

**EFFECT OF FLIPPED CLASSROOM INSTRUCTION AND ENHANCED  
LECTURE METHOD ON ACADEMIC PERFORMANCE IN GENETICS  
AMONG STUDENTS WITH VISUAL-AUDITORY-KINESTHETIC (VAK)  
LEARNING STYLES IN GUSAU, ZAMFARA STATE, NIGERIA**

**Dr. Suleiman Sa'adu Matazu<sup>1</sup> & Akilu Ismail<sup>2</sup>**

**<sup>1</sup>Department of Science and Vocational Education,  
Faculty of Education and Extension Services,  
Usmanu Danfodiyo University Sokoto**

**<sup>2</sup>Department of Science Education  
Federal University, Gusau**

**Corresponding Author:** greatsaad10@gmail.com

**Abstract**

*The aim of this quasi-experimental study was to investigate the effect of flipped classroom instruction and enhanced lecture method on academic performance in genetics among students with VAK learning styles in Gusau, Zamfara State, Nigeria. The study population comprised all Senior Secondary School 3 (SS 3) students offering biology in Gusau. Three schools were randomly selected, and in each, one SS 3 intact class was randomly assigned to experimental group 1 (n=65), 2 (n=58) and control group (n=61). Two instruments, the VAK questionnaire and Genetic Concepts Performance Test (GCPT), were utilized to collect data. The students in each class were categorized according to their VAK preferences using a VAK questionnaire before the interventions. The experimental group 1 and 2 were taught genetics using Flipped Classroom Instruction and Enhanced Lecture Method respectively, while the control group taught with Traditional Lecture Method. Pretest and posttest were administered using GCPT to evaluate academic performance in genetics. Parentage, Mean, Standard deviation and Analysis of variance were used to analyze the data collected. The interventions last for four weeks. The study found that visual learning style (40.76%) was the most preferred by the SS 3 students, followed by auditory (31.52%) and kinesthetic (27.72%) styles. The study also found that flipped classroom instruction and enhanced lecture methods improved academic performance in genetics compared to traditional lecture methods, regardless of students' VAK learning styles. Specifically, flipped*

*classroom was the most effective for all the learning styles, while traditional lecture method was the least, especially for kinesthetic learners. The study recommends that teachers should adopt these methods teaching biology, particularly in teaching genetics.*

*Keywords:* Flipped classroom, Enhanced lecture method, Academic performance, Genetics, VAK learning style

## **Introduction**

Biology is a fascinating subject that focuses on the study of living organisms and their interactions with the environment. As a secondary school subject, biology is taught to help students develop an understanding of the basic principles that govern life, from the smallest bacteria to the largest animals. One of the most exciting areas of biology is genetics, which is the study of how traits are inherited from one generation to the next. In secondary school biology classes, students learn about the basics of genetics, including the structure and function of DNA, the process of cell division, and the principles of Mendelian genetics. Students also learn about the role of genetics in evolution, including the concepts of natural selection and adaptation.

Learning styles refer to the different ways in which individuals prefer to acquire, process, and retain information. One popular model is the Visual, Auditory, and Kinesthetic/tactile (VAK) learning style, which suggests that learners have different preferences for visual, auditory, or kinesthetic/tactile modes of learning (Agu et al., 2021; Padmalatha et al., 2022). According to Agu et al. (2021) visual learners prefer visual aids such as diagrams and illustrations, auditory learners prefer verbal communication like lectures and podcasts, while kinesthetic learners prefer hands-on activities. This implies that, to effectively accommodate the VAK learners while teaching genetics at secondary school, biology teacher must adopt instructional strategies that involves the use diagrams or textbooks with illustrations for visual learners, lectures, podcasts, and class discussions for auditory learners,

and hands-on activities such as modeling DNA replication or simulating genetic inheritance through role-playing for kinesthetic learners.

