



Effects of Three Instructional Strategies on Students' Retrieval Practice in Senior Secondary School Biology

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Abstract

The paper examined the effect of three instructional strategies (enhanced inquiry, inquiry and 5Es instructional strategies) on students' retrieval practice in Biology. It adopted a quasi-experimental research design and sampled 232 biology students in four senior secondary schools randomly selected from two educational districts in Lagos State. Data were collected using the Students' Retrieval Practice Test (SRPT) and Mental Ability Test (MAT). Three hypotheses were tested at 0.05 level of significance. ANOVA was used to analyse the data. The results indicated that treatment had a significant effect on students' retrieval practice. However, enhanced inquiry instructional strategy had the most significant effect on students' retrieval practice. There was no significant effect of mental ability/ gender on students' retrieval practice. It can therefore be inferred that enhanced inquiry is effective. Mental ability and gender are not prerequisites for retrieval practice. Recommendations included that teachers should adopt enhanced inquiry instructional strategy amongst others.

Keywords: Enhanced inquiry, 5Es, mental ability, gender, retrieval practice

Introduction

Science education is very essential to every nation because the world is progressively shaped by science and technology (United Nations Educational, Scientific and Cultural Organisation UNESCO, 2017). Science has three natural disciplines in Secondary School in Nigeria namely: Physics, Chemistry and Biology. Biology is considered as the most popular of the three natural science disciplines amongst Senior School students in Nigeria (Jibril, Bello & Abimbola, 2015). Despite this popularity, researchers in Biology have observed students' weakness in abstract biology concepts (Udeani, 2002; Oladipo, 2009; Oztas, 2014; Oladipo, Adewumi & Ogundiwin, 2019). The commonest factor that has been identified as militating against the realisation of the objectives of Biology curriculum has been the uninspiring and traditional strategies employed by Biology teachers (Baron, 2000; Oladipo, 2009; & Ogundiwin, 2013). Although, teaching Biology effectively will enhance high order cognitive skills such as inquiry, critical thinking, creativity and problem-solving skills (Ghulam, Zeeghan, Sajjud-ur-Rehman & Sindbu, 2018), but then a large number of students have not acquired the skills they need in solving problems in science (Wasagu, 2019). Also, using one instructional strategy allows teaching to be boring to students and their interest might not be sustained (Njelita, 2015). Therefore, this study involves the integration of inquiry and 5Es to form enhanced inquiry.

The 5Es instructional strategy: It is in line with inquiry and it consists of five phases.

Engagement is the first phase where the teacher identifies student prior knowledge and misconceptions. It is a student-centered phase. *Exploration* is the phase that students are motivated to put in process skills, such as noticing, querying, probing, testing forecasts, guessing, and liaising, with other peers. The teacher acts as a facilitator. *Explanation* is the phase that students explain their own ideas first before the teacher tries to give explanations. This phase allows student misconceptions that may emerge during the engagement or exploration phases to be clarified. *Elaboration* phase is filled with activities that should motivate students to make use of their new comprehension of concepts, while strengthening new skills. Students are motivated to scrutinize their comprehension with their peers. *Evaluation* phase is different from the assessment done in a traditional science lesson. The assessment here includes both formal and informal. Portfolios, physical models, journal logs, concept maps can be used and might be evidence that students are learning.

Inquiry, as used in this study, involves the following: i. Use of Pictures and Materials:

Pictures make it possible to absorb large amounts of data quickly. A photograph is valued like a thousand words through which a complex idea can be transferred with just a single still image. ii. Reflection and Students Personal Journal: Reflection involves considering, examining, and thinking about the content of the lesson. Students' personal journal refers to a place where students record their views, activities and conclusions in the process of building their knowledge. iii. Class Project and Small Group

Discussion: Project based learning (PBL) based education on the students not the curriculum, a shift directed by the global world, which rewards immaterial assets such as initiative, passion and inventiveness while a small group is an operational method used by diverse schools with anticipated learning results. For this study, the strategies stated above were combined and 5Es integrated into it to form enhanced inquiry. Its effect on students' retrieval practice was now explored.

