



Enhancing students' retention in genetics using 5E learning cycle and WebQuest in secondary schools in Rivers State

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Abstract

This study investigated the effect of 5E learning cycle and Web Quest on students' retention in genetics in Secondary Schools in Rivers State. Three objectives, three research questions and three null hypotheses guided the study. The study adopted a quasi- experimental, non-equivalent, control group design. Three co-educational private schools were drawn using purposive sampling technique. The population of study comprised of Seven thousand, two hundred and thirteen (7,213) students, from which a sample size of 96 Senior Secondary two (SS2) students was drawn from three intact classes. The instrument for data collection was Genetics Retention Test (GRT), which consisted of fifty (50) multiple choice items. This was validated by six experts. The internal consistency was determined using Kuder – Richardson formula 21 and a reliability coefficient of 0.96 was obtained. The data obtained were analyzed using mean and standard deviation to answer the research questions. The hypotheses were tested at 0.05 level of significance using Analysis of Covariance (ANCOVA). The result of the study revealed that 5E learning cycle and webQuest had significant effect on students' retention of genetics. Also there was no significant joint interaction effect of 5E learning cycle and webQuest, on retention of male and female students taught genetics. Based on the findings of this study, it was recommended that teachers should adopt the use of 5E learning cycle and webQuest in teaching genetics.

Keywords: 5E Learning Cycle, Webquest, Retention and Genetic

Introduction

Education is an important component of scientific, technological and economic growth of any nation. It helps to solve society's challenge and meet its needs. The twenty-first century education lays emphasis on knowledge and skills such as critical thinking skills, problem solving, collaboration, communication, use of technology, creativity and innovation. This is a paradigm shift from education in the 20th century. Twenty-first century education refers to developing learning literacy and life skills as part of the classroom experience (Walker, 2021) ^[16]. These skills are expected of the teacher to inculcate in students, in the classroom to enable them fit into work places, pursue careers, live quality life while enhancing their performance and retention. So in the 21st Century, the roles of both the teacher and the student have changed. The teachers are facilitators of student learning and creators of productive classroom environments in which students can develop the skills they will need. This has brought about changes in the instructional strategies used in teaching and learning process, especially in the sciences.

Science has become the engine of wealth of many nations in the twenty-first century as seen in enhanced pharmaceuticals, smart phones, laptops, computers, laser procedures, human insulin production for illness treatment, genetically modified food, online doctors, health applications, scan machines, and so on. The contribution of science and technology to a country's economic and technological development is enormous as technology cannot advance without science subjects, especially Biology. Biology is one of the science subjects that is taught in Senior Secondary Schools. It is aimed to provide learners

with the skills, attitudes, and information necessary to care for themselves, other organisms, and the environment.

In the 21st Century, Biology and particularly genetics is at the center of biotechnological processes and genetic engineering as seen in gene cloning, DNA profiling, reverse transcription, artificial DNA synthesis, genetically modified food and artificial intelligence. The importance of genetics is expanding with swift speed because that is where the world is already on in terms of the gene industry. In spite of the importance of genetics, it has been a contributory factor in students' consistent poor performance in Biology. The cause of poor performance of Biology students is attributed to students' weakness in their recalling ability of difficult concepts (Abdullahi & Zayum, 2018) ^[2]. Likewise, the study conducted by Abdullahi and Jibrin (2017) ^[1], revealed that the major problems predominant in the academic performance and retention of students in science subjects is their recalling ability as a result of inappropriate instructional strategies adopted by teachers.

In the teaching and learning process, retention is particularly important. This refers to the ability to recall or recover data from long-term memory. Retention strengthens and supports the application of information and skills while also improving results. Students' retention improves their performance. Performance would be impossible to attain without retention, which occurs only after learning has taken place and been transferred to long-term memory. Students can only retain information if they grasp and comprehend the concepts. This can be accomplished through more student-centered teaching practices that include activity/task and information technology. The 5E learning cycle and web based teaching technique known as webQuest are one such student-centered model.