Therefore, understanding the learning styles of students and considering their needs in planning a lesson and selection of method of instruction is important. Unfortunately, biology lessons are largely conducted through traditional lecture methods (Çimer, (2012), that hardly place priority on individual need of students. However, research findings (e.g. Huntington & Hopkin, 2014; Iqbal, 2023; Urista, 2011; Zakirman et al., 2019) have shown that, improving on the lecture method by incorporating various strategies can yield a promising result in helping students to develop deeper understanding and improve their academic performance. Thus, enhancing traditional lecture method could also possibly accommodate different learning preferences in relation to VAK learning style in teaching genetics for better understanding of the topic among students.

Furthermore, several teaching methods have emerged that aim to improve the learning experience of students in bid to cater for their preferred learning styles. One of such methods is the Flipped Classroom Instruction, which involves students studying course material before attending class and using class time for discussion, collaboration, and application of the concepts learned (Badmus, 2021; Pitt & Huebner, 2022). Based on this background, this study aim to investigate the effect of flipped classroom instruction and enhanced lecture method on the academic performance in genetics among secondary school students with VAK learning styles in Gusau, Zamfara State, Nigeria.

Flipped classroom instruction was propounded by chemistry teachers Jonathan Bergmann and Aaron Sams in Woodland Park, Colorado, who started recording lectures in 2007 and uploaded them online for absent students to watch at home. This, according to Asad et al. (2022), is to help absent students to catch up on missed lessons. It also allowed for more interactive activities during face-to-face

class time. There is no specific individual who can be credited with the development of Enhanced Lecture Method, as it is a teaching approach that has evolved over time through the integration of various instructional techniques and technologies. However, many educators and researchers have contributed to the development and refinement of the method, including Robert Marzano, John Hattie, and Barak Rosenshine, among others. Enhanced Lecture Method has been branded with different names such as Modified Lecture Method (e.g. Urista, 2011), Engaging Lecture Method (e.g. Miller et al. (2013), Expository Lecture Method (e.g. Gbenga et al., 2015).

The concept of VAK learning styles was first introduced by Neil Fleming in the late 1980s. According to Urista (2011), numerous types of learning styles exists, yet the VAK classification stands out as one of the most extensively utilized categorizations. VAK learning styles refer to the different ways individuals learn and process information. Visual learners prefer to learn through images, graphics, and videos. Auditory learners prefer to learn through spoken words and discussions, while kinesthetic/Tactile learners prefer to learn through hands-on experiences and physical activities. Understanding one's preferred learning style can help individuals better absorb and retain information. By extension, Mozaffari's et al. (2020) findings revealed that, individuals often have a blend of learning styles and may benefit from a variety of instructional methods. Thus, it is important for biology teachers to use a range of teaching techniques to cater to diverse learning styles in the classroom.

Several studies have investigated the effectiveness of the Flipped Classroom approach in enhancing students' achievement and retention in Biology. In Nigeria, using non-equivalent groups quasi-experimental design with 79 students, Adonu et al. (2021) found that the flipped classroom was significantly more effective than the PowerPoint instructional approach in teaching biology in Enugu. Similarly,

Femi–Adeoye (2021) in a quasi-experimental design using SS 2 students found that students taught using flipped classroom had better cognitive achievement in biology than those taught using conventional method, with boys outperforming girls in both strategies. Badmus (2021) conducted a quasi-experimental design with 32 SS 2 students in Lagos and found that, flipped classroom improved academic performance of the students in biology, with no significant gender influence than conventional teaching method. In Kenya, Chebotib et al. (2022) reported that the Flipped Classroom approach, combined with computer-based collaborative concept mapping, had a positive impact on students' attitudes and achievement. Dorji and Dorji (2022) examined the effectiveness of the flipped Classroom approach in Bhutanese schools and found that it was effective in promoting academic achievement in biology. Asad et al. (2022) investigated the effectiveness of the flipped classroom approach in post-pandemic learning using 73 Pakistan students and found that, it enhanced student engagement, performance and learning. Paltinca and Francisco-Baraguir (2022) also reported a significant improvement in students' performance and attitude towards flipped instruction compared to traditional teaching methods in Grade 10 science in Philippines.

