



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

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ABSTRACT

This study determined the effects of two instructional strategies (Project and Inquiry) on students' achievement in selected abstract concepts in Biology. The study adopted the pretest-posttest control group, quasi-experimental design. 120 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: Biology Student Achievement Test and Teachers' Instructional Guides on Project and Inquiry strategies. Two hypotheses were formulated and tested at the 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. Project strategy (PS) treatment group 1 has the highest adjusted mean achievement scores than those in the Inquiry Strategy (IS) treatment group 11, and the students in the Conventional Strategy (CS) control group have the lowest adjusted mean achievement scores. This order is represented as PS > IS > CS. The male students showed greater improvements in mean gain of achievement scores than the female students. Based on the findings, Project and Inquiry strategies should be adopted for the improvement of students' achievement in abstract concepts in biology.

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1. INTRODUCTION

Biology is the science that deals with the study of varieties of living organisms, including plants, animals, and microorganisms. 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 with 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 within a community. Some researchers 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 in virtually all fields of education, such as agriculture, medicine, and pharmacy. Some researchers asserted that biology is a very important science subject that offers a basic requirement for further learning of several science-related professional courses like medicine, agriculture, pharmacy, nursing, among others.

Biology helps in the production of high-yielding varieties of crop plants and disease-resistant varieties. Biology helps in minimizing human suffering and curing hereditary abnormalities like hemophilia and Down syndrome. Some researchers (Muhammad-Jamiu & Muraina, 2023) reported that "the principles of genetics are applied in the field of medicine, agriculture and science. Some researchers 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 favourable life environment. Also, the contributions of the biologist are critical and dynamic in industries, technologies, crime detection, controlling environmental pollution, disease control, population control, and factual sciences (i.e., biology, physics, and chemistry).

Biology curriculum is design 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 work place and self-sustainability in the world economy (Khan & Muraina, 2023). The biology curriculum as a teaching subject has the following objectives as provided in the National Policy of Education (Muhammad-Jamiu & Muraina, 2023). They include. to understand 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 the society: to acquire ability to apply scientific knowledge to everyday life in matters of personal and community health and agriculture: to make room 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 giving problems to the students. Genes, cells, chromosomes, genetics, and hormones are considered difficult concepts by secondary school students (Josephine & Muraina, 2023). The available statistics from the West Africa Examinations Council (WAEC) Chief Examiner's Reports in 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, and 2018 also affirmed the plight of poor performance of students in some biology concepts. For instance, in WAEC Chief Examiner's reports in 2012 and 2013, showed that many examinees could not define gene, genotypes, gene mutation, and so on. Also, the WAEC Chief Examiner's reports in 2010, 2017, and 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.

The poor performance of students in Biology has all been attributed to the inappropriate methods of teaching mainly used by most biology teachers (Adewumi and Adeoye, 2023; Awolere, 2015). Hence, researchers (Awolere, 2015) suggested the use of active learning strategies. Among the strategies that have been explored in previous research are: Experiential strategy (Awolere, 2015), Inquiry strategy (Muraina *et al.*, 2021), Critical exploration strategy, Puzzled-Based Critical Thinking Motivation Strategies. 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 has caught the notice of researchers is the Project Strategy. Project strategy is an intentional process of diagnosing problems, critiquing experiments, distinguishing alternatives, planning investigation, researching conjectures, searching for information, and developing coherent arguments (Anette & Maija, 2022). 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 (Anette & Maija, 2022). 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 (Khan & Muraina, 2023; Olatoye & Adekoya, 2010). Project strategy of teaching involves assigning a particular work to students to complete during//their spare time and report back to the teachers as at 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 procedure of making a diligent search with minimal guidance from the teacher (Muraina *et al.*, 2023). Inquiry is often widely used in other terms, such as inquiry-based teaching and inquiry-based strategy, without clarifying connections and distinctions (Josephine & Muraina, 2023; Muraina & Oladele, 2023). 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 learners' imagination.

In the course of focusing on the students' performance was discuss gender is usually sufficient. 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 (Muraina *et al.*, 2023). Some researchers (Yuniskurin *et al.*, 2019) also show that females are better at spelling and perform better on tests of literacy, writing, and general knowledge in education. In contrast, some researchers (Okafor, 2021) showed that women were not only under-represented but their levels of achievement in the fields of sciences and technology were low compared to those of males.

Many studies have explored different instructional strategies for the teaching and learning of biology. For instance, cooperative and inquiry-based methods were researched, the scientific inquiry method was investigated (Muraina & Oladele, 2023), and the genetics exordium method (Yan, 2019). 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 academic achievement in abstract concepts in Biology. It also examined the influence of gender on students' achievement in abstract concepts in biology.

