
The Role of Flipped Classroom Approach on Students' Knowledge Retention in Biology Concepts

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Abstract: *This study was conducted to examine the role of flipped classroom approach on students' knowledge retention on biology concepts. A pretest, posttest non-equivalent control design was adopted for the study. The sample comprised of fifty-eight (58) level 300 biology students. 28 students constituted the control group and the experimental group was also made up of 30 students. The control and experimental groups were taught using conventional method and flipped classroom approach respectively. The instruments used for data collection were pretest, posttest and retention test. The reliability of the instruments was determined using test-retest reliability coefficient. The reliability coefficients were found to be 0.75, 0.74, and 0.78 for the pretest, posttest, and retention test, respectively. The data was analysed using t-test. The results of the study proved that there was statistically significant difference between the posttest and pretest mean scores of students taught using flipped classroom approach ($p=0.00$, $p<0.05$). The results also revealed a statistically significant difference in knowledge retention between students taught using flipped classroom approach and those taught using conventional method ($p=0.00$, $p<0.05$). The results also indicated a statistically no significant difference in knowledge retention between male and female students taught using flipped classroom approach ($p=0.06$, $p>0.05$). Flipped classroom was more effective than conventional method in enhancing student's academic performance and knowledge retention in biology concepts. It was therefore recommended that biology lecturers should adopt flipped classroom approach in teaching biology concepts.*

Keywords: flipped classroom, conventional method, academic performance, knowledge retention, biology concepts

INTRODUCTION

The integration of information and communication technologies (ICTs) in teaching and learning process has positively impacted teacher lesson delivery from basic level to tertiary level. In recent years, different education ideas have come into existence as a direct result of the widespread adoption of technology in the classroom (Shahzadi et al., 2022). Educational researchers are exploring on instructional strategies that are capable of engaging students at home and in school. One of the current instructional approach that is gaining recognition at the tertiary level is flipped classroom.

Flipped classroom therefore can also be described as a model of instruction that takes the best approach to a classroom or learning environment where students are placed at the center of learning. Effective comprehension, critical analysis, and student interest are enhanced by reversing the traditional learning context and dedicating part of classroom time to constructive learning (Olanrewaju & Richard, 2023). The one-on-one connection between teachers and students, increased learner engagement that promotes active learning, and personalized learning are just a few of the advantages of flipped classrooms. Additionally, it encourages self-paced learning and allows students to review materials at their own pace thereby promoting a deeper understanding of the subject matter. Numerous studies have documented high academic achievements and heightened involvement of students in the flipped classroom (Guy & Marquis, 2016). A flipped classroom allows students to engage fully during the teaching and learning process while the facilitator gives support to students who need additional help.

The flipped classroom approach allows learners the opportunity to access learning instruction at their own pace and to apply what they have learned through different activities provided as they enter the classroom for face-to-face interaction (Enfield, 2013). A flipped classroom enriches the learning environment which increases the effectiveness of the lessons and makes teaching and learning more communicative (Gencer et al., 2014). With the use of videos, flipped learning allows students to access material at any time and from any location, promoting their independence in the teaching and learning environment (Talbert, 2012). To convey learning content, improve learning, and provide additional practice opportunities, all of which often require a significant amount of time during constrained class hours, flipped learning shifts learning outside of the classroom which saves more time for effective classroom discussion (Kong, 2014).

Flipped classroom provides an opportunity for students to use most of the time in class for discussion and group work to enable them gain a deeper understanding of the concept (Sukerti et al., 2021). Flipped classroom model helps students acquire pre-notional concept of the lesson before the commencement of the in-class activities (Dorji & Dorji , 2022). Flipped classroom helps learners to acquire basic information of the lesson with the help of pre-recorded lesson videos presented as homework before attending class for in-class activities (Aydın & Mutlu, 2023). This

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instructional approach encourages students to finish reading the material at their comfort zones and participate in live problem-solving activities during in-class time (Fernandes, 2022). Flipped classroom empowers students to take active responsibility for their own learning and also transforms the teacher into a facilitator (Kiem & Keodavan, 2024).

A flipped classroom improves communication between the teacher and the students, guarantees effective involvement, encourages active student participation, and aids in the development of the necessary skills (McLean & Attardi, 2018). The flipped classroom method acknowledges the unique learning styles of each student, which enhances the learning environment and boosts student engagement (Nja, et al., 2022) while developing students' capacity for independent study, critical thinking, experience-building, and effective communication. In a flipped classroom, the teacher is no longer the controller of the content but a coach or facilitator who guides students during the teaching and learning process to complete a given task. With plenty of opportunity for student collaboration and teacher-student contact in the classroom, flipped learning encourages deeper engagement with the material (Aidoo et al., 2022).

Many scholars believe that flipped classroom model is superior to the conventional classroom model. Thai et al. (2017) conducted a study on the impact of flipped classroom design on the learning performance of students in higher education and found that flipped classroom students performed significantly higher than their cohorts in the conventional classroom. Casasola et al, (2017) also conducted a study on the effect of flipped classroom model on undergraduate students' performance in chemistry and concluded that students in the flipped classroom performed significantly better than those in the traditional classroom. Although scholars have shown that flipped classrooms are better than traditional classrooms (Jang & Kim, 2020), some scholars also argued that traditional classrooms are superior to flipped classrooms. Pi and Do (2017) investigated the effectiveness of flipped classroom learning using the smart device and found that the traditional classroom teaching approach is better than the flipped classroom model. Ma et al. (2013) also explored flipped classroom teaching in university information Technology public courses and found that the traditional teaching method is better than the flipped classroom approach. Some scholars also hold a neutral believe that flipped classroom model and conventional classroom teaching strategy have no significant difference in students' academic performance. American scholar, Clark compares the effect of flipped classroom model and conventional classroom teaching method on students' academic performance in mathematics. The results found no significant difference in students' academic performance between the flipped classroom model and the conventional teaching method (Clark, 2017). Despite different findings from these authors, there is enough evidence to prove that flipped classroom approach improves students' academic performance and makes teaching and learning easier for both teachers and their students (Esperval et al., 2020).

