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EFFECT OF INQUIRY-BASED LEARNING APPROACH ON SENIOR SECONDARY SCHOOL STUDENTS' RETENTION IN BIOLOGY

Dr. Regina, I. Enebechi
Department Of Science Education, Nnamdi Azikiwe University, Awka

Abstract: The study investigated the effect of Inquiry-based Learning Approach on Senior Secondary School Students' retention in biology. Influence of gender on mean retention scores of students when taught biology with inquiry-based learning (IBL) approach was also investigated in the study. The interaction effect of gender and strategy was also investigated. Two research questions were posed and three null hypotheses were formulated to guide the study. Quasi-experimental design of pre-test post-test non-equivalent control group was used for the study. The population of the study comprised 2624 SS II biology students. A sample size of 139 SS II biology students' was used for the study. Two instruments were used for data collection in this study namely: Biology Achievement Test (BAT) and Biology Retention Test (BRT). The same test (BAT) was used as pretest, posttest, and retention test (RT). At each stage after the pre-test, the items were reshuffled. The research questions were answered using mean and standard deviation, while Analysis of covariance (ANCOVA) was used to test the hypothesis at 0.05 level of significant. The results of the study revealed that IBL approach is more effective than the conventional approach in enhancing students' retention in Biology. Secondly, IBL approach enhances gender parity as it concerned students' retention in Biology. Based on these findings, the educational implications were identified and highlighted. It was recommended among others that Biology teachers should adopt the use of inquiry-based learning approach in their lessons in order to enhance students' retention ability in biology.

Keywords: Inquiry-Based Learning, Retention In Biology, Senior Secondary School Students

1.1 Introduction

According to constructivism, people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences. When we encounter something new, we have to reconcile it with our previous ideas and experience, may be changing what we believe or may be discarding the new information as irrelevant (Hewson, 2012). In any case, we are active creators of our own knowledge. Knowledge cannot be transmitted from one person to another. Instead knowledge construction occurs through active thinking of the learner (Cakir, 2008).

Inquiry-Based Learning is a constructivist approach to learning. It enables the learner to construct concepts from experience and from verbal interaction. Through inquiry learning, students' have the opportunity of getting first-hand experience in doing science and, to develop inquiry skills (Millar, 2009).The nature of science as "inquiry" has implications for the teaching and learning. Akpan (2015) in Nowsu (2015), presented science inquiry as

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"Engaging students in the intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigations, revising views, researching conjectures, searching for information, constructing models, debating with peers, communicating to diverse audiences, and forming coherent arguments" This definition of 'inquiry' shows the role of science inquiry for a dynamic world, and so its attributes have to be reflected in biology Education instruction for it to be effective. This should enhance the acquisition of the 21st century skills, such as critical thinking, creativity collaborative skills.

Biology is one of the science subject offered in the Nigerian secondary schools. It is a branch of natural science that deals with the scientific study of living things. It is concerned with the study of man and his environments, with the knowledge of biology, students are in the position to understand the structure and functions of different parts of the body, the environment in which they live and how best to conduct themselves there in. Comparative Education Study and Adaptation Centre, CESAC (2004) maintained that biology provides an avenue for teaching students the ability to apply learned science concepts and principles in science related problems. Biology is an important science subject and stands as the bedrock to the learning of other science courses like medicine, pharmacy, nursing, biochemistry, genetics and agriculture that are of great economic importance to the nation. Besides the importance of biology as the science of life, it is one of the science subjects that are mostly preferred by many students in secondary schools. For this reason, biology has a very high enrolment of students in the external examination (West African Examination Council, 2012).

Teaching biology in Nigerian secondary school is very vital. More so is the teacher effectiveness in determining whether the students learn in the biology classroom (Onyegegbu 2018) Teaching involves more than transmitting facts and information that form the basis for further learning. Learning also involves more than the ability to recall information. It is more important than ever that biology teachers help students know how to learn. The new era in education, is concerned with developing higher order thinking skills. Skills that prepare students for the 21stcentury careers involve more than memorization. Critical thinking, inquiry method, collaboration and problem solving are key. The way to help biology students in Nigerian secondary schools to gain these skills is by creating the lesson and laying more emphases on the process of incorporating active learning opportunities for students in the classroom.

