

Effects of Inquiry Strategy on Achievement And Retention of Basic Science And Technology Among Students In Karu LGA, Nasarawa State, Nigeria

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Abstract

The study investigated through experimentation the effects of Inquiry Learning Strategy on achievement and retention of Basic Science and Technology among students in Karu LGA of Nasarawa State, Nigeria. The study was guided by six research questions with corresponding hypotheses tested at the 0.05 level of significance. The target population comprised 3,050 JS II students in 41 public co-educational junior secondary schools. A quasi-experimental pre-test, posttest, post posttest control group design was adopted. Gender and Ability Levels served as moderator variables. Pretest was used to identify two intact classes with similar abilities randomly assigned to experimental and control groups. A sample of 152 students participated in the study. Data were collected with researcher-developed 40-item multiple-choice questions based on a table of specification for content validity and further appraised by experts for rational validity. The coefficient of internal consistency for the instrument was 0.82 obtained through Split-half method. Data collected were analyzed using mean and standard deviation for answering research questions and ANCOVA for testing the hypotheses. The study revealed no significant difference in the mean achievement gain scores of the two groups. However, the experimental group returned higher mean gain score than the control group. There was no significant interaction effect of gender and method on the mean achievement scores. Similarly, mean retention scores of students in both groups showed no significant difference. From the findings of the study, it is recommended that teachers of Basic Science and Technology should use inquiry strategy to introduce variation from lecture method, and to eradicate gender-related differences.

Key words: *Inquiry strategy, Achievement gain, Similarity in Ability Levels, Retention Scores*

Abstrait

L'étude a examiné par l'expérimentation les effets de la stratégie d'apprentissage par enquête sur la réussite et la rétention des sciences et technologies de base chez les étudiants de Karu LGA de l'État de Nasarawa, au Nigéria. L'étude a été guidée par six questions de recherche avec des hypothèses correspondantes testées au niveau de signification de 0,05. La population cible comprenait 3 050 élèves de JS II dans 41 collèges publics mixtes. Une conception de groupe témoin quasi-expérimentale pré-test, post-test, post-post-test a été adoptée. Le sexe et les niveaux de capacité ont servi de variables modératrices. Le prétest a été utilisé pour identifier deux classes intactes avec des capacités similaires assignées au hasard aux groupes expérimentaux et témoins. Un échantillon de 152 étudiants a participé à l'étude. Les données ont été collectées avec des questions à choix multiple de 40 items élaborées par les chercheurs, basées sur un tableau de spécifications pour la validité du contenu et évaluées par des experts pour la validité rationnelle. Le coefficient de cohérence interne de l'instrument était de 0,82 obtenu par la méthode Split-half. Les données recueillies ont été analysées à l'aide de la moyenne et de l'écart type pour répondre aux questions de recherche et de l'ANCOVA pour tester les hypothèses. L'étude n'a révélé aucune différence significative dans les scores moyens de gain de rendement des deux groupes. Cependant, le groupe expérimental a renvoyé un score de gain moyen plus élevé que le groupe témoin. Il n'y avait aucun effet d'interaction significatif du sexe et de la méthode sur les scores moyens de rendement. De même, les scores moyens de rétention des élèves des deux groupes n'ont montré aucune différence significative. À partir des résultats de l'étude, il est recommandé que les enseignants de sciences fondamentales et de technologie utilisent une stratégie d'enquête pour introduire une variation par rapport à la méthode des cours magistraux et pour éliminer les différences liées au sexe.

Mots clés: *Stratégie d'enquête, gain de réussite, similitude des niveaux de capacité, scores de rétention*

Introduction

Educationists in contemporary times advocate the use of active learning strategies to facilitate students' understanding and retention of basic ideas. Inquiry method is one of such strategies. Incidentally, most teachers of Basic Science and Technology in Karu area of Nasarawa State predominantly adopt the conventional lecture method of lesson delivery. Thus, students' participation is passive and mainly limited to listening, answering/asking questions and writing notes as lesson progresses (Anikweze, 2016). Ogbu, Musa, Kurumeh and Tyoor (2018) observed that conventional lecture method of teaching is one directional and tends to limit students' freedom to apply, analyze and synthesize the knowledge they have acquired.

