



*Effects of in-Class Flipped Classroom Model on ... Usman, A. A., Et. al. (2026)*

## **Effect of In-Class Flipped Classroom Model on Academic Performance in Practical Biology Concepts among Secondary School Students in Kebbi State, Nigeria**

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### **Abstract**

This study investigated the effect of In-Class flipped classroom model on academic performance in practical biology concepts among senior secondary school students in Kebbi State, Nigeria. A quasi-experimental group design involving pretest- posttest control group was adopted. A total of 383 students participated in the study. The instruments used for data collection was Biology Practical Academic Performance Test (BPAPT). Data were analyzed using t-test, ANOVA, and Scheffé post hoc test at 0.05 level of significance. Findings revealed that students taught practical Biology Concepts using In-Class flipped classroom model significantly outperformed those exposed to Conventional flipped classroom model ( $t = 20.554$ ,  $p = 0.001$ ). Although ANOVA indicated an overall significant gender difference ( $p = 0.001$ ), the Scheffé post hoc analysis revealed that gender differences within each instructional method were not statistically significant, implying that the model is gender-inclusive. The study concludes that In-Class flipped classroom is a more effective and equitable instructional approach for enhancing students' performance in practical biology. It recommends that biology teachers, curriculum planners, and policymakers integrate the In-Class flipped model into secondary school science instruction to promote active learning and improve practical skills acquisition.

**Keywords:** Practical biology, Academic performance, in-class and Conventional flipped classroom

### **Introduction**

Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa (Maureen, Glenn, Michael 2000). To invert means to turn inside out or upside down, which has the similar meaning with the word Flip. Flipping 'the classroom can improve the traditional lecture; it can provide a large range of mixture of educational methods in which students get prepared materials and then take part in structured In-Class activities. Bryan and Miller (2013) stated that the Flipped Classroom makes the students learn tasks before class to spot the difficulties. The tasks go through three similar procedures: first, before class all the students watch the teaching video designed by the teacher. Second, the students try to finish all the tasks given by the teacher. Third, all the students discuss with teacher or classmates through platform to share the answers and write down those unsolved and difficult questions. Thus, the students can work out the unsolved and difficult questions with classmates or teachers rather than get the basic information passively in class. Sams, Bergmann (2013) considered flipped classroom as a teaching method, which mainly proposes that what is traditionally done in the



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classroom is now done at home, and that students do homework or do some classroom activities in the class. From the previous studies, different scholars offer different definitions on the Flipped Classroom such as Bryan and Miller (2013); Lage, Platt & Treglia (2000). However, there are some similarities in the previous definitions, which focus on the student-based approach and inverting the teaching procedure. After learning the previous definitions of the Flipped Classroom, Sams, Bergmann (2013) define Flipped Classroom as pedagogical method in which students learn new knowledge through short videos, podcasts, e-books as well as internet outside class and consolidate what they acquired through classroom activities with the help of classmates and teachers. There is no exact model that a flipped classroom has to fit. Even though there are ineffective models of a flipped classrooms that do not allow for the pedagogy to be used to the fullest potential, there are more than one effective model that has the components necessary to be successful. Flipped classroom is concerned with the practice where content is made available to the learners before the teaching and learning contacts, usually for pre-class study while the In-Class activities are facilitated by the teacher to foster the comprehension of the content (Brewer & Movahedazarhouligh, (2018); O'Flaherty & Phillips, 2015). There are three major models or types of flipped classroom instructions methods, namely: Traditional or Conventional Flip, In-Class Flip and Mastery Flip (Bergmann and Sams (2012). Traditional flip, Students are usually assigned video, image or task as homework. The purpose of this homework is to introduce or preview the information that the students will need for the next lesson. The students watch the videos and complete any corresponding work that goes with it. The next day in class, the teacher reviews any questions the students may have and introduces the learning activity for the day. Students complete during class, the work that would have been traditionally assigned as homework. In all flipped classroom models, the teacher is available to facilitate discussion, guide learning, and help students solve problems as they work through a concept. Students are responsible for completing the learning activities by a particular due date. They are also responsible for taking ownership of their learning by completing any and all assigned as home learning exercises. Flipped classroom model is effective because it gives students an opportunity to interact, engage, and learn from their peers. The Traditional flip is the most recognized and most commonly used model of flipping the classroom (Johnson et al., 2015).