The 5E learning cycle developed by Dodge (1995) [6], helps students to build a strong knowledge base through active participation. The number of phases and the initials of each phase make up the 5E learning cycle. These five phases are as follows: Engagement, Exploration, Explanation, Elaboration, and Evaluation. Paxton (2021) [12] and Mulder (2019) [9], suggests that the learning cycle is beneficial in classroom as it can motivate students, engage students in an active learning process, facilitate collaboration and teamwork, help students form conclusions through questioning, investigating, observing, analyzing and problem-solving. Northern (2019) [10], establishes that the 5E's of inquiry-based learning enhances students' understanding of concepts in science, increases students' interest in the field and help students develop critical thinking skills. WebQuest strategy is a technology enhanced teaching strategy. The web Quest instructional technique is an inquiry exercise that uses links to access essential resources in the internet. The student focuses on the resources provided by their teachers instead of searching for resources. It also improves learning and retention of high-level thinking skills that include critical thinking skills, content thinking and creative thinking (Alireza; Khodabandelou, & Sherafat, 2021) [4].

Statement of the Problem

It has been observed that one of the areas in Biology, that students perform poorly, are questions on concept of genetics as indicated in the chief examiner's comments of student's strengths and weakness on genetics questions (2014-2018).

Table 1: Chief Examiner's Comments on Genetics Question (2014-2018)

Year	Comments
2014	Poor crossing of the genetic expression
2015	Poor response to questions on genetics and poor crossing of genetic expression
2016	Inability to apply the knowledge of genetics and poor crossing of genetic expression
2017	Teachers should lay emphasis on genetics
2018	Poor grasp of genetics

Source: Chief examiners comments (2014-2018)

This poor performance in genetics as shown in the comments of the chief examiners report is evident of students' poor grasp of the concept of genetics. Kanko (2021) [7]; Ayimbila and Akantagiriwoni (2021) [5], have attributed this poor performance in genetics to the predominant lecture method used in teaching this concept. It is absolutely necessary to explore other teaching strategies that are student-centered that can engage the students to be active, to collaborate, communicate and construct knowledge while learning and which may possibly enhance performance and retention. In view of this, the problem of this study is to investigate the effect of 5E learning cycle and webQuest on students' retention in genetics.

Aim and Objectives of the Study

The aim of this study is to investigate the effect of 5E learning cycle and webQuest on students' retention in genetics. Specifically, the objectives of the study are to:

1. Investigate the effect of 5E learning cycle on the mean retention scores of students' in genetics.

2. Determine the effect of webQuest on the mean retention scores of students' in genetics.
3. Examine the joint effects of 5E learning cycle and webQuest on the mean retention scores of male and female students in genetics.

Research Questions

The following research questions guided the study:

1. What is the mean retention scores of students taught using 5E learning cycle in genetics?
2. What is the mean retention scores of students taught using webQuest in genetics?
3. What is the joint effect of 5E learning cycle and webQuest on students' mean retention scores of male and female students in genetics?

Hypotheses

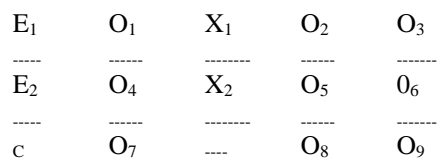
This study was guided by the following null hypotheses which were tested at 0.05 level of significance:

1. There is no significant difference in the mean retention scores of students taught genetics using 5E learning cycle, and those taught using Enhanced lecture method.
2. There is no significant difference in the mean retention scores of students taught genetics using webQuest, and those taught using Enhanced lecture method.
3. 5E learning cycle and webQuest have no significant effect on students' mean retention scores of male and female students taught genetics?

