Test (BSTSAT). The instrument was validated by Senior Lecturers in Science Education from University of Abuja and Senior Lecturers in Measurement and Evaluation from FCT College of Education, Zuba. Pearson Product Moment Correlation (PPMC) was used to establish reliability coefficient and 0.86 was obtained for the (BSTSAT). Two (2) research questions were raised with their corresponding null hypotheses. The research questions were answered using Mean ($\bar{x}$) and Standard Deviation (SD) while the null hypotheses were tested using Analysis of Co-variance (ANCOVA) and Sidak Post Hoc Multiple Comparison (SPMC). From the findings, it reveals that Guided Inquiry (GI) and Problem Solving Approaches (PSA) had higher significant achievement mean scores than the Traditional Lecture method, it reveals that GI and PSA demonstrated a great enhancement on achievement mean scores of Basic Science and Technology students' with different ability levels compare with their counterparts under Traditional Lecture method. Equally revealed from the study that GI and PSA influences the retention mean scores of Basic Science and Technology students significantly than the students under Traditional Lecture method. Based on the findings of the study, the following recommendations were made: Guided inquiry and Problem solving should be incorporated into the teaching method adopted to Basic science and Technology since it had the capability to enhance the students' academic achievement and retention

Keywords: Ability Levels, Achievement, Basic Science, Guided Inquiry, Problem-Solving, Retention, Traditional Method

Introduction

Nigeria's educational philosophy makes provision for equal opportunities for all citizens of the nation at the basic, secondary and tertiary levels both inside and outside the formal school system, (FRN, 2020) The United Nations Human Rights Declaration recognises the right to every individual to receive education from elementary (primary) to the highest (University or tertiary) level (Omiko,2016). The National Policy on Education in Nigeria (FGN, 2020) acknowledges that the major objective of education as the bedrock of a nation is to ensure proper administration, management and implementation of the education system to provide direction for educational activities. To realize these lofty ideas and the visions for the 6-3-3-4 system of education was introduced in 1988 with the following objectives as stated in the National Policy of Education (FRN, 2020): a). To provide a free and democratic society b.) To create a just and egalitarian society c.) To create a united, strong and self-reliant nation d.) To create a great and dynamic economy and e.) To create a Land of bright and full opportunities for all citizens (FRN, 2020)

This educational system was structured and designed to bring functionality to the system by producing graduates that make use of their heads, hearts and hands-on. The 6-3-3-4 system of education is tailored towards job orientation with its emphasis

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on manual activities, skills acquisition, technical proficiency and respect for the dignity of labour and economic efficiency.

The Federal Government of Nigeria later reintroduced another system of education 9-3-4 system with a nine-year basic education programme which necessitated the restructuring, review and realignment of existing primary science to integrated science to fit into the nine (9) years basic education programme (FGN, 2013). The new curriculum gave birth to Basic Science and Technology Education which covers the type of education given to children at the ages 0 – 15 years, from day care to junior secondary school (NERDC, 2012).

Basic Science and Technology began in Nigeria as Integrated Science, the emphasis is that all science subjects (Biology, Chemistry, Physics & others) were integrated and presented as a unified science subject through inquiry. With time, important societal issues were also in-cooperated into the Basic Science and Technology curriculum to enable learners to be aware of such issues and acquire skills for dealing with them. Nigeria is looking forward to being among the world's scientific and technologically advanced nations. The reason is not far-fetched as the nation wants to develop scientifically and technologically for its development in all spheres of life (Enemarie 2016). This development is expected to be reflected in its education, economy and politics. For any nation, especially Nigeria to achieve scientific and technological advancement. It is imperative to start planning for a quality Basic science and Technology education as a foundation for her citizens. This is because children begin career exploration at a very young age. Hence Basic Science and Technology are taught at the primary school level and junior secondary school levels to lay the foundation for the study of the core science subjects such as Biology, Physics, Chemistry and Geography at the senior secondary level of education However, with the introduction of Basic Science and Technology in our schools, the discipline has been faced with many challenges because there is a public outcry about the poor performance of students in the subject, the challenges ranging from *inadequate use of instructional materials, lack of qualified and experienced science teachers, poor student motivation and the most common being the use of poor instructional approaches (Anaekwe, 2020).* The shortage of scientific equipment are overloaded of Basic Science and Technology curriculum, lack of laboratory facilities, poor cognitive functioning of students, home conditions, peer group behaviour, school conditions to time allocated for Basic Science and Technology in the school time table (Dajal, 2019).

