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EFFECT OF INQUIRY-BASED LEARNING ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN GENETICS

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Abstract

A fundamental understanding of heredity and variation by secondary school students, predicate the need for teaching methods that foster critical thinking, problem solving and informed decision making which also promote interest and achievement gains in the subject. Thus, informing the current study which sought to examine the effect of inquiry-based learning (IBL) on secondary school students' achievement in genetics. Despite earlier studies the need to address students' achievement in genetics persists. Two research questions and two hypotheses guided he study. Quasi experimental pretest-post-test was the study design. Population of the study comprised 13, 596 biology students in Anambra State Public Secondary Schools. The sample size was made up of 300 SS3 biology students (134 male and 166 females) drawn from 6 intact classes of 135 (54 males and 81 females) with experimental group 165 (80 males and 85 females) and control group randomly assigned. The instruments for data collection Genetic Achievement Test (GAT) reliably established at coefficient of 0.86 respectively. Research questions were answered using mean and standard deviation while ANCOVA was used to test the hypotheses at 0.05 level of significance. Results revealed a p-value of 0.000 in achievement. Hence, rejecting the corresponding null hypotheses. Also, with a p-value of 0.905 for male and female students' achievement, the result accepted the null hypotheses for achievement. By implication, students exposed to IBL achieved significantly higher achievement than those exposed to lecture method. However, there is no significant difference in male and female students' mean achievement. Major contribution to knowledge of this study is that this study established that exposure of secondary school students to IBL approaches is essential in enhancing deeper learning for understanding of genetics and other science subjects, while improving their soft, investigative and critical thinking skills which are necessary in leveraging their future career paths and employability after school.

Keywords: Achievement, Biology, Inquiry Based Learning,

Introduction

Biology is the scientific study of life. It is the application of scientific reasoning and logic to foster an enhanced understanding of life. It is the branch of science that is basically concerned with the study of life in relation to natural environment (Okoye, 2019). It cuts across not only understanding of life and its natural environment but how phenomena within the natural environment affects life and could be manipulated to favour life. Aside understanding the natural environment in favour of life, Biology equip learners with necessary skills to build a progressive society. Also, the knowledge of Biology among others seek to provide knowledge, applied skills and competencies that are necessary for medical, agricultural, industrial and socio-economic boom. Provision of knowledge, applied skills and competencies

necessary for medical, agricultural, industrial and socio-economic boom, are in consonance with new discoveries in some Biology concepts such as genetics, which has significantly improved various aspect of human existence such as agriculture, security, population control, paternity issues among others.

Genetics is the scientific study of hereditary and variation in living things, with special focus on establishing the scientific basis for understanding of how characteristics or traits are transferred from parents to their offspring and from one generation to another (Obiakor, 2020). In recent times, the knowledge and principles of genetics has resulted in economic explosion of the industrial sector, offering significant boom in the areas of agriculture and food security through improving quality of crops and animals (Abdulahi, 2022). However, despite the importance of genetics, students have continued to achieve poorly in the content. Hence, raising serious concern to Biology Educators. Inability to demonstrate conceptual understanding of the concept, think critically and apply specific scientific logic were some of the weakness identified by WAEC Chief Examiner as contributing to the achievement gap in genetics. It also follows that students' inability to achieve meaningfully in genetics contributes to their overall achievement gap in Biology. Research effort so far in addressing achievement issues in genetics seems not enough and are delimited to enhancing conceptual understanding through learner engagement. However, conceptual understanding of genetics may not be feasible unless instructions are planned and presented in a manner that will engage students through series of investigative processes as well as independent knowledge creation as obtained in inquiry-based learning.