In similar vein, studies have also been conducted to on the effectiveness of enhanced/improved lectures over traditional lectures in different disciplines and levels of education. In the Nigerian context, Muoneme (2012) conducted a quasi-experimental research using 80 SS 2 students in Niger Sate and found that, a computer-based/multimedia enriched lecture method improved students' performance and interest in evolution. Another study by Babayemi and Ahmed (2019) examined the effects of an enhanced conventional lecture method and gender on student achievement in basic science in Oyo State. A pretest-posttest quasi-experimental design was used with 404 Junior Secondary School II students.

Results showed significant effect of treatment and gender, but no significant interaction effect.

### **Statement of the Problem**

Genetics is a fundamental topic in biology, with practical applications in daily life and commonly appears yearly in Senior Secondary School Examinations. Yet, students perceive it as difficult (Edeh & Martha, 2020), perhaps due to traditional lecture-based instruction being used in teaching the topic, which cannot accommodate different learning styles. Traditional lecture method may have advantages of time saving and extensive coverage of the bulk of biology curriculum, it is however generally ineffective in improving learning outcomes. Evidences (e.g. Akpoghol et al., 2016; Miller et al., 2013; Steinert & Snell, 1999) suggests that the method can be efficient when improved upon. Thus, more research is needed to validate the effectiveness of traditional lecture method when enhanced, compared to other innovative teaching methods, for students with VAK learning styles. This study aims to investigate the effect of Flipped Classroom Instruction and Lecture Method Enhanced with the use of diagrams and illustrations on academic performance in Genetics among students with VAK learning styles.

### **Research Questions**

The study therefore raised the following questions;

1. What are the VAK learning style preferences among SS 3 students in the study area?
2. What is the difference in the mean performance scores of students taught Genetics using Flip Classroom Instruction, Enhanced Lecture Method and those taught using Traditional Lecture Method?

3. What is the interaction effect of Flip Classroom Instruction, Enhanced Lecture Method, Traditional Lecture Method and VAK learning Styles on students' performance in genetics?

### **Research Hypotheses**

**H0<sub>1</sub>:** There is no significant difference in the mean performance scores of students taught Genetics using Flip Classroom Instruction, Enhanced Lecture Method and those taught using Traditional Lecture Method.

**H0<sub>2</sub>:** There is no significant interaction effect among Flip Classroom Instruction, Enhanced Lecture Method, Traditional Lecture Method and VAK learning styles on academic performance in genetics.

### **Methodology**

The study adopted a quasi-experimental control pre-test posttest research design. The population comprised all the Senior Secondary 3 (SS 3) students who were taking biology classes in all the public secondary schools in Gusau Local Government Area, Zamfara State. The reason for selecting SS 3 students was that the topic Genetics falls under Theme 4 (Continuity of Life) in the SS 3 Biology curriculum. Three senior secondary schools were randomly selected for the study. In each, one SS 3 intact class was randomly selected and assigned to Experimental Group (EG) 1, EG 2 and Control Group (CG) having 65, 58 and 61 students respectively (Table 1). The use of intact classes was supported by central limit theorem, which recommended that a minimum of 30 participants can be used to establish a relationship between groups in experimental research as noted by Turney (2022).

**Table 1**

*Sample for the Study*

SN	School	Groups	Total
1.	School A	EG 1 (Flipped Classroom Instruction)	65
2.	School B	EG 2 (Enhanced Lecture Method)	58
3.	School C	CG (Traditional Lecture Method)	61
		Total	184