Statement of the problem

The researcher students' academic performance in diversity of living organisms and plant physiology has been declining for the past three years. The researcher interacted with the students to know the cause for the declining performance of the students in these biological concepts. The students mentioned four causes: broad nature of the courses; abstract nature of some concepts in plant physiology; inadequate practical activities; and many technical concepts in biological classification. Fauzi and Mitalistiani (2019) stated that students encountered challenges in understanding Genetics, Biological classification, and Cell division. The academic performance of students in Biology is unsatisfactory (Bichi et al., 2019). This challenge stems from various factors that could be hindering students' understanding and success in these courses. Some of these factors include the complexity of the courses, lack of practical activities, limited teaching resources, and the instructional methods used by teachers. The difficulty experienced by students in learning biological concepts is due to the teaching styles of Biology teachers and students' attitudes toward Biology (Husna et al., 2023).

One of the most important variables in enabling meaningful and effective learning of biological concepts is the adoption of effective instructional methodologies. This necessitates that biology teachers should implement new teaching strategies capable of engaging students both in and out of the classroom. Flipped classroom is an innovative learner-centered teaching approach capable of engaging students in class and outside the classroom. Flipped classroom method encourages students to study the materials at home (Bishop & Verleger, 2013) and frees up classroom time for teacher- students interactive learning activities. Flipped classroom is proven to be an instructional strategy that empowers students to acquire critical thinking skills in the 21st century, stimulates students' self-learning and improves students' academic success (Jasmana et al., 2024). There is no published work seen concentrating on the role of flipped classroom approach on students' knowledge retention in biological concepts in the northern part of Ghana specifically Upper East Region. It is against this background that the researchers deemed it necessary to explore the role of flipped classroom approach on students' academic performance and knowledge retention in Biological concepts.

Research Objectives

The specific objectives of the study were to:

1. examine the difference between the posttest and pretest mean scores of students taught diversity of living organisms and plant physiology using flipped classroom approach.
2. determine the difference in knowledge retention between students taught diversity of living organisms and plant physiology using flipped classroom approach and those taught using conventional method.
3. examine the difference in knowledge retention between male and female students taught diversity of living organisms and plant physiology using flipped classroom approach.

Research Questions

The study was guided by the following research questions:

1. What is the difference between the posttest and pretest mean scores of students taught diversity of living organisms and plant physiology using flipped classroom approach?
1. What is the difference in knowledge retention between students taught diversity of living organisms and plant physiology using flipped classroom approach and those taught using conventional method?
2. What is the difference in knowledge retention between male and female students taught diversity of living organisms and plant physiology using flipped classroom approach?

Null Hypotheses

The following null hypotheses were formulated and tested at 0.05 significant level.

HO₁: There is statistically no significant difference between the posttest and pretest mean scores of students taught diversity of living organisms and plant physiology using flipped classroom approach.

HO₂: There is statically no significant difference in knowledge retention between students taught diversity of living organisms and plant physiology using flipped classroom approach and those taught using conventional teaching method

HO₃: There is statistically no significant difference in knowledge retention between the male and female students taught diversity of living organisms and plant physiology using flipped classroom approach.

LITERATURE REVIEW

Constructivism Learning Theory

Constructivism learning theory (CLT) is rooted in Jean Piaget and Vygotsky's critical social nature communication which is the foundation of the theory. Constructivism learning theory was developed by Jean Piaget, Lev Vygotsky, and John Dewey centuries ago (Alzaharani & Woollard, 2013). These people have intelligently made this learning theory suitable for the rapid change and dynamic world conditions of the modern world in the teaching and learning process.

The constructivism learning theory is normally credited to Jean Piaget who articulated processes by which knowledge is internalized by students (Bhattacharjee, 2015). There are two processes through which students construct new knowledge from their pre-existing experiences. These processes are accommodation and assimilation. Accommodation involves the conceptualisation of one's mental representation of the external environment to fit the new experiences he/she has gotten whereas assimilation is the process by which an individual incorporates new knowledge he/she had

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into an already existing model of existing experiences without changing the model (Adom et al., 2016).

Constructivism learning theory is an approach that attempts to build knowledge by adapting the cognitive structure of new information to previously obtained information (Nurhuda et al., 2023). Constructivism is a learning theory in which learners construct their knowledge through interaction with each other based on their existing experiences (Sharma & Poonam, 2016). Constructivism involves knowledge acquisition which emphasizes the active role of the learners in the construction of knowledge of the students and interpretation of reality (Pundir & Surana, 2017).

Constructivism theory of learning emphasizes that learning is an active process whereby students construct new knowledge based on their previous knowledge and understanding. Effective and efficient teaching enables learners to make connections between old and new knowledge to form new ideas (Faryadi, 2015). The constructivist teacher sets up problems and monitors students' explorations, guides the directions of students' inquiry and promotes new patterns of thinking (Pundir & Surana, 2017). A constructivism teacher places more emphasizes on learning process skills, not solely on learning outcomes (Muhajirah, 2020).

The role of the teacher in constructivist classrooms is to organize information around big ideas that engage the students' interest to assist students in developing new insights and connect them with their previous learning (Bhattacharjee, 2015). In constructivist classrooms, teachers only facilitate learning as mentors while students are the protagonists of the learning process (Orak & Al-khresheh, 2021). In a constructivism setting, learners not only absorb information inertly but also participate in the learning process and form new knowledge and new experiences based on existing knowledge (Oanh & Nhung, 2022). In a constructivist setting, the environment is democratic, the activities are interactive and learner-centered and learners are sceptor by the teacher who acts as a coach or facilitator (Umida et al., 2020). The role of the teacher in a constructivism classroom is to help students build their knowledge based on their prior knowledge and to control the learners during the teaching and learning process in the classroom (Alzahrani & Woollard, 2013). The teacher involves learners in experiences that contradict their existing knowledge and encourages collaborative discussion in a constructivist classroom (Golder, 2018).