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, which is required for students to identify resources and communicate effectively. These deficiencies had been found to result in 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 the 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 in the students' 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 in the understanding of abstract concepts in biology and consequently improve the achievement in biology. It also examined the influence of gender on students' achievement in abstract concepts in biology.

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;

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

Two research questions were formulated to guide the study:

- (i) What is the difference between the achievement mean score of the students exposed to project and inquiry strategies in abstract concepts in biology, and compared with their counterparts taught using a conventional strategy?
- (ii) 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?

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

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

2. 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 included the 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 is 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 of 0.86 was obtained as reliability coefficient. Teachers' Instructional guides on Project, Inquiry, and Conventional strategies, and Evaluation Sheet for Assessing Teachers' Performance during Training. The draft of the Teacher's Guide on (project, inquiry, and conventional) strategies and the evaluation sheet were 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 students' 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 and molecular Biology, and genetics. The treatment lasted for six weeks. The data collected were analyzed using descriptive statistics, Analysis of Covariance, and Scheffe post hoc test at a 0.05 level of significance.

3. RESULTS AND DISCUSSION

3.1. Research Question One: What is the difference between the mean score of the students exposed to project and inquiry strategies in abstract concepts in biology, and compared with their counterparts taught using a conventional strategy?

Table 1 shows the descriptive statistics of the students' 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.

Table 1. Descriptive statistics of achievement associated with treatment.

Parameter	Achievement Scores		
	Project Strategy	Inquiry Strategy	Conventional Strategy
No of cases	34.00	46.00	40.00
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

3.2. 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 2 displays the descriptive statistics of the students' achievement scores by gender. There were greater improvements in the mean gain achievement scores for male students (10.74) than for female students (6.74).

Table 2. Descriptive statistics of achievement associated 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

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

Table 3 shows that there was a significant main effect of 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. ANCOVA of post-test achievement scores of students by treatment, mental ability, and Gender.

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Corrected Model	1749.922	12	145.827	87.27	0.000	0.495
PREACH	31.183	1	31.183	1.866	0.175	0.017
Main Effect: Treatment Group	403.061	2	201.530	12.061	0.000*	0.184
Mental Ability	75.354	1	75.354	4.510	0.036*	0.040
Gender	26.390	1	26.390	1.579	0.212	0.015
2-ways Interactions	100.449	2	50.225	3.006	0.050*	0.053
Treatment x Mental Ability						
Treatment x Gender	49.557	2	24.778	1.483	0.232	0.027
Mental Ability x Gender	60.473	1	60.473	3.635	0.059	0.033
3-way Interaction	192.386	2	96.193	5.757	0.004*	0.097
Treatment x Mental Ability x Gender						
Error	1787.945	107	16.710			
Total	47468.000	120				
Corrected Total	3537.867	119				

*Significant at $p < 0.05$

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. The inquiry strategy was significantly different from project and conventional strategies in achievement scores. These results reveal that the direction of increasing effect of instructional strategy (treatment) on abstract concept achievement was conventional strategy, not performing better than Inquiry strategy, and Inquiry strategy not performing better than project strategy.

Table 4. 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 are significantly different at $P < 0.05$

3.4. 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 3 reveals 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.

3.5. Discussion of Findings

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 experimental groups based on the 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 control group, and from **Table 2**, the male respondents from the experimental group had a higher mean score than their female counterparts.

The results obtained from the study in **Table 3** 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 than those exposed to the Inquiry strategy and conventional strategies. These may be attribute 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 activity 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 in activities led to more understanding of abstract concepts in biology and the removal of misconceptions about such concepts. This result is in agreement with previous studies (Olatoye & Adekoya, 2010) who worked on 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. These findings are also supported by previous studies, which affirmed that project strategy is more effective than other strategies because it affords students the 'to study on their own. The findings were also supported by the Buck Institute for Education in 2002, which suggested that the project strategy encouraged collaboration among the students.

Inquiry strategy, when compared with conventional strategy (Akinwumi, 2009), 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 the conventional strategy. This study is in support (Muraina et al., 2021), 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 compare with the other treatment groups meant scores may not be unconnected with the fact that the group was exposed to the strategy which is teacher-centered conventional strategy to only allow students to listen passively, with little or no interaction with the teacher's mean while low achievement in conventional strategy repeats itself in this study as it was in the findings (Olatoye & Adekoya, 2010). This is because conventional strategy often compels learners to the passive recipient position of facts being subjected 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 research findings (Muraina et al., 2021), which established significant differences in treatment and gender on students' achievement. This finding is in mutual agreement with the findings, 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.

4. CONCLUSION

The findings of this study have shown that project and inquiry strategies are 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 in students because they 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.

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

- (i) Project and inquiry instructional strategies should be adopted as effective and viable strategies for studying abstract concepts in biology.
- (ii) Biology teachers should develop activities that will give room for learners to actively participate in the teaching and learning process.
- (iii) 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.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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