Research studies in Nigeria, have long shown that too many biology classroom teachings in the secondary schools reinforce learning as a spectator sport and are characterized by low-level lecture methods and assignments, rather than diverse instructional strategies that actively engage students in deeper learning. According to Onyegegbu (2008), engaging and exciting students in biology is the key to learning. When students participate and get involved, they are excited and are fully interested to pursue knowledge, prepare for life after secondary school and career ready. Instructional strategies are becoming increasingly diverse as teachers should learn to tap into students' interest, retention and ability to help them absorb their biology achievement and improve their chances in higher institutions and career pursuit. In world of fast technology development, it becomes necessary that secondary school biology teachers in Nigeria engage their students in displaying creativity, problem solving and skills to learn the biology content essential to succeed in life. One major way of achieving all these and to having a lively biology classroom is to incorporate Active Learning opportunities for the students through inquiry-based learning approach.

Inquiry-based learning approach on the other hand is a teaching method that allows students learn and experience biology first hand, by doing. The students use the inquiry process to develop explanations from their observations

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by integrating what they have learnt. They learn discrete biology concepts and skills and how to solve problems using practical approaches. According to Galileo Educational Network Association (2005), inquiry is a fluid process and one step may lead back to a previous step. Inquiry-based learning is often described as a cycle or a spiral, which implies formulation of a question, investigation, creation of a solution or an appropriate response, discussion and reflection in connection with results. (Bishop, Bextram& Lunsford, 2004).IBL is a student-centered and student-lead process. The purpose is to engage the students in active learning, ideally based on their own questions.

The cycle of inquiry has 5 global steps namely: Ask, investigate, create, discuss and reflect. The inquiry cycle begins with learners asking meaningful questions which are inspired by genuine curiosity about the subject matter. For example in studying the respiratory system of humans, the students may come out with questions like; how does air move through the lungs and how does carbon dioxide go out of the lungs, how does oxygen move from the lungs into the bloodstream, what do you think happens to the gases that the body cannot use?, which organ do you think is made up of air-carrying tubes and tiny sacs? Next, they investigate and gather information by researching, studying, observing or interviewing an expert in the field, either their teacher or even a resource person. In the create part of the cycle, students begin to make connections and shape their thoughts and ideas out of their prior experience as the topic becomes clearer. Next, students enter into discussion by sharing new ideas with others by mixing up. With this, they gather more information and deeper understanding of the topic.

The present study uses an inquiry-based teaching approach involving open inquiry approach. In open inquiry, teachers furnish the materials for students to investigate, but students must come up with the questions and methods for investigation, to ensure the success of this strategy. Colburn (2000) suggests that teachers can provide carefully planned inquiry-based assessments, create well established classroom rules for interaction and the handling of materials, offer guidance to students who exhibit frustration and prepare guided questions following the activity that tie into standards. This approach provides a great opportunity for students to develop inquiry skills and articulate scientific reasoning through an inquiry-based teaching (National Research Council, 2000). The use of inquiry-based learning approach allow students time to use their imagination, and originality, so as to develop divergent, convergent, associative and analytical thinking skills and attitudes needed to solve real life problems. They can only do this, if they are able to retain what they have been taught in school. Therefore, this study is also interested in finding out the effect of Inquiry based learning approach on students retention of difficult concepts in biology.

Retention is an individual's ability to remember and recall information, materials and experiences learned over time. This acquired materials in the mind need to be preserved in form of images for knowledge to develop. When a stimulating situation occurs, retained images are revived or reproduced to make memorization possible (Morris, 2004). Biology concepts therefore, need to be presented to the learners in a way or method that touches their sub consciousness, which can trigger quick recalling of the concepts being taught or learnt. Okeke (2004) stated that teachers could improve retention of concepts and information by explicitly creating memorable events involving visual or auditory images with projects, plays, simulations and other forms of active learning, to boost student's retention of the concept. Okeke (2004) further stated that whatever students have retained for about 12 to 24weeks after instruction, they might retain forever. In addition, the more time that passes after learning, the less information will be remembered. This form of forgetting is often referred to as "time decay" (Woolfok, 1998). For instance, neural connections, like muscles grow weak

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without use. Okoye (2012) refers to retention as the process of maintain the availability of new meanings or some part of them. It may be suggested that the amount of the original meaning that will be retained at any given point in time is a variable quantity. Forgetting represents a decrement in the availability of an acquired meaning that describes the loss in availability that occurs between the original establishment of the meaning and its later reproduction Okoyefi (2015). Considering the two terms, retention is seen as a positive aspect of memory while forgetting is seen as the negative aspect. Frequent reviews and tests, elaborated feedback and active involvement of students in learning projects have been associated with longer retention. Okoye (2012) further stated that active participation during instruction increases learning and retention. This study aims to find out if Inquiry-Based Learning could enhance biology student retention of knowledge in some difficult concepts in biology.

