Faculty of Natural and Applied Sciences Journal of Mathematics and Science Education
Print ISSN: 2814-0885 e-ISSN: 2814-0931
www.fnasjournals.com
Volume 5; Issue 3; March 2024; Page No. 108-115.

Flipped Classroom Learning and Academic Achievement in Genetics Concepts among Secondary School Students in Gusau, Zamfara State, Nigeria

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Abstract
This study investigated the effects of flipped classroom learning on academic achievement in genetics concepts among secondary school students in Gusau, Zamfara State, Nigeria. The study adopted a Quasi-experimental design. The population of the study comprised 5,804 SS 3 students of the 2020/2021 session from 29 senior secondary schools in Gusau Local Government Area, Zamfara State, Nigeria. The sample of the study consisted of 279 SS 3 Biology students drawn using a multistage sampling technique. An instrument tagged the Genetics Concepts Achievement Test (GCAT) was adapted and used for data collection. The GCAT was validated by experts and has a reliability coefficient of 0.78. Mean and standard deviation were used to answer the research questions, while the Z-test was utilized to test the hypotheses at a 0.05 level of significance. The results revealed that Flipped Classroom Learning led to greater improvement in students' academic achievement in genetic concepts compared to the lecture method with a significant difference observed in the mean academic achievement scores. The study also revealed that there is no significant difference in the mean academic achievement of male and female students taught genetics concepts using Flipped Classroom Learning. Based on the findings, it was recommended that Biology teachers should be encouraged to use Flipped Classroom Learning as the main strategy to teach genetics concepts in senior secondary schools. Also, Biology teachers should be trained by the Ministry of Education and other education agencies on effective procedures for implementing Flipped Classroom Learning in their classrooms by organizing seminars and workshops.

Keywords: Flipped Classroom Learning, Academic Achievement, Genetics Concepts, Secondary School Students.

Introduction

Biology is the study of different forms of living things, their evolution, structures, functions, growth, distribution and taxonomy (Ibe & Ukpai, 2013). It serves as a pre-requisite to the study of other professions like medicine, anatomy, nursing, pharmacology, biochemistry and agriculture among others. The vital role of the study of Biology in the economic, industrial and public life of the learners and the general humanity cannot be overstressed (Akambi & Kolawole, 2014). Considering how biological knowledge is related to building a sustainable relationship between nature and human society, the roles of Biology education need to be thoroughly rethought to respond to certain specific issues and changes in life and the modern world. The fields within Biology are further divided into Botany, Zoology, Genetics, Microbiology, Biochemistry, Parasitology, Molecular Biology, Cellular Biology, Physiology, etc.

Biology is one of the science subjects in Nigerian senior secondary schools, it is taught to help students develop an understanding of the basic principles that govern life, from the smallest bacteria to the largest animals (Isma'il & Matazu, 2023). However, despite the importance of the subject, academic achievement in biology among senior secondary school students in Nigeria, particularly in Zamfara State, has consistently been poor (Isma'il & Lukman, 2022). Specifically, the West African Examination Council Chief Examiner's report (2016 - 2021) has consistently highlighted students' weaknesses in answering questions from some difficult topics including Genetics. This resonates with Isma'il and Matazu (2024) findings who reported that both Biology teachers and students in Zamfara State perceived certain topics within the senior secondary school biology curriculum as difficult. According to Okolo and

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Oluwasegum (2020), several topics in Biology such as Genetics, Evolution, Mitosis and Meiosis pose a lot of difficulty for Biology students, in some cases even for Biology teachers.