Constructivism plays a vital role in interpreting learning outcomes and designing teaching and learning environments to support effective learning (Suhendi & Purwarno, 2018). Constructivism transforms the student from a passive receiver of information to an active participant in the teaching and learning process (Thomas, 2023). Constructivism has contributed significantly to the increased emphasis on active learning, experiential learning and students' academic success (Allen, 2022).

Constructivism learning theory says that individuals construct their knowledge based on their prior knowledge, experiences and the patterns of new information they encounter. Constructivism learning theory is a theoretical base of the flipped classroom (Hao, et al., 2024) in teaching and learning plant physiology and diversity of living organisms. In a flipped

classroom, several strategies are usually set by teachers to help students construct their knowledge.

How flipped classroom works

Students get instructional materials, for example, a video or reading material before going to a class (Barral et al., 2018). These activities are specifically designed to captivate the minds and spark their interest in the concept. The application of multimedia resources, interactive simulations, and real-life examples transforms the learning process into a vivid experience (Ebrahim & Naji, 2021). In-class activities concentrate on discussion, collaboration and hands-on experiments (Inengite & Zipamone, 2024). Instead of lecture-based teaching, the teacher asks students to discuss, form groups and do hands-on experiments. Students are asked to share their pre-existing knowledge, ask questions and collaborate with their peers to create their understanding of the topics. In the simulated classroom situation, the teacher contributes by providing the right direction and support but left the learning process to the students to be self-propelled (Lijie , et al., 2023).

The teacher helps the students to see how these concepts are encountered in daily activities. Teachers can influence the students to be self-explorers and to analyze real-life and conduct field observations or experiments to make sure the student has grasped the main issue. Students should see their learning process and be involved in metacognitive tasks at the end. The students ponder their understanding, track what they are good at and what needs more work, and then they lay out the goals for improvement. Teacher gives possibilities for self-appraisal, peer feedback, and contemplation on the experience of the learning process so that the learners develop metacognitive skills and comprehend in-depth (Oyewumi, 2021).

The teacher makes effective use of technology tools and resources to supplement learning experiences. The teacher introduces online simulations, virtual labs, online resources, and multimedia materials to make the learning process more dynamic and interactive (Hao, et al., 2024).

Empirical studies on the effect of flipped classroom approach on students' knowledge retention of learned materials

Previous studies have conducted to examine the effect of flipped classroom model on knowledge retention among students. Research into the effect of flipped classroom instructional approach in various academic fields and how it affects students' knowledge retention on a global and local scale have been conducted in different circumstances. For example, Aydin and Mutlu (2023) conducted a study on project-based learning and flipped classroom model impact on academic success, retention, and individual innovation competence. The results of their study showed that students had high retention scores when they used the flipped classroom method which proved flipped classroom model enhanced students' retention of learned concepts. A study by Vincent and Gillespie (2022) investigated the evaluation of flipped classroom approach on mathematics

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knowledge retention in the USA and revealed that there was statistically no significant difference in knowledge retention in mathematics between students who were exposed to flipped classroom and the cohorts who were also taught using a conventional method. Similarly, Bouwmeester et al. (2019) looked at flipping the medical classroom: effect on workload, interactivity, motivation and knowledge retention in the Netherlands. Their findings discovered that no significant difference existed between students who were exposed to flipped classroom and their counterparts who were also exposed to conventional classroom.

In addition, Noroozi et al. (2020) researched the effect of flipped classroom on L2 learners' development and retention of grammatical knowledge in Iran. Their findings reported that the use of the flipped classroom model resulted in significant improvement in learning and retention of conditional sentences. A study conducted by Alnahdi et al. (2022) investigated the effect of flipped classroom on knowledge retention of medical students. The findings of their study discovered that the flipped classroom model significantly and positively improved students' knowledge retention than students who were taught through the traditional method. Soltanabadi et al. (2021) researched the effect of flipped classroom on Iranian adolescent elementary EFL learners' vocabulary recall and retention and reported that flipped classroom significantly impacted students' vocabulary recall and retention.

Furthermore, Sakti et al. (2023) looked into the effect of flipped classroom on learning: A Meta-analysis in Indonesia and revealed that students in the flipped classroom retained more of what they learned. Bupo and Ibeneme (2022) researched the effect of the flipped classroom approach on students' retention of financial accounting among business students at River State University, Nigeria. The findings revealed that flipped classroom had a higher significant effect on students' knowledge retention in financial accounting retention than their colleagues who were taught through conventional method. Their finding also discovered that flipped classroom did not have a significant effect on students' knowledge retention in terms of gender. Sirakaya and Özdemir (2018) examined the effect of flipped classroom on students' academic achievement, self-directed learning, motivation, and retention and reported that flipped classroom positively impacted students' knowledge retention. McHugh (2018) also evaluated the effect of flipped classroom compared to traditional classroom on the retention of information and course engagement in a radiation safety course and reported that no significant differences were observed in students' critical thinking skills, knowledge retention, or student engagement between flipped classroom and traditional classroom students.

Golaki et al. (2022) researched the effect of flipped classroom through near-peer education on patient safety knowledge retention in nursing and midwifery students and reported that the flipped classroom model slightly increased students' knowledge retention means scores but failed to statistically improved knowledge retention of students. A study by Graham et al. (2019) investigated the effect of flipped classroom on knowledge acquisition and retention in an internal medicine residency program. Their findings discovered that the flipped classroom model significantly affected students' knowledge retention of learned materials. A study by Usman et al.

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(2022) explored gender differentials in the use of flipped classroom instructional models in enhancing achievement and retention in oral English content of senior secondary schools in Minna, Niger State, Nigeria. The results of their study reported that students experienced high knowledge retention when they were taught using a flipped classroom strategy.

