



Research Article

Effect of flipped classroom instructional strategy on students' knowledge retention in diversity of living organisms and plant physiology concepts

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This study investigated the effect of flipped classroom instructional strategy on students' knowledge retention in the concept of diversity of living organisms and plant physiology. One group pretest, posttest experimental design was adopted for the study. The sample size comprised of thirty biology students. The students were taught using flipped classroom instructional strategy. The instruments used for data collection were pretest, posttest, retention test, questionnaire and interview. The reliability of the pretest, posttest and retention test was determined using test-retest reliability coefficient, and was found to be .75, .74 and .78, respectively. The reliability of the questionnaire was determined using Cronbach alpha and was found to be .80. The data were analysed using mean, standard deviation, *t*-test and thematic analysis. The results of the study proved that there was statistically significant difference between the retention test and pretest mean scores of students taught using flipped classroom instructional strategy. The results of the study also revealed a statistically significant difference between the retention test and posttest mean scores of students taught using flipped classroom instructional strategy. The results further revealed that students had positive attitude towards the adoption of flipped classroom instructional strategy in teaching diversity of living organisms and plant physiology. It was concluded that flipped classroom instructional strategy significantly and positively improved students' knowledge retention in diversity of living organisms and plant physiology. It was therefore recommended that biology teachers should adopt flipped classroom instructional strategy in teaching concepts in Biology, Chemistry and Physics.

Keywords: Diversity, flipped classroom, knowledge retention, living organisms, plant physiology

1. Introduction

The integration of Information, Communication Technology [ICT] in education has significantly impacted teaching and learning. The integration of technological devices to improve teaching and learning has been widely used across the educational system (Santiago et al., 2021). In the 21st century, an era where the use of technology has become rampant and access to information is easier, students are expected to be active in acquiring knowledge, interpreting knowledge rather than directly receiving information from teachers (Sirakaya & Özdemir, 2018).

The role of teachers and students has been changed to facilitate the effective acquisition of scientific knowledge. Changes in teachers and students' roles have led to a shift from the teacher-centered to learner-centered approach (Donkoh & Amoakwah, 2024). This approach encourages students to take active responsibility for their learning, actively participate in it, control it, and create their own conducive learning environment. Learners have a major task to perform in the teaching and learning process. The 21st century talents encompass problem-solving, critical thinking, effective communication, creativity, information literacy, and self-direction.

The instructional strategies adopted by teachers in presenting content knowledge do not help students acquire critical thinking and problem-solving skills. The lecture method of teaching is unable to help students participate effectively in class and to motivate students to prepare before attending class (Talan & Gulsecen, 2019). Teachers, researchers, and curriculum developers have

explored various teaching approaches to engage students and inspire them to study before class time. Flipped classroom strategy is an instructional strategy capable of engaging students in class and outside the classroom.

Bergman and Sams (2012) observed that flipped classroom gives a warm-up before class, allowing students to know exactly the task to complete. The pre-existing knowledge allows for a conscious grasp of the subject matter to be covered either online, individually, or collaboratively (Noroozi et al., 2021). Flipped classroom promotes active participation and independence as students become more focused and accountable for their learning (O'Flaherty & Philips, 2015). The flipped classroom allows the students to engage with the concepts that will be taught in the classroom at their own pace, whether they have to rewind, go back, or pause to understand the concept better. Thus, it enables a student-centered approach to instruction and learning while providing appropriate developmental support depending on the student's learning style and needs (Mahasneh, 2020). Pre-class material may be reviewed at learners' discretion to dedicate more time to understanding difficult sections and spending less time on sections that have already been understood (Olawale & Olalere, 2017).

The flipped classroom approach of teaching embraces the principle of diversity as well as respects each person's mode of learning. Every student can decide what kind of teaching material is easier to grasp, thus the visual ones, or those that can be explained audibly (Mayer, 2010). This makes the learning experience of the students more effective when the learning needs of the students are evaluated, and teaching/learning resources and strategies applied in the class are diverse.

Flipped classroom promotes higher-order thinking skills. As a result of a direct turn on the use of time in class, directing most of it to application and solving problems. Flipped classroom models enhance the development of higher-order thinking skills such as critical thinking, analysis, synthesis, and evaluation (Kay et al., 2019). The flipped classroom approach, which became quite popular in recent years, lays significant stress on the facilitation of higher levels of thinking (Santiago et al., 2021) as students need to develop a success-oriented outlook on the future in the contemporary world. The practical incorporation of concepts introduced in class provides the students with ways of learning that would otherwise not be possible in traditional classroom settings, which include problem-solving, critical thinking, analysis, synthesis, and evaluation (Bouwmeester et al., 2019).

In a flipped classroom, learners attain the basics of the subject matter at home by watching and listening to online video materials and solving assigned tasks, which enables them to prepare well for in-class activities (Zupanec et al., 2022). A flipped classroom enhances students' learning outcomes and enriches students' learning environment (Ng & Lam, 2022). Flipped learning increases students' engagement, conceptual understanding and knowledge retention (Purwanto, 2020). Flipped classroom is cost-effective and facilitates students' understanding of the subject matter and problem-solving skills (Doo, 2022). This study, therefore, sought to examine the effect of flipped classroom instructional strategy on students' knowledge retention in diversity of living organisms and plant physiology concepts. The following research questions were formulated to guide the study:

RQ 1) What is the effect of flipped classroom instructional strategy on students' knowledge retention in diversity of living organisms and plant physiology?

RQ 2) What are students' attitudes towards the use of flipped classroom approach in teaching and learning of diversity of living organisms and plant physiology?

RQ 3) What are students' perceptions towards flipped classroom approach in teaching and learning of diversity of living organisms and plant physiology?