Genetics is the branch of Biology that is concerned with the study of the Deoxyribonucleic acid (DNA) of organisms, how DNA manifests as genes and how those genes are inherited by offspring (Greenwood, 2021). Genetics has become increasingly important with the emergence of technologies of recombinant DNA and the subsequent emergence and availability of genetically modified food and organisms (GMOs). Issues such as DNA cloning, screening and GMOs are hotly debated in various countries of the world including Nigeria where a high level of scientific literacy is needed among the general public to address issues and give informed consent about the uses of the new technologies (Ansuman, 2019). Genetics forms one of the central pillars of Biology and it overlaps with many other areas such as Medicine, Biotechnology and Agriculture. To this end, Biology students must receive an effective knowledge of Genetics to be able to understand trends in genetics research and the application of genetic technologies to the social, legal, and ethical issues involved. Different teaching strategies lead to different instructional outcomes, a teacher can choose the strategy which is appropriate to the subject and topic he wants to teach. Consequently, the selection of teaching strategies should be in accord with an individual difference of students and the particular subject matter. The choice of teaching strategy relies upon the selected learning activities and thus, the key to the teaching method is to bring about the desired learning outcomes in students by selecting the proper strategies and consequently the proper content and techniques (Clark & Starr, 2001). A particular teaching strategy may be better than another for a given purpose. Tan et al. (2020) asserted that effective instruction requires merging of technological, pedagogical and content knowledge functioning as a single construct instead of viewing them as independent entities. The biology education research community has identified several evidence-based instructional practices and overall hands-on inquiry-based and active-learning approaches which seem to have a positive impact on student learning and academic achievement in Biology (James & Singer, 2016). Birgili et al. (2021) stated that, with recent developments in active-learning strategies and advances in instructional design and 21st-century technology, some educators encourage the implementation of active and innovative educational models like Flipped Classroom Learning.

Flipped Classroom Learning is a method by which students gain exposure to new learning content outside of the classroom, typically either through reading, lecture videos (available from the internet or pre-recorded by teachers), or power points. The teacher and students then use class time to do more difficult work of assimilating basic knowledge and translating it into problem-solving, engagements, discussions, or debates (Hunley, 2016). According to Vidor (2017), a flipped classroom allows the teacher to accommodate different student learning styles for more differentiated instruction, providing students with different avenues to learning. The additional time in the classroom provided by the flipped classroom learning strategy develops active learners who take control of their learning rather than passive learners who only receive information from the teacher and internalize it with no feedback. Also, it provides students with flexibility if they miss some class periods. In addition, flipped classroom learning can be considered complementary to the traditional classroom setting because it encourages classroom time to be arranged more toward active learning (Roach, 2014). There is an increasing focus in the research on the effectiveness of flipped classroom learning strategies; therefore, it is important to understand how this movement from conventional learning strategies changes students' academic achievement. Academic achievement is standardized test scores, grades, and overall academic outcomes which have to do with the aspects of the student's academic setting, such as the interactions with peers and teachers, and other student influences within the school environment (Bacon, 2011). It is individual or group effort which is highly important for an organization such as the school as a whole and the individual's learning process, students' academic achievement comprises both a behavioural and an outcome aspect of individual students and it is a multi-dimensional and dynamic concept (Patrick, 2005). It is good to note that students' academic achievements are not consistent over the years according to WAEC Chief Examiners' reports of 2016-2021.

Furthermore, several recent studies have shown a decline in the academic achievement of students in science subjects including Biology (Ugwuanyi & Okeke, 2020; Ugwuanyi et al., 2020; Inyama et al. 2020). The fluctuation in students' academic achievement in Biology and not being able to attain high academic achievement specifically in some concepts and the subject in general created a gap that necessitated more studies on students' academic achievement in various concepts of Biology. Agboola and Oloyede (2007) emphasize that, for effective instruction, a science teacher must be able to use several teaching strategies and implement them where they are applicable and most effective. Therefore, the teacher is the important agent and the methods he uses in the teaching and learning process exert effects on the students' academic achievement. The acquisition of knowledge at all levels of education depends on the