Finally, Olanrewaju and Richard (2023) looked into students learning interests, academic performance, and learning retention in college physics using flipped classrooms and traditional classrooms in Nigeria. The results of the study revealed that the flipped classroom learning strategy significantly influenced students' learning retention in physics. Gasparič et al. (2024) examined the effectiveness of flipped learning and retention of knowledge and students' perceptions. Their results demonstrated that students who were taught through flipped classroom learning and teaching approach showed a higher level of knowledge retention than their counterparts who were taught through the conventional method. Similarly, a study that explored the effect of flipped classroom learning and traditional method on retention and satisfaction among operating room students and concluded that flipped classroom students gained higher knowledge retention than their cohorts who were taught through the traditional method (Abarghouie et al., 2020).

Although most of the research studies revealed that the flipped classroom approach significantly and positively impacted students' knowledge retention, other research studies reported no significant difference in students' retention of learned materials when taught using the flipped classroom instructional strategy.

METHODOLOGY

Research design

The study adopted a pretest, posttest non-equivalent control group quasi-experimental design. The participants were sampled using a convenience sampling technique and were randomly put into two groups, control and experimental groups.

Participants

The population of the study included all science students at C. K. Tedam University of Technology and Applied Sciences. The sample of the study consisted of 58 biology students. The control group students were made up of 28 students and the experimental group was also made up of 30 students. The students in the control group were taught using conventional method and those in the experimental group were also exposed to flipped classroom approach.

Research instruments

The instruments used in data collection were pretest, posttest, and delayed test (knowledge retention test). The test items were developed from plant physiology and diversity of living organisms. Each test instrument was divided into sections A and B. Section A was multiple

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choice questions and section B was theory questions. Each item in section A had four options, A-D, one key, and three distractors which reflected students' misconceptions about diversity of living organisms and plant physiology. The students were required to answer all questions in both sections.

The instruments used for data collection were developed by the researchers and were given to experts in science education for validation. The recommendations of the experts were taken into consideration. The reliability of the instruments was determined using test-retest reliability coefficient. The reliability coefficients were found to be 0.75, 0.74, and 0.78, for the pretest, posttest, and retention test (delayed test), respectively.

Interventions

The students in the experimental group were introduced to plant physiology and diversity of living organisms using flipped classroom approach. This instructional approach was used in presenting lessons to the students both in and out of class with the help of a software called Open Broadcasting Software (OBS). This software helped the instructor to deliver the lesson at home and record it in a video form. The instructor prepared the lessons on concepts in plant physiology and diversity of living organisms in a PowerPoint format. The teacher then delivered the lesson and record using OBS studio and sent to the students through email, Google classroom and telegram for them to download and study at home. This mode of presentation aid students to play, watch, listen and sometimes pause when necessary for better clarification. This was done every week to enable students prepare adequately for in-class activities.

During the in-class session, students were engaged in practical activities and group discussion. Students were put into groups and assigned tasks for them to perform and share the solution with other group members. During this session, the teacher guided the student's in identification of specimens, drawing the specimens, and also stating the Domain, Kingdom, Phyla/Division and Classes of specimens with reasons. The teacher also guided the students to state the specimens' adaptive feature and economic importance.

The students in the control group were also taught using the conventional teaching method. The students were introduced to concepts in plant physiology and diversity of living organisms using PowerPoint presentations. Concepts in plant physiology and diversity of living organisms were prepared using PowerPoint and presented to students in class and assignments were given to students to complete at home. Practical activities were also organized for students once every week on diversity of living organisms and plant physiology.

Data Analysis

The data collected from the students were analysed using t-test with the help of Statistical Package of Social Sciences (SPSS) version 27. The null hypotheses were tested at an alpha level of 0.05. The researchers used effect size (Cohen's d) to examine how important any

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observed differences are. An effect size of 0.8 and above indicates a substantial difference (Cohen, 1988).

RESULTS AND DISCUSSION

The results of the study were organized based on the research questions and null hypotheses. The hypotheses were tested in order to answer the research questions. To conduct such test, it was necessary to test for normality to determine whether the parametric test assumptions were met.

Table 1: Normality test results

		Shapiro-Wilk		
Variable		Statistic	Sig.	Description
Pretest	Experimental	.955	.267	Normal
	Control	.967	.494	Normal
Posttest	Experimental	.965	.466	Normal
	Control	.924	.062	Normal
Retention test	Experimental	.960	.340	Normal
	Control	.951	.208	Normal

From Table 1, the p-values of the pretest, posttest and retention test (delayed test) of the experimental and control groups were greater than 0.05. This proved that the test scores of the students were normally distributed. Therefore, parametric test (t-test) was safe to use for comparing the groups.

Research question 1: What is the difference between the posttest and pretest mean scores of students taught diversity of living organisms and plant physiology using flipped classroom approach?

This research question sought to determine if any significant difference exists in the posttest and pretest mean scores of students taught diversity of living organisms and plant physiology using flipped classroom approach. The results are shown in Table 2.

Table 2. t-test summary of posttest and pretest mean scores of students taught using flipped classroom approach

Test	N	Mean	SD	df	t-value	p-value	Remarks	Effect Size (Cohen's d)	95% CI	
									Lower	Upper
Posttest	30	66.33	4.93	29	26.1	0.00	Significant	1.47	1.18	1.76
Pretest	30	35.50	4.19							

Source: Field data, 2024 Significant level = 0.05 df=degree of freedom

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Table 2 is a t-test summary of the posttest and pretest mean scores of students exposed to diversity of living organisms and plant physiology using flipped classroom approach. The mean scores of the posttest was 66.33 with standard deviation 4.93. The mean score of the pretest was 35.50 with standard deviation 4.19. The mean difference was 30.83. A null hypothesis was formulated to determine if there is any significant difference between the mean scores.

Null Hypothesis 1 (H₀₁): There is statistically no significant difference between the posttest and pretest mean scores of students taught diversity of living organisms and plant physiology using flipped classroom approach.

From Table 2, $t(29) = 26.10$, $P=0.00$, $p<0.05$. The p-value (0.00) is less than the alpha level (0.05) and hence the null hypothesis which states that statistically no significant difference exists between the posttest and pretest mean scores of students taught using flipped classroom was rejected. The effect size was 1.47 with a confidence interval for Cohen's d (1.18, 1.76). This indicates that the effect size was substantially large based on Cohen's benchmarks (small: 0.2, medium: 0.5 and large: 0.8 and above). The effect size shows that flipped classroom significantly improved students' academic performance in plant physiology and diversity of living organisms.