The next is the In-Class flip which similar has characteristics like the Traditional flip, with the exception that students need to complete video-watching or learning activities at home. In the In-Class flip, all learning activities, including the introductory lecture or activity, is done within the classroom. The classroom is set up into stations where groups of student work independently, collaboratively, or a combination of the two, to complete the project-based, critical thinking activities. Gonzalez (2014) stressed the importance of having a few infinite stations where the activity is never really over but has many possibilities and variations that can be useful for students who complete an activity early. They can use these stations as reinforcement while waiting for the rest of their group to complete the original task. The difference between the In-Class flips and simple station work is the role of the teacher. The teacher is free to move between the stations to guide learning, help clear up any misconceptions, but never having to redeliver the lesson itself (Gonzalez, 2014). As identified by Bergmann and Sams (2012), the Mastery Flip has three main components: Students work either in small groups or individually at an appropriate pace. The teacher formatively assesses students and gauges student understanding. Students demonstrate mastery of objectives on summative assessments. For students who do not master a given objective, remediation is provided. As activities are completed, students demonstrate their knowledge in the summative assessments. If their performance on those assessments meets the criteria, they are free to move on to the next set



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of learning objectives. If not, they complete additional learning activities until they have mastered the concept. Academic performance refers to the student's level of achievement, typically measured through Practical test assessment and main examinations which can be within School, Academic performance of students has always been a subject of interest to every educational institution. Whereas there is a consensus that schools should play a major role in this process, there seems to be disagreement about what exactly that role should be. While some believe that the primary focus of schools should be the academic preparation of students (Hirsch,2001). Others however believe that efforts of schools should be integrated with other social institutions such as family and community towards educating children (Huitt, 2007). In fact, heads of educational institution, teachers and parents are primarily responsible for students' academic performance (Darling-Hammond, 2010), and that schools should efficiently and effectively organize themselves towards this task (Engelmann & Carnine, 1991). Biology is the scientific study of life. It is a natural science with a broad scope but has several unifying themes that tie it together as a single, coherent field. Biology is a natural science discipline that studies living things. (Hillis, et al 2020) Biology practical teachings are important in order to understand biology concepts, Science education targets to enhance the understanding of the natural world by students and how it works, then the students have to experience and spot the relevant of science phenomena. Recent studies advocate for a change in teaching method so that student participate fully and understand different science concepts (Miller & Levine, 2010). Students should understand processes and structure; develop skills in manipulation, processing of science information and conducting scientific investigations (Akinwumi & Falemu 2020).

### **Statement of the Problem**

Biology as a science subject requires trained techniques and the laboratory attendants employed. In few school's laboratory attendants are dropouts no basic knowledge of how to prepare specimen for biology Practical. In most cases, these laboratory attendants lack technical know how to operate, maintain, repair or service the few available equipment when they broke down. According to the Kebbi State Ministry of Education (2023/2024) student perform poor in biology practical leading to their failure in biology examiners. Similarly, WAEC Chief Examiners (2023/2024) reported that performance of candidate in practical biology fell below expectation. The report discussed the candidate Weakness under the following sub headings: Poor Spelling, Poor Observation, Poor mathematical Skills, and Poor deductive reasoning, Mis-interpretation of question, poor knowledge of biology, Lack of engagement, Lack of time and Teacher professionalism. The examiner lamented that there were many Candidates who could not answer correctly a single question in section A. In most cases, they have wild guesses and quite unrelated answer that were sometimes Un-biological. Based on the poor academic (2023/2024) Stated that objectives of practical Biology are not being realized to a satisfactory extent. The WAEC Chief Examiner's (2023/2024) pointed out that the poor academic performance in biology practical are caused by Lack of Well quipped laboratory, Inadequate qualified biology teachers, limited time-table hours Poor Observation, Poor drawing and labelling and Poor comparison of Specimens, these begin state of affairs is disturbing. They also Observed that the biology laboratory was in-adequately as a result of the students were not adequately involved only Practical lessons. The students only Watched teachers 'demonstration exercise. And also, the majority of secondary schools in Kebbi State do not have laboratories exist, the learners therefore have to memorized practical work theoretically in order to pass the examination when they are writing practical biology Papers. Most of the learners sit for examination without being exposed to Practical Work. Despite this, available data indicates an underachievement rate in the subject. Studies have linked the achievement issue to varying factors and reasons, but one variable that has continually