Inquiry is an innovative teaching-learning strategy and considered as one of the applications of constructivism theory. The teacher as posited by Coffman and Riggs (2006) engages the students actively in high level questioning and thinking skills e.g. analyzing, evaluating and summarizing. Students are encouraged to 'do' rather than 'listen'. The teacher makes students rub minds together towards finding solution to the problem by constructing probing questions. This helps students reflect and build from previous knowledge and towards the understanding of the new concepts. The process involves students finding out basic concepts via active investigation and use of guiding questions (Jin & Bierma, 2011). Thus, inquiry strategy encourages meaningful learning which involves teacher-learner and learner-learner interaction and students' capacities to develop skills themselves.

The inquiry teaching strategy being advocated in the present study is a problem-based teaching-learning which could be applied in teaching science and technology concepts. Learners are positioned in inquiry learning contexts and required to discover the fundamentals and popular principles of the subject-matter by modeling or following the investigatory processes of professional researchers (Kirschner, Sweller & Clark, 2006). Minimal guidance is available for learners to choose in form of process or task-relevant information.

Two main assumptions are observed by the authors as a guide for the use of inquiry teaching strategy involving minimal guidance. First, students are challenged to solve genuine problems or get complex knowledge in information-laden settings supported by the assumption that students will construct or find their own solutions, leading to effective learning experience. The second assumption is that inquiry-based teaching seems to assume that knowledge can be acquired most conveniently through experience based on the procedural steps of the subject – matter or the discipline being studied. Supporters of the inquiry teaching strategy are of the view that proper direct guidance will interfere with the natural processes by which learners draw on their unique prior knowledge or experience and learning methodologies to construct newly situated knowledge aimed at achieving their set goals (Kirschner, Sweller & Clark, 2006).

Achievement is the degree of academic performance of students, that is, the measurable change in behaviour determined by the difference between the mean pretest scores and mean post test scores. It is the past-oriented way of trying to measure the degree of attainment of success of an individual in an area or activity after adequate training has been carried out (Mangal, 2014).

Retention has to do with how properly one can store and retain the learned things or materials in one's memory storage and may provide a base for the measurement of the ability and capacity of one's memory. It can be measured by testing an individual's performance through reproduction or retrieval, i.e. in terms of recognition and recall. Retention in this study is measured based on the comparison of the mean of posttest score and the mean of post posttest score. In effect, retention indicates the extent to which the method of teaching has prevented forgetting by facilitating remembering (Anikweze, 2018).

Basic Science and Technology curriculum encourages guided inquiry and activity-centred teaching and learning with the use of materials that are locally sourced. In addition, the contents of the curriculum are fortified with real-life examples which are indigenous in nature and familiar to learners.

These environmentally friendly examples engender the advancement of relevant qualities and survival strategies for successful living in contemporary and global world (Igbokwe, 2015). Basic Science and Technology Curriculum revised in 2012 offers contents and greater learning experiences which will engender the inculcation of functional, practical and relevant skills for job creation and wealth generation with the aim of reducing poverty within the communities and the nation at large.

Statement of the Problem

The persistent poor performance of students in Basic Science and Technology (BST) subject at the Basic Education Certificate Examinations (BECE) organized and conducted by the Educational Resource Services (ERS) of the Nasarawa State Ministry of Education as well as that of the National Examinations Council (NECO) at national level lives much to be desired. Results of students in BST as posted by the two examining bodies in recent years have shown high percentage of failure. This situation has become a source of concern to stakeholders in the education industry who wonder about what has gone wrong. The trend leaves stakeholders in doubt about the effectiveness of instructional materials and instructional delivery approaches used by teachers for the teaching and learning of Basic Science and Technology. Children generally need teachers with varied innovative teaching strategies to be able to harness the creative potentials with which they are naturally endowed. The thrust of this study therefore, was to find out the effects of inquiry strategy on achievement and retention of Basic Science and Technology among students of Nasarawa State, Nigeria.