The instructional strategy that a teacher adopts in the classroom has direct effects on the achievement of the students. Because of the visible loop holes in the conventional strategy in Basic Science and Technology classrooms in North Central and the obvious abysmal achievement by students, there is a need for a paradigm shift from the conventional method to non - non-conventional teaching strategies *to make teaching and learning meaningful to the learners (Balarabe, 2016).*

The effective methods of teaching Basic science and Technology are innovative ways of imparting knowledge to learners, such techniques include inquiry which may be Guided or Unguided, Problem-Solving Approach, Cooperative method, Guided Discovery method, Laboratory activity method, Concept Mapping method and many others (Ogbole 2015). The Guided Inquiry approach can be used in science classrooms in carrying out laboratory exercises where the teacher provides fairly structured procedures to enable learners to investigate (Omokaadejo, 2015). They not only create a pleasant classroom atmosphere but also determine the appropriate learning strategies in heterogeneous classes. Therefore, it can be ascertained that the selection of learning strategies significantly affects student learning outcomes (*Oyasola and Adegoke, 2021).* One learning model that can motivate students in learning is the problem-solving approach because it provides an opportunity for students to get more involved in the learning process and stimulates students to think critically and be problem-oriented (*Ikyanyi, et- al. 2023 &Kala and Yusuff, 2023),*

The issue of students' under achievement as a factor of differential learning outcomes has attracted the attention of educational researchers. It is common in the conventional classroom to find students of mixed academic ability lumped together to be given the same treatment as if they have everything in common (Lee, 2021). In a normal Basic Science and Technology class, the entire population of the students have varieties of learning abilities, their abilities are varied. It is well known that every student has a different way of learning and progressing at different speeds, thus, some students may find the learning task easy while others may find it difficult to understand (Wyman and Watson, 2020) Ability levels vary and can be determined in three levels (i) high achievers (ii) middle/average achievers and (iii) low achievers. It is a widespread opinion that high-achieving students are considered students with high ability who perform better than low-ability students. Therefore, there is a need for innovative instructional strategies to provide equal achievement opportunities for high, medium and low-ability students (Kaya, 2015).

Basic Science and Technology concepts need to be presented to the learners in a way or method that touches their sub-consciousness which can trigger quick recalling of the image being taught or learned using such a teaching method as *guided inquiry and problem-solving* learning strategies, all the students with different learning abilities would be able to collaborate in terms of understanding, explaining and retaining concepts they have learned in a Basic Science and Technology class. From all the studies viewed in support of effective methods on students' achievement, not much work has been done on how to improve the academic achievement of lower ability levels to increase the higher ability levels. Based on this, the present study is determined to see how to bridge the gaps between students with different ability levels using Guided Inquiry and Problem-Solving Approaches among Unity Colleges in North Central Nigeria

Statement of the Research Problem

Determining which pedagogical approach is most effective in teaching and learning specifically at the Basic education level amongst science instructors, head teachers and private schools' proprietors has remained unresolved in their teaching method. The continuous dismal performance of students in sciences in both internal and external examinations has remained worrisome (Anaekwe, 2020). Several factors have been attributed to these poor performances, these factors range from poor methods of teaching, inadequate infrastructural facilities, lack of competent teachers and lack of interest on the part of the students to the difficult nature of some Basic Science concepts *(Balarabe, 2016*

The problem however is how Guided Inquiry and Problem-solving Approaches can be used to improve student's academic achievement and retention in Basic Science and Technology. Therefore, the primary research problem is to investigate whether Guided Inquiry and Problem-Solving approaches can significantly improve students' academic achievement and retention of different ability levels in Basic Science and Technology concepts in junior secondary school 3 among unity colleges, North Central Nigeria.

