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EFFECT OF FLIPPED CLASSROOM INSTRUCTIONAL MODEL ON STUDENTS' RETENTION OF BIOLOGY CONCEPTS AMONG SECONDARY SCHOOL STUDENTS IN BAYELSA STATE

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Abstract

The study examined the effect of the flipped classroom instructional model on secondary school students' retention of biology concepts in Bayelsa West Senatorial District of Bayelsa State. The study adopted the "pre-test and post-test control group quasi-experimental design." The sample consisted of 159 SSS 2 students from four purposively selected public schools in the district, which were assigned to an experimental group (n = 83) and control group (n = 76) and taught using the flipped classroom instructional model and the modified lecture method, respectively. Nine weeks were dedicated to the research. Two research questions were answered, and two null hypotheses were tested at a 0.05 significance level. Instruments used in the study include two instructional guides and a Biology Retention Test (BRT). The BRT had a reliability of 0.70 using Kuder-Richardson Formula 21 (KR – 21). Data was analysed using mean and standard deviation. Analysis of Covariance (ANCOVA) was utilised to test the hypotheses at a 0.05 significance level. The study's findings revealed that students taught with the flipped classroom instructional model had significantly better biology retention than those taught with the modified lecture method, and there was no significant gender difference in students' retention of biology concepts. Amongst others, it was recommended that the flipped classroom be adopted to teach in secondary schools.

Keywords: Biology, Gender, Flipped Classroom Model, Modified Lecture, and Retention

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Introduction

The study of biology is one of the most popular and vital fields in the world today. It is a science-oriented field that primarily studies all lives and living organisms. Suwono et al. (2017) cite biology as a leading branch of science, with its framework deeply rooted in the everyday life and living of individuals. Its study covers a broad scope and range encompassing various contents, from minuscule microscopic organisms to the entire biosphere (Abudulsalam et al., 2020; Onu et al., 2020). The study of biology also pays particular concern to the interactions of living things with the non-living components of the environment

Araoye (2016) states that knowledge of biology equips individuals with fundamental skills and knowledge needed to maintain their well-being of man. It equips individuals with essential insights and an understanding of natural environmental concepts, laws, and principles. It is necessary for successful continued living in the technologically scientifically advanced society, as its knowledge and framework play indispensable roles in significant fields that affect living and serve as a preparation for and prerequisite to pursuing a vast number of science-oriented careers, including medicine, agriculture, pharmacy, biotechnology, environmental sciences, microbiology, etc. (Annan et al., 2019; Joda, 2019). It is also influential in national development through its application to the variety of units that affect humankind and the whole nation.

Considering the importance of the subject, students' successful learning of biology is quite pivotal. It is not just enough for students to understand concepts at the moment. What matters more is their ability to recall and use those concepts and understandings for an extended period after learning or instruction. It is not uncommon to see scenarios where students who seemed to have grasped the knowledge of a concept during classroom biology instruction fail to recall or practically forget about those previously learned concepts and contents when required of them after an extended period.

A student's knowledge retention thus refers to their ability to recall information gained after an extended period. It involves the learner's ability to commit what has been learned into their memory or mental framework and to remember and recall those stored fragments of knowledge as required. Various variables contribute to a learner's retention ability, including the nature of the content, the relevance attached to the content by the learners, and the strategy or model with which the content was taught (Louis et al., 2020). Thus, considering the importance of knowledge retention, it becomes crucial for studies to explore not just how to enhance students understanding during a lesson but also how to improve concretisation of the learned concept and hence knowledge retention, as this will be the true determinant of students' achievement in the subject in the future.

Students' retention level of biology concepts can be inferred from their achievement in biology. Reports from several studies have shown a trend of poor performance in biology, most notably during the Senior School Certificate Examinations (SSCE). Ibe and Abamuche (2019) state that the West African Examination Council (WAEC) chief examiner’s report has always shown persistent underperformance of students in obtaining a credit pass in biology. Also, Adewale et al. (2016) assessed the academic performance of secondary school biology students in their SSCE for five years in five randomly selected secondary schools located at Owerri Municipal of Imo state. They reported that the number of students with a credit pass in biology was on the low end of the spectrum.