2. Literature Review

2.1. Flipped Classroom

The flipped classroom approach is an active, student-centered approach that consists of two components: active learning inside the classroom and online-based learning outside the classroom (Adnan et al., 2022). The flipped classroom model is an innovative pedagogical model that challenges the conventional or traditional structure of teaching (Kiem & Keodavan, 2024). Flipped classroom is an innovative instructional strategy used as a blended learning model that involves providing learning materials through online and offline instructional design that helps students acquire the pre-notional concept lesson before the commencement of classroom teaching (Dorji & Dorji, 2022). Flipped classroom approach is a pedagogical method and a type of blended learning that reverses the traditional learning environment by delivering instructional content online to students, outside the classroom (Mobolaji & Henry, 2019). The flipped classroom is a conceptual change and constructivist teaching approach that effectively provides a learning environment in which students actively participate, construct their science knowledge, and develop critical thinking skills (Gayeta & Caballes, 2017). A flipped classroom means flipping the teaching and learning process in the classroom and outside the classroom by activating the role of modern technological devices in preparing and delivering lessons to students (Elian & Hamaidi, 2021). Suhartono et al. (2021) asserted that a flipped classroom is also known as an inverted classroom where traditional or conventional classroom activities carried out in class become activities carried out at home.

The flipped classroom model is a creative and exciting approach to the educating and learning process that switches the teaching procedures of a normal class (Halili et al., 2019). Teaching in a traditional classroom often implies that, during the class, students listen to a teacher and receive a particular knowledge, and then, they practice what has been given to them during and after the classes. However, as in the case of the flipped classroom approach, where the teachers deliver concepts to the students in a form that is easily accessible, like videos or other learning resources, class time is primarily spent on various activities such as discussions or solving various problems (Zainuddin & Halili, 2016).

This model of teaching and learning referred to as the flipped classroom approach relies on reversing the conventional methods of teaching with more emphasis on the extra- course learning material and fact-based knowledge. As for the given approach, students get more opportunities for instruction and learning as they have free access to the materials during the class (Kumari, 2021) so they can spend more time to master the materials or to discuss the points that are not quite clear for them. This makes it possible to practice diverse lessons at varied speeds and without leaving any concept that a learner finds difficult or advancing when a particular topic is mastered.

The flexibility that is embedded into the flipped classroom model will enhance more reasonable and engaging interactions in class. Rather than giving a lecture and students taking notes, the valuable time generated through face-to-face conferences can be utilized in questioning, answering, and discussing as well as providing one-on-one tutorials for the students (Alsowat, 2016). It enhances the flow of lessons because it assists students in having better knowledge of the area of study as well as sharpening their analytical minds and the ability to solve problems (Sukerti et al., 2021).

In a flipped classroom, activities which are usually performed at home as an assignment in a deductive model, are interactively undertaken in the classroom with the guidance of the teacher (Naing et al., 2023). The role of the teacher in a flipped classroom is to guide the students in the teaching and learning process. Unlike the traditional classroom where students are passive in the teaching and learning process, flipped classroom students are actively engaged in the teaching and learning process. In a flipped classroom, students gain the basics of the teaching content by watching and listening to pre-recorded lesson videos and solving certain tasks which enable them to prepare for active class participation (Zupanec et al., 2022).

The flipped classroom approach is divided into two components; the outside classroom component where relevant materials or materials to be studied in class are made available to students to study at home and in in-class component where students carry out discussions on materials that have been provided by the teacher. In the out-of-class component, students learn the course materials in their comfort zones by watching instructional videos (Lo & Hew, 2017). Students are actively engaged in discussions and problem-solving with guidance from the teacher in the inside class component. The teacher develops content and makes it available to the students before the class, thereby allowing the students to read, interpret and synthesise new knowledge from the content before the scheduled class discussion (Onyema et al., 2021). The flipped classroom approach is applied by moving the lecture outside through technology while the classroom time is used to engage students in learner-centered learning activities such as inquiry, problem-solving activities, and discussions. In a conventional classroom, students acquire knowledge in the classroom and assignments are given to them to complete at home. In the flipped classroom, on the other hand, video lesson is recorded and shared with students to study for in-class discussion (Egara & Mosimege, 2023).

2.2. Pillars of Flipped Classroom Instructional Strategy

Flipped learning creates a dynamic and participatory learning environment where the direct mode of instruction is moved from a group learning space to an individual learning space (Flipped Learning Network, 2014). The teacher guides the students during the teaching and learning process. Flipped learning has four main pillars; Flexible Environment, Learning Culture, Intentional Content and Professional Educator.

2.2.1. Flexible environment

Flexible Environment is the first pillar of flipped learning. The learning environment should be flexible to enable students to choose where and when to learn (Filiz & Benzet, 2018). The learners decide what strategy to use and when and where they learn. The provision of a flexible learning environment helps students obtain support from their cohorts or consult the teacher when the need arises (Demirel, 2016). A flexible learning environment should accommodate a variety of group and individual activities. A flexible lesson plan allows students to study and absorb the content at their own pace (Ramesh & Chethan, 2021). A flexible learning environment also helps students choose when and where to view the pre-recorded video lesson and be more flexible in their learning (Jafarigohar et al., 2019). Teachers who flip their classes are flexible in their expectations of students' timelines for learning and how learners are evaluated or assessed (Chaudhari & Lashemi, 2019). Teachers build appropriate assessment systems that objectively measure understanding in a manner that is meaningful to students and the teacher (ALRowais, 2014). In a flexible learning environment, the teacher establishes space and time that allow learners to interact and reflect on their learning (Kim et al., 2021).

