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Enhancing students' performance 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' performance in genetics in Secondary Schools in Rivers State. Three objectives and three research questions guided the study while three null hypotheses were tested at 0.05 level of significance. 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. Three intact classes were used. The instrument for data collection was Genetics Performance Test (GPT) which consisted of fifty (50) multiple choice items adapted for the study. This was validated by six experts. The internal consistency was determined using Kuder – Richardson formula 21 and a reliability coefficient of 0.98 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' performance in genetics. There was no significant joint interaction effect of 5E learning cycle and webQuest, on performance of male and female students taught genetics. Based on the findings of this study, it was recommended that students should be taught genetics using 5E learning cycle and webQuest as it enhances performance.

Keywords: 5e learning cycle, webquest, performance and genetics

Introduction

The scientific and technological growth of any nation is dependent on the capability, quality and preparation of its human resources. Education is the means by which scientific and technological information is acquired, making it a necessary component of every form of growth. In this twenty-first century, science has become the engine of wealth of many developed nations as seen in all of the enhanced pharmaceuticals, biotechnology, genetic engineering, laptops, computers, laser procedures, insulin production, and so on. These were invented and improved through research. Researchers had to learn the fundamental ideas at the Secondary School level in order to lay a solid foundation for their findings. Biotechnology and genetic engineering are built on the foundation of Biology and concept of genetics as seen in gene cloning, Ectolife concept, DNA profiling, reverse transcription, artificial DNA synthesis, and artificial intelligence.

The concept of genetics taught in Secondary School has been a contributory factor to students' consistent poor academic performance in Biology. Abaidoo (2018) [1], defines academic performance as the knowledge gained, which is assessed by marks by a teacher and/or educational goals set for learners and teachers to be achieved over a specific period of time. The learners' success in educational institution is usually measured by academic performance. Some of the factors that have contributed to the poor performance of students in Biology, include availability of textbooks, crowded classrooms, and overloaded syllabuses (Bichi, Ibrahim and Ibrahim, 2019) [7]. Abidoye and Olurundare (2020) [2], also ascribed students' poor academic performance in Biology to the lecture method used in our Secondary Schools. The poor performance in Biology, particularly genetics, demonstrates the ineffectiveness of Biology teaching methodology. Clearly, the lecture method which is teacher centered has had an impact on teaching and learning of genetics hence the need for student centered approach such as 5E learning cycle and webQuest.

The 5E learning cycle, developed by Dodge (1995) [8], is one such student-centered model. This is a constructivist-based, inquiry-based technique that helps students improve their critical thinking skills while simultaneously assessing their prior knowledge. 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. Muhammad; Omwirhiren and Abubakar (2021) [11], asserts that the 5E learning approach was particularly helpful in improving higher-order thinking skills of students.

WebQuest is one example of how teachers can incorporate technology into their classrooms. Technology promotes innovative teaching and learning, as well as useful knowledge and skills. The webQuest, makes it possible for the learning of a given content, by allowing the digital inclusion as well as promoting the digital knowledge of students (Barroso &Coutinho, 2019) [6]. Nwanekezi and Ugonwa (2021) [13], continues that it focuses on using information instead of looking for the information, and it also supports learners to analyse, synthesize and evaluate. The teacher can create webQuest using different programs, but the most common and simple form is to create a word processing document that includes links to websites. A

webQuest can be printed on paper, presented in a PowerPoint, or on the internet itself. There are two kinds of webQuests as outlined by Dodge (1995) [8], the short-term webQuest and a long-term webQuest. Introduction, task, process, evaluation, and conclusion are all important features of webQuest activities.

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. Ayimbila and Akantagriwoni (2021) [5], have attributed this poor performance in genetics to the predominant lecture method used in teaching this concept. Genetics is the foundation of genetic engineering and that is where the world is already on. It is absolutely necessary to explore other teaching strategies that can engage the students to be active, generate ideas, construct knowledge while learning and which may possibly enhance performance. In view of this, the problem of this study is to investigate the effect of 5E learning cycle and webQuest on students' performance 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' performance in genetics. Specifically, the objectives of the study are to:

1. Determine the effect of 5E learning cycle on the mean performance scores of students' in genetics.
2. Ascertain the effect of webQuest on the mean performance scores of students' in genetics.
3. Determine the joint effect of 5E learning cycle and webQuest on the mean performance scores of male and female students in genetics.