Research question 2: What is the difference in knowledge retention between students taught diversity of living organisms and plant physiology using flipped classroom approach and those taught using conventional method?

This research sought to determine if there is any difference in knowledge retention between students taught diversity of living organisms and plant physiology using flipped classroom and those taught using conventional method. The results are shown in Table 3.

Table 3. t-test summary of retention test means scores of students in the experimental and control groups

Group	N	Mean	SD	df	t-value	p-value	Remarks	Effect Size (Cohen's d)	95% CI	
									Lower	Upper
Experimental	30	69.43	2.80	56	10.22	0.00	Significant	0.70	0.50	0.82
Control	28	58.25	5.25							

Source: Field data, 2024 Significant level = 0.05 df=degree of freedom

Table 3 is an independent sample t-test summary of the retention test mean scores of students in the control and experimental groups. From table 4, the mean score of students in the control was 58.25 with a standard deviation of 5.25. The mean score of students in the experimental group was 69.43 with a standard deviation of 2.80. The mean difference between participants in the experimental and control groups was 11.18. A null hypothesis was formulated to determine if a statistically significant difference exists between the mean scores of students in the control and experimental groups.

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Null hypothesis 2 (HO₂): There is statistically no significant difference between the retention test mean scores of students taught diversity of living organisms and plant physiology using flipped classroom approach and those taught using conventional method.

From table 3, $t(56) = 10.22$, $p < 0.001$, $p < 0.05$. The p-value was less than the significance level (0.05), so the null hypothesis was rejected. This proved that the mean score of students in the experimental group differed significantly from their counterparts in the control group. Students who were taught using flipped classroom approach performed significantly higher than their counterparts taught using conventional method. The effect size was large, with Cohen's $d = 0.70$, 95% CI (0.50, 0.82). The effect size of 0.70 with a confidence interval of (0.50, 0.82), indicated a large and significant difference between the two groups, with the true effect size lying between 0.50 and 0.82. The effect size indicates that the flipped classroom approach positively impacted the experimental group students' knowledge retention in diversity of living organisms and plant physiology.

Research question 3: What is the difference in knowledge retention between male and female students taught diversity of living organisms and plant physiology using flipped classroom approach?

This research question sought to determine if any significant difference exists in male and female students' knowledge retention in diversity of living organisms and plant physiology when taught using flipped classroom approach. The results are shown in Table 4.

Table 4. t-test summary of knowledge retention test mean scores of male and female students taught using flipped classroom approach

Group	N	Mean	SD	df	t-value	p-value	Remarks	Effect Size (Cohen's d)	95% CI	
									Lower	Upper
Male	17	70.29	2.34	28	2.02	0.06	Not Significant	0.30	0.003	0.56
Female	13	68.31	3.04							

Source: Field data, 2024 Significant level = 0.05 df=degree of freedom

Table 4 is an independent samples t-test summary of the knowledge retention test scores of male and female students taught using flipped classroom approach. The mean score of the retention test of male students in the experimental group was 70.29 with standard deviation 2.34. The mean score of the retention test of female students in the experimental group was also 68.31 with a standard deviation of 3.04. The difference in mean score of the retention test between the male and female students in the experimental group was 1.98. A null hypothesis was formulated to determine if a statistically significant difference exists between retention test mean scores of male and female students after they were exposed to flipped classroom approach.

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Null hypothesis 3 (HO₃): There is statistically no significant difference in knowledge retention between male and female students taught diversity of living organisms and plant physiology using flipped classroom approach.

From Table 4, $t(28) = 2.02$, $p = 0.06$, $p > 0.05$. The effect size was medium with a Cohen's $d = 0.30$, 95% CI (0.003, 0.56). The p -value was slightly greater than 0.05 and hence the null hypothesis was retained. This proved that there was statistically no significant difference between the retention test mean scores of male and female students taught using flipped classroom approach. The effect size was small, with Cohen's $d = 0.30$ indicated that the intervention had small impact on male students than female student's knowledge retention in the concept of diversity of living organisms and plant physiology. The confidence interval, CI (0.003, 0.56) indicates that the true effect size falls within the range of 0.003 and 0.56.

DISCUSSION

This study was investigated to determine the role of flipped classroom approach on students' academic performance and knowledge retention in selected concepts in biology. The study found that statistically significant difference exists between the posttest and pretest mean scores of students taught in diversity of living organisms and plant physiology using flipped classroom approach. The results of the study support the findings of Talan and Gulsecen (2019) who reported that a statistically significant difference exists between the posttest and pretest mean scores of students exposed to flipped classroom instructional strategy. The finding of the study also corroborates the findings of Gayathri and Vijayarani (2019) who revealed that students' academic performance significantly improved after they were exposed to flipped classroom strategy.

The study also found that there was statistically significant difference in knowledge retention between students taught using flipped classroom and their cohorts who were also taught using conventional teaching method. The finding is in line with Makinde (2020) who reported that students in the experimental group who were taught using flipped classroom approach experienced higher knowledge retention than their cohorts in the control group who were taught using conventional classroom approach. This finding also supports the findings of Bupo and Ibeneme (2022) that students exposed to flipped classrooms had better knowledge retention than their counterparts in the control group who were taught using a conventional classroom approach. The finding also collaborates with the findings of Sirakaya and Özdemir (2018) who reported that students exposed to flipped classroom approach experienced higher knowledge retention than those in the control group.

In addition, the study found that there was statistically no significant difference in knowledge retention between male and female students taught using flipped classroom approach. This finding confirmed the findings of Usman et al. (2022) who found that both male and female exposed to

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flipped classroom retained the content equally. The findings further corroborate the findings of Olanrewaju and Richard (2023) who stated that no significant difference exists in the retention test results of both male and female students exposed to flipped classroom approach. The results contradict with Bupo and Ibeneme (2022) who reported that female students performed significantly higher than their male cohorts in the retention test when both were taught using flipped classroom. The findings were inconsistent with the findings of Makinde (2020) who asserted that the female students' performance in the retention test was significantly higher than their male counterparts when both were taught using a flipped classroom approach.