Purpose of the Study

The main purpose of the study was to investigate the effects of inquiry strategy on achievement and retention of Basic Science and Technology among students. Specifically, the study set out to:

Find out the posttest achievement scores of students taught Basic Science and Technology using inquiry teaching strategy relative to their counterparts taught using conventional lecture method;

Compare the retention scores of students taught Basic Science and

Technology using inquiry teaching strategy with conventional lecture method;

Determine the interaction effect of gender and inquiry teaching strategy or lecture method on achievement of students taught Basic Science and Technology and

Determine the interaction effect of gender and the experimental and control teaching strategies on retention of students taught Basic Science and Technology.

Research Questions

The following research questions were posed to guide the investigation:

What is the mean posttest score of students taught Basic Science and Technology using inquiry strategy relative to that of their counterparts taught using the conventional lecture method?

What is the mean post posttest (retention) score of students taught Basic Science and Technology using inquiry strategy and relative to their counterparts taught using the conventional lecture method?

What is the interaction effect of gender with inquiry strategy and lecture method on the achievement gain of students in both experimental and control groups?

What is the interaction effect of gender with inquiry strategy and lecture method on retention of students taught Basic Science and Technology differentially in both experimental and control groups?

Statement of Hypotheses

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

Ho1: There is no significant difference between the mean posttest score of students taught Basic Science and Technology using inquiry teaching strategy and that of their counterparts taught with conventional teaching method.

Ho2: There is no significant difference between the mean post posttest (retention) score of students taught Basic Science and Technology using

inquiry teaching strategy and that of their counterparts taught with conventional teaching method.

Ho3: There is no significant interaction effect of gender and the teaching methods on the mean posttest scores of students in experimental and control groups.

Ho4: There is no interaction effect of gender and the teaching methods on the mean retention (post posttest) scores of students in experimental and control groups.

Research Methodology

The research design is quasi-experimental pre-test, posttest, post-posttest control group. The population consisted of 3,050 JS II students comprising 1,701 males and 1,349 females in 41 public co-educational junior secondary schools in Karu LGA of Nasarawa State during the 2017/2018 academic session. A random sample of 10 schools was selected from the 41 public junior schools in which 10 intact streams of JS II were selected and subjected to pre-test. Ultimately, two intact classes with similar abilities based on their mean and standard deviations in the pretest were picked for the study and randomly assigned to experimental and control groups. A sample size of 152 students participated in the investigation.

The instrument used for data collection was a 40-item researcher-developed multiple-choice achievement test on Basic Science and Technology (BST). Items were selected from standard Basic Science and Technology questions of Basic Education Certificate Examinations (BECE) and adapted with minor modifications. The instrument was based on a modified table of specification according to Bloom's Taxonomy of Educational Objectives for content validity. The modification was in line with Yoloye's (1984).modification of Bloom's Taxonomy of Education into three levels of cognitive domain for Junior Secondary Students. These are: knowledge, comprehension and application. Further validation by three experts in Science Education and Educational Measurement and Evaluation at the Nasarawa State University provided logical validity. The coefficient of internal consistency of the instrument was obtained through pretesting and

Split-half method of determining reliability which yielded an index of 0.82. The same instrument used for pre-test was used for posttest and post-posttest. However, in posttest and post posttest, the items were reshuffled to form parallel tests in order to guard against the effects of test sensitization, memory and practice effect as well as intervening variables in test-retest strategy (Anikweze, 2013). Three lesson plans based on topics from the JS II syllabus were developed for each of the teaching strategies as tools to enhance the investigation. Data collected were analyzed using mean and standard deviation for answering the research questions and ANCOVA statistics testing the hypotheses.

Results

Research Question 1: What is the mean posttest score of students taught Basic Science and Technology using inquiry strategy relative to that of their counterparts taught using the conventional lecture method?

This question was answered by considering the contents of Table 1.