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effectiveness of teaching strategies measured in terms of knowledge of what to teach, how to teach, when to teach as well as teaching and learning materials to be used (Aggarwal, 2016). Research findings indicated several topics in Biology which include Genetics, Evolution, and Ecology pose a lot of difficulties for Biology students to learn (Okolo & Oluwasegun, 2020). The WAEC Chief Examiners' reports of 2016, 2017, 2018, 2019 and 2021 on Biology indicated many candidates had poor responses to questions on Genetics and many students avoided the Genetics questions which led to failure in their examination. This failure can be attributed to factors such as unqualified teachers, inadequate teaching and learning materials, poor laboratories and poor use of teaching methods (Pawar & Sapre, 2014). Therefore, there is a need to use more effective approaches to enhance students' academic achievement. There is a need to find out the effectiveness of other alternative teaching strategies that will help students to better learn and understand Genetics concepts and improve their academic achievement. It is against this background that this research study investigated the Effects of Flipped Classroom Learning on Academic Achievement in Genetics Concepts among Secondary School Students in Gusau, Zamfara State, Nigeria.

Objectives of the Study

The objectives of the study are;

1. To determine the difference in the academic achievement of students taught genetics concepts using Flipped Classroom Learning and those taught with lecture method in Gusau, Zamfara State, Nigeria.
2. To find out if there is any difference between the academic achievement of male and female students taught genetics concepts using Flipped Classroom Learning in Gusau, Zamfara State, Nigeria.

Research Questions

In line with the objectives of the study, the specific questions to be addressed are:

1. What is the difference in the academic achievement of students taught genetics concepts using Flipped Classroom Learning and those taught with lecture method in Gusau, Zamfara State, Nigeria?
2. What is the difference between the academic achievement of male and female students taught genetics concepts using Flipped Classroom Learning in Gusau, Zamfara State, Nigeria?

Hypotheses

The following null hypotheses were formulated at 0.05 alpha level of significance.

$H0_1$: There is no significant difference between the academic achievement of students taught genetics concepts using Flipped Classroom Learning and those taught with the lecture method in Gusau, Zamfara State, Nigeria**.**
$H0_2$: There is no significant difference between the academic achievement of male and female students taught genetics concepts using Flipped Classroom Learning in Gusau, Zamfara State, Nigeria.

Methodology

The research design adopted for this study is a Quasi-experimental design (pre-test and post-test experimental control group). The design was considered to be appropriate because the general procedure in quasi-experimental design is an independent variable (Flipped Classroom Learning) manipulated to determine its effect on a dependent variable (Academic Achievement) (Muthomi & Mbugua, 2014). The Experimental Group (EG) and the Control Group (CG) were selected with random assignment. A pretest and post-test were administered to both the experimental and control groups, and the scores from the pre-test placed the students in the same prior knowledge level while the post-test after the treatment determined the effectiveness of the treatment and measured the academic achievement of students. The experimental group was taught Genetics Concepts for six weeks using Flipped Classroom Learning guided by the Flipped Classroom Learning Lesson Plan while the control groups were also taught for the same period of six weeks using the lecture method.

The population of the study comprised all Senior Secondary School 3 Students of Gusau Local Government, Zamfara State. Data obtained from Zamfara State Ministry of Education (2021) shows that there are 29 senior secondary schools in Gusau Local Government Area. The total population of SS3 students in the area of the study is 5,804 consisting of 2,766 male and 3,038 female students respectively. A multistage sampling technique was employed to select schools and classes for participation. In the first stage, cluster sampling was utilized to divide the population of schools into clusters. In the second stage, four schools from these clusters were randomly selected to ensure a representative sample. Upon selecting the schools, four intact classes of SS3 were randomly selected from each. Two

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of these classes from each school were then assigned as experimental groups, while the remaining two were designated as control groups. An instrument tagged Genetics Concepts Achievement Test (GCAT) was adopted from past question papers of WAEC 2010-2021 and used for data collection. The GCAT consisted of 30 multiple-choice Genetics Concepts test items with four options (A-D) from which the students select the correct answers. The GCAT was validated by experts and subjected to pilot testing which has a reliability coefficient of 0.78 by using the test-retest method. The data were analyzed using frequency count, mean and standard deviation to answer the research questions, while inferential statistics (independent sample Z-test) was used to test the hypotheses at $\alpha = 0.05$ level of significance, using Statistical Package for Social Sciences (SPSS) version 20.0.