EDUCATIONAL IMPLICATIONS AND PRACTICES

Technology has brought a paradigm shift to teaching and learning globally, leading to significant transformation in educational practices. Teachers have moved from direct instruction to facilitation, focusing on guiding discussions, problem-solving and active learning. The findings of the study will motivate biology teachers to integrate student-centered methods of teaching such as flipped classroom approach to improve students' knowledge retention in biological concepts. The findings of the study will encourage biology teachers to adopt flipped classroom approach in presenting their lessons to enable them to engage their students in class and outside the classroom. This study will also help biology teachers recognize the effectiveness of pre-class materials (pre-recorded lesson videos, reading materials) in preparing students for deeper learning. The study will provide valuable insights for teachers and students, emphasizing the benefits of flipped classroom approach in improving students' knowledge retention in biological concepts.

CONCLUSIONS AND RECOMMENDATIONS

This study was explored to determine the role of flipped classroom approach in enhancing student's academic performance and knowledge retention in diversity of living organisms and plant physiology. The results of the study revealed that there was statistically significant difference between the mean scores of the posttest and pretest scores of students taught using flipped classroom approach. This indicated that the academic performance of students significantly after they were exposed to flipped classroom instructional strategy. The study further revealed that flipped classroom approach significantly enhanced the knowledge retention of students in diversity of living organisms and plant physiology than those taught using conventional teaching method. This is a clear indication that the intervention implemented was highly effective. In addition, the study showed a statistically no significant difference in knowledge retention between the male and female students taught in diversity of living organisms and plant physiology using flipped classroom approach. Based on the findings of the study, it is recommended that biology lecturers lecturing diversity of living organisms and plant physiology courses should adopt flipped classroom

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approach as their instructional method when presenting concepts in these courses to students. It was also recommended that students should be provided with data on monthly basis and laptops to enable lecturers engage them both in and out of the lecture halls.

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REFERENCES

- Abarghouie, M. H., Omid, A., & Ghadami, A. (2020). The effect of traditional lecture and flipped classroom on learning, learning retention and satisfaction among operating room students: A comparative study. *Nursing and Midwifery Studies*, 9, 189-93.
- Adom, D., Yeboah, A., & Ankrah, A. K. (2016). Constructivism Philosophical Paradigm: Implication for Research, Teaching and Learning. *Global Journal of Arts Humanities and Social Sciences*, 4(10), 1-9.
- Aidoo, B., Macdonald, M. A., Vesterinen, V.-M., Pétursdóttir, S., & Gísladóttir, B. (2022). Transforming Teaching with ICT Using the Flipped Classroom Approach: Dealing with COVID-19 Pandemic. *Educational Sciences*, 12, 1-12.
- Allen, A. (2022). An Introduction to Constructivism: Its Theoretical Roots and Impact on Contemporary Education. *Journal of Learning Design and Leadership*, 1(1), 1-11.
- Alnahdi, M., Agha, S., Khan, M. A., & Almansour, M. (2022). The flipped classroom model: Exploring effect of flipped classroom on knowledge retention of medical students. *J Ayub Med Coll Abbottabad*, 34(4), 755-761.
- Alzaharani, I., & Woollard, J. (2013). The Role of the Constructivist Learning Theory and Collaborative Learning Environment on Wiki classroom , and the Relationship between Them. *3rd International Conference For e-learning & Distance Education*, (pp. 1-9). Southampton.
- Aydın, G., & Mutlu, O. (2023). Project-based learning and the flipped classroom model supported project-based learning's impact on academic success, retention, and individual innovation competence. *International Journal of Contemporary Educational Research*, 10(4), 823-833.
- Barral, A. M., Ardi-Pastores, V. C., & Simmons, R. E. (2018). Student Learning in an Accelerated Introductory Biology Course Is Significantly Enhanced by a Flipped Learning Environment. *CBE—Life Sciences Education*, 17(3), 1-9.

 Publication of the European Centre for Research Training and Development-UK

- Bhattacharjee, J. (2015). Constructivist Approach to Learning—An Effective Approach of Teaching Learning. *International Research Journal of Interdisciplinary & Multidisciplinary Studies (IRJIMS)*, 1(6), 65-74. <http://www.irjims.com/>
- Bichi, A. A., Ibrahim, F. B., & Ibrahim, R. H. (2019). Assessment of Students Performance in Bioogy: Implication for Measurements and Evaluation of Learning. *Journal of Education and Learning*, 3(3), 301-308.
- Bishop, J. L., & Verleger, M. A. (2013). The flipped classroom: A survey of the research. *In Proceedings of the ASEE Annual Conference*.
- Bouwmeester, R. A., Kleijn, R. A., Berg, I. E., Cate, O. T., Rijen, H. V., & Westerveld, H. E. (2019). Flipping the medical classroom: Effect on workload, interactivity, motivation and retention of knowledge. *Computers & Education*, 139, 118-128.
- Bupo, G. O., & Ibeneme, O. T. (2022). Effect of flipped classroom approach on student's retention in financial accounting among business education students in Rivers State Universities. *Rivers State University Journal of Education*, 25(2), 108-122. <http://www.rsujoe.com/>
- Casasola, T., Nguyen, T., Warschauer, M., & Schenke, K. (2017). Can flipping the classroom room work? Evidence from undergraduate chemistry. *International Journal of Teaching and Learning in Higher Education*, 29(3), 421-435.
- Clark, K. R. (2017). The effects of the flipped model of instruction on student engagement and performance in the secondary mathematics classroom. *Journal of Educators Online*, 12(1), 91-115. doi:<https://doi.org/10.9743/JEO.2015.1.5>
- Cohen J. (1988). *Statistical power analysis for the behavioral sciences*. New York, NY: Routledge Academic.
- Dorji, S., & Dorji, K. (2022). Flipped classroom in teaching biology: Assessing students' academic achievement in tang central school, Bumthang district. *Interdisciplinary Journal of Applied and Basic Subjects*, 2(2), 1-8.
- Ebrahim, A. H., & Naji, S. A. (2021). The Influence of Flipped Learning Methods on High School Learners' Biology Attainment and Social Intelligence in Kuwait. *EURASIA Journal of Mathematics, Science and Technology Education*, 17(8), 1-17.
- Enfield, J. (2013). Looking at the Impact of the flipped Classroom Model of Instruction on Undergraduate Multimedia Students at CSUN. *Tech Trends*, 57(6), 14-27.
- Esperval, H. C., Philippines, C., & Tan, M. J. (2020). Effectiveness of Using a Flipped Classroom in Improving English Grammar Proficiency. *International Journal of Sciences: Basic and Applied Research*, 51(2), 45-57
- Faryadi, Q. (2015). Teaching Philosophy Statements. *Journal of Rsearch and Method in Education*, 5(6), 61-66.
- Fauzi, A., & Mitalistiani, D. (2019). High School Biology Topics that Perceived Difficult by Undergraduate Students. *Didaktika Biologi: Jurnal Penelitian Pendidikan Biologi*, 2(2), 73-84.