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been brought to light is issues related to strategies used to teach biology. According to the West African Senior School Certificate Examination (WASSCE) Chief Examiner ‘s report in kebbi state on student performance in practical biology: The performance of the candidates 2023 was worse than the previous year with a population of 1,068,564, raw mean score of 29 and standard deviation of 08.25 this year (2024) against that of WASSCE for school candidate, 2022 which had a population of 1,048,242, and a raw mean score of 36 and standard deviation of 11.66. It is against these problems that the current study aims to bridge this gap by investigating the effect of In-Class and Conventional Flipped classroom model on students’ academic performance in practical biology in kebbi state, Nigeria.

### Objectives of the Study

The main objective of this study is to examine the effect of In-Class Flipped classroom Model on Academic Performance in Practical Biology among secondary school Students in Kebbi State, Nigeria. The Specific Objectives are to:

1. Determine the difference between academic performance of Senior secondary school students taught practical biology using in-Class flipped model and those exposed to Conventional flipped classroom model in kebbi State, Nigeria
2. Assess the difference between Male and Female academic performance of senior secondary school students expose to In-Class Flipped and those expose to Conventional flipped classroom model in Practical Biology in Kebbi State. Nigeria.

### Research Questions

Based on the above research objectives, the following research questions were raised.

1. What is the mean difference in academic performance scores of secondary school students taught practical biology concept using in-Class flipped model and those exposed to Conventional flipped classroom model in kebbi State, Nigeria?
2. What is the mean difference in academic performance scores between male and female secondary school students taught practical biology concept using in-Class flipped model and those exposed to Conventional flipped classroom model in kebbi State, Nigeria?

### Research Hypotheses

The following null hypotheses were formulated;

- Ho<sub>1</sub>. There is no significant difference between the academic performance of secondary school students taught Practical Biology using In-Class Flipped classroom model and those Exposed to Conventional Flipped classroom model in Kebbi State Nigeria.
- Ho<sub>2</sub>. There is no significant difference between the academic performance of secondary school students taught Practical Biology using In-Class Flipped classroom model and those Exposed to Conventional Flipped classroom model in Kebbi State Nigeria.

### Research Methodology

A quasi-experimental research design was used for this study, with a target population of 23,730 biology SS II students in all the 119 public secondary schools distributed among 6 educational zones in Kebbi State. About 383 SSII biology Students comprising of 218 Males and 165 Females Students were selected within four secondary schools in two educational zones (Birnin Kebbi and Argungu), using purposive and multi Stage Sampling techniques.

**Table 1: Summary of the sample size of schools, groups and students according to gender**

S/N	Name of Schools	Group	SS2 Males	SS2 Females	Total
1	G. D. S. S. Argungu	Experimental 1	58	42	100



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2	S.S.S.	Argungu	Experimental	2	56	43	99
3	G.D.S.S.	B/Kebbi	Control	1	56	43	99
4	S.H.G.G.S	B/Kebbi	Control	2	48	37	85

<b>Total</b>					<b>218</b>	<b>165</b>	<b>383</b>
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Multi stage and purposive sampling were used to ensure a more representative sample for the populations. Also, intact Classes were used for each group i.e two experimental groups and two control groups. Biology Practical Academic Performance Test (BPAPT) was used as the instrument for data collection and was submitted to experts for validation. Some of their observations are; contents are adequate to answer the research Questions, Construct Validity was examined and found okay. A pilot test was conducted in Dankoji Government Day Secondary School (DGDSS), Argungu which is not part of sample, using test - retest method with two weeks interval. Data obtained after the test were analysed using Pearson Product Moment Correlation coefficient (PPMCC). The reliability of Co efficient arrived at was 0.77. The data collection was made in three phases that is Pre-treatment, Treatment and Post- Treatment stage. Data was collected using a Pre-Test for Biology Practical Academic Performance Test (BPAPT) for both experimental and the control groups two weeks before the commencement of treatment phase of the research. This research aimed to comparing two models of flipped Classroom strategy, namely: Traditional and in Class Flipped Models. In this research Traditional Flipped classroom model was involved giving each student all the information's including images and specimen to study at home. During the lesson, what students observed at home was used to facilitate learning using guided discussion learning approach While for In-Class model, no student was given any task to study at home. Instead, the students were divided into groups and assigned a space in the classroom to study the images and specimen in the classroom for sometimes. Later, observation was used by the teacher to facilitate learning through discussion and guided learning strategy. This was done to determine the entry consistency between the groups. As treatment, one set of experimental group was taught Digestive System and Germination using In-Class Flipped Classroom; while the Control group was taught Digestive System and Germination using Traditional Flipped classroom. At the end of the treatment, the groups in different schools were administered Biology Practical Academic Performance Test (BPAPT) again as Post Test and the Score of Students was used as data. The data collected were analysed using independent sample t-test for Biology Practical Academic Performance Test (BPAPT), while ANOVA was used for analyse the difference between genders and Scheffe's Post Hoc, to comprised test for difference between Performance of Male and Female Students