Table 1: Mean achievement scores of Students taught BST using Inquiry Strategy

Groups	Pretest Mean ($\bar{x}$)	Pretest SD.	Posttest Mean ($\bar{x}$)	Posttest SD	N	Mean Gain
Inquiry teaching	15.00	2.817	25.28	2.786	64	9.83
Control	14.00	4.239	23.11	3.894	88	9.54
Difference	+1.00	-1.422	+2.17	-1.108	24	+0.97

Table 1 shows the mean posttest scores of the two groups. Evidently, the Inquiry group had a higher posttest mean (25.28) with lower SD (2.79) than the Control group with mean of 23.11 and SD of 3.89. The difference between mean gain score of the experimental group and the Control group was minimal (+.97)

H₀₁: There is no significant difference in the mean achievement scores of students taught energy concepts using inquiry strategy and conventional lecture method.

This hypothesis was tested as shown in Table 2 below based on post-hoc test following ANCOVA statistical analysis. The post-hoc test result shows that there is no significant mean difference between the achievement of the Inquiry group and the Control ($p = .012$; $p < .05$). The researchers therefore have a strong reason for rejecting the null hypothesis.

Table 2: Comparison of Experimental and Control Groups on Students' Posttest Scores

Treatment	Mean Difference (I-J)	Std. Error	Sig.*	95% Conf. Interval for Difference	
				Lower Limit	Upper Limit
Inquiry teaching	2.790*	.556	.000	1.693	3.887
Control	4.084*	.515	.000	3.069	5.099

b. Adjustment for Multiple Comparisons: Least Significant Difference (equivalent to no adjustments).

Based on estimated marginal means; *The mean difference is significant at the .05 level.

Research Question 2: What is the mean post posttest (retention) score of students taught Basic Science and Technology using inquiry strategy and relative to their counterparts taught using the conventional lecture method?

Table 3: Mean Retention Score of Students Taught BST Using Treatment

Group	Posttest Mean ($\bar{x}$)	Posttest SD	Post Posttest Mean ($\bar{x}$)	Post Posttest S D	N	Mean Loss
Inquiry teaching	25.28	2.786	23.36	2.465	64	1.92
Control	23.11	3.894	20.35	3.404	88	2.76
Difference	2.17	-1.108	3.01	-1.061		

The post posttest is expected to capture the amount of loss due to memory decay after a period of time following the learning. Table 3 reveals that while the post posttest mean score of the Inquiry group was 23.36, that of the Control group was 20.35. Thus, there was a difference in retention capacity between the two learning strategies. The results show that with mean loss of 2.76 for the control group, retention is poorer when students are taught using lecture method than when an active method such Inquiry strategy is used which had a mean loss of only 1.92.

Ho2: Ho2: There is no significant difference between the mean post posttest (retention) score of students taught Basic Science and Technology using inquiry teaching strategy and that of their counterparts taught with conventional teaching method.

The comparison is shown in Table 4.

Table 4: Comparisons of Groups on Students Retention of Basic Science & Technology

Dependent (J) Treatment	Variable: Retention Score			
	Mean	Std.	Sig.*	95% Confidence Interval for Difference
	Difference	Error		Lower Limit Upper Limit
Experimental (Inquiry)	2.877*	.521	.000	1.850 3.903
Control (Lecture)	5.098*	.482	.000	4.147 6.048

Centred on estimated marginal means; *The mean difference is significant at the .05 level.

The post-hoc test presented in Table 4 shows where the mean differences between the experimental group and control lie after the retention test. The result shows that there is a significant mean difference between control and inquiry teaching strategy ($p = .000$; $p < .05$). The finding shows that there is a significant mean difference between posttest and retention (post posttest) scores in Basic Science and Technology.

Research Question 3: What is the interaction effect of gender with inquiry strategy and lecture method on the achievement gain of students in both experimental and control groups?

