

Effect of Two Instructional Strategies on Students' Achievement at Selected Abstract Concepts

A Case Study on Biology Learning in Kwara State, Nigeria

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ABSTRACT

This study determined the effects of two instructional strategies (Project and Inquiry) on students' achievement in selected abstract concepts of Biology. The study adopted the pretest-posttest control group, a quasi-experimental design. 120 SS II Biology students from six co-educational schools in two Local Government Areas (LGAs) of Kwara state were randomly selected. Participants were randomly assigned to treatment groups. The instruments used were: the Biology Student Achievement Test ($r=0.88$) and Teachers Instructional guides on Project and Inquiry strategies. Two hypotheses were formulated and tested at a 0.05 level of significance. The data collected were analyzed using analysis of covariance, the treatment had a significant main effect on students' achievement on some selected abstract concepts in Biology ($F(2, 107) = 12.061$; $p < 0.05$, partial $\eta^2 = 0.184$). Project strategy (PS) treatment group 1 has the highest adjusted mean achievement scores ($\bar{x}=23.21$) than those in the Inquiry Strategy (IS) treatment group 11 ($\bar{x}=17.81$) and the students in the Conventional Strategy (CS) control group have the lowest adjusted mean achievement scores ($\bar{x}=17.20$). This order is represented as PS > IS > CS. The male students showed greater improvements in mean gain of achievement scores by 21.94 and female students by 17.13. Based on the findings Project and Inquiry strategies should be adopted for the improvement of students' achievement in abstract concepts in biology.

Keywords

Abstract Concept
Achievement
Biology
Inquiry Learning
Project-based Learning

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Introduction

Biology is the science that deals with the study of varieties of living organisms including plants, animals, and micro-organisms. The importance of biology in our daily lives lies in the fact that biology attempts to find out the unifying principles that exist among diverse organisms having morphological and functional inequalities. Biology covers the study of all living things and their interactions in the biosphere. This is a very important task because we can know the behavior or functioning of each population when it faces other individuals from other populations or the specific sectors of the biosphere that are affected and/or benefited by that behavior or functioning of the populations into a community.

Ref. [1] reported that biology plays a crucial role in everyone's lives and touches almost every aspect of our existence. The importance of Biology is shown virtually in all fields of education such as agriculture, medicine, and pharmacy. Ref. [2] and [3] asserted that biology is a very important science subject that offers a basic requirement for further learning of several sciences-related professional courses like medicine, agriculture, pharmacy, and nursing among others.

Biology helps in the production of high-yielding varieties of crop plants and their disease-resistant varieties. Biology helps in minimizing human suffering and curing of hereditary abnormalities like hemophilia, and Down's syndrome. Ref. [4] reported that "the principles of genetics are applied in the field of medicine, agriculture, and science. Ref. [3] stressed the importance of biology that "a sound theoretical and practical knowledge of biology is very necessary for the management of our natural resources, provision of good health facilities for the masses, adequate food supply and favorable life environment. Also, the contributions of the biologist are critical and dynamic in industries, technologies, crime detection, controlling of environmental pollution, disease control, population control, and factual sciences (i.e. biology, physics, and chemistry).

The biology curriculum is designed to provide students with the knowledge of the key concepts in biology, to promote their knowledge of the world around them, as well as develop broadly applicable skills such as problem-solving communication, critical thinking, and objectives reasoning ability to prepare the students for workplace and self-sustainability in the

world economy [5]. The biology curriculum as a teaching subject has the following objectives as provided in the National Policy of Education [4]. They include understanding certain key biological concepts necessary for successful living in a scientific and technological world to illuminate the problems of sex reproduction, growth, pollution health, etc. for the benefit of society: to acquire the ability to apply scientific knowledge to everyday life in matters of personal and community health and agriculture: to make rooms for technological advancement to disperse superstitions beliefs in a technological method.