**Presentation of Results**

Based on the results obtained the analysis and interpretation were done with the use of tables to provide a clear picture of the findings as follows:

**Research Question One:** What is the mean difference in academic performance scores of secondary school students taught practical biology concept using in-Class flipped model and those exposed to Conventional flipped classroom model in kebbi State, Nigeria?

**Table 2: Descriptive Statistics Result of the Biology Practical Academic Performance Test (BPAPT) between Experimental and Control Group**

Group	N	Mean	Standard Deviation	Mean Difference
<b>Experimental</b>	199	26.3618	5.1561	11.6716
<b>Control</b>	184	14.6902	5.9512	
<b>Total</b>	<b>383</b>			



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Table 2 is a summary of Mean and standard deviation calculated to assess the difference in the Biology practical academic performance test (BPAPT) in practical biology between experimental (in-class flipped classroom) and control (conventional flipped classroom) groups. The result shows the experimental group, which was exposed to the in-class flipped classroom model, had a mean score of 26.36 with a standard deviation of 5.16, indicating relatively high performance with moderate variability among students' scores. In contrast, the control group, which was taught using the conventional flipped classroom model, recorded a mean score of 14.69 with a standard deviation of 5.95, reflecting lower academic performance and slightly greater dispersion of scores compared to the experimental group. The mean difference between the experimental and control groups was 11.67, showing that students exposed to the in-class flipped classroom model outperformed those in the conventional flipped classroom model by a wide margin. Furthermore, the difference in standard deviation between the two groups was 0.79 (SD = 5.95 -5.16), indicating that scores in the control group were more widely spread than those of the experimental group. This suggests that, in addition to achieving higher academic performance, students in the experimental group demonstrated more consistent learning outcomes. Overall, the results indicate that the in-class flipped classroom model was more effective in enhancing students' academic performance in practical biology than the conventional flipped classroom model.

**Research Question two:** What is the mean difference in academic performance scores between male and female secondary school students taught practical biology concept using in-Class flipped model and those exposed to Conventional flipped classroom model in kebbi State, Nigeria?

**Table 3: Descriptive Statistics Result of Male and Female Students' Posttest Academic performance in Practical Biology between Experimental and Control Group.**

Group	Gender	N	Mean	Std. Dev.	Mean Difference
<b>Experimental</b>	<b>Male</b>	114	26.7105	5.1245	0.8164
	<b>Female</b>	85	25.8941	5.1916	
<b>Control</b>	<b>Male</b>	105	14.0476	6.2070	1.4967
	<b>Female</b>	79	15.5443	5.5164	
<b>Total</b>		<b>383</b>			

Table 3 presents the descriptive statistics of male and female students' post-test academic performance in practical biology across the experimental and control groups. In the experimental group, male students recorded a mean score of 26.71 with a standard deviation of 5.12, while female students had a mean score of 25.89 and a standard deviation of 5.19. The mean difference between male and female students in the experimental group was 0.82, indicating a very small difference in performance in favour of the male students. The difference in standard deviation between the two subgroups was 0.07, suggesting nearly identical variability in their performance. In the control group, male students obtained a mean score of 14.05 with a standard deviation of 6.21, whereas female students recorded a mean score of 15.54 and a standard deviation of 5.52. The mean difference between male and female students in the control group was 1.50, slightly in favour of the female students. The difference in standard deviation was 0.69, indicating greater variability in performance among male students in the control group. Overall, the results show that male and female students in the experimental group performed at nearly the same level, with minimal differences in both mean scores and variability. In contrast, although slight gender differences were observed in the control group, these differences were small. This suggests that the in-class flipped classroom model promoted comparable academic performance among male and female students in practical biology.