Bichi et al. (2019) state that over the years, there has been little to no improvement in students' achievement in biology at the SSCE, and the available data shows that students' performance continues to decline. The study further revealed that in 2014, 2015, and 2016, biology students' performance was always below average, and in 2018, only 28% of the students obtained a credit pass in biology.

Several reasons have been attributed to students' poor retention of biology concepts. One prominent issue attributable to poor biology learning outcomes is the use of poor instructional strategies. The instructional strategy used goes a long way to determine the experiences of the students in a learning environment and the success of a learning process. Thus, addressing instructional strategy deficiencies is crucial for fostering better learning outcomes. Muhammed and Sulai (2017) and Okoye andOwuachu (2018) state that the conventional instruction model is ineffective in concretising students' understanding of biology concepts. Biology classroom instruction is typically carried out through enhanced variations of the lecture method.

The plain version of the lecture method (without modifications) typically involves the teacher transmitting knowledge to the students verbally. The students then use collected notes to engage in studies at home. The lecture method places the teachers at the centre of the teaching-learning process, making them autonomous and a storehouse for all knowledge, and the learners as passive receivers of knowledge heavily reliant on the teachers' administrations for learning to occur (Joda, 2018; Nnorom&Obimalume, 2021). Mohammed (2019) describes the lecture method as fact-oriented, with little input from the learners. The lecture instructional model expects the students to listen and absorb information continually. This act creates little value in the students' preparation to meet the objectives for which the schooling was being designed.

Recognising the limitations of the plain lecture method has facilitated the use of modified variations of the method in learning situations (modified lecture method) that tend to be more student-centred. However, if the achievement trends are anything to go by, more than these modifications may be needed to overcome the deficiencies associated with the lecture method. This issue underlines the need to introduce innovations into the biology instructional process.

The flipped instructional model is a learner-centred Instructional innovation that can potentially enhance the learning process and outcomes. It is a relatively new strategy that involves overhauling the typical instructional dynamics, whereby the class is flipped, moving lecture and traditional classroom activities outside the classroom (usually through the aid of technology) and moving other out-of-class activities like homework and exercises into the classrooms (Sedraz et al., 2018).

The core tenet of this strategy is the changing of the standard teaching approach in the form of inversion, where instruction that used to take place in the class is now carried out at home by the students in advance for the classes through resources like videos created by the teacher. The work that used to be done at home is then taken to the classroom and carried out in the teacher's presence (Jwair, 2018; Sergis et al., 2018). In this model, the classrooms are designed to be a place for assimilation and to concretise understanding of learned materials, usually using strategies like problem-solving, discussion, and collaborative activities. This strategy can benefit learners in several ways, including engaging and enhancing the learners' problem-solving skills and concept mastery, encouraging cooperative learning, and improving learning outcomes (Cormier & Voisard, 2018). The instructional model deemphasises in-class lectures in favour of collaborative, practical activities while giving the

students a much more significant role in their learning (Lai & Hwang, 2016). It is a form of blended learning approach to teaching.

The flipped instructional model has three main parts: "pre-class preparation, in-class learning activities, and post-class learning consolidation" (Jdaitawi, 2019). Pre-class learning preparation is the first stage in the flipped classroom model, where students access the instructional/lecture material and study it at their own pace in preparation for the next phase. The next stage is in-class learning, which involves utilising participatory and collaborative learning activities in the classrooms for revising, discussing, presenting (etc.) the content of the lessons assessed by the learners in the previous stage. The in-class learning activities help to reinforce, concretise and broaden the students' understanding of learned concepts. Post-class learning consolidation, being the final stage, primarily involves reviewing the materials to enhance the learning outcomes and promoting teachers' feedback.