2.2.2. Learning culture

The second pillar of flipped learning is learning culture. Learning culture encompasses respect, openness and tolerance in the classroom. In a traditional learning environment, the teacher is the main source of information hence making the learner passive in the teaching and learning process. In a flipped learning environment, there is a shift from a teacher-centered classroom to a learner-centered classroom where the actual class time is used for exploring the content in detail and creating better learning opportunities for students to explore (ALRowais, 2014). The teacher gives opportunities to learners to be involved in meaningful learning activities (Kim et al., 2021). Students can learn the content outside the group learning period, and the teacher can use face-to-face interactions to ensure students' understanding and synthesis of the material (Chaudhari & Lashemi, 2019). Students are actively engaged in knowledge construction and obtaining meaningful learning (Rahman et al., 2020).

2.2.3. *Intentional content*

The third pillar of flipped learning is learning content. Learning content consists of various content and materials created by teachers to optimise for specific content areas and learners' needs (Kaya, 2021). Learning content gives teachers the freedom to select what to teach and what tools to employ, creating a learner-centered environment that supports active learning (Baltaci, 2022). Intentional content is used by educators to maximise classroom time and promote learner-centered, active learning strategies based on grade level and subject matter (Filiz & Benzet, 2018). Flipped learning teachers determine what they need to teach and what materials learners should handle on their own. Teachers using the flipped classroom model consider how teaching is used to provide fluency and how they can develop cognitive comprehension of learners (Ozdamli & Asiksoy, 2016). Intentional content allows for the effective application of the intended objectives, taking into consideration the subject matter and educational level. Flipped learning teachers maximise class time so that learners can actively involve in learning and teaching activities. Flipped learning instructors create relevant learning content mostly in videos for their learners. The pre-recorded videos are made available to students to study at their own pace and prepare for in-class activities.

2.2.4. *Professional educator*

The fourth pillar of the flipped classroom is a professional educator. Flipped learning depends heavily on professional teachers. Professional educators play several roles in the classroom, including preparing and implementing teaching and learning processes in class and outside the classroom, monitoring students' growth, assessing students and providing immediate feedback (Kaya, 2021). In a flipped classroom, the professional teacher has a less visible role but remains an essential ingredient to the success of flipped learning. The professional teacher roles in a flipped classroom are more demanding than in a conventional classroom (Jafarigohar et al., 20219). During class time, professional teachers observe students and provide them with immediate feedback. Flipped classroom teachers also seek help from their peers to enhance the effectiveness of their teaching in the classroom. Professional teachers reflect on their practice, collaborate to improve their teaching, embrace constructive criticism and tolerate chaos in the classroom (Flipped Learning Network, 2014). To promote effective learning in a flipped classroom, professional instructors must remain on top of their game despite being less visible (Ramesh & Chethan, 2021). The professional teacher conducts formative assessment and records data to inform future instruction (Kim et al., 2021).

2.3. **Benefits of Flipped Classroom Approach**

A flipped classroom approach is an instructional practice where the student-teacher roles are turned upside down with the students taking the major role in the teaching and learning process. As per the flipped classroom model of teaching, content delivery takes place outside the classroom environment preferably in the form of videos or other forms of digital learning materials and in-class learning is conducted through discussions, problem-solving, group activities and the like. The flipped classroom approach offers several benefits to both teachers and students.

A flipped classroom brings about individualized instruction. An advantage associated with the flipped classroom model is its ability to allow the teacher to offer individualized lessons. Students may get materials, that are presented in class, and move through the course individually to achieve success and academic progress, while teachers can pay more attention to individual learners and their difficulties (Kumari, 2021). Its efficient market will keep track of individual student areas where they require help so that the teachers can address them to help bring more individuality into the learning schemes.

The flipped classroom approach is an instructional strategy that integrates technology into the teaching-learning process, significantly enhancing students' academic achievement, classroom participation, scientific-process skills, and motivation. For example, in Turkish primary education,

a flipped mastery learning model notably improved 4th-graders' academic performance, while maintaining their self-regulation skills (Acar & Özler, 2024). Similarly, within data-analysis instruction for university students, this method led to measurable gains in achievement, engagement, and motivation (Eltahir & Alsalihi, 2025). The flipped classroom approach helps students acquire the necessary information for the lesson with the support of educational videos presented as homework before the in-class session (Aydm & Mutlu, 2023). Flipped learning allows teachers to present content in a captivating manner outside the classroom to ensure flexible and better engaging understanding for learners (Vincent & Gillespie, 2022).

The flipped classroom model increases interaction between learners and teachers and also enables students to excel, most especially those with special needs (Mahasneh, 2020). Flipped learning helps to cater to the diverse learning needs of students since this instructional approach present content to students in multiple modes. Flipped learning enhances students' engagement, increases students' learning experience and eventually students' academic performance (Asad, et al., 2022). A flipped classroom provides more opportunities for students and teachers to discuss the material more in-class and even expand the scope of the content. A flipped classroom allows teachers to spend more time with students who are struggling and at the same time allows academically advanced students the freedom to work ahead. Flipped learning enables students to learn at their own pace.

In the flipped learning environment, lesson videos are sent to students which allows them to study anywhere and at any time (Mandasari & Wahyudin, 2021). A flipped classroom improves the critical thinking skills of students. The flipped classroom is a learner-centered instructional strategy and can impact positively students' academic success, motivation and participation in the class (Sookoo-Singh & Boisselle, 2018). A flipped classroom creates a flexible environment for collaborative learning in the classroom. A flipped classroom enhances students' self-confidence (Zaid, 2020). A flipped classroom provides ample time for meaningful in-class activities such as debates, peer-assisted learning and problem-based learning (Al Mulhim, 2021).

Flipped learning supports active learning and a learner-centered approach which enables students to acquire knowledge through the utilization of a constructive approach (Atwa et al., 2022). A flipped classroom provides the teacher time to teach each student individually rather than the entire class as a whole (Fernandes, 2022). A flipped classroom allows the teacher to devote more time to deepening the conceptual understanding of students (Arslan, 2020). Flipped learning enables students to study the course material at their own pace and hence bridges the individual differences gap in the classroom (Falode & Mohammed, 2023).