Methodology

Research Design

The study adopted the quasi experimental design specifically, a pretest, posttest, post posttest(retention), and non-randomized control groups. The design can be represented structurally as shown below:



- E₁ = Experimental group I
- E₂ = Experimental group II
- C = Control group
- O₁ = Pretest score for experimental group I
- O₂ = Posttest score for experimental group I
- O₃ = Retention score for experimental group I
- O₄ = Pretest score for experimental group II
- O₅ = Posttest score for experimental group II
- O₆ = Retention score for experimental group II
- O₇ = Pretest score for control group
- O₈ = Posttest score for control group
- O₉ = Retention score for control group
- X₁ = the treatment on experimental group I
- X₂ = the treatment on experimental group II
- = Not treated with 5E learning cycle and webQuest technique
- = Intact class.

Population of the Study

The population for the study comprised of seven thousand, two hundred and thirteen (7,213) Senior Secondary two (SS2) Biology students in private schools in Obio-Akpor Local Government Area of Rivers State.

Sample and Sampling technique.

The sample for the study consists of ninety-six (96) Senior Secondary two (SS2) students from three intact classes of three private schools in Obio-Akpor Local Government Area. The schools were selected using purposive sampling technique based on the following criteria:

- Schools that are co-educational,
- that consent to be used for research study,
- have well equipped Biology laboratory,
- has a minimum of twenty-five students per class,
- fully equipped ICT laboratory with internet facilities and
- qualified Biology teachers

Instrument for data collection

The research instrument developed for the study was Genetics Retention Test (GRT). The instrument was adapted by the researcher based on the contents of instruction and blooms taxonomy. It was based on knowledge, comprehension, and application level of blooms taxonomy. It was made up of fifty (50) multiple choice objective test items of the options A – D. The (GRT) was designed to measure retention ability in genetics.

Validity of the Instrument

To ensure content and face validity of the instrument, it was subjected to scrutiny by six experts consisting of researcher’s supervisors, two Senior Secondary School Biology teachers and two experts in measurement and evaluation. They were requested to assess the instrument in terms of clarity of expression, suitability of items, accuracy of answers and content coverage.

Reliability of the Instrument

The reliability of Genetics Retention Test (GRT) was determined by administering the instrument for a pilot test, on thirty (30) SS2 Biology students in a similar private school that was not selected for the study. The internal consistency of the instrument was determined using the Kuder- Richardson KR21 technique. The reliability coefficient of the (GRT) was 0.96. It was considered appropriate for the study.

Method of Data Collection

The three sampled private schools were randomly assigned to experimental and control groups. 5E learning cycle was

used for experimental group I, webQuest was used for experimental group II while Enhanced lecture method was used for control group. Three intact classes, one from each school were used for the study. Classes, were randomly selected into their experimental and control groups. In the design, both the experimental and the control groups were pre-tested to ensure group equivalence, thereafter exposed to treatment for three (3) weeks. After the treatment for three (3) weeks, the students were subjected to posttest. The Genetics Retention Test (GRT) was administered as post-posttest, it contains the same questions, but the items were also reshuffled in numbering. It was re-administered to the sample after two weeks to determine their retention capacity.

Method of Data Analysis

The research questions were answered using mean and standard deviation while the Analysis of Covariance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. All statistical analyses were done using Statistical Package for Social Sciences (SPSS) version26.

Results and Analysis

Research question 1

Table 2: Mean retention scores of the students taught using 5E learning cycle in genetics.

Method	n	Post test Mean	Post- post test Mean	Mean gain
5E learning cycle	31	58.13	65.03	6.90
Enhanced Lecture method	32	52.94	54.94	2.00

What is the mean retention scores of students taught using 5E learning cycle in genetics?

Table 2 shows that the students taught genetics using the 5E learning cycle retained more with a higher mean gain of 6.90 compared to students taught using Enhanced lecture method with a mean gain of 2.00

Research Question 2

What is the mean retention scores of students taught using webQuest in genetics?