The flipped classroom model is also valuable for teaching science subjects like biology. Due to its nature and content base, it is challenging to present biology concepts to students within the limited time frame of the conventional teaching methods. The flipped classroom helps in this regard, with the class being utilised for the more practical activities that enhance learning while the students are free to acquire the theoretical understanding of the concepts at their own pace and at a time more convenient for them (Flodnes, 2016; Sergis et al., 2018).

The flipped classroom model being relatively new, findings on the strategy have largely been limited, especially its effect on the biology classroom. Previous studies were primarily set in other subject contexts. Furthermore, most studies of this nature were set in higher institutions rather than secondary schools, which is the focus of this study, and they had a different geographical scope from that of this study.

Marinelli et al. (2017) assessed how well the flipped classroom works in anesthesiology resident students' achievement and retention. They reported that the flipped classroom model significantly enhanced the retention rate of the participants when compared to the traditional lecture method. The study by Fard et al. (2021) explored the efficacy of the flipped model on students' language learning and reported that the flipped classroom was effective in enhancing students' retention in language learning. However, Bouwmeester et al. (2019) explored how flipping a medical classroom affects the students' retention rate. They reported no discernible impact on students' retention rates from using the flipped classroom.

Other than just instruction strategy, a series of other variables can influence students' learning outcomes in biology, including the gender of students, which can also affect the effectiveness of instructional strategies like the flipped classroom. The influence of gender over learning is attributable to gender inequality in scientific careers, which Kalpazidou and Cacace (2017) state is still a persistent problem in our world, as well as stereotypes over which gender is better at particular fields (Banchefsky & Park, 2018). However, the issue of gender and its influence over academics and education has largely remained inconclusive, with several contrasting reports from various studies.

The lack of studies exploring the effects of the flipped classroom on biology was also evident with the gender variables. Doyle andNillsson (2019) assessed the existence of variation in engineering students learning gains (achievement and retention) and perceptions based on gender when taught with the flipped classroom model. They reported that the flipped classroom model had a more significant effect on the material retention rate of female students than male students. Abolarinwa (2020) investigated the impact of three modes flipped model of instruction on students' achievement and retention, with gender as a

moderator variable and reported that gender did not affect the students' retention rate in physics when taught with the flipped instructional model.Thus, this study explores the effectiveness of the flipped instructional model in the students' retention of biology concepts and examines the moderating effects of the gender variable.

Statement of the Problem

Biology is one of the most important fields of study, with its knowledge and understanding having considerable implications for our modern society's quality of life and living. However, despite its relevance and popularity, students' achievement in the subject is low, indicating poor retention. This poor retention rate can be prominently attributed to poor instructional strategy, as the modified lecture method prominently used by teachers may need to be revised to ensure meaningful learning outcomes in the subject. Recognising the flaws of the conventional instructional approaches raises the need to introduce instructional interventions. One such intervention is the flipped classroom instructional model, which can proffer solutions to biology learning problems. As a relatively new strategy, not much work or documentation has been done on the flipped classroom instructional model compared to other classroom instructional models. Furthermore, most of the available studies were conducted in higher institutions rather than secondary schools, in subject areas other than biology, and different geographical scopes than this study's. Thus, this study determines the "effect of flipped classroom instructional model on students' retention of biology concepts among secondary school students in Bayelsa state." Additionally, the research ascertains how gender influences the dependent variable.

Research Questions

1. What is the mean retention score of students taught biology with the flipped classroom instructional model and those taught with the modified lecture method?
2. What is the mean retention score of male and female students taught biology with the flipped classroom model and those taught with the modified lecture method?

Null Hypotheses

Ho1: "There is no statistically significant difference in the mean retention score of students taught biology with flipped classroom instructional model and those taught with the modified lecture method."

Ho2: "There is no statistically significant difference in the mean retention score of male and female students taught biology with flipped classroom model and those taught with the modified lecture method."

Methodology

A "pre-test post-test control group quasi-experimental design" was adopted for the study. The study's population consisted of two thousand eight hundred and twenty-nine (2,829) senior secondary two (SS 2) students in Bayelsa West Senatorial District (Bayelsa State Post-Primary Schools Board, 2020). A total of 159 students from four mixed-gender schools in the district made up the sample. A four-stage sampling was adopted for the study. Two municipalities were selected using a systematic selection strategy based on the following criteria: (i) Roads serving the local government areas are a necessity given the state's topography; (ii) At least ten (10) public secondary schools with access to roads should be located within each local administrative district.