The study equally investigated the influence of gender on mean retention scores of students when taught biology with inquiry-based learning approach. Note however, that gender is studied as a moderator variable aimed at establishing its influence on the effect of inquiry-based learning (IBL) on the dependent variable (retention).An issue of contention in Nigeria today is the issue of gender in the society including the educational system. Gender is a set of characteristics distinguishing between males and females, particularly in the case of man and woman which depending on the context, may vary from sex to social role to gender identity (Bland, 2003). According to Enebechi and Nzewi (2019), gender roles are roles which society assigns to a man or woman in accordance with theculture and tradition of that society. It is not like sex, which is biologically determined and universal too. The issue of closing gender gap in sciences has remained elusive. In recent times, gender related issues in science education have continued to receive serious attention judging from the number of studies done to that effect Babajide (2010) opined that educational practitioners give science subjects, including physics and chemistry, masculine outlook. In addition to this, studies by Ogunleye (2002), Ezirim(2006), Okwo and Otuba (2007), show that achievement in science subjects depends on gender. However, Nwosu (2001) found out that students' acquisition of science process skills is not gender specific. In addition, studies by Ogunleye and Babajide (2011), Agomuoh, and Nzewi (2003) lend credence to significant gender differences in science achievement. Madu(2004) and Agomuoh (2010) found out that gender influences students' conceptual shift in favour of male students.

1.2 Statement of problem

Biology is a popular science subject offered by both science-oriented and art-based students in S.S.C.E. There is an increasing yearly enrolment in SSCE biology, but each year students achieve poorly in the examination. Teachers as well as parents have expressed concern about the poor performance of students in biology. This has created an educational gap of students not continuing their studies in biology at tertiary institution not minding that this subject stands as the bedrock to the learning of other science courses like Medicine, Pharmacy, Nursing, Biochemistry, Genetics etc that are of great economic importance to the nation. This gap can be filled by devising a more effective approach for improving the situation in order to meet the needs of the students and the society at large. It is therefore certain that a more teaching approach that will help students retain what they have learnt in a long-term memory be sort.

In view of this, inquiry-based learning approach may be useful in teaching biology in order to improve the persistent poor performance in biology. The problem of this study posed as a question therefore is: What effect does inquiry- based Learning Approach have on senior secondary school students' retention in biology in Enugu State.

1.3 Purpose of the study

The purpose of the study is to determine the effect of inquiry-based learning approach on senior secondary

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school students' retention in biology. Specifically, the study aimed at determining:

1) The effects of Inquiry-Based Learning (IBL) approach and conventional approach on students' mean retention scores in biology.

2) The influence of gender on mean retention scores of students in biology using inquiry-based learning approach.

1.4 Research Questions

The following research questions guided the study:

1) What are the mean retention scores of students taught biology with IBL approach and those taught with conventional approach?

2) What are the mean retention scores of male and female students taught biology with inquiry-based learning approach?

1.5 Research Hypotheses

The following null hypotheses (Ho) guided the study and were tested at 0.05 levels of significance.

Ho_1: There is no significant difference in the mean retention scores of students taught biology with IBL approach and those taught with conventional approach.

Ho_2: There is no significant difference in the mean retention scores of male and female students taught biology with IBL approach.

Ho_3: There is no significant interaction effect of teaching approach and genders on students' mean retention scores in biology

2.1 Method

Quasi-experimental design was adopted for the study (pre-test, Post-test, non-equivalent control Group Design). The design was adopted because intact classes were used to avoid disruption of normal class lessons, as it was not possible to have complete randomization of the subjects. The population of the study comprises 2624 senior secondary class two (SS2). Biology students in the government owned coeducational secondary schools in Enugu East Local Government Area of Enugu State (Planning, Research and Statistics Department, Post Primary Schools Management Board (PPSMB) 2020. The sample size of 139 SS II biology students from four intact classes, drawn from two senior secondary coeducational schools in Enugu East LGA formed the sample size of the study. Two co-educational secondary schools were drawn from 12 co-educational governments owned senior secondary schools in Enugu East Local Government Area of Enugu State using simple random sampling technique). Biology Achievement Test (BAT) was used as instrument for data collection. The same test (BAT) was used aspretest, posttest, and retention test (RT).The instrument was validated by three experts in the Department of science Education (Measurement and evaluation and biology units) all in faculty of Education, Enugu State University of Science and Technology). The reliability index of the instrument was 0.89 using Kuder-Richardson Formular 21(K-R 21)**.** Data collected from the study were analyzed using mean and standard deviations to answer the research questions and analysis of covariance (ANCOVA) to test the hypotheses.