Research Questions

The following research questions guided the study:

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

Methodology

Research Design

The study adopted the quasi-experimental design specifically, a pretest, posttest and non-randomized control groups. The design is represented structurally as shown:

E_1	O_1	X_1	O_2
-----	------	--------	------
E_2	O_3	X_2	O_4
-----	------	--------	------
C	O_5	----	O_6

E_1 = Experimental group I
E_2 = Experimental group II
C = Control group
O_1 = Pretest score for experimental group I
O_2 = Posttest score for experimental group I
O_3 = Pretest score for experimental group II
O_4 = Posttest score for experimental group II
O_5 = Pretest score for control group
O_6 = Posttest score for control group
X_1 = the treatment on experimental group I
X_2 = 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 all Senior Secondary two (SS2) Biology students in private schools in Obio-Akpor Local Government Area of Rivers State, with a total number of seven thousand, two hundred and thirteen (7,213) students. (Rivers State Senior Secondary Schools Enrollment Data for Private Schools, 2020-2021)

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 Performance Test (GPT). 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 GPT was used for the pre-test and posttest. The GPT was designed to measure students' performance 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. In order to ease the task of the experts, the research topic, objectives, research questions and hypotheses of the study were presented to the experts in addition to the research test instrument.

Reliability of the Instrument

The reliability of Genetics Performance Test (GPT) 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 (GPT) was 0.98 It was considered appropriate for the study.

Method of Data Collection

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 GPT as posttest to determine students' performance.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.

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.

Results and Analysis

Research question 1

What are the mean performance scores of students taught using 5E learning cycle in genetics?

Table 2: Mean performance scores of the students taught using 5E Learning cycle in genetics

Method	n	Pre test Mean	Post test Mean	Mean gain
5E learning cycle	31	36.65	58.13	21.48
Enhanced Lecture method	32	38.19	52.94	14.75

As shown on table 2, the students taught genetics using the 5E learning cycle performed better with a higher mean gain of 21. 48 than students taught with Enhanced lecture method with a mean gain of 14.75.

Research Question 2

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

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

Method	n	Pre-Test Mean	Post test Mean	Mean gain
WebQuest	33	35.64	55.64	20.00
Enhanced Lecture method	32	38.19	52.94	14.75

Table 3 indicates that the students taught genetics using the webQuest performed better with a higher mean gain of 20.00 than students taught with enhanced lecture method a mean gain of 14.75.

Research Question 3

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

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

Method	Gender	n	Pre test mean	Post test Mean	Mean gain
5E learning cycle	Male	19	35.68	58.00	22.32
	Female	12	38.16	58.33	20.17
WebQuest	Male	22	36.27	52.64	16.37
	Female	11	34.36	61.64	27.28

Table 4 shows that the female students taught genetics using WebQuest performed the most with a higher mean gain of 27.28, followed by male students taught genetics using 5E learning cycle with a mean gain of 22.32. This implies that the female students performed better when taught using webQuest than the male students and other students taught using 5E learning cycle.

Hypotheses

Hypothesis 1: There is no significant difference between the mean performance 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 performance scores of students taught genetics using 5E learning cycle and Enhanced lecture method.

Source	Type III sum of squares	D f	Mean Square	F	P-value
Corrected Model	1397.846[a]	2	698.923	8.942	0.000
Intercept	3255.721	1	3255.721	41.625	0.000
Pretest	973.458	1	973.458	12.454	0.001
Method	559.243	1	559.243	7.155	0.010
Error	4689.900	60	78.165		
Total	200088.000	63			
Corrected Total	6087.746	62			

a. R Squared = .230 (Adjusted R Squared =.204)

Table 5 shows that method has a calculated $F_{1,60}$ =7.155 ($p<0.05$) with significant value of 0.010. Therefore, performance is significant for students taught genetics using 5E learning cycle and Enhanced lecture method. Hence the null hypothesis is rejected and the alternate hypothesis accepted

Table 6: Post-hoc analysis on the mean performance 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	5.990*	2.239	0.010	1.511	10.470
Enhanced lecture	5E learning cycle	-5.990*	2.239	0.010	-10.470	-1.511

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 indicates that 5E Learning cycle contributed mostly to the
significant difference on the performance of students taught genetics.