Research Questions

The following research questions guided the study:

1. What are the main effects of Guided Inquiry and Problem-solving approaches on Basic Science and Technology *Mean* ($\bar{x}$) achievement scores of students in Unity Colleges in North - Central, Nigeria?
2. What are the main effects of Guided Inquiry and Problem-Solving Approaches on Basic Science and Technology *Mean* ($\bar{x}$) retention scores among High, Medium and Low students in Unity Colleges in North - Central, Nigeria?

Research Hypotheses

The following null hypotheses were formulated and tested at 0.05 alpha levels of significance

$H0_1$: There is no significant main effect of Guided Inquiry and problem-solving approaches on Basic Science and Technology *Mean* ($\bar{x}$) achievement scores among students in Unity Colleges in North - Central, Nigeria

$H0_6$: There is no significant main effect of Guided Inquiry and problem-solving approaches on Basic Science and Technology *Mean* ($\bar{x}$) retention scores among High, Medium and Low students in Unity Colleges in North - Central, Nigeria

Methodology

Factorial 2x2x3 Experimental design was adopted as research design for the study. The population of the study consisting of Sixteen thousand two hundred and forty (16240) Basic science and Technology students 111 (JSS3) from twenty four (24) Unity Colleges in North central, Nigeria. The sample size of 373 (198 male and 175 female) Junior Secondary School Basic Science and Technology Students of class 3 (JSS III) were randomly drawn from three states of North Central (FCT, Niger & Nassarawa) Nigeria. The research instruments used were Basic Science and Technology Students' Achievement Test (BSTSAT) and Basic Science and Technology Students' Retention Test (BSTSRT). The instruments were validated by Senior Lecturers in Science Education from University of Abuja and Senior Lecturers in Measurement and Evaluation from FCT College of Education, Zuba. Pearson Product Moment Correlation (PPMC) was used to establish reliability coefficient and 0.86 was obtained for the (BSTSAT) and 0.86 for (BSTSAT). Two (2) research

questions were raised with their corresponding null hypotheses. The research questions were answered using Mean ($\bar{x}$) and Standard Deviation (SD) while the null hypotheses were tested using Analysis of Co-variance (ANCOVA) and Sidak Post Hoc Multiple Comparison (SPMC).

Result

Research Question One: What are the main score effects of Guided Inquiry and Problem-Solving Approaches on Basic Science and Technology *Mean* ($\bar{x}$) achievement scores of students in Unity Colleges in North – Central Nigeria?

Table 1 Comparison of the Mean and Standard Deviation of Pretest and Post-test results for Guided Inquiry and Problem-solving and Traditional Lecture Method in Basic Science and Technology students' Achievement,

Group		Pretest		Post-test		Mean Gain
		Mean	SD	Mean	SD	
Guided Inquiry	143	23.43	8.45	61.59	5.37	38.16
Problem-solving	120	18.29	5.77	57.49	7.81	23.62
Traditional Method	110	22.96	8.48	36.09	13.43	13.49

The result in Table 1 indicates the mean and standard deviation of the pretest and post-test of Guided Inquiry, Problem-Solving and Traditional Lecture methods. The pretest mean scores of the three groups were 23.43, 18.29 and 22.96 respectively, while the post-test standards were 61.59, 57.49 and 36.09 with standard deviations of 5.37, 7.81 and 13.49 respectively. From the post-test, the three groups improved their Basic Science and Technology students' achievement. However, students who learned with the Guided Inquiry approach had the highest mean gain of 61.59 and the Problem-Solving approach mean of 57.49, while the Traditional Lecture method had the lowest mean gain of 36.09. Therefore, Guided Inquiry and Problem-Solving Approaches were more effective in enhancing students' achievement in Basic Science and Technology.