2.2 Presentation and Analysis of Data

1. Research question 1: What are the mean retention scores of students taught biology with IBL approach and those taught with conventional approach?

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Table 1: Mean and standard deviation of students mean retention Scores in biology

Groups Pre-test		Post-test					
Mean mean gain							
	N	Mean	SD	Mean	SD	Gain	difference
Experimental Group	71	22.194	.4032.427	.8210.238.88			
Control Group		6824.35	5.08			28.607.42	4.25

Result in **table 1**shows the mean retention scores of students exposed to inquiry-based learning approach and conventional approach. From the table, it was shown that mean retention scores of 22.19 and 24.35 has associated standard deviation of 4.40 and 5.08 obtained for students exposed to inquiry-based learning approach and those not exposed to respectively at the pre-test. However, at the post-test, mean retention scores of 32.42 and 28.60 with standard deviation of 7.82 and 7.42 were recorded for students exposed to inquiry based learning approach and those exposed to conventional/teacher-demonstration) approach. Moreover, mean gain score difference of 8.88 was recorded for the two groups in favour of inquiry-based learning approach proved superior over the conventional approach in enhancing retention in biology. The result therefore, indicates that inquiry-based learning approach is more effective compared to conventional approach in enhancing students' retention in biology.

For the standard deviation (SD) the maximum score of the retention scores was 90 and its 1/5 is 18 (Nworgu, 2006).**:** Since the post SD for both groups (Experimental:7.82 and control: 7.42) are below 18 for the retention ability, the relatively low SD therefore indicated homogeneity because the scores clustered around the mean (Nworgu, 2006). Nworgu (2006) also maintained that relatively high mean scores with low SD indicated mastery of the content. This may also be said to be true of the students taught with inquiry based learning approach.

Table 2:

Research question 2: What are the mean retention scores of male and female students taught biology with inquiry-based learning approach?

Gender		Pre-test		Retention		Gain	Gain Score
Scores	Difference						
N	Mean	SD	Mean	SD			
Male	29	28.86	5.27	30.93		3.79	31.29
Female	42	29.79	3.78	31.29		3.12	31.03

Result in Table 2 showed that male students taught biology using inquiry-based learning approach had adjusted mean of 31.29 while their female counterparts taught biology using inquiry-based learning approach had adjusted mean score of 31.03. The result showed that male students taught biology using inquiry-based learning approach had higher retention score than their female counterparts in biology.

Hypothesis 1:

Ho_1: There is no significant difference in the mean retention scores of students taught biology with IBL approach and those taught with conventional approach.

Table 3:

Summary of analysis of covariance (ANCOVA) of students mean retention scores in biology when exposed to IBL, approach and conventional approach

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Sources	Type III Sum of Squares	dfsquare	Mean F	Sig.	Decision r
Corrected Model	449.894[a]	4	112.474	5.612	
.000					
Intercept	3848.164	1	3848.164	192.025	.000
Pretest BAT	31.634 1	31.6341.579	.211		S
Method	337.464	1	337.464	16.840	NS
.000					NS
Gender	6.429	1	6.429	.321	
.572					
Method Gender *	11.127	1	11.127	.555	
.458					
Error	2484.943 124	20.040			
Total	74811.000	129			
Corrected Total	2934.837	128			

Key: S=Significant, SN= Not Significant

The summary of result in Table 3 shows that teaching strategy is a significant factor on students retention scores in biology; = 16.840, P = .000. Thus, the null hypothesis of no significant difference in the mean retention scores of students in biology is rejected. This is because the associated probability value of .000 is less than the alpha level of 0.05. Therefore, there is significant difference in the mean retention scores of students in biology in favour of students exposed to IBL. This means that the use of IBL approach in teaching biology significantly improved students' retention ability as buttressed by mean gain of 10.23 for experimental group as against 4.25 for control group.

Hypothesis 2

Ho_2: There is no significant difference in the mean retention scores of male and female students taught biology with IBL approach.

Result in Table 3 was also used to test hypothesis two. The result from the Table showed that gender is not a significant factor on students' retention ability in biology. F = .321, P = .572. Thus, the null hypothesis of no significant difference in the mean retention scores of male and female students in biology is not rejected or uphold. This is because; the associated probability value .572 is greater than the alpha level of 0.05.Therefore there is no significant difference in the mean retention scores of male and female students when taught biology with IBL approach.

