Impact of Flipped Learning Pedagogy on Senior High School Physics Students' Attainment, Retention and Feedback in Studying Electronics

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Abstract

The study aimed to explore the impact of Flipped Learning Pedagogy (FLP) on the attainment and retention of senior high school physics students studying electronics and the nature of the feedback given by students taught electronics concepts using FLP. The study was conducted in two intact classes comprising 103 research participants from the Old Tafo Municipality in Ghana using a quasi-experimental pre-test/post-test non-equivalent control group design. On the instrumentations of the study, this study employed two different sets of Electronics Concept Test and a semi-structured interview guide to collect both quantitative and qualitative data. Split-Plot Analysis of Variance (SPANOVA) revealed a significant effect of FLP use on student retention (Wilk's Lambda = 0.038, $F(3,99) = 830.746$, $p = 0.000<0.05$; effect size = 0.962) in learned electronics concepts. The students' feedback on FLP was positive, indicating that FLP helped them better understand electronic concepts, remain focused on their studies, and collaborate with their classmates for better study. Based on the results obtained, it was concluded that the use of FLP in the teaching and learning of electronics enhances students' retention of knowledge of electronic concepts and consequently promotes positive feedback on electronic concept studies. Therefore, it was recommended that SHS Physics teachers in Old Tafo Municipality who wish to improve their students' retention of learnt electronics concepts and develop positive feedback on electronics studies should consider adopting FLP as an option.

Keywords flipped learning pedagogy; retention of knowledge; electronic concepts; feedback on learning

Introduction

One of the most intricate and complicated problems for both teachers and students is learning retention (Olifer, 2020). It has been observed that some learners learn almost in the classroom yet perform poorly on monthly assessments and yearly exams (Toheed et al., 2017). After a certain amount of time, students lose interest in the subject they have learned. According to Akpan et al. (2019), retention is essential for knowledge transfer because it saves teachers time when they have to review and re-examine the material that students have already learned. Learning retention is the amount of information that a person can still recall after a given amount of time. It is the capacity to hold onto newly learned information and to call upon it when needed. Akpan et al. (2019) note that the retention process occurs when learning is maintained in long-term memory so that it can be precisely found, recognised, and retrieved at a later time. Retention is gained through the use of effective teaching techniques rather than rote memory (Ajayi & Angura, 2017).

Teaching strategies have a significant impact on student academic success,

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 DOI: https://dx.doi.org/10.4314/ajesms.v20i1.3

regardless of how thorough and well-developed the curriculum is. Njiru and Karuku (2015) assert that the effectiveness of teachers putting it into practice determines its success. Buabeng et al. (2014) mentioned that the most crucial strategies teachers use to achieve a lesson's goals are teaching approaches. For students studying Physics in the classroom to reach their greatest potential, Buabeng et al. (2014) stated that using appropriate teaching techniques is a requirement for teachers. Moreover, Buabeng et al. added that a Physics teacher must create lesson plans using effective teaching pedagogies that can pique students' interest in the subject and equip them with the skills necessary to respond appropriately to scenarios in which their understanding of Physics may be useful. Given this, Olifer (2020) implies that teachers must use effective teaching techniques if they want Physics students to reach their full potential in the classroom, especially in the concept of electronics. One such instructional approach that can help students reach their full potential in the classroom is Flipped Learning Pedagogy (FLP).

FLP is an instructional approach in which learning activities take place in class and information transmission teaching is moved outside the classroom (Sargent & Casey, 2020). Therefore, this approach inverts the conventional idea of classroom-based learning, where everything, except assignments and homework, is done in a classroom (Fisher et al., 2020). In other words, in an FLP, students complete their core curriculum outside of class and use their in-class time to apply concepts (Ceylan & Elitok, 2017). The FLP is student-oriented because its application emphasizes students' subjective initiative and shifts the focus of instructional delivery from "teacher-centred to student-centred" (Koray et al., 2023). Zainuddin et al. (2019) also stated that FLP is a novel student-centred strategy to improve knowledge transmission and optimise class time. Under an FLP, students complete their core curriculum outside of class and use their in-class time to apply concepts (Ceylan & Elitok, 2017). Since it was initially referred to as an "inverted classroom" in 2000, flip teaching has grown in popularity among college students (Bassett et al., 2020). Research by Kuswandi (2019) indicates the potential contribution of active pedagogies, such as FLP, to more equitable STEM outcomes for a variety of student groups.