Even though the Biology curriculum contains reliable objectives for the teaching and learning of biology, it appears that some concepts in the subject are causing problems for the students. According to Ref. [6] genes, cells, chromosomes, genetics, and hormones are considered difficult concepts by secondary school students. The available statistics from the West Africa Examinations Council (WAEC) Chief Examiner's Reports from 2010 to 2018 also affirmed the spite of poor performances of students in some biology concepts. For instance, in WAEC Chief Examiner's reports in 2012 & 2013 showed that many examinees could not define genes, genotypes, gene mutation, and so on. Also, the WAEC Chief Examiner's reports from 2010, 2017 & 2018 revealed that candidates were unable to list transmittable characteristics; inability to draw genetics crosses properly and those candidates who attempted the genetic diagram performed it wrongly [7].

Many studies have explored different instructional strategies for the teaching and learning of biology. For instance, cooperative and inquiry-based methods were researched by Ref. [8], the scientific inquiry method was investigated by Ref. [9], and the genetics exordium method by Ref. [10]. However, not much has been done using two strategies for teaching and learning abstract concepts in Biology. It is this gap that this research work stands to fill. This research study seeks to find out the effect of two instructional strategies (Project and Inquiry) on students' academic achievement in abstract concepts in Biology. It also examined the influence of gender on students' achievement in abstract concepts in biology.

A. Statement of the Problem

The poor performance of students in biology every year in the Senior School Certificate Examination suggests that the teaching strategies used by teachers were inadequate. These strategies did not help students learn and develop a high degree of independence that is required for students to identify resources and communicate effectively. These deficiencies have been found to result in a low turnout of students who gained admission to higher institutions to read Biological science-related courses. Several research studies have been carried out using instructional strategies to address this poor academic performance of the students in the subject (biology). However, it is necessary to carry out a study where students will be equipped with the instructional materials needed to engage in scientific activities that

will remove misconceptions in biology and automatically lead to improvement of the student's performance in the subject.

Thus, this research study, therefore, seeks to determine to what extent the project and inquiry strategies of teaching would help students understand abstract concepts in biology and consequently improve their achievement in biology. It also examined the influence of gender on students' achievement in abstract concepts in biology.

B. Purpose of the Study

The purpose of this study was to investigate the interaction effect of two instructional (Project and Inquiry) strategies and mental ability on students' achievement in abstract concepts in Biology in Kwara State. Specifically, the study sought to;

1. Determine the difference between the achievements mean scores of the students exposed to project and inquiry strategies in abstract concepts in biology and compare them with their counterparts taught using conventional strategy.
2. Find out the effect of treatment (project and inquiry) and gender on student achievement in abstract concepts in biology.

C. Research Questions

Two research questions were formulated to guide the study:

1. What is the difference between the achievements mean scores of the students exposed to project and inquiry strategies in abstract concepts in biology and compared with their counterparts taught using the conventional strategy?
2. Is there any significant gender difference in the achievement mean scores of students exposed to project and inquiry strategies in abstract concepts in biology and their counterparts taught using the conventional strategy?

D. Research Hypotheses

To guide the study two null hypotheses were formulated and were tested at a 0.05 level of significance:

H₀₁: There is no significant difference in the achievements mean score of students exposed to project and inquiry strategies in abstract concepts in biology and their counterparts taught using the conventional strategy.

H₀₂: There is no significant interaction effect of treatment (project and inquiry) and gender on student achievement in abstract concepts in biology and their counterpart taught using the conventional strategy.

Literature Review

The poor performance of students in Biology has all been attributed to the inappropriate methods of teaching mainly used by most biology teachers [1],[11],[12]. Hence

researchers such as Ref. [11], [12] suggested the use of active learning strategies. Among the strategies that have been explored in previous research are; Experiential strategy [12], Inquiry strategy [13], Critical exploration strategy [2],[14], and Puzzled-based Critical Thinking Motivation Strategies [15]. Despite all these strategies, students still experienced a high rate of poor performance in the senior secondary school certificate examinations.