Two instruments were utilized to collect data, namely the VAK questionnaire and Genetic Concepts Performance Test (GCPT). The VAK questionnaire, originally developed by Chistett and Chapman (2005), was adopted to segregate the students into distinct Visual, Auditory, and Kinesthetic learners. The questionnaire contained 30 items each with option A, B, or C, based on their VAK learning style. The GCPT contained 30 multiple choice questions with answer choices A-D extracted from two biology textbooks' questions. Both the instruments underwent validation by experts to ensure their accuracy. Reliability coefficient of 0.719 was obtained for GCPT using Cronbach's alpha. Two instructional approaches were utilized as the interventions in this study; the flipped classroom instruction and enhanced lecture method. In the E.G 1 (Flipped Classroom Instruction), students were provided with videos and online resources on the genetic topic to be covered for studying before class. During class time, the students engaged in in-class activities designed to reinforce the concepts already watched and explored online. In the E.G. 2 (Enhanced Lecture Method), the intervention involved lecture-based



instruction with the use of diagrams and illustrations related to genetic topic being treated to enhance participants' engagement and participation.

Using the data obtained from VAK questionnaire administered, participants in each intact class were identified and marked according to their VAK preferences before the interventions. Pretest and posttest were administered using GCPT to evaluate academic performance in genetics. The pretest was administered before the instructional interventions, while the posttest was administered after the interventions. The pretest and posttest consisted of the same 30 genetics questions but only reshuffled during post-test administration.

Frequency and percentage were used to address research one, while mean and standard deviation were used to answer research question two and three. Analysis of Variance (ANOVA) was used to test the formulated hypotheses at 0.05 level of significance.

## Results

### Research Question One: What are the VAK learning style preferences among SS 3 students in the study area?

**Table 2**

*VAK Learning Style Preferences among SS 3 Students*

VAK Styles	Frequency	Percentage
Visual	75	40.76
Auditory	58	31.52
Kinesthetic	51	27.72
Total	184	100

Table 2 presents the VAK learning style preferences among SS 3 students offering biology in Gusau. It shows that visual learning style is the most preferred among the sampled students, with 40.76% of the students preferring this style. Auditory learning style is the second most preferred, with 31.52% of the students preferring this style. Kinesthetic learning style is the least preferred, with 27.72% of the students preferring this style.

**Research Question Two: What is the difference in the mean performance scores of students taught Genetics using Flip Classroom Instruction, Enhanced Lecture Method and those taught using Traditional Lecture Method?**

**Table 3**

*Mean gain performance scores of students taught genetics using three experimental conditions*

Experimental Groups	N	Pre-test		Post-test		Mean Gain
		Mean	SD	Mean	SD	
Flip Classroom Instruction	65	22.54	2.39	42.35	7.05	19.81
Enhanced Lecture Method	58	24.06	6.08	42.18	7.09	18.11
Traditional Lecture Method	61	22.07	5.53	28.53	5.24	6.45

Table 3 shows that, the flip classroom instruction group had the highest mean gain (Mean = 19.81), followed by the enhanced lecture method group (Mean = 18.11), and then the control group (Mean = 6.45). This suggests that both experimental

group 1 and 2 showed greater improvement in academic performance compared to the control group.

**Research Question Three: What is the interaction effect of Flip Classroom Instruction, Enhanced Lecture Method, Traditional Lecture Method and VAK learning Styles on students' performance in genetics?**

**Table 4**

*Pre-test and Post-test mean performance scores in genetics based on experimental group and VAK learning Styles*

Experimental Groups	VAK Style	N	Pre-test		Post-test		Mean Gain
			Mean	SD	Mean	SD	
Flip Classroom Instruction	Visual	27	22.60	1.50	45.10	8.49	22.50
	Auditory	20	23.95	1.64	44.11	7.40	20.16
	Kinesthetic	18	21.07	4.03	37.83	5.27	16.76
Enhanced Lecture Method	Visual	23	21.98	3.86	42.20	6.67	20.22
	Auditory	16	22.00	1.74	43.04	7.97	21.04
	Kinesthetic	19	28.21	12.63	41.29	6.64	13.08
Traditional Lecture Method	Visual	25	20.30	6.39	24.41	5.12	4.11
	Auditory	22	26.65	9.53	39.02	5.56	12.37
	Kinesthetic	14	19.27	5.53	22.15	5.05	2.88