Results

Research Question 1: What is the difference in the academic achievement of students taught Genetics Concepts using Flipped Classroom Learning and those taught with lecture method in Gusau, Zamfara State, Nigeria?

To answer research question 1, mean and standard deviation were used. Post-test scores of Secondary School students taught genetics concepts using flipped classroom learning and lecture methods were computed and presented in Table 1.

Table 1: Mean and Standard Deviation of Post-test Scores for Experimental and Control Groups

Group	N	Mean	SD	Mean Diff
Experimental	159	17.03	3.51	
				5.479
Control	120	11.55	3.23	

Table 1 shows that the means and standard deviations of the experimental group are 17.03 and 3.51 and those of the control group are 11.55 and 3.23 respectively. The mean difference in the academic achievement scores was found to be 5.48 in favour of the experimental group. This shows that the experimental group performed better than the control group due to exposure to a flipped classroom learning strategy. The result also showed that the standard deviation of the experimental group (3.51) was higher than that of the control group (3.23), which indicates that the control group achievement scores are closely around the mean score more than the experimental group achievement scores. To find out if the mean difference was statistically significant, the corresponding hypothesis was therefore tested.

$H0_1$: There is no significant difference between the academic achievement of students taught Genetics Concepts using Flipped Classroom Learning and those taught with lecture method in Gusau, Zamfara State, Nigeria. The post-test scores of the subjects in the experimental and control groups were compared using Z-test statistics to test this hypothesis. Table 2 shows the result obtained.

Table 2: Z-test Analysis on the Mean Academic Achievement of Experimental and Control Groups

Group	N	Mean	SD	Standard Error	Df	Sig (2-tailed)	Decision
Experimental	159	17.03	3.51	0.278			
					277	.001*	*Significant
Control	120	11.55	3.23	0.295			

Table 2 result presented shows that the significant (2-tailed) value is 0.001 which is less than $p \leq 0.05$. Therefore, there is a significant difference in the mean academic achievement scores of the experimental and control groups. This implies that there was a significant difference in the mean academic achievement of Secondary School students taught genetics concepts using flipped classroom learning and those taught using the lecture method.

Research Question 2: What is the difference between the mean academic achievement of male and female students taught Genetics Concepts using Flipped Classroom Learning in Gusau, Zamfara State, Nigeria?

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To answer research question 2, mean and standard deviation were also used. The post-test mean scores of the experimental group were subjected to descriptive statistics based on gender (i.e. male and female). The mean and standard deviation were computed and presented in Table 3.

Table 3: Mean and Standard Deviation of Male and Female Students of Post-test Score for Experimental Group

Group	N	Mean	SD	Mean Diff
Male	75	16.85	3.482	
				0.35
Female	84	17.20	3.549	

Table 3 shows that the means and standard deviations of male students in the experimental group are 16.85 and 3.482 and those of female students are 17.20 and 3.549 respectively. The mean difference in the academic achievement scores was found to be 0.35 in favour of females. This shows that there is a difference in male and female academic achievement scores when taught using a flipped classroom learning strategy. Also, the result shows that the standard deviation of females in the experimental group (3.54) is more than that of males (3.48). The result indicates that the standard deviation of male academic achievement scores is closer to the mean score than the female scores. To find out if the difference is statistically significant, the corresponding hypothesis ($H0_2$) was tested.

$H0_2$: There is no significant difference between the academic achievement of male and female students taught genetics concepts using Flipped Classroom Learning in Gusau, Zamfara State, Nigeria.

To test hypothesis 2, post-test scores of the male and female students in the experimental group were compared using Z-test statistics.