2.4. Empirical Studies on Perceptions of Students towards Flipped Classroom Approach

Literature reviews on students' perceptions towards the flipped classroom approach in various academic fields on global and local scales has been conducted in various disciplines.

For instance, Pervaiz and Rehman (2022) conducted a study on the perceptions of Pakistani ESL students about flipped learning and reported that students had positive attitudes toward the flipped learning approach. The findings of the authors further revealed that students perceived flipped learning to be an effective method that improved their academic performance and participation in class activities. Fauzan and Ngabut (2018) conducted a study on the perception of students about flipped learning in the class of writing skills and reported that students positively perceived flipped learning as an instructional approach that enhanced their performance. Flipped learning approach shifts the mode of instruction from teacher-centered to learner-centered.

Moreover, Eneova and Akaneme (2020) investigated the perceptions of lecturers and students on the use of flipped classroom instructional model in teaching and learning at Federal University in Enugu State. The findings of their study revealed that learners were satisfied with the flipped learning model. The results of their study further proved that the perceived usefulness of flipped learning is; to facilitate active learning, increase classroom interaction, and improve collaborative teamwork. Hung (2022) examined English as foreign language student's perceptions of flipped classroom during the covid-19 pandemic and beyond. The findings of the study revealed that

students had relatively positive perceptions of online flipped learning. The findings further demonstrated that students perceived that flipped classroom attracts their attention and interest in the teaching and learning process. A study by Luna and Winters (2020) explored students' perceptions of flipped learning and traditional face-to-face: a case of redesign assessment. The findings of the study revealed that students had positive perceptions of flipped learning. Their findings also revealed that students had a positive perception of the usefulness of course materials in flipped learning.

In addition, Warman (2021) investigated the use of google classroom in flipped English learning during the covid-19 pandemic. The results of the study proved that flipped learning helped students understand the content and this caused students to have positive perceptions towards flipped learning. Aziz and Haskim (2023) explored students' perceptions of the flipped classroom approach in distance learning during covid-19 pandemic and reported that students had positive perceptions towards flipped classroom because it increased their self-motivation and helped them understand the concept better. Jafarigohar et al. (2019) investigated the incorporation of flipped learning into EFL classrooms' performance and perceptions and revealed that the participants in the flipped learning group were satisfied with learning English in the flipped classroom and hence had positive perceptions towards flipped learning. A study by Mahmud et al. (2023) also looked at students' attitudes toward the flipped classroom mode of online learning classrooms and demonstrated that students viewed the flipped classroom as a useful, interactive, productive and entertaining instructional strategy. Flipped learning leads to a high level of student satisfaction, self-pacing and self-dependency and hence makes students have positive attitudes towards flipped classroom.

Also, Halili et al. (2021) looked at students' perceptions towards flipped classroom approach and reported that students had positive perceptions in terms of learner motivation, learning and engagement using the flipped classroom approach. A study conducted by Maidin and Shukor (2021) explored students' perceptions of the flipped classroom approach in learning communicative English among community college students. The findings of the study revealed that most of the participants had positive perceptions towards the use of flipped classroom and were very motivated to learn due to the effectiveness of the flipped classroom approach.

Finally, a study by Husnawadi (2021) investigated students' perceptions towards flipped classroom-mediated tasks: insights from Indonesia post-earthquake English as a Foreign Language writing pedagogy. The findings of the researchers discovered that the majority of the students perceived the use of flipped classrooms to be effective for learning easy writing. A study conducted by Noroozi et al. (2021) examined students' perceptions of the incorporation of flipped learning into L2 grammar lessons and reported that students have positive perceptions of flipped learning because it is satisfactory, engaging, and effective. Contradictory findings regarding students' perceptions of flipped classrooms were also reported in a study in which researchers investigated students' perceptions toward flipped basic English practicum classroom and reported that students preferred a teacher-led lesson over a flipped classroom model. The researchers reported that the flipped classroom model employed in their study was not beneficial to the students (Setianingsih & Arroyyani, 2023).

3. Method

3.1. Research Design and Study Area

This study adopted one group, pretest, posttest experimental design. This design made use of only one group where pretest was conducted before the treatment and posttest was conducted after treatment to examine the effectiveness of the treatment. The study was conducted at C. K. Tedam University of Technology and Applied Sciences.

3.2. Sampling Technique and Sample Size

Convenience sampling technique was adopted for the participants in this study. The sample size of the study comprised of 30 level 300 biology students from one intact class. In terms of sex, the male students who participated in the study were 17(56.67%), and the female students were 13(43.33%). Also, regarding the age range of the participants, 17(56.67%) had ages ranging from 18-25, 8(26.67%) had ages ranging from 26-30 and 5(16.675%) also had ages ranging from 31-35.

3.3. Instruments

The instruments used for data collection were mainly pretest, posttest and post-posttest (retention test/ delayed test), questionnaire, and focus group interview and were developed by the researchers. The instruments were dubbed Students' Knowledge on Diversity of Living Organisms and Plant Physiology Concepts Test [SKDLOPPCT], Students' Academic Performance in Diversity of Living Organisms and Plant Physiology Concepts Test [SAPDLOPPCT], and Students' Knowledge Retention on Diversity of Living Organisms and Plant Physiology Concepts Test [SKRDLOPPCT]. The SKDLOPPCT, SAPDLOPPCT, and SKRDLOPPCT were used as pretest, posttest and retention test, respectively. Each test was made up of 40 multiple-choice items and 10 theory questions, except the pretest, which was made up of 15 theory questions.