Table 5: Interaction Effect of Gender on Achievement of Students taught BST after Treatment has been administered

Gender	N	Groups	Pretest Mean ($\bar{x}$)	Pretest SD	Posttest Mean ($\bar{x}$)	Posttest S D	Mean Gain
Male	35	Inquiry teaching	15.31	2.878	25.83	2.802	10.52
Female	44		14.39	4.706	24.20	3.974	9.81
Difference			0.92	-1.827	1.63	1.172	1.11
Male	29	Control	15.62	2.783	24.62	2.665	9.27
Female	44		12.75	3.584	22.02	3.527	9.27
Difference			2.87	-0.801	2.6	0.862	0.27
Interaction	64	Inquiry teaching	15.45	2.817	25.28	2.786	9.83
	88	Control	13.57	4.239	23.11	3.894	9.54
Difference			1.88	-1.422	2.17	1.108	0.29

Table 5 shows the mean scores, the standard deviations and the mean gain scores of experimental and control groups by gender. For the varied teaching techniques, the male had higher mean gain score than their female counterparts. For example, male students taught using inquiry teaching strategy had higher mean gain score of 10.52 as against their female counterparts who had mean gain score of 9.8. The gain score is obtained by subtracting the pretest mean from the posttest mean score. In the Control group, both males and females scored the mean gain of 9.27.

Ho3: There is no significant interaction effect of gender and the teaching methods on the mean posttest scores of students in experimental and control groups.

Table 6: Comparisons of Gender Groups on Students Achievement in Basic Science & Tech

Gender	Mean Difference (I - J)	Std. Error	Sig.*	95% Confidence Interval for Difference ^b	
				Lower Bound	Upper Bound
Female	1.223*	.466	.009	.305	2.141
Male	-1.223*	.466	.009	-2.141	.305

Centred on estimated marginal means; b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

*. The mean difference is significant at the .05 level.

Table 6 shows the post-hoc test between gender and groups, where the difference between the groups lie after the posttest in Basic Science and Technology. The result reveals that there was a significant interaction effect of gender on mean achievement of students ($p = .009$; $p < .05$).

Research Question 4: What is the interaction effect of gender with inquiry strategy and lecture method on retention of students taught Basic Science and Technology differentially in both experimental and control groups?

Table 7: Interaction Effect of Gender on Retention of Students taught BST after Administering Treatments

Groups		Posttest Mean ($\bar{X}$)	Posttest SD	Post Posttest Mean ($\bar{X}$)	Post Posttest S D	N	Mean Lower diff.
Gender							
Male	Inquiry teaching	25.83	2.802	23.86	2.625	35	1.97
Female		24.20	3.974	21.11	3.578	44	3.09
Total Mean		25.67	3.749	23.26	3.852	79	
Male	Control	24.62	2.665	22.76	2.149	29	1.86
Female		22.02	3.527	19.59	3.075	44	2.43
Total Mean		24.18	3.873	22.14	3.846	73	
Male	Interaction	25.28	2.786	23.36	2.465	64	1.92
Female		23.11	3.894	20.35	3.404	88	2.76
Total Mean		24.96	3.872	22.72	3.880	152	

Table 7 shows the posttest and post posttest (retention) mean scores, standard deviations and mean loss difference by gender and groups. The evidence from the study shows that the mean interaction effect of inquiry strategy and female gender had a higher mean loss difference of 3.09. Mean interaction of male students and inquiry teaching strategy had mean loss difference of 1.97. The interaction effect of gender and the control method of teaching show that female students had a higher mean loss of 2.43 as against their male counterparts with a lower mean loss of 1.86.

Ho4: There is no interaction effect of gender and the teaching methods on the mean retention (post posttest) scores of students in the experimental and control groups.