One of the active instructional strategies that caught the notice of researchers is the Project Strategy. The project strategy is an intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning an investigation, researching conjectures, and searching for information and coherent arguments [16],[17]. Project strategy seems to have the components to motivate teachers and students to develop cooperative work mainly aiming at the students to perceive and understand all the necessary stages required to arrive at a logical conclusion [17]. Project instructional strategy is described as a systematic teaching strategy that engages students in learning knowledge and skills through an extended inquiry process structured around complex, authentic questions and carefully designed products and tasks [5],[18]. The project strategy of teaching involves assigning a particular work to students to complete during his/her/their spare time and reporting back to the teachers when demanded.

Inquiry strategy on the other hand is a student and teacher-centered instructional strategy that engages students in investigating real-world questions that they choose within a broad thematic framework. Inquiry is a style or strategy of teaching where the learner seeks to discover and create answers to a recognized problem through the procedure of making a diligent search with minimum guidance from the teacher [19]. Inquiry is often widely used in other terms such as inquiry-based teaching and inquiry-based strategy without clarifying connections and distinctions [6],[9]. Inquiry strategy involves investigation, searching, defining a problem, formulating a hypothesis, gathering and interpreting data, and arriving at a conclusion. The teacher needs to shift to learner-centered strategies of teaching by giving assignments and class activities that will challenge the learner's imagination.

In the course of focusing on the students' performance discussing gender usually suffice. Gender has also remained an important issue that is relevant to the field of education because it has been linked with students' achievement. Gender refers to the classification of human beings based on sex due to the roles they perform. Most studies show that on average girls do better in school than boys [2],[19]. The study of Ref. [20] also shows that females are better at spelling and perform better on tests of literacy, writing, and general knowledge in education. In contrast, Ref. [21] showed that women were not only under-represented but their levels of achievement in the fields of sciences and technology were low compared to the males.

Methods

This study adopted the pretest-posttest control group quasi-experimental research design. The population consisted of all senior school students in Oke-ero and Irepodun Local Government Areas while the target population comprised senior school students in SSS II offering Biology. A sample of 120 students was randomly selected using balloting. Six instruments were used for data collection which are Abstract Concepts in Biology Achievement Test, the achievement test consists of two sections, A and B. Section A seeks personal information on the students while section B consists of the achievement test made up of 30 items. Originally, 60 questions were set on abstract concepts. The questions were given to four teachers teaching biology in secondary school and one experienced evaluator to establish the validity of the questions. This was carried out to ascertain whether the instrument was fit for the students. After their scrutiny, 50 questions were left.

These 50 questions were the one that falls within the discriminating power of 4-7 as those that fall below 4 were considered too simple and those that fall above 7 were considered to be difficult for the students. The questions were trial-tested in a secondary school that was not nominated for the research study. Kr 20 was used in analyzing the data and 0.86 was obtained as the reliability coefficient. Teachers' Instructional guides on Project, Inquiry, and Conventional strategies, and Evaluation Sheet for Assessing Teacher's Performance during Training. The draft of the Teacher's Guide on (project, inquiry, and conventional) strategies and evaluation sheet was given to five experienced Biology tutors in selected secondary schools. This was done to ensure the face, content and construct validity of the guide and evaluation sheet. These teachers are seasoned WAEC, NECO, and NABTEB examiners, and based on their comments and suggestions necessary amendments were made.

The researchers administered the instruments as a pre-test and the student's scores were recorded. Thereafter, the researchers taught the experimental groups 1 and 2 the abstract concepts using project and inquiry strategies, while the control group was taught with the conventional method. The abstract concepts that were selected for this study were related to evolution molecular Biology and genetics. The treatment lasted for six weeks. The data collected were analyzed using descriptive statistics, Analysis of Covariance, and Scheffe Posthoc test at 0.05 level of significance.

Results

A. Research Question one

What is the difference between the achievements mean scores of the students exposed to project and inquiry strategies in abstract concepts in biology and compared with their counterparts taught using the conventional strategy?