The pretest (SKDLOPPCT) was made up of two sections, A and B. Section A was made up of forty (40) multiple-choice items. Each item or question had three distractors which reflected students' misconceptions about diversity of living organisms and plant physiology and one key. Section B was also comprised of fifteen (15) essay questions. The students were to answer all questions in both sections. Both sections were marked over 80 marks, consisting of forty (40) marks for section A and forty (40) marks for section B. The time allotted for the pretest was one hundred and twenty minutes (2 hours).

The posttest (SAPDLOPPCT) was administered to the students after the intervention. The test was also made up of two sections, A and B. The test items were questions mainly on the concept of plant physiology and diversity of living organisms. Section A consisted of forty (40) multiple-choice items, and Section B consisted of ten (10) theory questions. Each multiple-choice item had one key and three distractors. Section A and B were marked over eighty (80), forty (40) marks for Section A, and forty (40) marks for Section B. Two hours (120 minutes) were allotted for participants to respond to the posttest.

The retention test (SKRDLOPPCT) was conducted to examine the impact of flipped classroom instructional strategy on students' knowledge retention in diversity of living organisms and plant physiology. The retention test was conducted two weeks after the posttest was administered. The retention test was also made up of sections A and B. Section A comprised forty (40) multiple-choice questions, and Section B comprised ten (10) theory questions. Both sections were marked over eighty (80) marks, forty (40) for section A, and forty (40) marks for section B.

The reliabilities of the instruments were determined using test-retest reliability coefficient and were found to be 0.75, 0.74 and 0.78 for the pretest, posttest and retention test, respectively. The reliability of the questionnaire was also examined using Cronbach alpha reliability coefficient and was also found to be 0.80.

3.4. Intervention

The students were taught on diversity of living organisms and plant physiology using flipped classroom instructional strategy. This instructional strategy was used in presenting concepts on diversity of living organisms and plant physiology to students in-class and outside the classroom. The biological concepts lessons were prepared in PowerPoint format. A software called Open Broadcasting Software [OBS] was used in videotaping the lessons at home by the teacher. The lessons to be presented to students in each week were recorded in a video form using OBS studio and sent to students through email, telegram and Google classroom for students to download and

study at home by watching the video lessons. This was termed as out of class activities and it was done to enable students prepared for effective participation in classroom activities.

During the in-class session, the students were put into groups to engage in practical activities, group discussion and presentations. The students were assigned task to perform and share their findings with their colleagues in other groups. Specimens were given to students to identify, state their Domain, Kingdom, Phylum/Division and Classes and also support their answers with reasons. The teacher also guided the students to state the adaptive features, habitats and economic importance of the specimens. During the in-class session, opportunity was given to students to ask question on aspects of the video lessons which they did not understand. Students pointed the concepts which they consider difficult for further explanation by the teachers. The teacher also summarised the lesson with the involvement of the students.

3.5. Data Analysis

The quantitative data was analysed using mean, standard deviation and *t*-test with the aid of Statistical Package of Social Sciences version 27. The *t*-test was used to compare the mean differences and also test the null hypothesis. The qualitative data was also analysed using thematic analysis.

4. Results

The results of the study were organized according to the research questions and corresponding null hypotheses. The null hypotheses were tested to provide answers to the research questions. Prior to conducting the *t*-tests, tests for normality were performed to assess whether the assumptions required for parametric testing were satisfied.

Table 1

Normality test results

Variable	Shapiro-Wilk		
	Statistic	Sig.	Decision
Pretest	.96	.27	Normal
Posttest	.97	.47	Normal
Retention test	.96	.34	Normal

As shown in Table 1, the *p*-values for the pretest, posttest, and retention (delayed) test scores were all greater than .05, indicating that the data were normally distributed. Therefore, the assumptions for parametric testing were met, and it was appropriate to use the *t*-test to compare the mean scores.

4.1. Research Question One

This research question sought to examine students' knowledge retention in diversity of living organisms and plant physiology after they were taught through flipped classroom approach. The results are shown in Tables 2 and 3.

Table 2

T-test summary of retention test and pretest mean scores of students taught using flipped classroom instructional strategy

Test	N	Mean	SD	df	t	p	Effect size (d)	95% CI	
								Lower	Upper
Retention test	30	69.43	2.80	29	36.87	.001	2.7	2.16	3.18
Pre-test	30	35.50	4.20						

Table 2 presents the independent samples *t*-test summary comparing the retention test and pretest scores of students taught using the flipped classroom instructional strategy. The mean retention test score was 69.43 (*SD* = 2.80), while the mean pretest score was 35.50 (*SD* = 4.20),

resulting in a mean difference of 33.93. A null hypothesis was formulated to determine whether this difference was statistically significant following the implementation of the flipped classroom approach.

Null Hypothesis 1: (HO₁): There is statistically no significant difference in the retention test and pretest mean scores of students taught diversity of living organisms and plant physiology using flipped classroom instructional strategy.

Table 2 shows a statistically significant difference between the pretest and retention test scores of students taught using the flipped classroom instructional strategy, $t(29) = 36.87$, $p < .01$. Since the p-value was less than the significance level of .05, the null hypothesis was rejected. This indicates that the flipped classroom strategy had a significant and positive impact on students' knowledge retention in the topics of diversity of living organisms and plant physiology. The effect size was large, with Cohen's $d = 2.7$ and a 95% confidence interval ranging from 2.16 to 3.18, suggesting a substantial and meaningful effect of the instructional approach.

Table 3

T-test summary of retention test and posttest mean scores of students taught using the flipped classroom instructional strategy

Test	N	Mean	SD	df	t	p	Effect size (d)	95% CI	
								Lower	Upper
Retention test	30	69.43	2.80	29	2.99	.004	0.80	0.25	1.30
Post-test	30	66.33	4.93						

Table 3 presents the independent samples t-test summary comparing the retention and posttest scores of students taught using the flipped classroom instructional strategy. The mean retention test score was 69.43 ($SD = 2.80$), while the posttest mean score was 66.33 ($SD = 4.93$), yielding a mean difference of 3.10. A null hypothesis was formulated to determine whether this difference was statistically significant following students' exposure to the flipped classroom approach in the topics of diversity of living organisms and plant physiology.