Table 3: Mean retention scores of the students taught using webQuest in genetics

Method	n	Post test Mean	Post- post test Mean	Mean gain
WebQuest	33	55.64	62.36	6.72
Enhanced Lecture method	32	52.94	54.94	2.00

Table 3 shows that the students taught genetics using the webQuest retained more with a mean gain of 6.72 compared to students taught using Enhanced lecture method with a mean gain of 2.00. Research Question 3

What is the joint effect of 5E learning cycle and webQuest on students’ mean retention scores of male and female students in genetics?

Table 4: Joint interaction effect of 5E learning cycle and webQuest on students’ mean retention scores of male and female students in genetics.

Method	Gender	n	Post test mean	Post-posttest Mean	Mean gain
5E learning cycle	Male	19	58.00	64.21	6.21
	Female	12	58.33	66.33	8.00
WebQuest	Male	22	52.64	59.55	6.91
	Female	11	61.64	68.00	6.36

From table 4, it shows that the female students taught genetics using 5E learning cycle retained the most with a higher mean gain of 8.00. This implies that the female students retained more when taught using 5E learning cycle.

Hypotheses

Hypothesis 1: No significant difference exists in the mean retention scores of students taught genetics using 5E learning cycle, and those taught using Enhanced lecture method.

Table 5: Summary of Analysis of Covariance on the mean retention scores of students taught genetics using 5E learning cycle and Enhanced lecture method.

Source	Type III sum of squares	df	Mean square	F	P-value
Corrected model	5234.031 ^a	2	2617.016	35.691	0.000
Intercept	430.261	1	430.261	5.868	0.018
POST TEST	3629.446	1	3629.446	49.499	0.000
METHOD	516.625	1	516.625	7.046	0.010
Error	4399.397	60	73.323		
Total	235714.000	63			
Corrected Total	9633.429	62			

^a R squared = .543 (Adjusted R squared = .528)

Table 5, indicates that the main effect of method as a calculated $F_{1,60} = 7.046(p<0.05)$ with significant value of 0.010. This shows that retention is significant among

students taught using 5E learning cycle and Enhanced lecture method. Therefore, the null hypothesis is rejected and the alternate hypothesis accepted.

Table 6: Post-hoc analysis on the mean retention scores of students taught genetics using 5E learning cycle and Enhanced lecture method.

Method (I) 5E Learning cycle	Method (J)	Mean difference (I-J)	Std. Error	Sig. ^b	95% confidence interval for difference ^b	
					Lower Bound	Upper Bound
	Enhanced lecture	5.939*	2.237	0.010	1.463	10.414
Enhanced lecture	5E learning cycle	-5.939*	2.237	0.010	-10.414	-1.463

Based on estimated marginal means

*The mean difference is significant at the 0.05 level

b Adjustment for multiple comparisons: least significant difference (equivalent to no adjustments)
The post-hoc analysis on table 6, shows that 5E learning cycle contributed the most to the significant difference on the retention of students taught genetics.

Hypothesis 2: No significant difference exists in the mean retention scores of students taught genetics using webQuest and those taught using Enhanced lecture method.

Table 7: Summary of Analysis of Covariance on the mean retention scores of students taught genetics using webQuest and Enhanced lecture method.

Source	Type III sum of squares	df	Mean square	F	P-value
Corrected model	6436.608 ^a	2	3218.304	46.373	0.000
Intercept	190.637	1	190.637	2.747	0.102
POST TEST	5540.673	1	5540.673	79.836	0.000
METHOD	394.850	1	394.850	5.689	0.020
Error	4302.839	62	69.401		
Total	234768.000	65			
Corrected total	10739.446	64			

^a R squared = .599(Adjusted R squared = .586)

Table 7, indicates that the main effect of method as a calculated $F_{1,62} = 5.689(p<0.05)$ with significant value of 0.020. This shows that retention is significant among

students taught using webQuest and Enhanced lecture method. Therefore, the null hypothesis is rejected and the alternate hypothesis accepted.

Table 8: Post-hoc analysis on the mean retention scores of students taught genetics using webQuest and Enhanced lecture method.