Table 8: ANCOVA Test on Effects of Gender and Teaching Methods on Mean Retention Scores of Students

Source	Type III Sum Squares	of Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	673.985 ^a	3	224.662	18.738	.000	.215
Intercept	3317.430	1	3317.430	276.687	.000	.574
Gender	60.391	1	60.391	5.037	.026	.024
Posttest Scores	603.885	1	603.885	50.366	.000	.197
Gender * Posttest Scores	40.899	1	40.899	3.411	.066	.016
Error	2457.919	205	11.990			
Total	111041.000	209				
Corrected Total	3131.904	208				

a. R Squared = .215 (Adjusted R Squared = .204)

Table 8 shows that there was no significant interaction effect of gender and treatments on the retention score of students $\{F(1, 205) = 3.41, P > 0.05, \text{Partial } \eta^2 = .016, R^2 = .00025\}$. The implication of this is that since p-value

(.000) of the F-ratio was not significant, it follows that the null hypothesis on the interaction effect of gender and retention scores was not restored. Therefore, the R Squared shows that the independent variables accounted for only .02% of the variation in the interaction effect of gender on retention of students' in BST. The estimated partial Eta squared indicates that gender and mean retention score accounted for 1.6% of the variance observed in the post posttest.

Discussion of Results

Results of the analyses in Tables 1, 2, 3, and 4 revealed slightly higher mean achievement gains and better retention capacity for the experimental group taught using Inquiry Teaching Strategy than the Control Group engaged with the conventional teaching method. However, hypothesis testing did not prove that there is a significant mean difference between the Inquiry Strategy and Conventional lecture method. The findings seem to lend credence to the argument that Inquiry Strategy as an instructional guidance might not be suitable for new-comer learners. Educationists who oppose the Inquiry Strategy suggest that new-comer learners need to be provided with direct and maximum instructional guide on the subject-matter or concepts of the lesson, and that learners should not be left to discover the procedures or concepts themselves (Kirschner, Sweller&Clark, 2006). Guided inquiry might be preferable to Inquiry because it provides detailed information or guidelines which explain the concepts and procedure required of a student to learn.

In terms of interactive effect of gender with the methods of teaching, the study revealed that there was no significant difference in the mean posttest scores of male and female students in Basic Science after treatment. However, there was evidence that students exposed to Inquiry Strategy slightly outscored their counterparts in the Control Group. The study is in agreement with that of Eziyi, Mumuni and Nwanekezi (2016) which proved Guided Inquiry Instructional Strategy to be more effective in teaching and understanding of concepts of photosynthesis than the conventional lecture method. Furthermore, results of this study were supported by Ugwu (2014)

who found out that Guided Inquiry Instructional method was superior to conventional instructional method in facilitating students' achievement and interest in Basic Science.

Evidence from this study suggests an improvement to Jerome Brunner's theory of 1961 on instructional learning which argues that learning is an active process where the learner constructs knowledge based on current and past experience.

Conclusion

Based on the findings of this study, the following conclusions are made:

Achievement of students taught Basic Science and Technology using Inquiry teaching strategy is moderately higher than that of their counterparts taught with the conventional lecture method. However, no statistically significant difference was found in the performance of students differentially taught using the two approaches.

Retention was significantly higher for students taught using the Inquiry Strategy compared to those taught using the conventional lecture method.

No significant difference was found in the interaction of gender with the teaching methods on the achievement and retention of the learners. Nevertheless, the male students' mean gain score was higher for Inquiry strategy than for conventional lecture method. Although, the female students had better retention when taught with Inquiry strategy than their male counterparts, the female participants in the study generally recorded the greatest mean loss in terms of retention.

Recommendations

Based on the findings from this study, the following recommendations are proffered:

Since Inquiry Strategy belongs to the category of 'active learning' methods, teachers should adopt Inquiry Strategy in their methodological approaches to the teaching of Basic Science and Technology as a way of introducing variation rather than the monotony of conventional lecture method.

Teachers should not regard gender as a significant factor in students'

achievement and retention of concepts, but should rather create an effective teaching-learning environment that will help harness the potentials inherent in male and female students alike. The teacher must learn to vary his/her techniques, strategies and methods of teaching to eradicate gender-related differences in performance and ensure gender equity in performance.

Empirical evidence from this study suggests that Inquiry Strategy has not been as effective as Guided Inquiry previously researched into by Eziyi, Mumuni and Nwanekezi (2016) and Ugwu (2014). There is therefore an evidence to advocate Guided Inquiry in preference to the Inquiry Strategy since the latter provides learners with guidelines to assist in solving problems and discovering constructs.

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