Table 3: ANCOVA Result for Guided Inquiry, Problem-Solving, and Traditional Lecture Approaches in Basic Science and Technology Students' Achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	14029.75[a]	3	4676.58	121.68	.00	.50
Intercept	135102.01	1	135102.01	3515.12	.00	.91
Pretest	2774.14	1	2774.140	72.18	.00	.16
Group	7669.29	2	3834.64	99.77	.00	.35
Error	14182.33	369	38.43			
Total	1212320.00	373				
Corrected Total	28212.08	372				

a. R Squared = .50 (Adjusted R Squared = .49)

Results in Table 3 show post-test findings of Guided Inquiry, Problem-Solving and Traditional Lecture Approaches. The value F (2, 369) = 99.77, P= (0.01) < 0.05, indicates a significant difference between the mean of the Guided Inquiry, Problem-Solving and Traditional Approaches group achievement in Basic Science and Technology. Therefore, the hypothesis was rejected. The partial eta square (n^2) (.351) shows that about 35.1% of total variances in the Basic Science and Technology students' achievement scores (dependent variable) is due to the effect of instructional Approaches. To determine the significant difference, Sidak multiple comparisons were conducted and the result is presented in Table 3b.

Table 3b: Sidak Post-hoc Multiple Comparison of Achievement of Basic Science and Technology Students Taught Basic Science and Technology with Guided Inquiry, Problem-solving Approaches and Those Taught with Traditional Lecture Method

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Guided inquiry	Problem-Solving	2.51*	.78	.004	.63	4.39
	Traditional Method	11.40*	.82	.000	9.37	13.30
	Guided Inquiry	-2.51*	.78	.004	-4.40	-.63

Problem-solving	Traditional Method	8.83*	.82	.000	6.87	10.79
Traditional	Guided Inquiry	-11.34*	.82	.000	-13.31	-9.37
Method	Problem-solving	-8.83*	.82	.000	-10.79	-6.87

Sidak's post-hoc analysis in Table 4.9b indicated that the observed significant difference was between the group taught using the Guided Inquiry learning group and the Problem-Solving learning group with a mean difference of 2.51 P-value of .004 which was significant at 0.05 level. There was a significant difference between the Guided Inquiry learning group and those taught with the Traditional Lecture group, the mean difference is 11.34, *P*-value of .00 which is also significant at 0.05 levels. The mean differences are in favour of the guided inquiry learning group. Similarly, there was a significant difference between the Problem-solving learning group and the Traditional Lecture group with a mean difference of 8.83, p=0.00, the mean difference is in favour of the Problem-Solving learning group. Therefore, the Guided Inquiry and Problem-Solving groups did better than the Traditional Lecture group. However, the group that contributed most to making it significant was Guided Inquiry because of its higher mean differences of 11.34 compared with other groups.

Hypothesis Six (HO_6). There is no significant main effects of Guided Inquiry and Problem-solving Approaches on Basic Science and Technology *Mean* ($\bar{x}$) Retention scores among High, Medium and Low students in Unity Colleges. To test this formulated hypothesis, Analysis of Co-variance was used and the findings presented in Table 4

Table 4 ANCOVA Result for Guided Inquiry-Based, Problem-Solving Traditional Lecture Approaches on Basic Science and Technology Students' Retention Score

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	12559.80[a]	3	4186.60	114.43	.000	.48
Intercept	111490.04	1	111490.04	3047.25	.000	.89
Pretest	3516.62	1	3516.62	96.12	.000	.21
Group	6151.83	2	3075.92	84.07	.000	.31
Error	13500.63	369	36.59			
Total	1055980.00	373				
Corrected Total	26060.43	372				

a. R Squared = .48 (Adjusted R Squared = .48)

Table 4 shows the main effects of instructional approaches (Guided Inquiry, Problem-Solving and Traditional Lecture method) on students' retention scores There was a significant difference in the retention score in Basic Science and Technology students between the three groups, F (2, 369) = 84.07, p = (0.00 <0.05). The partial $\eta 2$ = 0.31, indicating that only 31.3% of the total variance is accounted for by the instructional approaches. To determine the direction of the significant difference, Sidak multiple comparisons were conducted and the result is presented in Table 4b