Null Hypothesis 2: (HO₂): There is statistically no significant difference in the retention test and posttest mean scores of students taught diversity of living organisms and plant physiology using flipped classroom instructional strategy.

Table 3 indicates a statistically significant difference between the posttest and retention test scores of students taught using the flipped classroom instructional strategy, $t(29) = 2.99$, $p = .004$, $p < .05$. Consequently, the null hypothesis was rejected. This result suggests that the flipped classroom strategy had a significant effect on students' knowledge retention in the areas of diversity of living organisms and plant physiology. The effect size was large, with Cohen's $d = 0.80$ and a 95% confidence interval of 0.25 to 1.30, indicating a meaningful and substantial impact of the instructional approach.

4.2. Research Question Two

To address the third research question concerning students' attitudes toward the flipped classroom instructional strategy in teaching and learning diversity of living organisms and plant physiology, the mean and standard deviation were computed from participants' responses to a 15-item questionnaire. Respondents rated their level of agreement with each item on a 5-point Likert scale: Strongly Agree = 5, Agree = 4, Not Sure = 3, Disagree = 2, and Strongly Disagree = 1. Mean scores ranging from 1.00 to 2.99 indicated negative attitudes, while scores from 3.00 to 5.00 reflected positive attitudes toward the instructional strategy.

Table 4

Student's attitude towards the use of flipped classroom approach (FCA) in teaching and learning diversity of living organisms and plant physiology

Item	N	M	SD	Rank	Conclusion
FCA helped me retain more information about diversity of living organisms and plant physiology.	30	4.90	.31	1 st	Positive attitude
FCA catered for my learning needs about diversity of living organisms and plant physiology.	30	3.97	.56	11 th	Positive attitude
FCA made diversity of living organisms and plant physiology lessons practical.	30	4.80	.41	2 nd	Positive attitude
FCA helped me concentrate on the lesson.	30	4.63	.62	6 th	Positive attitude
FCA helped me understand diversity of living organisms and plant physiology better.	30	4.77	.43	3 rd	Positive attitude
FCA increased my interest in diversity of living organisms and plant physiology.	30	4.57	.50	7 th	Positive attitude
FCA made the lesson visual for me.	30	4.73	.45	4 th	Positive attitude
FCA enhanced my critical thinking skills.	30	4.53	.68	8 th	Positive attitude
FCA helped me improved my performance in diversity of living organisms and plant physiology.	30	4.80	.41	2 nd	Positive attitude
I am able to contribute in class effectively through FCA.	30	4.53	.63	8 th	Positive attitude
FCA increases my problem-solving skills.	30	4.67	.55	5 th	Positive attitude
I am able to study at home through FCA.	30	4.67	.48	5 th	Positive attitude
I recommend FCA to other Biology lecturers.	30	4.40	.56	10 th	Positive attitude
FCA made the lesson learner-centered.	30	4.40	.68	10 th	Positive attitude
FCA motivated me to learn more about the concept of diversity of living organisms and plant physiology.	30	4.43	.57	9 th	Positive attitude
Weighted mean and standard deviation		4.58	.52		

Table 4 shows that the overall student response reflected a positive attitude toward the adoption of the flipped classroom approach in teaching and learning diversity of living organisms and plant physiology. The weighted mean score of the questionnaire was 4.58 ($SD = 0.52$), indicating strong agreement with the effectiveness of the strategy. Among individual items, the highest-rated statement was "FCA helped me retain more information about diversity of living organisms and plant physiology", with a mean of 4.90 ($SD = 0.31$), ranked first. This was followed by "FCA made diversity of living organisms and plant physiology lessons practical" and "FCA helped me improve my performance in diversity of living organisms and plant physiology", both ranked second with a mean of 4.80 ($SD = 0.41$). The lowest-rated item was "FCA catered for my learning needs about diversity of living organisms and plant physiology", which still received a positive mean score of 3.97 ($SD = 0.56$). Overall, the results suggest that students held a favorable attitude toward the use of the flipped classroom strategy for learning content in diversity of living organisms and plant physiology.

4.3. Research Question Three

This research question was formulated to collect qualitative data from the participants through focus group interview. The sample of the students who participated in this interview session was twenty-five (25). They were divided into five groups. Group One students numbered P₁-P₅, Group Two; P₆-P₁₀, Group Three; P₁₁-P₁₅, Group Four; P₁₆-P₂₀ and Group Five, P₂₁-P₂₅.

4.3.1. Benefits from flipped classroom approach

The responses of the students proved that flipped classroom approach has several benefits. The responses of the students on the benefits that they gained from flipped classroom approach are categorized into themes and each theme is backed by the statements of the students.

Improved academic performance and knowledge retention. The participants reported that flipped classroom instructional strategy improved academic performance and knowledge

retention in the concepts of diversity of living organisms and plant physiology. The participants reported that the Flipped Classroom Instructional Approach significantly enhanced their academic performance and knowledge retention in key biological concepts, particularly in the areas of diversity of living organisms and plant physiology. They attributed this improvement to the opportunity to engage with foundational content before class, allowing for deeper exploration and application of knowledge during in-class activities. The flipped classroom method was reported to promote active learning and enhance students' comprehension of complex scientific concepts through collaborative discussions, problem-solving tasks, and hands-on activities. The opportunity to access instructional materials at their own pace contributed to a more personalized learning experience, enabling students to revisit challenging content as needed. This flexibility catered to a variety of learning styles and reinforced students' understanding of difficult topics. Consequently, students expressed increased confidence and preparedness during assessments, which translated into improved academic performance and long-term retention of knowledge. As expressed by participants, "Flipped classroom helped me improve my performance in diversity of living organisms and plant physiology" [p3, p7, Focus Groups 1 and 2], and "Flipped classroom enabled me to remember the concepts of diversity of living organisms and plant physiology very well" [p15, Focus Group 3]. These reflections suggest that the flipped classroom approach not only supported academic achievement but also fostered enduring conceptual understanding.