Kuswandi (2019) further asserts that the use of FLP served as an inspiration for the advancement of electronic education. Akçay and Akçay (2018) show that inclusive STEM education, which cannot ignore electronics, is promoted by active and interactive teaching strategies such as Flipped Learning Pedagogy. These approaches also result in more equitable educational outcomes and, most importantly, close the opportunity gap between various groups of students. In an FLP, Atkins (2018) claims that before arriving at class, students should familiarise themselves with important terms and concepts through readings and/or taped videos. In doing so, students have the flexibility and the chance to learn at their own pace because they can view the pre-recorded lessons on their phones at any time and from any location. Moreover, Stratton et al. (2020) stated that FLP focuses on themes, solving problems, and engaging in innovative classroom activities to foster teacher-student engagement. Stratton et al. added that the application of FLP is to develop critical thinking abilities, communication skills, and student involvement.

The rationale for and justification of the study was that the interaction of the first author with physics students from the high school at the study site revealed that most of the students had difficulty with electronic concepts. For example, Ama, not her real name, said: "*I cannot relate the real* *component of a circuit board to the symbols learned in the classroom because I have not seen some of the circuit elements before*." Eric, not his real name, also said, *"I could not understand the electronic content learned in the previous class because the content was too abstract to me." Takyi, also not his real name,* said: *"Because the concepts of electronics learned were too abstract to me, I couldn't retain the concepts learnt."*

Some studies have demonstrated the effect of FLP on student learning outcomes; however, there is an existing gap in explaining the effect of FLP on student retention of learned electronics concepts and the nature of student feedback on FLP. Therefore, with the desire to assist our research subjects in overcoming their learning difficulties in electronic concepts and to fill this identified gap about FLP in electronics studies, this study was initiated. FLP was selected because of its ability to personalise learning according to student's learning needs where students can learn at their own pace (Karabulut-ilgu et al., 2018), and the opportunity it gives learners to actively engage in the teaching and learning process (Lai, 2021). Hence, the following research questions guided the study:

1. What is the impact of Flipped Learning Pedagogy (FLP) on senior high school students' retention of learned electronics concepts?
2. What is the nature of feedback given by senior high school Physics students who are taught electronics concepts using FLP?

Methodology

This study was premised in the realm of the postpositivist paradigm using a quasi-experimental pre-test and post-test non-equivalent control group design in which both quantitative and qualitative data were collected. This study was conducted between April 2023 and June 2023, using third-year SHS Physics students at Old Tafo Municipality in the Ashanti Region of Ghana as research subjects. Based on the research paradigm and the design adopted, two intact classes were randomly selected from two participating schools and assigned as experimental (n = 50) and control groups (n = 53). The experimental group was subjected to FLP, which was characterized by watching videos outside the classroom coupled with in-class discussions, whereas the control group was subjected to in-class discussions without the video sessions, as outlined in the in-class activities section of this article. The researchers carried out various teaching activities in both groups. Specifically, the flipped learning activities were supervised by the lead author, whereas the conventional teaching method was implemented by the third author.

Instruments

The electronics content considered in this study were intrinsic and extrinsic semi-conductors, construction and action of the bipolar junction transistor, transistor biasing and configurations, and operation of the transistor as a switch and amplifier. These content were selected based on the Ghanaian Physics curriculum for senior high schools (Ministry of Education, 2010). The instruments for data collection were tests and an interview guide. The tests were in the form of pre-test, post-test, delayed post-test 1 and delayed post-test 2, which were used to assess students' retention of electronics concepts under consideration in this study. The pre-test and post-test consisted of two different sets of eight essay-type items on the electronics concepts, while the delayed post-test 1 and delayed post-test 2 consisted of parallel and reshuffled items from the pre-test and post-test, respectively.