Inquiry-based learning (IBL) is a pedagogical approach that emphasizes student-driven exploration and critical thinking. Studies in favor of inquiry-based learning revealed improved retention and achievement in the areas of Chemistry, Mathematics and Basic Science respectively. It is therefore unknown whether inquiry-based learning will replicate same improvement in Biology specifically genetics. Perhaps, as Biology students are drilled through the investigative learning and independent knowledge creation processes of inquiry, their interest may be sustained and by extension enhance their achievement in genetics. From the fore going, the current research therefore seeks to investigate the achievement and interest of Biology students in genetics when exposed inquiry-based learning irrespective of their gender.

The findings of the study would be beneficial to: Biology teachers and students, Curriculum planners, Government and Ministries of Education, Co-researchers, and Professional bodies among others. The study was carried out in Anambra state using 300 SS3

students of public coeducation secondary schools in Anambra state. The research design for the study was a quasi- experimental design with a validated "Genetic Achievement Test" (GAT) as instrument for the data collection. All the research questions will be answered using mean and standard deviation while Analysis of Covariance (ANCOVA) will be used to test the hypotheses at .05% level of significance.

Purpose of the study

1. The mean achievement scores of students taught genetics using inquiry-based learning and those taught using lecture method of instruction.
2. The mean achievement scores of male and female students taught genetics using inquiry-based learning and those taught using conventional method of instruction.

Research Questions:

1. What is the difference in the mean achievement scores of students taught genetics using inquiry-based learning and those taught using conventional method of instruction?
2. What is the difference in the mean achievement scores of male and female students taught genetics using inquiry-based learning and those taught using conventional method of instruction?

Hypotheses

1. There is no significant difference in the mean achievement scores of students taught genetics using inquiry-based learning and those taught using conventional method of instruction.
2. There is no significant difference in the mean achievement scores of male and female students taught genetics using inquiry-based learning and those taught using conventional method of instruction.

Methods

The research design adopted for this study was the pretest-posttest non-equivalent control group quasi-experimental design**,** due to the use of intact classes without random assignment. According to Cohen, Manion, and Morrison (2018), this design allows for comparison between experimental and control groups using pretest and posttest measures and helps control threats to internal validity such as history, maturation, and testing effects. The study was conducted in Anambra State involving 300 SS3 Biology students drawn from six coeducational public secondary schools**.** The students were divided into two groups: experimental (IBL) and control (lecture method)**.** Each school had two intact SS3 classes,

randomly assigned as either experimental or control group to avoid disrupting school schedules.

Qualified Biology teachers with B.Ed. or B.Sc. (Ed) Biology and a minimum of three years teaching experience were trained for one week using the validated IBL lesson plans. The training involved micro-teaching sessions monitored by the researcher to ensure consistency in instructional delivery across schools. The instrument used was the Genetics Achievement T**est** (GAT), a researcher-developed 40-item multiple-choice test based on senior secondary school genetics curriculum and WASSCE past questions. The test was validated by experts in Science Education, and the reliability determined using Kuder-Richardson formula 21 (KR-21), yielding a reliability index of 0.74. The GAT was administered as both pretest and posttest to students in both groups. Section A of the test collected demographic data (e.g., gender), while Section B contained the test items. The experimental group was taught genetics using IBL strategies, including questioning, exploration, group investigation, hypothesis formulation, and conclusion drawing. The control group received instruction through the conventional lecture method. The treatment lasted for **s**ix weeks. Data collected were analyzed using mean and standard deviation to answer the research questions, while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Results

Research Question One: What is the mean achievement scores of students taught genetics using inquiry based learning and those taught using lecture method of instruction?

Table 1: Mean achievement scores of students taught genetics using inquiry-based learning and those taught using lecture method of instruction.