Higher Engagement. The availability of pre-recorded lecture materials on topics such as diversity of living organisms and plant physiology enabled students to engage with the content prior to classroom sessions. This pre-class exposure ensured that students arrived in class better prepared, allowing them to participate more actively in discussions and hands-on activities. Engaging with the material beforehand not only enhanced in-class interactions but also contributed to deeper understanding and improved retention of scientific concepts. The participants' responses suggest a high level of academic engagement outside the classroom, driven by the flexibility and accessibility of the pre-recorded resources. One student explained, "I was able to engage properly in classroom discussion through flipped classroom approach" [p9, Focus Group 2], while another added, "I participated effectively in class during the practical session due to the provision of pre-recorded lecture videos on plant physiology and diversity of living organisms" [p18, Focus Group 4]. These findings highlight the role of pre-class learning in promoting active engagement and meaningful participation during in-class activities.

Increased interaction. The feedback from the participants reveals that the flipped classroom approach created more opportunities for meaningful engagement with both the course materials and classroom community. By interacting with pre-recorded lecture content prior to class, students arrived better prepared, which allowed in-class time to be utilized for collaborative discussions, practical exercises, and project-based learning. This shift in instructional design fostered a more interactive and student-centered learning environment. Students also emphasized enhanced interaction with both their peers and the lecturer during classroom sessions. One participant remarked, "I interacted with my colleagues during the in-class activities due to the pre-recorded materials provided for me to study at home" [p17, Focus Group 4]. Similarly, another student stated, "I was able to participate in-class and also contribute effectively because of the pre-recorded lecture videos" [p21, Focus Group 5]. These insights suggest that the flipped classroom model not only enriched academic engagement but also strengthened social interaction and collaboration among students.

Personalised learning. The responses of the students clearly indicated that the flipped classroom approach provided them with the flexibility to control their own learning process. Being able to pause, rewind, and rewatch the pre-recorded lecture videos allowed students to engage with the content at a pace that suited their individual learning needs. This autonomy not only supported deeper understanding of complex topics but also accommodated diverse learning styles within the classroom. As one participant noted, "Pre-recorded videos helped me learn on my own" [p20,

Focus Group 4], highlighting the value of self-directed learning. Another participant emphasized the convenience and effectiveness of this approach by stating, "I was able to watch videos on concepts in plant physiology and diversity of living organisms at my hostel. I even pause the videos sometimes and replay in order to understand the content well" [p23, Focus Group 5]. These reflections suggest that the flipped classroom model fosters personalized and student-centered learning environments.

4.3.2. Satisfaction from flipped classroom approach

The students' responses revealed a high level of satisfaction with the implementation of the flipped classroom approach in teaching diversity of living organisms and plant physiology. This method, which allowed students to access pre-recorded lecture materials before class, enabled them to study at their own pace and come to class better prepared for interactive learning. Many students emphasized that the approach supported more effective in-class participation and deeper engagement with the subject matter. For instance, one participant explained that although they found the flipped classroom method beneficial, "the cost of data did not permit me to get access to all the pre-recorded lecture videos," and therefore rated their satisfaction as 7 out of 10 [p12, Focus Group 3]. Another student also rated their satisfaction as 7, citing "poor internet connectivity" as a limiting factor [p14, Focus Group 3].

Despite such infrastructural challenges, several participants expressed high satisfaction with the model. One student rated their experience 8/10, stating that the pre-recorded lecture videos "helped me participate effectively in class" [p10, Focus Group 2], while another echoed this sentiment, sharing that the videos "helped me to learn at home" [p21, Focus Group 5]. The highest satisfaction ratings came from students who particularly appreciated the interactive and engaging nature of the in-class activities. One noted, "My satisfaction is 9 out of 10 because the in-class activities were very interesting and engaging" [p4, Focus Group 1], while others emphasized conceptual gains, with a student stating, "I understood the concept very well through flipped classroom approach," giving a rating of 9.5 out of 10 [p17, Focus Group 4; p23, Focus Group 5].

Taken together, these responses indicate that while technological barriers posed some difficulties, the flipped classroom approach was generally perceived as effective and rewarding, especially in fostering student-centered learning, active participation, and conceptual understanding.

4.3.3. Impact of flipped classroom approach on interaction among students

The participants reported that the adoption of the flipped classroom instructional strategy significantly enhanced their interaction with both the lecturer and their peers during the learning of diversity of living organisms and plant physiology. By shifting the acquisition of foundational knowledge to the pre-class phase through pre-recorded materials, classroom time was freed for deeper engagement and collaborative learning. Students came to class equipped with prior knowledge, which enabled more meaningful discussions, peer-supported learning activities, and targeted questioning. In this environment, the role of the instructor transformed from a traditional lecturer to a facilitator who provided personalized feedback, clarified misconceptions, and supported small-group problem-solving. As one student noted, "I interacted with my lecturer and colleagues very well through the use of flipped classroom in teaching diversity of living organisms and plant physiology" [p8, Focus Group 2]. Another participant emphasized the improved teacher-student dynamics, stating, "There was positive interaction between the lecturer and the students through the implementation of flipped classroom approach" [p9, Focus Group 2]. These reflections suggest that the flipped classroom model created a more interactive and student-centered learning environment, fostering both academic and social engagement.