Publication of the European Centre for Research Training and Development-UK

- Fernandes, R. S. (2022). Effectiveness of Flipped Classroom on Achievement in Educational Technology of Pre-service Teachers. *International Journal of Innovative Research in Multidisciplinary*, 8(7), 111-115.
- Gasparič, R. P., Glavan, M., Mihelič, M. Ž., & Zuljan, M. V. (2024). Effectiveness of flipped learning and teaching: Knowledge retention and students' perceptions. *Journal of Information Technology Education: Research*, 23, 1-24.
- Gayathri, H., & Vijayarani, K. (2019). Effectiveness of flipped classroom strategies on enhancing learning performance of chemistry and in certain selected variables among XI standard students. *International Journal of Research and Analytical Reviews*, 6(1), 597-601.
- Gencer, B. G., Gurbulak, N., & Adiguzel, T. (2014). A new approach in learning and teaching: the flipped classroom. *Proceedings of International Teacher Education Conference*, (pp. 881-888). Sarkaya, Turkey.
- Golaki, S. P., Kamali, F., Bagherzadeh, R., Hajinejad, F., & Vahedparast, H. (2022). The effect of flipped classroom through near peer education (FC through NPE) on patient safety knowledge retention in nursing and midwifery students: a solomon four-group design. *BMC Medical Education*, 22, 1-11.
- Golder, J. (2018). Constructivism: A Paradigm for Teaching and Learning. *International Journal of Research and Analytical Reviews (IJRAR)*, 5(3), 678-687.
- Graham, K. L., Cohen, A., Reynolds, E. E., & Huang, G. C. (2019). Effect of a flipped classroom on knowledge acquisition and retention in an internal medicine residency program. *Journal of Graduate Medical Education*, 11(1), 92-97. <https://doi.org/10.4300/JGME-D-18-00536.1>
- Guy, R., & Marquis, G. (2016). Guy, R., The flipped classroom: A comparison of student performance using instructional videos and podcasts versus the lecture-based model of instruction. *Issues in Informing Science and Information Technology*, 13, 1-3.
- Hao, L., Tian, K., Leng, C. H., Salleh, U. K., Ge, S., & Cheng, X. (2024). The effect of project-based learning and project-based flipped classroom on critical thinking and creativity for business English course at Higher Vocational Colleges. *Malaysian Journal of Learning and Instruction*, 21(1), 159-189.
- Husna, H., Nerita, S., & Safitri, E. (2023). Analysis of Students' Difficulties in Learning Biology. *Journal of Biology Education Research*, 4(1), 1-9.
- Inengite, I., & Zipamone, A. T. (2024). Effect of Flipped Classroom Model on Students' Academic Achievement in Biology among Secondary Schools in Bayelsa State. *Scholarly Journal of Science and Technology Research & Development*, 3(5), 1-12.

 Publication of the European Centre for Research Training and Development-UK

- Jang, H. Y., & Kim, H. J. (2020). A meta-analysis of the cognitive, affective, and interpersonal outcomes of flipped classrooms in higher education. *Education Sciences, 10*(4), 1-17.
- Jasmana, M. W., Sulisetijonob, S., & Mahanal, S. (2024). Flipped classroom strategies in biology learning: A systematic literature review. *JPBI (Jurnal Pendidikan Biologi Indonesia), 10*(1), 164-184. <https://doi.org/10.22219/jpbi.v8i3.22992>
- Kiem, M. T., & Keodavan, X. (2024). Unpacking the advantages and challenges of flipped classrooms in initial mathematics teacher education in Vietnam. *EURASIA Journal of Mathematics, Science and Technology Education, 20*(5), 1-12.
- Kong, S. C. (2014). Developing information literacy and critical thinking skills through domain knowledge learning in digital classrooms: an experience of practicing flipped classroom strategy. *Computers and Education, 78*, 160-173.
- Lijie , H., Kun, T., Leng, C. H., Salleh, U. K., Shigang, G., & Xinliang, C. (2023). Project-Based Flipped Classroom on Critical Thinking and Creativity in Business English Teaching: A case study. *JURNAL KURIKULUM & PENGAJARAN ASIA PASIFIK, 11*(3), 1-14.
- Makinde, S. O. (2020). Impact of flipped classroom on mathematics learning outcome of senior. *African Journal of Teacher Education, 9*(2), 23-42.
- Ma, X., Zhao, G., & Wu, T. (2013). An Empirical Study of Flipped Classroom Teaching in University Information Technology Public Courses. *Journal of Distance Education, 31*(1), 79-85. Retrieved from <https://doi.org/10.15881/j.cnki.cn33-1304/g4.2013.01.008>
- McHugh , S. A. (2018). Evaluating the Effects of a flipped classroom compared to a traditional classroom on retention of information and course Engagement in a radiation safety course. *Theses and Dissertations*.
- McLean, S., & Attardi, S. M. (2018). Sage or guide? Student perceptions of the role of the instructor in a flipped classroom. *Active Learning in Higher Education, 24*(1), 49–61. doi:<https://doi.org/10.1177/1469787418793725>
- Muhajirah, M. (2020). Basic Learning Theory (Behaviorism, Cognitivism, Constructivism, and Humanism). *International Journal of Asian Education, 1*(1), 37-42. Retrieved from <https://doi.org/10.46966/ijae.v1i1.23>
- Nja, C. O., Orim, R. E., Neji, H. A., Okwetang, J. O., Uwe, U. E., & Ideba, M. A. (2022). Students' attitude and academic achievement in a flipped classroom. *Heliyon, 8*(1), 1-14.
- Noroozi, A., Rezvani, E., & Ameri-Golestan, A. (2020). The effect of flipped classroom on L2 learners' development and retention of grammatical knowledge. *Turkish Online Journal of Distance Educatio, 21*(4), 14-30.