Table 1 **Nature of pre-test, post-test, delayed post-test 1 and delayed post-test 2 items**

Item Type	Sample Items
Pre-test	Explain the mechanism of conduction in: i) Intrinsic semi-conductor; and ii) Extrinsic semi-conductor.
	How does a transistor operate as an amplifier?
Post-test	Explain how P-type and N-type semiconductors are formed.
	If the current flowing into the emitter of a bipolar junction transistor increases without any change in the voltage applied to the base, what effect would this have on the current flowing into the collector?
Delayed Post-test 1	Describe conduction occurs in the two major types of semi-conductors.
	In the amplification of signals, briefly describe the role of a transistor.
Delayed Post-test 2	Briefly explain the distinction between the formation of a P-type semiconductor and an N-type semiconductor.
	If the emitter current increases without a base voltage being provided, what would happen to the collector current?

The semi-structured interview guide contained five open-ended items designed to collect students' feedback on the use of FLP in the teaching and learning of electronics. The interview was conducted after delayed post-test 2 with nine randomly selected participants from the experimental group. After the design of the instruments, they were validated by two SHS physics teachers who had taught for a minimum of eight years, as well as two physics education lecturers from Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED). The teachers and lecturers were asked to evaluate the appropriateness of the items on the tests and interview guide, which were designed to measure students' retention of the electronic concepts learned and the nature of students' feedback on the use of FLP in the teaching and learning of electronics. This was followed by pilot tests of the instruments in which the results of the pilot test were used to determine the reliability. Using inter-rater reliability (Cohen's kappa measure of agreement) for the tests, the pilot test results produced kappa values of 0.737, 0.772, 0.812, and 0.765 for the pre-test, post-test, delayed post-test 1, and delayed post-test 2, respectively, indicating substantial agreement (Mchugh, 2012; Wong et al. 2021).

Pre-Class Preparation

In the pre-class phase, the researchers prepared the teaching contents on the electronics concepts under study. This began with searching and downloading the appropriate videos covering electronics concepts for the Ghanaian senior high physics curriculum that was in line with the electronics concepts under consideration. The videos were in the form of visual tutorials and real-world examples to make the concepts real to the students. The video sessions were in two folds. The first session took place between the period of April 7, 2023, and April 16, 2023, when students were on a short break from school. To allow students to have access to the videos during this period, students provided WhatsApp numbers (personal, parents, or guardians) through which the videos were sent to them. The second session for the viewing of the video began during the period between April 17, 2023 and May 2, 2023, when the students had resumed. Since most of the students were boarded and were not allowed to use phones at school, the students watched the videos in their computer laboratory, using the period scheduled for the intervention, one week before each class lesson. During this session, the researchers sought permission from the computer laboratory technicians of the experimental school to install the videos on their computers so that students could view them before class activities. During the video sessions, the lead author monitored the students to ensure full participation and also provided clarification on areas where the students found difficulty understanding. Additionally, students were asked to make notes on the videos they watched and also given group assignments based on the video content during the video sessions and were scheduled to present them in their in-class sessions.

In-Class Activities

In the in-class phase for the experimental group, which took place between the period of May 3, 2023, and June 2, 2023, the research subjects convened in the classroom to discuss the various electronics concepts learned in the video sessions. During the in-class phase, under the guidance of the lead author, the research subjects engaged in peer teaching, concept mapping, small group and whole class discussions, and cooperative problem-solving sessions to reinforce their understanding of the electronic content watched in the video sessions before in-class activities. The importance of this phase was to correct any misconceptions or alternative understanding that might have existed. In the control group teaching, which also lasted between the period of April 17 and June 2, 2023, under the guidance of the third author, the researchers used similar teaching strategies, such as peer teaching, concept mapping, small group and whole class discussions, as well as cooperative problem-solving sessions. However, they missed the opportunity to watch videos on electronics, as in the case of the experimental group, as presented in the Appendix.