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**Hypothesis One (H<sub>01</sub>):**

There is no significant difference between the academic performance of secondary school students taught Practical Biology using In-Class Flipped classroom model and those Exposed to Conventional Flipped classroom model in Kebbi State Nigeria.

**Table 4: Independent Samples t-test Analysis of Academic Performance in Practical Biology between Experimental and Control Group**

Group	N	Mean	SD	df	t-Cal	p-Value	Decision
<b>Experimental</b>	199	26.3618	5.1561	381	20.554	0.001	H <sub>01</sub>
<b>Control</b>	184	14.6902	5.9512				Rejected

Table 4 presents a summary of independent t-test comparison to determine the significance of the mean difference between academic performance of experimental group and control group. The mean and the standard deviation of the experimental group is 26.36 and SD is 5.16 respectively, while in the control group the Mean is 14.69 and SD is 5.95 respectively. Thus, since the p-Value of 0.001 was less than < 0.05 level of significance ( $p=0.001 < 0.05$ ), the null hypothesis one (H<sub>01</sub>) was rejected which means the Mean difference between the two group is statistically significant. Therefore, the students exposed to the In-Class flipped classroom model performed significantly higher than those exposed to the Conventional flipped classroom model in practical biology in Kebbi state, Nigeria. Hence, In-Class flipped classroom model was a more effective in enhancing academic performance of students in practical biology in Kebbi state, Nigeria than the Conventional flipped classroom model.

**Hypothesis Two (H<sub>02</sub>):**

There is no significant difference between the academic performance of secondary school students taught Practical Biology using In-Class Flipped classroom model and those Exposed to Conventional Flipped classroom model in Kebbi State Nigeria.

**Table 5: ANOVA Analysis of Posttest Academic Performance in Biology Practical between Male and Female Students in the Experimental and Control Group in Kebbi State**

Variation	Sum of Squares	df	Mean Square	F-Cal	p-Value	Decision
<b>Between</b>	13157.078	3	4385.693	143.145	0.001	H <sub>04</sub>
<b>Within</b>	11611.851	379	30.638			Rejected
<b>Total</b>	<b>24768.930</b>	<b>382</b>				

Table 5: presents a summary of Analysis of Variance (ANOVA) conducted to determine whether a significant difference exists in the posttest academic performance in biology practical among male and female Secondary School Students in the experimental and control groups in Kebbi State. The result of the ANOVA showed a calculated F-value of 143.145 with 3 and 379 degrees of freedom and a p-value of 0.001 at the 0.05 level of significance. Since the p-value of 0.001 was less than the 0.05 level of significance ( $p = 0.001 < 0.05$ ), the null hypothesis two (H<sub>02</sub>) was rejected. This indicates that there was a statistically significant difference in posttest academic performance in biology practical among male and female students in the experimental and control groups. Therefore, academic performance in biology practical differed significantly across gender and treatment groups in Kebbi State, Nigeria. The specific locations of these differences are further explained using the Scheffé's post hoc multiple comparison test presented in Table 6.

**Table 6: Scheffe's Post Hoc Comparison Test for Difference between Performance of Male and Female Students in the Experimental and Control Group in Kebbi state**

Treatment Group	Gender	N	Subset for alpha = 0.05	
			1	2
	Male	105	14.0476	



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<b>Control</b>			
	Female	79	15.5443
	Female	85	25.8941
<b>Experimental</b>			
	Male	114	26.7105
		<b>0.332</b>	<b>0.797</b>

Table 5: is a summary of the Analysis of Variance (ANOVA) computed to determine the significance of the mean differences in the academic performance in biology practical of male and female Senior Secondary School students exposed to In-Class flipped classroom model and those exposed to Conventional flipped classroom model in Kebbi state, Nigeria. The results of the analysis revealed that there was statistically significant difference among performance of male and female students in the experimental and control group at calculated F ratio of 143.145, with a p-Value of 0.001 at 0.05 level of significance  $F(3, 379) = 143.145, p = 0.001$  &  $\alpha = 0.05$  level of significance. Therefore, since the p-Value of 0.001 is less than 0.05 level of significance ( $p < 0.05$ ), the null hypothesis two ( $H_{02}$ ) was also rejected. This implies that a statistically significant difference exists among the means of males and females in the groups.