Table 4: Z-Test Analysis on Male and Female Students' Mean Academic Achievement Scores in Experimental Group

Group	N	Mean	SD	Stand. Error	p-value	Decision
Male	75	16.85	3.482	0.402		
					0.533	**Not Significant
Female	84	17.20	3.549	0.387		

Results presented in Table 4 show that the significant (2-tailed) value of 0.53 was more than $P \leq 0.05$. Therefore, there is no significant difference in the mean scores of male and female students. This implies that there is no significant difference in the mean academic achievement of male and female students taught genetics concepts using flipped classroom learning and those taught using the lecture method in Gusau, Zamfara State, Nigeria.

Discussion

The findings from Research Question 1 and Hypothesis 1 as contained in Tables 1 and 2 revealed that there is a significant difference in the mean academic achievement of students taught genetics concepts using flipped classroom learning and lecture method. The mean and standard deviation of the experimental group were 17.03 and 3.51 and that of the control group were 11.55 and 3.23 respectively. The mean difference in the mean academic achievement scores was found to be 5.48 in favour of the experimental group. This implies that the experimental group achieved significantly better than their counterparts in the control group as a result of exposure to a flipped classroom learning strategy. Consequently, flipped classroom learning is a more effective instructional strategy than lecture methods and can be used to improve the academic achievement of students in teaching genetics concepts. This finding agrees with several studies such as that of Almodaires et al. (2019) who concluded that there is a significant difference in the academic achievement of students taught science subjects including Biology using the Flipped Classroom Learning strategy and those taught using the lecture method. Similarly, the finding also supports Ezenwabachili and Okoli (2021) who have shown the effectiveness of Flipped Classroom Learning in promoting students' academic

achievement in science subjects. In contrast, the findings of Faisal et al. (2020) showed that there is no statistically significant difference between the experimental and control groups.

Another finding of Research Question 2 and Research Hypothesis 2 in Tables 3 and 4 revealed that there is no significant difference in the mean academic achievement of male and female students taught genetics concepts using Flipped Classroom Learning. This shows that when Biology teachers employ a teaching strategy that helps in delivering instruction in a manner that appeals to different learners and allows practice and active learning in the classroom, it improves students' academic achievement regardless of gender, and this means that Flipped Classroom Learning is effective in improving academic achievement of both male and female. The means and standard deviations of female students in the experimental group are 17.20 and 3.549 and those of male students are 16.85 and 3.482 respectively. The mean difference in the academic achievement scores was found to be 0.35 in favour of females. This finding conforms with many findings such as Gambari et al. (2017) who concluded that there is no significant gender difference in the students' academic achievement in various science subjects including Biology. The finding is also in line with the results of Hamaidi and Elian (2018), and Badmus (2021) who revealed that gender has no significant effect on the academic achievement of students when taught with a flipped classroom learning strategy. However, the findings opposed that of Amedu (2015) whose finding concluded that there is a significant difference between the male's and females' mean scores in favour of the males.

Conclusion

The study concludes that students taught with the Flipped Classroom Learning strategy performed better than students taught genetics concepts using the lecture method. This implies that the Flipped Classroom Learning strategy enhanced students' academic achievement in learning genetics concepts. The study also concludes that there is no significant difference between the academic achievement of male and female students who learnt genetic concepts using the Flipped Classroom Learning strategy; hence gender does not affect learning when students are taught using the Flipped Classroom Learning strategy.

Recommendations

The study recommends that:

1. Biology teachers should be encouraged by the school management to use Flipped Classroom Learning as the main teaching strategy to improve the teaching and learning of genetics concepts in senior secondary Biology.
2. Biology teachers should be trained by the Ministry of Education on effective procedures for implementing Flipped
3. Classroom Learning strategy in their classrooms by organizing extensive seminars and workshops.
4. Students should be encouraged by the teachers to use the Flipped Learning strategy at home as they can achieve high academically regardless of gender. And teachers should use the Flipped Classroom Learning strategy in teaching both male and female students.
5. The federal and state governments through the Ministry of Education and other educational agencies should provide teachers with learning materials based on the Flipped Classroom Learning strategy because it improves students' academic achievement of both male and female students.

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