Assessment

After the intervention, the students in both the experimental and control groups were repeatedly assessed on the electronics concepts learned. These assessments were classified as post-test, delayed post-test 1, and delayed post-test 2. (Sample of the assessment questions used were: explain how a transistor behaves as a switch; explain how P-type and N-type semiconductors are formed; differentiate between a polarised capacitor and a non-polarised capacitor; explain why the conductivity of a semi-conductor increases with temperature; state the role of a capacitor in the amplification of signals, etc.). In the final phase of the assessment, data were taken on the nature of feedback students give on the utilisation of FLP. Accordingly, nine (9) students from the experimental group were randomly selected for semi-structured interviews to solicit students' feedback.

Results and Discussion

The results were analysed based on the research questions, with research question 1 using mean, standard deviation, and split-plot analysis of variance, while research question 2 was answered using thematic analysis.

Effects of FLP on Students' Retention

Students' retention of electronics concepts was assessed at a three-week interval between the post-test, delayed post-test 1 and delayed post-test 2 to compare the trend in retention between the experimental and control groups. The precise time frame for assessing learners' retention of concepts has been debated in the literature. Coleman (2022) and Clearwater (2022) found that students often lose between 50% and 70% of the information they acquire in a day or two and 90% weekly. Kovács et al. (2019) assessed learners' retention after two months, whereas Valderama and Oligo (2021) assessed it weekly for seven consecutive weeks. Also, Faught et al. (2016) employed a three-month interval across 12 months to assess students' retention. Accordingly, the three-week interval period for assessing the retention of students in electronics concepts was deemed appropriate as highlighted in the literature (Clearwater, 2022; Coleman, 2022; Faught et al., 2016; Kovács et al., 2019). Table 2 presents descriptive statistics (mean and standard deviation) on pre-test, post-test, delayed post-test 1, and delayed post-test 2 scores on the trend in retention of electronics concepts between the experimental and control groups.

the experimental group obtained a higher mean score in delayed post-test 1 with a mean score, M = 22, and standard deviation, SD = 2.4, compared to the control group with a mean score, M = 14, and standard deviation, SD = 3.5, where the mean difference was 8.07. In the post-test 2, it can be observed that the experimental group demonstrated a higher performance (M = 20, SD = 2.8) than the control group's (M = 9, SD = 3.4), with a mean difference of 10.73. The trend in retention between the

Table 2 **Descriptive statistics of the experimental and control groups' attainment in the pre-test, post-test, and delayed post-tests scores**

Group	**Pre-test**		**Post-test**		**Delayed Post-test 1**		**Delayed Post-test 2**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Experimental	8	1.9	23	2.5	22	2.2	20	2.8
Control	9	2.0	19	2.8	14	3.5	9	3.4
MD	1.46		4.36		8.07		10.73	

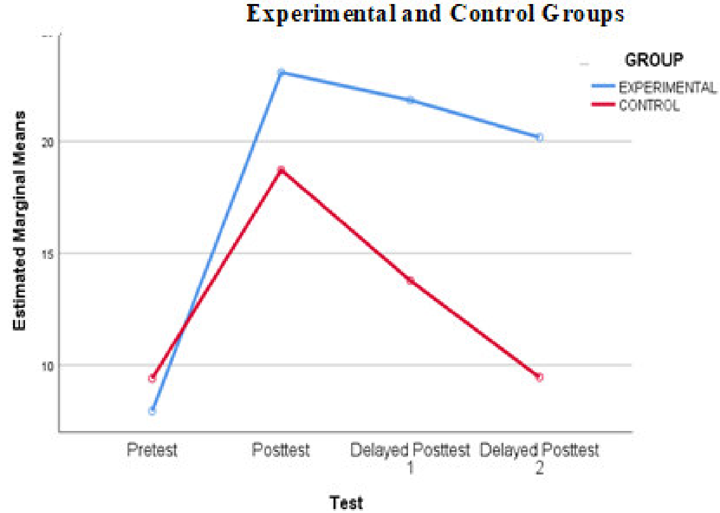
From Table 2, it can be observed that the control group obtained a higher mean score in the pre-test (M = 9, SD = 2.0) than the experimental group (M = 8, SD = 1.9), with a mean difference of 1.46. In the post-test, the experimental group obtained a higher mean score (M = 23, SD = 2.5) than the control group's mean score (M = 19, SD = 2.8), with a mean difference of 4.36 suggesting the experimental group had a greater improvement in their attainment than the control group.