Observations of classroom engagements and enquiries made by the researchers show that some students find Biology to be difficult because of the voluminous notes given by teachers. Also, teachers give tests or examinations which are high stakes to students which creates fear and undue anxiety in students. Therefore, a day before the exam/test, they try to memorize what has been taught in order to perform well. Consequently, students find it difficult to apply this knowledge to another situation that arises later. Hence, there is a need for retrieval practice by students which will enhance their learning and ultimately contribute to their performance. Retrieval practice is when the learner "retrieves" certain knowledge from memory. Doing this often, importantly in different contexts, the learner builds up the ability to recollect this knowledge, helping prolonged retention and convey of knowledge from one situation to another. (Rohrer, Taylor & Sholar, 2010). Retrieval is the process of getting back information from long-term memory, where it was encrypted for the basis. Retrieval processes are involved in all circumstances in which knowledge is expressed, including situations where learners must generate inventive and unusual ideas.

Statement of the problem

One of the objectives of teaching Biology in senior secondary school is for students to acquire meaningful and relevant knowledge in Biology and be able to apply scientific knowledge to everyday life in matters of personal and community health and agriculture. To achieve this, retrieval practice in classrooms is expedient. For application of knowledge to occur the students must first understand the knowledge and then be able to retrieve it when confronted with a similar situation. Most studies carried out on retrieval practice have shown the effect of retrieval on students' achievement. However, little work has been done on the influence of different instructional strategies on students' retrieval practice in Biology. It is as a result of this observation that the present study is being undertaken to investigate the effect of three

instructional strategies on students' retrieval practice in Biology.

Purpose of the study

The main purpose of the study was to examine the effects of Enhanced, 5Es & inquiry instructional strategies on students retrieval practice in Biology.

The specific objectives were to determine:

1. The effect of treatment on students retrieval practice in Biology.
2. The effect of gender on students retrieval practice in Biology.
3. The effect of mental ability on students retrieval practice in Biology.

Hypotheses

The following hypotheses were tested at 0.05% level of significance.

1. There is no significant main effect of treatment (inquiry-based instructional strategy, 5Es, enhanced inquiry instructional strategy and lecture method) on students' retrieval practice in Biology.
2. There is no significant main effect of gender on students' retrieval practice in Biology.
3. There is no significant main effect of mental ability on students' retrieval practice in Biology.

Methodology

The research design for this study was the non-equivalent group quasi-experimental design because the effect of the independent and moderator variables was investigated. The study adopted the 4x3x2 factorial design. The independent variable for the quasi-experimental design is the instructional strategy. It is at 4 levels. -inquiry, 5Es, enhanced inquiry strategies and lecture method. Mental ability and gender are the moderator variables. Mental ability is at 3 levels: high, medium and low. Gender at 2 levels: male and female while the dependent variable is retrieval practice. The target populations are the biology students and teachers in the Senior Secondary Schools in Lagos State. The study sampled 232 SS II Biology Students in four public co-educational schools. Gender effect was investigated in this study therefore co-educational schools were selected. Two stages of the multistage sampling procedure were used. Stage 1: Random sampling technique was used to select two educational districts out of the six districts in Lagos State. Stage 2: Stratified random sampling was used to select four co-educational schools out of the two educational districts selected for the study. The



instruments that were used for data collection included the Students Mental Ability Test (SMAT) and Students Retrieval Practice Test (SRPT).

Procedure

The schools were visited for familiarization. Permission to conduct the study was obtained from the principal of the school and the consent of the teachers was sought. The use of treatment was implemented over a period of 8 weeks to SS 2 Biology students in all the experimental groups. The first experimental group was exposed to 5Es instructional strategy while the second group was exposed to inquiry strategy. The third experimental group was exposed to enhanced inquiry and the fourth group which is the control group was exposed to lecture method simultaneously. They were given Biology retrieval practice test at three stages to

determine their retrieval practice. Prior to the intervention, the students were given a student's mental ability test. The students' mental ability test was to determine if there will be an influence of students' mental ability on their retrieval practice. The data collected were analyzed using ANOVA precisely for testing the hypotheses which was rejected at a probability value less than or equal to 0.05 (5% alpha level). Pairwise comparison Post-hoc test was also used.