Table 4b Sidak post-hoc Multiple Comparison of the Retention Score of Basic Science and Technology Students Taught Basic and Technology with Guided Inquiry, Problem-solving and Those Taught with Traditional Lecture Method

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig. [b]
Guided Inquiry	Problem-solving	-.16	.77	.99
	Traditional Method	9.05*	.80	.00
Problem-solving	Guided Inquiry	.16	.77	.99
	Traditional Method	9.21*	.80	.00
Traditional Method	Guided Inquiry	-9.05*	.80	.00
	Problem-solving	-9.21*	.80	.00

Sidak's post-hoc analysis in Table 4b indicated that the observed significant difference was between the group taught with Guided Inquiry and Traditional Lecture Approaches with a mean difference of 9.05. Similarly, a significant difference exists between students taught with Problem-Solving and Guided Inquiry and Traditional Lecture Approaches with a mean difference of .16 and 9.21, respectively.

Discussion

The findings on the effect of Guided Inquiry and Problem-solving Instructional Approaches (GI, PSA) on Basic Science and Technology Students achievement and retention among unity colleges in North Central, Nigeria, The discussion is based on the research questions and its corresponding null hypotheses The following discussions were presented based on the findings:

The findings indicate a noteworthy discrepancy in pre-test scores between students instructed in Basic Science and Technology using Guided Inquiry and Problem-solving Approaches and those taught with the Traditional Lecture method. This outcome aligns with Oyasola and Adegoke (2021) discovery, which highlighted significant disparities in student achievement when Guided Inquiry and Problem-solving were utilized. Moreover, the study revealed that when employing Guided Inquiry and Problem-solving approaches in Basic Science and Technology yielded notably superior effects on students' academic achievement compared to the Traditional Lecture teaching method. These findings also concur with Ikyanyi, *et- al.* (2023) and Kala and Yusuff (2023), whose respective studies revealed that there were significant differences in the academic achievement of students exposed to the Guided Inquiry and Problem-solving Approaches to the Traditional Lecture method

The findings on the main effect of Guided inquiry and Problem-solving approaches on Basic science and Technology *Mean* ($\bar{x}$) retention scores among High, Medium and Low students in Unity colleges. The result shows that there are main effects of instructional approaches (Guided inquiry, Problem-solving and Traditional method) on students' retention scores. The analysis of students' scores according to ability level revealed that high-ability students were significantly better in terms of retention of learned materials than the average ability level which in turn retained more of the learned Basic science and Technology concepts than the low-ability students according to Moses, (2018). The treatment favoured the two experimental groups more than the control group in terms of retention of Basic Science and Technology students in Unity College

Conclusion and Implications

The study investigated the effect of Guided Inquiry and Problem-solving Instructional Approaches on Basic Science and Technology Students' achievement and Retention among unity colleges in North Central, Nigeria. The findings of the study revealed

greater enhancements in Basic Science and Technology students' achievement and retention than those taught with the Traditional Lecture method. With Guided Inquiry and Problem-solving Approaches exhibited higher means scores in Basic Science and Technology students' achievement and retention of different ability levels than those taught using the Traditional Lecture method

Based on the findings of the study, the researcher concluded that: Guided Inquiry and Problem-solving Approaches emerge as superior instructional approaches for fostering Basic Science and Technology achievement and retention among junior secondary students compared to the Traditional Lecture method. The significant enhancements observed in achievement and retention underscore the effectiveness of Guided Inquiry and Problem-solving.

Research findings provide compelling evidence supporting the efficacy of Guided Inquiry and Problem-solving in enhancing critical thinking, creativity, Problem-solving, manipulative skills and Basic Science achievement /retention of different ability levels among junior secondary students. By embracing Guided Inquiry and Problem-solving as pedagogical approaches

Recommendation:

Based on the research findings:

Educational institutions should consider integrating Guided Inquiry and Problem-solving Approaches into the curriculum, particularly in Basic Science and Technology at the junior secondary level. By incorporating Guided Inquiry and Problem-solving Approaches principles and activities into lesson plans, educators can effectively promote creative thinking skills and enhance Basic Science and Technology achievement and retention of different ability levels among students

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