The further analysis of the data to ascertain the effect of the flipped learning pedagogy experiment on the groups' retention of their attainments in electronics concepts learned in physics yielded the rest of the descriptive statistics results presented in Table 2. From the table,

experimental and control groups can be inspected graphically using the estimated marginal means of the pre-test, post-test, delayed post-test 1, and delayed post-test 2 scores for both groups, as shown in Figure 1.

In Figure 1, it can be observed that, in all the tests, the experimental group obtained higher estimated marginal mean scores than

Figure 1 **Retention Trends in Electronics Concepts of Experimental and Control Groups**



the control group. In addition, there was a sharp increase from the pre-test to the post-test for both groups. As time progressed, the estimated marginal means for the control group decreased sharply from post-test to delayed post-test 1 and subsequently to delayed post-test 2. However, the experimental group witnessed a relatively small decrease in the estimated marginal mean scores from post-test to delayed post-test 1 and subsequently to delayed post-test 2. The decrease in estimated marginal mean scores was a result of the decay in knowledge of electronics concepts within both groups as time passed. However, Figure 1 shows that the decay of electronics concepts within the control group was much greater than within the experimental group.

The results presented in Table 2 and Figure 1 were tested using a Split-Plot Analysis of Variance (SPAVOVA) known as Mixed Between Within-Subjects Analysis of Variance to assess the impact of FLP pedagogy and conventional teaching methods on the retention of electronic concepts by SHS Physics students in four time periods (pre-intervention, post-intervention, delayed post-intervention 1, and delayed post-intervention 2). After ensuring non-violation of assumptions, the SPANOVA was conducted, and the results are presented in Table 3.

Table 3 **SPANOVA results on pre-test, post-test, delayed post-test 1 and delayed post-test 2 scores of experimental and control groups**

	Effect	Value	F	Hyp. Df	Error df	Sig.	Partial Eta Squared
Time of Test	Wilks' Lambda	0.038	830.746	3	99	0.000	0.962
Time of Test*Group	Wilks' Lambda	0.181	149.464	3	99	0.000	0.819

Using Wilk's Lambda presented in Table 3 as the statistic for judgement by comparing the two groups, there was a significant interaction between the teaching method and time of test (Wilks' Lambda=0.181, F(3, 99) =149.467, p=0.000, partial eta squared=0.819). Furthermore, there was a significant main effect for the test time of test (Wilks' Lambda=0.038, F(3, 99) =830.746, p=0.000<0.05, partial eta squared =0.962) with both groups showing a reduction in test scores throughout the four testing periods, as presented in Table 3, suggesting a significant difference in the retention of electronics concepts between the use of Flipped Classroom Strategy and the Conventional teaching method.

Since there was a significant interaction effect between the teaching method and the time of test, simple effect analysis was conducted to determine significant differences in scores at each time of test for experimental and control groups, of which the results are presented in Table 4. In

Table 4 **Simple effect analysis of pre-test, post-test, delayed post-test 1 and delayed post-test 2 scores of experimental and control groups**

Test	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	p	95% Confidence Interval for Difference Lower Bound	Upper Bound
Pre-test	Experimental	Control	-1.456*	.385	.000	-2.220	-.692
Post-test	Experimental	Control	4.363*	.519	.000	3.333	5.393
Delayed Post-test 1	Experimental	Control	8.066*	.577	.000	6.923	9.210
Delayed Post-test 2	Experimental	Control	10.727*	.618	.000	9.501	11.953

conducting the simple effect analysis, a Bonferroni adjustment was made since four comparisons were made simultaneously, to reduce the risk of committing Type I error – that is rejecting the null hypothesis when it is true (Pallant, 2011). The Bonferroni correction was done by dividing the original α-value, which is 0.05 by the number of comparisons made, which is four. This then provided a new α-value of 0.0125. Therefore, the mean differences in Table 4 are significant if their p-values are less than 0.0125. Table 4 shows the results of the simple effect analysis of pre-test, post-test, delayed post-test 1 and delayed post-test 2 scores of experimental and control groups

The results presented in Table 4 revealed that there were significant differences between the experimental and control groups at the four testing times, the pretest (mean difference = 1.456, $p = 0.000<0.0125$), post-test (mean difference = 4.363, $p = 0.00<0.0125$), delayed post-test 1 (mean difference = 8.066, $p = 0.000= 0.00<0.0125$), and delayed post-test 2 (mean difference = 10.727, $p = 0.000= 0.00<0.0125$). In the pretest, the difference favoured the control group; however, in the post-test, delayed post-test 1 and delayed post-test 2, the differences favoured the experimental group, as shown in Table 2 and Figure 1.