Table 1. Descriptive Statistics of Achievement Associates with Treatment

Parameter	Achievement Scores		
	Project Strategy	Inquiry Strategy	Conventional Strategy
No of cases	34	46	40
Pre-test mean	13.09	9.63	9.98
Pre-test SD	3.11	2.67	3.08
Post-test mean	23.21	17.80	17.20
Post-test SD	3.01	5.01	5.81
Mean Gain	+9.12	+8.17	+7.22

Table 1 shows the descriptive statistics of the student's achievement scores. The mean gain score for project strategy was 9.12 while that of inquiry strategy was 8.17 over that of conventional strategy which was 7.22. Thus, the project strategy had a higher mean gain than the inquiry strategy while the inquiry strategy had a higher mean gain than the conventional strategy.

H_{01} : There is no significant difference between the achievements mean score of students exposed to project and inquiry strategies in abstract concepts in biology and their counterparts taught using the conventional strategy

Table 2. ANCOVA of post-test achievement scores of students by treatment, mental ability, and Gender

Source	Sum Squares	of df	Mean Square	F	Sig.	Eta Squared
Corrected Model	1749.922	12	145.827	87.27	.000	.495
PREACH	31.183	1	31.183	1.866	.175	.017
Main Effect: Treatment Group	403.061	2	201.530	12.061	.000*	.184
Mental Ability	75.354	1	75.354	4.510	.036*	.040
Gender	26.390	1	26.390	1.579	.212	.015
2-ways Interactions	100.449	2	50.225	3.006	.050*	.053
Treatment x Mental Ability	49.557	2	24.778	1.483	.232	.027
Treatment x Gender	60.473	1	60.473	3.635	.059	.033
3-way Interaction	192.386	2	96.193	5.757	.004*	.097
Treatment x Mental Ability x Gender						
Error	1787.945	107	16.710			
Total	47468.000	120				
Corrected Total	3537.867	119				

*Significant at $p < 0.05$

Table 2 shows that there was a significant main effect on treatment on the Academic Achievement of the Students ($F_{2, 107} = 12.061$ $P < .05$, $\eta^2 = 0.184$). The effect size of 18.49% was fair. Therefore, the null hypothesis is rejected. This means that there was a significant difference in the mean achievement scores of subjects exposed to treatment based on these findings, hypothesis 1 was rejected.

Table 3. Scheffe Post-hoc Tests Analysis of Post-tests Achievement Score According to Treatment Group

Treatment	N	Mean	Project strategy	Inquiry strategy	Conventional strategy
Project strategy	34	23.21		*	*
Inquiry strategy	46	17.81	*		*
Conventional strategy	40	17.26	*	*	

Pairs of groups significantly different at $P < 0.05$

Furthermore, the source of the significant difference obtained in Table 4 was traced using the Scheffe post-hoc test as presented in Table 4. Table 4 revealed that group 1 (project strategy) was significantly different from Inquiry and conventional strategies in their achievement scores. Inquiry strategy was significantly, different from project and conventional strategies in achievement scores. These reveal that the direction of increasing effect of instructional strategy (treatment) on abstract concept achievement was a conventional strategy not performing better than the Inquiry strategy, Inquiry strategy not performing better than the project strategy.

B. Research Question two

Is there any significant gender difference in the achievement mean scores of students exposed to project and inquiry strategies in abstract concepts in biology and their counterparts taught using the conventional strategy?

Table 4. Descriptive Statistics of Achievement Associates with Gender

Parameter	Achievement Scores	
	Male	Female
No of cases	50	70
Pre-test mean	11.20	10.39
Pre-test SD	3.52	3.07
Post-test mean	21.94	17.13
Post-test SD	4.13	5.42
Mean Gain	+10.74	+6.74

Table 4 displays the descriptive statistics of the students' achievement scores with gender. There were greater improvements in the mean gain achievement scores for male students (10.74) than for female students (6.74).

H_{02} : There is no significant interaction effect of treatment (project and inquiry) and gender on student achievement in abstract concepts in biology and their counterpart taught using the conventional strategy.