Results

Table 1 shows the descriptive statistics of the effect of treatment on students' retrieval practice in Biology. Of the 232 participants, 63(27.16%) were for 5Es, 60 (25.86%) for inquiry, 57 (24.57%) for enhanced inquiry, and 52 (22.41%) for control.

Table 1 : Descriptive statistics of retrieval practice gain by treatment

Treatment		N	Mean	Std. Deviation
5Es	Stage 1	63	11.7143	2.61773
	Stage 2	63	10.5397	2.97747
	Stage 3	63	14.4127	3.38228
	Average	63	12.2216	2.07701
Inquiry	Stage 1	60	7.3833	3.83601
	Stage 2	60	9.1667	3.16852
	Stage 3	60	15.4000	5.10633
	Average	60	10.6498	2.39055
Enhanced Inquiry	Stage 1	57	16.4035	3.52977
	Stage 2	57	13.5965	1.85029
	Stage 3	57	20.2105	4.23310
	Average	57	16.7365	2.04479
Control	Stage 1	52	8.3077	3.36964
	Stage 2	52	9.6731	2.96860
	Stage 3	52	8.4231	3.70662
	Average	52	8.8015	2.53938

Table 1. above showed the effect of treatment among biology students on retrieval practice were M=16.74, SD= 2.04 for enhanced inquiry, M=10.64, SD= 2.39 for inquiry, M= 12.22, SD=2.08

for 5Es and M= 8.80, SD= 2.53 for control. This result indicates that enhanced inquiry is the most effective teaching method for retrieval practice in Biology followed by Inquiry, 5Es and control.

Table 2: Inferential statistics of univariate Analysis of Variance (ANOVA) of Treatment on Retrieval practice

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1917.419 ^a	3	639.140	124.801	.000	.622
Intercept	33809.394	1	33809.394	6601.734	.000	.967
Treatment	1917.419	3	639.140	124.801	.000*	.622
Error	1167.654	228	5.121			
Total	37377.491	232				
Corrected Total	3085.073	231				

* Main effect is significant at 5% level. Dependent Variable: Retrieval Practice
The test for significant main effect of treatment on students' retrieval practice in Biology is determined using univariate analysis of variance (ANOVA). The ANOVA test shows, since $P = 0.000 < 0.05$ at F-



value = 124.801, there is significant variation in teaching methods (treatment) on students' retrieval practice. Therefore, the hypothesis is rejected. Hence, there is significant main effect of treatment on students' retrieval practice in Biology. Parameter estimates and multiple comparisons of means (post-hoc test) were carried out to determine which teaching method is most effective in retrieval practice.

The parameter estimates result revealed for retrieval practice that Treatment 3 (enhanced inquiry) had the most significant main effect on students' retrieval

practice at $t = 18.284$ ($p < 0.05$), followed by Treatment 1 (5Es) at $t = 8.066$ ($p < 0.05$) and Treatment 2 (Inquiry) at $t = 4.311$ ($p < 0.05$). Further, enhanced inquiry, 5Es and inquiry treatment methods are 0.595, 0.222 and 0.075 times more likely to improve retrieval practice than lecture method (control), respectively. Also, a unit increase in enhanced inquiry, 5Es and inquiry will increase students' retrieval practice by 7.935, 3.420 and 1.848, respectively. The results are further supported using pairwise comparison of main effects.