Publication of the European Centre for Research Training and Development-UK

- Nurhuda, A., Khoiron, M. F., Azami, Y. S., & Ni'mah, S. J. (2023). Constructivism Learning Theory in Education: Characteristics, Steps and Learning Models. *Research in Education and Rehabilitation*, 6(2), 234-242.
- Oanh, P. T., & Nhung, N. T. (2022). Constructivism learning theory: A Paradigm for Teaching and Learning English in secondary education in Vietnam. *International Journal of Scientific and Research Publications*, 12(12), 93-98.
- Olanrewaju, M. A., & Richard, O. K. (2023). Students' learning interest, academic achievement and learning retention in college physics as observed from flipped classroom learning strategy and traditional lecture method. *International Journal of Research Publication and Reviews*, 4(9), 323-329. <http://www.ijrpr.com/>
- Orak, S. D., & Al-khresheh, M. H. (2021). In Between 21st Century Skills and Constructivism in ELT: Designing a Model Derived From a Narrative Literature Review. *World Journal of English Language*, 166-176.
- Oyewumi, F.-A. K. (2021). Effect Of Flipped Classroom Strategy On Senior Secondary School Students' Achievement In Biology. *International Journal of Innovative Social & Science Education Research*, 9(3), 208-212. <http://www.seahipaj.org>
- Pi, S., & Do, S. (2017). The effectiveness of the flipped learning using the smart device. *Journal of Digital Convergence*, 15(4), 65-71.
- Pundir, R., & Surana, A. (2017). Constructivism Learning: A Way to Make Knowledge Construction. *The International Journal of Indian Psychology*, 3(2), 158-162.
- Sakti, R. H., Jalinus, N., Sukardi, S., & Wulansar, R. E. (2023). The effect of flipped classroom in learning: A meta-analysis. *Proceedings of the 9th International Conference on Technical and Vocational Education and Training (ICTVET 2022)* (pp. 191–197). Padang: Atlantis Press. doi:https://doi.org/10.2991/978-2-38476-050-3_21
- Shahzadi, A., Shahzadi, S., & Munir, N. (2022). Flipped classroom approach to enhance students' academic performance at the university level: Teachers' perspective. *Global Educational Studies Review*, 7(2), 498-507.
- Sharma, H. L., & Poonam. (2016). Constructivist Approach for Teaching English: Making sense of Paradigm shift from the Traditional Approach. *International Journal of science and Research*, 5(10), 788-791.
- Sirakaya, D. A., & Özdemir , S. (2018). The effect of a flipped classroom model on academic achievement, self-directed learning readiness, motivation and retention. *Malaysian Online Journal of Educational Technology*, 6(1), 76-91.
- Soltanabadi, M. I., Izadpanah, S., & Namaziandost, E. (2021). The effect of flipped classroom on Iranian adolescents: Elementary EFL learners' vocabulary recall and retention. *Education Research International*, 1-9.

Publication of the European Centre for Research Training and Development-UK

- Suhendi, A., & Purwarno, P. (2018). Constructivism Learning Theory: The Contribution to Foreign Language Learning and Teachong. *The 1st Annual International Conference on Language and Literature*, (pp. 87-95).
- Sukerti, G. N., Rudiastar, E., & Susana, K. Y. (2021). The effectiveness of flipped learning in teaching writing. *Journal of Social Sciences and Humanities*, 10(1), 78-92.
- Talan, T., & Gulsecen, S. (2019). The Effect of Flipped Classroom on Students' Achievement, Academic Engagement aand Satisfaction Levels. *Turkish Online Journal of Distance Education*, 31-60.
- Talbert, R. (2012). Inverted classroom. *Colleagues*, 9(1), 1-2.
- Thai, T. N., De Wever, B., & Valcke, M. (2017). The impact of a flipped classroom design on learning performance in higher education: looking for the best “blend” of lectures and guiding questions with feedback. *Computers & Education*, 107, 113-126.
- Thomas, S. (2023). Assessment And Evaluation of Learning in a Constructivist Paradigm. *International Journal for Multidisciplinary Research (IJFMR)*, 5(2), 1-4.
- Umida, K., Dilara, A., & Umar, E. (2020). Constructivism in Teaching and Learning process. *European Journal of Research and Reflection in Educational Sciences*, 8(3), 134-137.
- Usman, K., Isiaka, G., Kadage, T. A., Taiwo, Y., Olutunu, D., & Oluwafemi, A. (2022). Gender differentials in the use of flipped classroom instructional models In enhancing achievement and retention In oral-english contents of senior secondary school In Minna, Niger State, Nigeria. *International Journal of advanced humanities Research*, 2(2), 1-21. <https://ijahr.journals.ekb.org/>
- Vincent, G., & Gillespie, P. (2022). Evaluation of flipped mathematics Courses knowledge retention. *Journal of Education & Social Policy*, 9(2), 15-20.