Table 2 revealed that gender had no significant main effect on the academic achievement of the students ($F_{(1,107)} = 1.579$ $P < 0.05$. partial eta square (η^2) = 0.015. The effect size of 1.5% was fair. Therefore, hypothesis two was not rejected

Discussion

The study examined the effect of two instructional strategies (project and inquiry) on student's achievement in abstract concepts in biology. The research questions were aimed at evaluating the academic achievement of biology students in the pre-test and post-test of the control and the experimental groups based on abstract concepts in biology. The result from Table 1 indicated that the mean score of the post-test of the experimental group was higher than that of the mean score of the post-test of the control group and from Table 4, the male respondents from the experimental group had a higher mean score than their female counterparts.

The results obtained from the study in Table 2 revealed that there was a significant interaction effect of treatment on students' academic achievement in abstract concepts in Biology. The findings show that both strategies (project and Inquiry strategies) enhanced students' achievement over and above the conventional strategy. This result suggests that the project strategy effectively disseminated the achievement of learners exposed to it more than those exposed to the Inquiry strategy and conventional strategies. These may be attributed to the systematic and organized nature of the project and Inquiry strategies developed and implemented in the course of the research study in which the learners were allowed to engage in various learning activities that enabled them to find out and develop their knowledge of the abstract concepts individually or in groups and use their thinking skills for planning, execution, evaluation, reporting, and recording. They also formulated hypotheses, gathered materials, recorded and analyzed data, and concluded the lessons all by themselves with minimal teacher interference.

Furthermore, the involvement of the students in the experimental group activities led to more understanding of abstract concepts in biology and the removal of misconceptions about such concepts. This result is in agreement with Ref. [18] who worked on three teaching strategies project, demonstration, and lecture strategies. It was found that students exposed to project strategies brought about the most significant improvement in their achievement scores. This finding is also supported by Ref. [8] who affirmed that project strategy is more effective than other strategies because it allows the students to study on their own. The findings were also supported by Ref. [22] which suggested that the project strategy encouraged collaboration among the students.

Inquiry strategy when compared with the conventional strategy by Ref. [23] analysis showed that the Inquiry strategy was more effective. The findings further showed that the

Inquiry strategy contributed significantly to a better understanding of biological abstract concepts by students than their counterparts treated with conventional strategy. This study is in support of Ref. [13] who found that the guided Inquiry strategy of teaching biology enhanced achievement better than the conventional strategy. The poor performance of the conventional strategy in the post-test achievement mean score when compared with the other treatment groups meant scores may not be unconnected with the fact that the group was exposed to the strategy which is a teacher-centered conventional strategy to only allow students to listen passively, with little or no interaction with the teacher's meanwhile low achievement in conventional strategy repeats itself in this study as it was in the findings of Ref. [18],[23]. This is because conventional strategy often compels learners to the passive recipient position of fact subjected down to (him/her) by the teachers.

Moreover, the study showed that gender has no significant main effect on students' achievement. That is, gender did not influence achievement. Some researchers reported that there is a significant effect of gender on the achievement of students, however, the findings of this work disagree with the research findings of Ref. [13], which established significant differences in treatment and gender on students' achievement. This finding is in mutual agreement with the findings of [15], and [23] who found that gender did not have a significant main effect on students' achievement. The reason was that both males and females were given the same opportunity to participate actively in the classroom activities which were the function of the two strategies (project and Inquiry). The two strategies disallow discrimination or gender marginalization.

Conclusion

The findings of this study have shown that project and inquiry strategies are more effective in improving students' academic achievement in abstract concepts in biology than the traditional or conventional teaching strategy. The reason for this was that the two instructional strategies enhanced the development of critical thinking of students because it allowed them to actively participate in learning activities and create a positive environment for effective interaction. It is noteworthy that students showed a higher level of commitment and involvement in solving abstract concepts and related problems in biology when taught using these strategies.

Limitation and Suggestions

From the results obtained and the discussion made, the following recommendations are therefore made

1. Project and inquiry instructional strategies should be adopted as effective and viable strategies for studying abstract concepts in biology.

2. Biology teachers should develop activities that will give room for learners to actively participate in the teaching and learning process.
3. In-service biology teachers should vary and use instructional strategies that align with students' mental ability rather than stick with only one method of instruction.

Conflict of Interest

The authors declare that there is no conflict of interest.

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