Table 3 Post-Hoc Tests: Pairwise Comparisons based on Least Significance Difference

Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound Upper Bound	
Retrieval Practice	5Es	Inquiry	1.57175*	.40822	.000	.7674	2.3761
	5Es	Enhanced Inquiry	-4.51490*	.41369	.000	-5.3300	-3.6998
	5Es	Control	3.42005*	.42400	.000	2.5846	4.2555
	Inquiry	Enhanced Inquiry	-6.08666*	.41857	.000	-6.9114	-5.2619
	Inquiry	Control	1.84829*	.42877	.000	1.0034	2.6931
	Enhanced Inquiry	Control	7.93495*	.43397	.000	7.0798	8.7901

*. The mean difference is significant at the 0.05 level.

The post-hoc analysis result indicates that enhanced inquiry is the most effective teaching method for retrieval practice in Biology, since there is a

significant mean difference compared to other teaching methods respectively.

Table 4: Summary of Univariate Analysis of Variance (ANOVA) of Gender of Students on Retrieval Practice.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	48.180 ^a	1	48.180	3.649	.057	.016
Intercept	33627.820	1	33627.820	2546.812	.000	.917
Gender	48.180	1	48.180	3.649	.057	.016
Error	3036.894	230	13.204			
Total	37377.491	232				
Corrected Total	3085.073	231				

Dependent Variable: Retrieval Practice

The test for significant main effect of gender on students' retrieval practice in Biology is determined using univariate analysis of variance (ANOVA). The test shows there is no significant gender difference

on students' retrieval practice. Therefore, the hypothesis is accepted. Hence, there is no significant gender effect or preference on students' retrieval practice in Biology.

Table 5: Summary of Univariate Analysis of Variance (ANOVA) of Mental Ability of Students on Retrieval Practice

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	25.611 ^a	2	12.806	.959	.385	.008
Intercept	25055.848	1	25055.848	1875.424	.000	.891



Mental Ability	25.611	2	12.806	.959	.385	.008
Error	3059.462	229	13.360			
Total	37377.491	232				
Corrected Total	3085.073	231				

Dependent Variable: Retrieval Practice

The test for significant main effect of students' mental ability on retrieval practice in Biology is determined using univariate analysis of variance (ANOVA). The ANOVA test shows there is no significant variation in mental ability of students on retrieval practice at $F\text{-value} = 0.959$. Therefore, the hypothesis is accepted. Hence, there is no significant main effect of mental ability on students' retrieval practice in biology.

Discussions

Effect of Treatment on Students' Retrieval Practice

This study revealed that there is a significant main effect of treatment on students' retrieval practice with enhanced inquiry having the most significant effect. This is in consonant with Schmid & Bogner (2013) who found that inquiry-based teaching has significant effect on students' recall ability. It shows that enhanced inquiry will allow for more/increased retrieval ability than 5es and inquiry strategies. Also, the Effect of Gender on Students' Retrieval Practice showed that there is no significant effect of gender on students' retrieval practice. This finding supports Onyishi et al (2019) who observed that there was no significant gender effect on student's recall ability. This indicates that gender is not a barrier to students retrieving information. Similarly, there was no significant effect of mental ability on students' retrieval practice. This finding disagrees with Agarwal et al (2017) who found that students with lower working memory capacity benefitted greatly from retrieval practice and their retrieval ability was greatly increased indicating that lower ability students are able to retrieve better.

Conclusion and Recommendation

It was found that there was significant main effect of treatment on students' retrieval practice in Biology. However, enhanced inquiry had the most significant effect on students' retrieval practice. This strategy is better in increasing students' ability to retrieve the concepts taught in Biology. Furthermore, gender did not have effect on student's ability to retrieve the concepts taught in Biology. This implies either male or female can benefit immensely from the strategy as it is not gender sensitive as indicated from the result. Also, mental ability did not have effect on students' ability to retrieve the concepts taught in Biology. Based on the findings of this study, the following

recommendations are made: Teachers should adopt enhanced inquiry to enhance students' retrieval practice and learning of Biology. Students should be encouraged to use personal science journal as this will assist them in monitoring their own ideas/knowledge about the concept taught which would finally influence their ability to retrieve concept and ideas when needed.

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