Hypothesis 2: There is no significant difference between the mean performance scores of students taught genetics using webQuest and those taught using Enhanced lecture method.

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

Source	Type III sum of squares	D f	Mean square	F	P-value
Corrected model	1767.689[a]	2	883.845	10.834	0.000
Intercept	1799.098	1	1799.098	22.052	0.000
PRETEST	1649.355	1	1649.355	20.217	0.000
METHOD	321.053	1	321.053	3.935	0.052
Error	5058.157	62	81.583		
Total	198532.000	65			
Corrected Total	6825.846	64			

[a] R Squared =.559 (Adjusted R squared = .586)

Table 7 shows that method has a calculated $F_{1,62}$ =3.935 ($p<0.05$) with significant value of 0.052. Therefore, performance is not significant for students taught genetics using webQuest and Enhanced lecture method. Hence the null hypothesis is accepted.

Hypothesis 3: There is no significant joint effect of 5E learning cycle and webQuest on students' mean performance scores of male and female students taught genetics?

Table 8: Summary of Analysis of Covariance on the joint effect of 5E learning cycle and webQuest on students' mean performance scores of male and female students taught genetics?

Source	Type III sum of squares	D f	Mean square	F	P-value
Corrected model	2874.873[a]	6	479.145	6.036	0.000
Intercept	3943.951	1	3943.951	49.683	0.000
Pretest	1809.977	1	1809.977	22.801	0.000
Method	674.163	2	337.081	4.246	0.017
Gender	363.459	1	363.459	4.579	0.035
Method*gender	476.620	2	238.310	3.002	0.055
Error	7064.961	89	79.832		
Total	306088.000	96			
Corrected total	9939.833	95			

[a] R squared .289 (Adjusted R squared =.241)

Table 8 shows that the joint effect of 5E learning cycle and webQuest on male and female students' performance in genetics is not significant since the main effect of method and gender has a calculated $F_{2,89}$ = 3.002($p> 0.05$) with a significant value of 0.055.

Discussion of Findings

Performance of students taught genetics using 5E Learning cycle and those taught with Enhanced lecture method.

The result from research question and hypothesis one, show difference in the performance of students exposed to 5E learning cycle and Enhanced lecture method. The results from table 2 and table 5 revealed that students exposed to 5E learning cycle performed better than students taught genetics using Enhanced lecture method. Hence the null hypothesis was rejected at 0.05 level of significance. This could be attributed to the fact that 5E learning cycle is activity-oriented, student-centered and involve learners' engagement with learning materials at every step. This is in agreement with the study of Nooradia, *et al* (2020), Okafor (2019) [14], Khan, *et al* (2020) [10], that showed that 5E learning cycle enhanced students' performance more than lecture method.

Performance of students taught genetics using webQuest and those taught with Enhanced lecture method.

The result obtained in tables 3 and 7 shows that students performed better with webQest in comparison to students exposed to Enhanced lecture method. Hence the null hypothesis was rejected at 0.05 level of significance. This is in line with the findings of Alebous (2021) [4], Salic-Hairulla, *et al* (2020) [15] and Uttams (2019) [16], that students taught genetics using webQuest performed better than students taught using the lecture method. This could be because webQuest is inquiry –oriented and encourages student interaction, in which students receive information through the internet, transform it to information that is more meaningful to them, discuss and make meaningful contributions to the topics.

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

Results on tables 4 and 8 indicated that there was no significant difference in the performance of male and female students taught genetics using 5E learning cycle and webQuest.Although the females had slightly higher mean performance score. This finding is in agreement with the findings of Ajaja and Urhievwejire (2019), Irungu, *et al* (2019) [9], that there was no significant interaction effect between method and gender on students' performance.

Conclusions

The study revealed that 5E learning cycle and webQuest was more effective in enhancing students' performance in genetics when compared to Enhanced lecture method. Further on, there was no significant joint interaction effect of method and gender on the performance of students taught genetics.

Recommendations

Based on the findings of this study, the following recommendations are made;

1. Students should be taught genetics using 5E learning cycle and webQuest, as it has been found to be effective in enhancing performance.
2. The 5E learning cycle and webQuest should be adopted by Biology teachers to teach difficult concepts as it is student – centered and activity based.

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