4.3.4. Enhanced conceptual understanding

The participants indicated that the implementation of the flipped classroom approach significantly enhanced their understanding of key biological concepts, particularly those related to diversity of

living organisms and plant physiology. This improvement was largely attributed to the structured format of the method, which provided access to learning materials – such as pre-recorded videos, readings, and interactive modules – prior to class sessions. Engaging with the content beforehand allowed students to arrive in class with a foundational understanding, making in-class time more productive and meaningful. Through collaborative activities, hands-on experiments, and guided discussions, students were able to reinforce their learning, clarify misconceptions, and explore complex ideas in greater depth. One participant explained, “Yes. This is because I was able to engage with the material at home before attending class” [p13, Focus Group 3], while another emphasized, “Flipped classroom enhanced my understanding of diversity of living organisms and plant physiology concepts due to the provision of pre-recorded videos” [p12, Focus Group 3; p24, Focus Group 5]. These statements reflect the students’ perception that the flipped classroom model not only supported their comprehension of scientific content but also fostered more active and effective learning experiences.

5. Discussion

This study was conducted to determine the effect of flipped classroom instructional strategy on student’s knowledge retention in diversity of living organisms and plant physiology. The results of the study revealed that there was statistically significant difference in knowledge retention between the retention test and pretest mean scores of students taught using flipped classroom instructional strategy. The students’ knowledge retention improved significantly after the were taught using flipped classroom instructional approach strategy. The results of the study confirmed the finding of Bupo and Ibeneme (2020), who reported that flipped classroom had a significantly higher effect on students’ knowledge retention in financial accounting. The finding of the study also supports the findings of Olanrewaju and Richard (2023) who revealed that flipped classroom learning strategy positively influences students' learning retention.

The study also revealed that there was a statistically significant difference between the retention test and posttest mean scores of students taught using flipped classroom approach. The results were inconsistent with the findings of Noroozi et al. (2020) who reported that no significant difference exists between the posttest and retention tests results of students taught using flipped classroom approach. The finding is in line with Makinde (2020) who examined impact of flipped classroom mathematic learning outcome of senior secondary school students and revealed that students who were taught using flipped classroom approach experienced higher knowledge retention. The finding also collaborates with the findings of Sirakaya and Özdemir (2018) who explored effect of a flipped classroom model on academic achievement, self-directed learning readiness, motivation and retention and found that students exposed to flipped classroom approach experienced higher knowledge retention.

The results of the study revealed that students had positive attitude toward flipped classroom approach in teaching and learning of diversity of living organisms and plant physiology. The findings confirmed the study of Shahani et al. (2021) who showed that students had positive attitude towards flipped classroom teaching and agreed that it was useful to them in diverse ways. The findings further corroborate the findings of Abuhmaid and Abood (2020) who reported that students exhibited positive attitudes towards flipped classroom teaching. The findings contradict the findings of Setianingsih and Arroyyani (2023) who reported that flipped classrooms were found not beneficial to students. The findings of the study further confirmed the findings of Maidin and Shukor (2021) who revealed that students had positive attitude towards flipped classroom.

The findings are in line with Shekhipour et al. (2021) who revealed that flipped classrooms increased students’ motivation, self-efficacy, engagement, self-confidence, and autonomy. The findings also support the findings of Mahmud et al. (2023) who revealed that students viewed flipped classroom as a useful, productive, interactive, and entertaining learning approach. The findings reflected in the study of Farrah and Qawasmeh (2018) who opined that students considered the flipped classroom as exciting, engaging, and motivating. The responses of the

participants also confirmed the findings of Aziz and Hashim (2023) who reported that students agreed that flipped learning increased students' self-motivation and enhanced active and independent learning. The results also support the findings of Gokdogan et al. (2023) who revealed that flipped classrooms increase students' academic performance. The findings of the study confirmed the findings of Doo (2022) who found that flipped learning facilitate students understanding of the lectures, provide review opportunity for learning and also provide flexible learning environment for students. The results of the study support the findings of Halili et al. (2021) who reported that students had positive perceptions towards flipped classroom approach in terms of students' motivation, learning and engagement.

6. Conclusions

This study was explored to investigate the effect of flipped classroom instructional strategy on students' knowledge retention in diversity of living organisms and plant physiology. The results of the study revealed that there was a statistically significant difference between the retention test and pretest performance of students taught using flipped classroom instructional strategy. The results further revealed that there was a statistically significant difference between the retention test and posttest mean scores of students taught using flipped classroom instructional strategy. The results of the study proved that flipped classroom instructional strategy significantly improved students' knowledge retention in diversity of living organisms and plant physiology. The study also found that students had positive attitude towards flipped classroom instructional strategy in teaching and learning diversity of living organisms and plant physiology.

7. Educational implications and Recommendations

Flipped classroom instructional strategy has the potential to revolutionize the way lecturers at C.K. Tedam University of Technology and Applied Sciences conduct their lessons. The ability to conduct lessons asynchronously is quite beneficial, as time restrictions are a regular concern for many lecturers due to the enormous topic areas in courses that must be covered during a semester. Time wasted during class can be regained by delivering the content asynchronously. With the global shift toward learner-centered teaching methods, the flipped classroom instructional strategy is a feasible current learner-centered paradigm that lecturers and teachers may implement to help students take greater responsibility for their learning.

Flipped classroom instructional strategy utilises classroom time for more individualised learning as needed by students in the 21st century. This instructional approach also allows students to finish lectures at their speed and study as many times as necessary to feel acquainted with the topic or concept. This instructional approach also enables students to study before attending lectures which allows them to participate effectively during in-class activities. This instructional strategy is also beneficial to students because it allows them to receive the content in their comfort zones.

Based on the findings of the study, it is recommended that lecturers should adopt a flipped classroom instructional strategy in teaching concepts in Biology, Chemistry and Physics courses.

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