Group	N	Post-Test Score (A)		Pre-Test Score (B)		Mean Difference Score (A – B)
		Mean	SD	Mean	SD	
IBL (Experimental group)	135	88.00	12.80	27.50	6.90	60.50
Lecture Method (Control Group)	165	58.00	15.20	29.50	7.70	28.50

Table 1 presents the pretest and posttest mean achievement scores of students taught genetics using Inquiry-Based Learning (IBL) and the Lecture Method. The IBL group had a pretest mean of 27.50 (SD = 6.90) and a posttest mean of 88.00 (SD = 12.80), resulting in a mean gain of 60.50. The Lecture Method group recorded a pretest mean of 29.50 (SD = 7.70)

and a posttest mean of 58.00 (SD = 15.20), with a mean gain of 28.50. Thus, students taught with IBL outperformed those taught with the Lecture Method by 32.00 points, indicating that IBL led to significantly higher achievement in genetics.

Research Question Two: What is the mean achievement scores of male and female students taught genetics using inquiry based learning?

Table 2: Mean achievement scores of male and female students taught genetics using inquiry-based learning.

Gender	N	Post Test Score (A)		Pre Test Score (B)		Mean Difference Score (A – B)
		Mean	SD	Mean	SD	
Male	54	81.50	11.20	22.00	7.50	59.50
Female	81	70.30	13.80	23.50	9.30	46.80

Table 2 shows the pretest and posttest mean scores of male and female students taught genetics using Inquiry-Based Learning (IBL). Males had a pretest mean of 22.00 (SD = 7.50) and a posttest mean of 81.50 (SD = 11.20), yielding a gain of 59.50. Females had a pretest mean of 23.50 (SD = 9.30) and a posttest mean of 70.30 (SD = 13.80), with a gain of 46.80. This indicates that male students achieved 12.70 points more than their female counterparts, suggesting a higher improvement in genetics among males exposed to IBL.

Hypotheses Testing

Table 3: Analysis of covariance (ANCOVA) of students' interest and achievement in genetics.

Test Variables (Method)	Df	Mean Square	F-Value	Sig	Remark
Treatment effect on Achievement	1	50234.678	162.589	.000	S

Ho1: There is no significant difference in the mean achievement scores of students taught genetics using inquiry-based learning and those taught using the lecture method of instruction

Data presented in Table 3 (1) indicate the level of significance of the effect of Inquiry-Based Learning (IBL) on student achievement in genetics. The calculated F-value is 162.589, with a significant value of 0.000. Since the probability value (0.000) of the F-statistic (162.589) is less than the 0.05 level of significance, the study rejects the null hypothesis that "there is no significant difference in the mean achievement scores of students taught genetics using inquiry-

based learning and those taught using the lecture method of instruction." This indicates that students taught genetics using inquiry-based learning significantly achieved higher than those taught using the lecture method.

Table 4: Analysis of covariance (ANCOVA) of gender effect on achievement in Genetics

Test Variables (Gender)	Df	Mean Square	F-Value	Sig	Remark
Effect of gender on achievement	1	3.245	0.014	.905	NS

Ho_2: There is no significant difference in the mean achievement scores of male and female students taught genetics using inquiry-based learning.

Data presented in Table 4 (1) indicate the level of significance of the effect of gender on students' achievement in genetics. The calculated F-value is 0.014, with a significant value of 0.905. Since the probability value (0.905) of the F-statistic (0.014) is greater than the 0.05 level of significance, the study fails to reject the null hypothesis that "there is no significant difference in the mean achievement scores between male and female students taught genetics using inquiry-based learning." This suggests that gender does not significantly affect the achievement of students exposed to inquiry-based learning in genetics.

Discussion

Achievement of students taught genetics using Inquiry-Based Learning (IBL) is significantly higher than those taught with the conventional lecture method. This suggests that the use of IBL in teaching genetics enhances students' academic performance in Biology. The use of IBL aligns with the nature of Biology as a science that thrives on observation, experimentation, reasoning, and discovery. It engages students actively and allows them to explore, inquire, and build knowledge independently traits that are essential in mastering a complex Biology concept like genetics. The drastic improvement in achievement scores for students taught with IBL compared to their peers in the lecture group indicates that IBL fostered deeper conceptual understanding and retention. Thus, students exposed to IBL were better able to understand hereditary principles, critical for applying scientific logic in solving real-life problems, such as improving crop yield, disease resistance, and understanding paternity issues.