Hypothesis 3

Ho_3: There is no significant interaction effect of teaching approach and genders on students' mean retention scores in biology

Data in Table 3 showed a non-statistical significant mean interaction effect of gender on mean retention score of students in biology F =555, P=.458. The null hypothesis therefore was not rejected indicating that there was no significant interaction effect of instructional method and gender on mean retention score of students taught biology using inquiry-based learning.

2.3 Summary of findings

The findings of the study were summarized as follows:

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1. IBL approach is more effective than the conventional approach in enhancing students' retention in Biology. The result of this finding as seen in table 1 showed that mean retention scores of 22.19 and 24.35 has associated standard deviation of 4.40 and 5.08 obtained for students exposed to inquiry-based learning approach and those not exposed to respectively at the pre-test. However, at the post-test, mean retention scores of 32.42 and 28.60 with standard deviation of 7.82 and 7.42 were recorded for students exposed to inquiry based learning approach and those exposed to conventional/teacher-demonstration) approach. Moreover, mean gain score difference of 8.88 was recorded for the two groups in favour of inquiry-based learning approach proved superior over the conventional approach in enhancing retention in biology. The result therefore, indicates that inquiry-based learning approach is more effective compared to conventional approach in enhancing students' retention in biology.

For the standard deviation (SD) the maximum score of the retention scores was 90 and its 1/5 is 18 (Nworgu, 2006).Since the post SD for both groups (Experimental:7.82 and control: 7.42) are below 18 for the retention ability, the relatively low SD therefore indicated homogeneity because the scores clustered around the mean (Nworgu, 2006). Nworgu (2006) also maintained that relatively high mean scores with low SD indicated mastery of the content. This may also be said to be true of the students taught with inquiry based learning approach.

This finding is in line with Adebola (2012) who studied the effect of problem-solving model as strategy for improving secondary school students' achievement and retention in further mathematics. Findings from his study showed that problem-solving strategy had significant main effect on students' achievement and retention in Further Mathematics. The study is equally in line with Okereke (2006) who investigated the effects of constructivists' instructional approach on students' achievement and retention in basic ecological concepts in Biology. The result of the study showed that students taught ecological concepts using constructivist instructional approach performed better than those taught using the conventional approach. The study also showed that students taught ecological concepts using constructivist instructional approach had higher retention score than their counterparts taught using the conventional lecture approach.

2. IBL approach enhances gender parity as it concerned students' retention in Biology.

The result of this finding as seen in table 2 showed that male students taught biology using inquiry-based learning approach had adjusted mean of 31.29 while their female counterparts taught biology using inquiry-based learning approach had adjusted mean score of 31.03. The result showed that male students taught biology using inquiry-based learning approach had higher retention score than their female counterparts in biology.

This study is in line with Ukozor (2011) who investigated the effect of constructivist teaching strategy on senior secondary school students' achievement and self-efficacy in physics.A significant effect of gender on students' physics academic achievement was found in favour of male students.

The findings of this study is at variance with that of Baser (2006) who carried out a research out a meta-analysis of gender differences in students' performance and conceptual change in physics. The result of this study suggested that gender differences in physics is not significant..

2.4 Conclusions

From the discussion, the following conclusions were made:

1) The use of IBL approach significantly increased the students' mean retention ability scores in biology compared to the conventional approach.

2) IBL approach enhances gender parity as it concerned students' retention in Biology.

3) With the use of inquiry-based learning approach, students have the responsibility of learning on their own, with the teacher acting as guides. Inquiry-based learning approach also provides students the opportunities to participate actively in the teaching-learning process, since the method is student-centered. This gives the students greater opportunity to be responsible for their own learning, equipping students with the necessary skills and competencies needed for living and making meaningful contribution to the development of the society.

2.5 Recommendations:

Based on the findings of this study, the following recommendations were made by the researcher:

1) Biology teachers should adopt the use of inquiry-based learning approach in their lessons in order to enhance students' retention ability in biology.

2) Government agencies and professional associations whose responsibility is to design and revise the curriculum for secondary schools should incorporate and emphasize the use of inquiry-based learning approach in teaching and learning of biology in senior secondary schools.

3) Government in conjunction with other professional associations should organize workshop, seminars; conferences and in-service training on a regular basis to train teachers on the use of inquiry-based learning approach since the approach have been found to be effective in enhancing student's retention ability in biology.

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