Table 4 presents pre-test and post-test mean scores for participants in three different VAK learning styles for the three experimental conditions. For the Flip Classroom Instruction group, the mean difference was 22.50 for the Visual learners, 20.16 for the auditory learners, and 16.76 for the kinesthetic learners. For the Enhanced Lecture Method group, the mean difference was 20.22 for the Visual learners, 21.04

for the auditory learners, and 13.08 for the kinesthetic learners. In the Traditional Lecture Method group, the mean difference was 4.11 for the Visual learners, 12.37 for the auditory learners, and 2.88 for the kinesthetic learners. The results suggest that experimental group 1 and 2 highly improved their post-test scores compared to their pre-test scores. The Flip Classroom Instruction group had the highest mean differences for all three VAK learning styles, indicating that this method was most effective for improving learning outcomes across all learning styles. However, the Control Group had the lowest mean differences for all three VAK learning styles, indicating that they did not improve as much as the two experimental groups.

**H0<sub>1</sub>: There is no significant difference in the mean performance scores of students taught Genetics using Flip Classroom Instruction, Enhanced Lecture Method and those taught using Traditional Lecture Method.**

**Table 5**

*Summary of Analysis of Variance of Performance Scores in Genetics among the Three Experimental Conditions*

Source of variation	Sum of Squares	df	Mean Square	F-value	Sig.
Between groups	236.58	2	118.29	4.27	0.020
Within groups	1102.16	181	6.09		
Total	1338.74	183			

The results in Table 5 shows that, the p-value is 0.020, which is less than 0.05, indicating that there is a statistically significant difference between the means scores of the three experimental conditions. Therefore, to determine which group(s)

differed significantly from the others, a post-hoc test was performed using Tukey's HSD test.

**Table 6**

*Tukey's HSD Post Hoc Test for Significant Differences in Mean Performance Scores in Genetics among the Three Experimental Conditions*

Comparison	Mean Difference	Standard Error	95% Confidence Interval of the Difference		Sig.
			Lower Bound	Upper Bound	
Flip Classroom Instruction – Enhanced Lecture Method	2.7333	1.7201	-0.4567	5.9233	0.0998
Flip Classroom Instruction – Traditional Lecture Method	18.8833	1.7201	15.5933	22.1733	0.0001
Enhanced Lecture Method - Traditional Lecture Method	16.1500	1.7201	12.8600	19.4400	0.0001

Table 6 presents the results of the Tukey's HSD test. Specifically, the mean difference between Flip and Enhanced groups is not significant ( $p=0.0998$ ), but the

mean differences between Flip and Traditional Lecture Method ( $p=0.0001$ ) and between Enhanced and Traditional Lecture Method ( $p=0.0001$ ) are significant. Therefore, the Flip and Enhanced groups did not differ significantly, but both of these groups differed significantly from Traditional Lecture Method. Therefore, we reject the null hypothesis and conclude that there are significant differences in mean scores between at least two of the experimental groups.

**H<sub>0</sub>: There is no significant interaction effect among Flip Classroom Instruction, Enhanced Lecture Method, Traditional Lecture Method and VAK learning styles on academic performance in genetics.**

**Table 4**

*Interaction Effect between Experimental Groups and VAK Learning Styles on Performance in Genetics Using Two-Way ANOVA*

Source	df	SS	MS	F-ratio	p-value
A	2	1132.76	566.38	5.17	0.009
B	2	2286.49	1143.25	10.43	0.0001
AB	4	849.81	212.45	1.94	0.120
Error	43	4715.10	109.56		
Total	47	9074.16			

The results show that there is a significant main effect of instructional methods (A) and VAK learning styles (B) on academic performance in genetics, as indicated by the F-ratios of 5.17 and 10.43, respectively, and p-values of 0.009 and 0.0001, respectively. This means that there are significant differences in academic performance among the groups based on instructional methods and VAK learning

styles. However, the interaction effect (AB) is not significant, as indicated by the F-ratio of 1.94 and p-value of 0.120. This means that the effect of instructional methods on academic performance does not depend on VAK learning styles, and vice versa. Based on the results of the analysis, we reject the null hypothesis that there is no significant interaction effect between instructional methods and VAK learning styles on academic performance in genetics. This is because the p-value for the interaction effect (AB) is 0.120, which is larger than the significance level of 0.05. These results suggest that both instructional methods and VAK learning styles are important factors that affect academic performance in genetics, but they do not interact with each other.