Method (I) webQuest	Method (J)	Mean difference (I-J)	Std. Error	Sig. ^b	95% confidence interval for difference ^b	
					Lower Bound	Upper Bound
	Enhanced lecture	4.973*	2.085	0.020	0.805	9.141
Enhanced lecture	webQuest	-4.973*	2.085	0.020	-9.141	-0.805

Based on estimated marginal means

*The mean difference is significant at the 0.05 level

b Adjustment for multiple comparisons: least significant difference (equivalent to no adjustments)

The post-hoc analysis on table 8 shows that webQuest contributed the most to the significant difference on the retention of students taught genetics

Hypothesis 3: There is no significant joint effect of 5E learning cycle and webQuest on students' mean retention

scores of male and female students taught genetics?

Table 9: Summary of Analysis of Covariance on the joint effect of 5E learning cycle and webQuest on students' mean retention scores of male and female students taught genetics

Source	Type III sum of squares	df	Mean square	F	P-value
Corrected model	7792.327 ^a	6	1298.721	17.535	0.000
Intercept	806.676	1	806.676	10.892	0.001
POSTTEST	5493.479	1	5493.479	74.172	0.000
METHOD	696.012	2	348.006	4.699	0.011
GENDER	11.898	1	11.898	0.161	0.690
METHOD * GENDER	36.310	2	18.155	0.245	0.783
Error	6591.673	89	74.064		
Total	368678.000	96			
Corrected total	14384.000	95			

^a R squared = .542(Adjusted R squared = .511)

Table 9, indicates that the joint effect of 5E learning cycle and webQuest on male and female students' retention in genetics is not significant, since the main effect of method and gender has a calculated $F_{2,89}=0.245$ ($p>0.05$) with a significant value of 0.783.

Discussion of Findings

Effect of 5E Learning cycle on students' retention in genetics.

Table 2 and table 5, revealed that the students taught genetics using the 5E learning cycle retained more than students taught using Enhanced lecture method, hence the null hypothesis was rejected. It was further confirmed by a post-hoc analysis that 5E learning cycle contributed the most to the significant differences. This agrees with the view of Muhammad; Omwirhirem and Abubakar (2021), that students taught with 5E learning cycle retained higher than those taught using conventional lecture method. Similarly, Tambaya (2018), showed that pre-NCE Biology students taught genetics using 5E teaching cycle in all ability levels retained more than those exposed to lecture method of instruction.

Effect of webQuest on students' retention in genetics

The results shown on Tables 3 and 7 indicates that the students taught genetics using the webQuest retained more than students taught using Enhanced lecture method. Hence the null hypothesis was rejected. It was further confirmed by a post-hoc analysis that webQuest contributed the most, to the significant differences. This finding also conforms with the finding of Alireza and Ellahe (2020) and Uttams (2019), that students taught genetics using webQuest strategy retained more than students taught using the convectional approach..

Joint effect of 5E learning cycle and webQuest on retention of male and female students

Table 4 shows that female students retained more when taught genetics using 5E learning cycle than the male counterparts. Table 9 indicates that the joint effect of method and gender on students' retention in genetics is not significant. In agreement with the findings of this study, is the findings of Nwoye; Okeke and Nwosu, (2020), which revealed that there was no significant interaction effect of treatment and gender on students' academic retention.

Conclusions

Based on the findings of this study, it was concluded that 5E learning cycle and webQuest was more effective in enhancing students' retention in genetics when compared to Enhanced lecture method. There was also no significant joint interaction effect of method and gender on the retention of students taught genetics.

Recommendations

1. Students should be taught genetics using 5E learning cycle and webQuest as it has been found to be effective in enhancing retention.
2. There is need for training and retraining of Biology teachers through workshops, seminars and conferences on the implementation of 5E learning cycle and webQuest as a teaching strategy to teach Biology concepts.
3. Publishers should incorporate webQuest into their books as valuable resources and links for further reading or task

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