The improved performance can also be explained by the fact that IBL places students at the center of learning. In this process, learners construct knowledge through guided discovery and investigative activities that mirror scientific inquiry. As emphasized in the study's theoretical framework, this pedagogical process mirrors the scientific nature of

Biology, making it easier for students to relate content with real-life applications. The practical and problem-solving orientation of IBL bridges the gap between abstract concepts and tangible experiences, which likely contributed to the achievement gains observed. These findings agree with those of Nwagbo (2016) and Ibe and Nwosu (2017), who reported that student-centered and inquiry-based strategies significantly improve students' performance in science subjects.

Furthermore, the study showed that while male students recorded slightly higher mean achievement scores than their female counterparts when taught with IBL, the difference was not statistically significant. This indicates that gender does not significantly influence achievement in genetics under IBL. This finding is critical, as it suggests that effective instructional strategies like IBL can equalize academic opportunities for all learners, regardless of gender. Both male and female students demonstrated meaningful learning outcomes when exposed to inquiry-driven teaching, further reinforcing the universal effectiveness of IBL. This finding corroborates those of Danjuma (2015), Muhammad (2017), and Hayatu & Okoronka (2016), who all reported no significant gender influence on students' achievement in science and mathematics when effective teaching methods were used.

However, the finding contrasts with those of Gupta, Pasrija, and Kavita (2015) and Oluwatelure (2015), who reported gender-based achievement differences in similar science-related studies. These contrasting findings may be due to differences in subject matter, cultural contexts, or instructional delivery methods. The implication of this finding is that instructional strategy not gender is the key determinant of academic achievement in challenging science topics like genetics. When learners are exposed to methods that actively engage them and align with the scientific nature of the subject matter, they perform better irrespective of their gender. Inquiry-Based Learning, in this case, addressed the weaknesses highlighted by the WAEC Chief Examiner, such as lack of conceptual understanding and poor application of scientific reasoning, by involving students in hands-on, minds-on learning.

In summary, the study has revealed that Inquiry-Based Learning significantly enhances students' achievement in genetics, a critical component of the Biology curriculum. The method fosters deeper understanding, builds scientific skills, and supports academic equity across gender lines. Its implementation in classrooms, especially for difficult Biology concepts like genetics, could help reverse poor achievement trends and equip students with the knowledge and skills necessary for Nigeria's medical, agricultural, and socio-economic advancement.

Conclusion

The use of the Inquiry-Based Learning (IBL) approach in teaching Biology (genetics) significantly enhanced students' achievement in genetics compared to the conventional lecture method. The approach facilitated deeper conceptual understanding, encouraged active student participation, and promoted scientific reasoning. Furthermore, gender differences among students exposed to IBL were not statistically significant, indicating that IBL is equally effective for both male and female students in genetics learning.

Recommendations

The following recommendations were made based on the findings and conclusion of the study:

1. Biology teachers should adopt the Inquiry-Based Learning (IBL) approach to effectively engage students in hands-on learning, foster scientific investigation, and improve achievement in complex Biology topics such as genetics.
2. The Ministry of Education, State Education Boards, and other stakeholders should organize regular workshops, training, and seminars for Biology teachers to expose them to the practical application of IBL strategies in classroom instruction.
3. Curriculum developers should integrate and emphasize IBL strategies in the Biology curriculum, especially for conceptually demanding topics like genetics, to ensure meaningful learning experiences for all students.
4. Teacher training institutions should incorporate IBL methodology into their training programs to equip prospective Biology teachers with the pedagogical skills necessary for implementing inquiry-based strategies effectively.
5. Since IBL was found not to be gender-biased, it should be promoted as an equitable teaching method capable of supporting both male and female students to achieve academic success in science subjects.

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