The schools were then selected through the following criteria: (i) all of the schools must be public institutions; (ii) all of the schools must have proper facilities for information and communication technology; (iii) the biology educators in the school have to consent to participate in the study. Consequently, a complete class was employed, and two schools were selected at random to serve as the Experimental and Control groups, respectively.

This research used three instruments: "Instructional Guide on Flipped Classroom Instructional Model (IGFCIM), Instructional Guide on Modified Lecture Method (IGMLM), and Biology Retention Test (BRT)." The instruments received expert and content validation from biological science and science education experts and professional SS2 biology teachers. The BRT had a reliability of 0.70 using Kuder-Richardson Formula 21 (KR – 21).

The researcher trained teachers to use the instructional guide during the first two weeks of data collection. The researcher and teachers administered the pre-test during the third week. The control and experimental groups were treated using the IGFCIM and IGMLM, respectively, during the third to fifth week. The BRT was re-administered to the students four weeks after the end of treatment to get their retention scores.

The research questions were analysed using "mean and standard deviation", while "Analysis of Covariance (ANCOVA)" inferential statistics were utilised to test the hypotheses at a 0.05 level of significance.

Results

Research Question 1: "What is the mean retention score of students taught biology with flipped classroom instructional model and those taught with modified lecture method?"

Table 1: *Summary of Mean and Standard Deviation of Pre-test and Post-test Scores on the Effect of Instructional Strategies on Students' Achievement in Biology.*

Instructional Strategies	**N**	**Pre-testScores**		**Retention Scores**		**Mean**
		X	**SD**	**X**	**SD**	**Gain**
Flipped Classroom	83	46.51	10.38	60.92	12.34	14.41
Modified Lecture	76	39.09	12.55	52.57	8.88	13.48
Total	159	42.96	12.02	56.92	11.57	13.96

Students taught using the Flipped Classroom approach had a higher retention score (60.92) than those taught using the Modified Lecture Method (52.57), as shown in Table 1. The result also shows that students exposed to the Modified Lecture Method (13.48) had a lower mean gain score than those taught with the Flipped Classroom (14.41). This suggests that learners instructed using the Flipped Classroom teaching model retained learning better than those instructed using the Modified Lecture method.

Research Question 2: "What is the mean retention score of male and female students taught biology with flipped classroom instructional model and those taught with modified lecture method?"

Table 2: *Summary of Mean and Standard Deviation of Pre-test and Post-test Scores on the Effect of Instructional Strategies on Male and Female Students' Retention in Biology.*

Instructional Strategy	Gender	N	Pre-test		Retention		Mean
			X	SD	X	SD	Gain
Flipped Classroom	**Male**	50	48.24	10.49	61.38	12.42	13.14
	Female	33	43.88	9.78	60.21	12.37	16.33
	Total	83	46.51	10.38	60.92	12.34	14.41
Modified Lecture method	**Male**	39	39.44	12.09	52.92	8.31	13.48
	Female	37	38.73	13.17	52.19	9.55	13.46
	Total	76	39.09	12.55	52.57	8.88	13.48
Total	**Male**	89	44.38	11.99	57.67	11.56	13.29
	Female	70	41.16	11.90	55.97	11.61	14.81
	Total	159	42.96	12.02	56.92	11.57	13.96

The results reported in Table 2 reveal that the retention score of male students taught using Flipped Classroom (61.38) was larger than their female counterparts (60.21). Additionally, male students taught using the Modified Lecture Method had a higher retention score (52.92) than female students (52.19). Overall, male students taught using the Flipped Classroom and Modified Lecture Method had a higher retention score (57.67) than female students (55.97). The table also shows that female students taught with both instructional styles had a mean gain score of 14.81, higher than male peers' (13.29).