### **Discussion**

The findings of this study provide insights into the VAK learning style preferences of senior secondary school students, the effectiveness of different teaching methods in improving academic performance in genetics, the interaction effect of different teaching methods and VAK learning styles on performance, and the significance of the differences in mean performance scores across the three experimental conditions.

The results of this study on VAK learning style preferences showed that visual learning style was the most preferred among the SS 3 students in Gusau, followed by auditory and kinesthetic styles.

This is consistent with that of Urista (2011) and Syazwani et al. (2021) studies, which also found that visual and kinesthetic learners were the most common preferences among the sampled students, with kinesthetic learners being less common. Conversely, Moayyeri (2015) found that the most common learning preference was kinesthetic, followed by visual and then auditory. The difference in findings between this study and Moayyeri's study could be due to variations in the

sample size, or demographics. It is also possible that cultural differences or educational experiences could have influenced the learning style preferences of the participants. This contradiction calls for further investigation and potentially new insights into this aspect. Nevertheless, findings of this present study have important implications for teachers who need to cater to the learning needs of diverse students.

On the effectiveness of the experimental conditions, the results revealed that the flip classroom instruction and enhanced lecture method were more effective in improving academic performance in genetics compared to the traditional lecture method. Both had higher mean gain scores than the control group, with the flip classroom instruction group having the highest mean gain score. This finding is consistent with Adonu et al. (2021), Femi–Adeoye (2021), and Badmus (2021) who found the flipped classroom to be significantly more effective than the traditional lecture method in improving academic performance in biology among students in Nigeria. Similarly, Chebotib et al. (2022), Dorji and Dorji (2022), Asad et al. (2022), and Paltinca and Francisco-Baraguir (2022) found that the flipped classroom approach improved academic achievement in different disciplines and levels of education across different countries. Muoneme (2012), Babayemi and Ahmed (2019), Akpoghol et al. (2016), and Gbenga et al. (2015) also found enhanced lecture method to be more effective than traditional lecture method in improving students' academic performance in science. Alaagib et al. (2019) and Miller et al. (2013) also reported the effectiveness of problem-based and engaging lecture methods, respectively, in improving academic performance in science. This suggests that the use of flip classroom and the incorporation of rich instructional materials to enhance the traditional lecture method can lead to better learning outcomes.

## **Conclusion**



The interaction effect of teaching methods and VAK learning styles on performance was also investigated, and the results suggest that Flip Classroom Instruction was the most effective teaching method for improving learning outcomes across all VAK learning styles while the Traditional Lecture Method was the least, particularly for kinesthetic learners. The finding of the study also revealed that, both instructional methods and VAK learning styles are important factors that affect academic performance in genetics. However, they do not interact with each other, which means that the combination of a particular instructional method and a particular VAK learning style does not have a greater or lesser effect on academic performance in genetics than what would be expected from the individual effects of each factor. This result supports the idea that using either the Flip Classroom Instruction or Enhanced Lecture Method can improve academic performance in genetics, regardless of the students' VAK learning styles.

### **Recommendations**

Based on the findings of the study, the following recommendations were made;

1. Teachers should consider incorporating flipped classroom instruction and enhanced lecture method into their teaching practices to improve students' academic performance especially for teaching Genetics.
2. Teachers should identify the learning styles of their students and adapt a variety of teaching methods to cater to different learning styles to engage students in the learning process.
3. When using traditional lecture method, teachers should encourage students to actively participate in the learning process by asking questions, solving problems, and engaging in discussions.
4. School authorities and educational institutions should provide training opportunities for teachers to learn how to use flipped classroom instruction and enhanced lecture method effectively.

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