Table 6 presents results of Scheffe's Post Hoc multiple comparison test to show where significant difference exists in the mean performance of students in biology practical between male and female in the experimental and control group. The result of the multiple comparison revealed that the academic performance of experimental Male (Mean = 26.71) and Female (Mean = 25.89) students exposed to In-Class flipped classroom model were significantly different from their control Male (Mean = 14.05) and female (Mean = 15.54) students exposed to the Conventional flipped classroom model. However, no significant mean difference exist between male and female students' performance in Biology practical in both experimental ( $p=0.797$ ) and control ( $p=0.332$ ) group.

### Discussion of Findings

This study assessed the effects of In-Class flipped classroom model on academic performance in biology practical among senior secondary school Students in Kebbi state, Nigeria. The first finding of the study revealed that students exposed to the In-Class flipped classroom model performed significantly better than those exposed to the Conventional flipped classroom model in biology practical in Kebbi state. This finding confirmed the finding of a similar research study conducted by Malto, Dalida, and Lagunzda (2018), who conducted a similar study in Philippines, to evaluate the impact of the flipped classroom approach on students 'academic achievement and attitude toward biology. They found that flipped classroom group showed significantly higher academic performance in biology than the control group exposed to Conventional method suggesting that exposure to flipped classroom instruction enhanced students 'understanding of biological concepts and fostered better performance in the subject. Similarly, the finding of this study corroborated the findings of Nja, Orim, Neji, 2022), who conducted a similar study in Calabar, Nigeria, to examine how the flipped classroom approach influences students 'attitudes and academic achievement. Nja, et al (2022), found that flipped classroom strategy significantly improved second-year chemistry students 'academic performance, particularly in the redox reaction test. Overall, the results indicated that integrating flipped classroom practices positively impacted both students 'engagement with chemistry and their academic outcomes. Also, the finding of this study supported the findings of Eze (2023), who examined the impact of flipped learning on the interest and achievement of Nigeria Certificate in Education (NCE) mathematics students in Trigonometry in Kano State. They found that significant differences exists in achievement scores between the experimental and control groups in which



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students taught Trigonometry using the flipped classroom approach achieved higher mean scores than those taught with the traditional lecture method. The study recommended that mathematics lecturers in Nigerian colleges of education should adopt flipped learning as a teaching strategy, and that this method be integrated into mathematics instruction at all levels of the Nigerian education system to enhance both student interest and academic performance. In addition, the finding was in line with the findings of Ogunleye, Onifade, Ogundeji, and Sonde (2024), who also studied the effect of Flipped Classroom Strategy on the Performance and Cognitive Style of Senior Secondary School Biology Students in Ogun State, Nigeria. The results of their study revealed that students exposed to flipped method performed significantly better than those exposed to Conventional lecture method suggesting the efficacy of the flipped classroom model on enhanced academic performance in biology. Similarly, the finding of the study confirmed the results of a similar study by Susuoroka, Afful, Kwadwo, and Sawyer (2024), who explored how the flipped classroom teaching strategy influences students' motivation in numeracy and their academic performance in basic schools within Tumu Municipal, Ghana. The findings revealed that the flipped classroom model was more effective than traditional teaching methods in enhancing both numeracy achievement and motivation among Ghanaian basic school pupils. They recommended that basic schools should adopt the flipped classroom approach to foster higher motivation and improved learning outcomes.

### Conclusion

Based on the findings of this study, it can be concluded that the In-Class flipped classroom model is a more effective instructional approach than the Conventional flipped classroom model in teaching practical biology at the secondary school level. Students exposed to the In-Class flipped classroom model demonstrated significantly higher academic performance. These outcomes suggest that the In-Class flipped approach promotes active participation, meaningful interaction, and deeper understanding of biological concepts during practical activities.

### Recommendations

Based strictly on the findings of this study, it is recommended that:

1. Biology teachers in secondary schools should explore the use of In-Class flipped classroom model for teaching practical biology, as the model was found to significantly improve students' academic performance.
2. Since students exposed to the In-Class flipped model demonstrated better learning outcomes, its use should be encouraged during biology practical lessons to promote active participation and deeper understanding of concepts.

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