Hypothesis 1: "There is no statistically significant difference in the mean retention score of students taught biology with flipped classroom instructional models and those taught with modified lecture methods."

Table 3: *One-way Analysis of Covariance (ANCOVA) of Retention Scores of Students Taught Biology with Flipped Classroom and Modified Lecture Method Instructional Strategy*

Source of Variation	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8524.174	2	4262.087	52.598	.000	.403
Intercept	12261.681	1	12261.681	151.320	.000	.492
Pre-test Scores	5758.160	1	5758.160	71.061	.000	.313
Instructional Strategies	705.537	1	705.537	8.707	.004*	.053
Error	12640.921	156	81.032			
Total	536389.000	159				
Corrected Total	21165.094	158				

*"R Squared = .403 (Adjusted R Squared = .395) *= Significant at p < 0.05 alpha level"*

The result in Table 3 shows that the main effect was significant on students' retention in Biology ($F_{1,156}$ = 81.032; p < 0.05; partial eta squared = 0.053), which gives an effect size of 5.3 percent. Thus, the null hypothesis, "there is no statistically significant difference in

students' retention scores in biology when taught with flipped classroom and modified lecture method instructional strategies", was not accepted.

Hypothesis Two: "There is no statistically significant difference in the mean retention scores of male and female students taught biology with the flipped classroom model and those taught with the modified lecture method."

Table 4: *2 x 2 Factorial Analysis of Covariance (ANCOVA) of Retention Scores of Male and FemaleStudents Taught Biology with Flipped Classroomand Modified Lecture Method Instructional Strategies.*

Source of Variation	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8552.711	4	2138.178	26.108	.000	.404
Intercept	12050.148	1	12050.148	147.135	.000	.489
Pre-test Scores	5749.356	1	5749.356	70.201	.000	.313
Instructional Strategies	726.854	1	726.854	8.875	.003*	.054
Gender	6.109	1	6.109	.075	.785	.000
2Way-interactions	22.098	1	22.098	.270	.604	.002
Instructional Strategies * Gender						
Error	12612.384	154	81.899			
Total	536389.000	159				
Corrected Total	21165.094	158				

*"R Squared = .404 (Adjusted R Squared = .389) *= Significant at p < 0.05 alpha level"*

The result in Table 4 shows that the main effect was insignificant on male and female students' retention in Biology ($F_{1,154}$ = 81.899; p < 0.05; partial eta squared = 0.002), giving an effect size of 0.2 percent. Thus, the null hypothesis, "there is no statistically significant difference between male and female students' retention scores in Biology when taught with Flipped Classroom and Modified lecture methods instructional strategies", was accepted.

Discussion of Findings

This research showed that students taught with the flipped classroom instructional model had significantly higher mean retention scores than those taught with the modified lecture method. This finding agrees with that of Marinelli et al. (2017) and Fard et al. (2022), which reported that the flipped classroom model significantly enhanced the retention rate of students. However, this contradicts the findings of Bouwmeester et al. (2019), which reported that the flipped classroom model had no significant effect on students' retention.

This research found no statistically significant difference in retention rates between male and female students taught the same biology topic using the flipped classroom instructional model or the modified lecture method. This finding agrees with Abolarinwa (2020), who reported

that gender did not affect the students' retention rate when taught with the flipped instructional model. This finding disagrees with that of Doyle & Nillsson (2019), which reported that the flipped classroom model had a more significant effect on the material retention rate of female students than male students.

Conclusion

Based on the results of this research, the flipped classroom instructional model is superior to the modified lecture technique for teaching biological concepts. Thus, the flipped classroom educational style is optimal for boosting the success and retention of secondary school biology students. Gender does not influence students' retention rate of biology concepts.

Recommendations

1. Teachers in Nigerian secondary schools should use the flipped classroom format to teach biology to their students better.
2. The government and educational authorities should conduct seminars and in-service training courses on using new teaching methods like the flipped classroom.
3. The government, educational authorities, and the general community should work towards providing digital resources that will support the use of innovative instructional approaches like the flipped classroom.

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