The findings of this study are congruent with those of Ajayi and Angura (2017) and Kuswandi (2019). Specifically, Ajayi and Angura (2017) intimated that integrating video teaching and learning has a greater impact on the academic performance of students and also enhances their retention. In the 21st century, where students are more prone to computers and technology, visual exposure to concepts and theories in the study of electronics will help students learn at a faster pace and retain such information for a very long period.

Nature of feedback from Students on FLP

In this phase of the analysis, students were interviewed to obtain student feedback on the use of FLP in the teaching and learning of electronics. The analysis of the feedback from the students revealed four major themes: a better understanding and retention of electronics concepts, improved focus on Electronics studies; enhanced ability to solve problems in electronics, and increased collaboration with classmates. Some presentative feedback from the students is presented as follows:

Theme 1 Better Understanding and Retention of Electronics Concepts

The responses of the participating students indicated that they had improved their understanding of electronics concepts after their exposure to FLP. Students pointed out that the reason for this was because the videos presented to them outside classroom hours gave them better pictures and clarifications of the concepts. This made some unfamiliar concepts more real to them as they watched the videos. The consequence is that students can retain concepts better, as reflected in the quantitative findings. For instance, two students made the following articulations:

Student 1: *I have understood the concept of electronics better now than ever before. I never knew that the electronics concept could be that interesting and easy to understand. Now I know I can do better on electronic tests and assignments because of how you taught us. Your teaching approach helped me link the lesson to the real world, which has gone a long way in helping me.*

Student 2: *Sir, after you taught us using that new method, I now could understand and relate electronic concepts to real-life situations. Because of this, I can easily remember the things we learned. All this while I did not even know electronic concepts were that real.*

Theme 2 Improved Focus on Electronics Studies

Students again pointed out that, they remained focused on their books and studies as they were engaged in the Flipped classroom. This is because, the videos which were given to them outside classroom periods kept them on their toes, trying to always learn at least a concept at a time before the classroom hours. They asserted that the videos made them so focused that, though they were not in the confined classroom, they were always on their books at every little time they got as though they were in the classroom. For example, two students gave the following feedback:

Student 3 *I like studying and for that matter, I am always on my books whenever we are in school. After you introduced your new teaching method to us, I became so serious and focussed on my studies both on campus and in the house in ways that I never thought would be possible.*

Student 4 *Nothing could take away my attention whenever I was studying through the videos. Even during classroom hours, the interaction with friends made me focus more on what was being taught. I always felt there was a task ahead of me and for that matter, there was no time to be loitering around and engaging in things that are not beneficial to me as a student.*

Theme 3 Enhanced Ability to Solve Problems

The students' ability to solve problems in electronics was improved after their exposure to the FLP. This is because students were exposed to several videos that explained electronics concepts and problems in detail. Students were also made to interact with their peers during classroom hours, which gave them more insight into what challenged them as they watched the videos. The teacher also elucidated the more complex problems in electronics that were beyond the capacity of the students. In the words of two students, the following feedback was solicited:

Student 5 *I can now make boastful claims that there is not a problem in electronics I cannot solve. All the problems I could not solve from the first test, which caused me to have a very low score now became very cheap. I could now solve them all with ease. An example is how N-type and p-type semiconductors are formed. I had no idea earlier although we had been taught before. I could solve it and had a full score for that particular problem with the help of the approach you used to teach us.*

Student 6 *After you taught us, I now felt so enlightened about electronics and relieved because initially I was bothered with my performance in the first test. however, in the second test, I was able to answer almost all the questions correctly and that earned me a very good mark in the last test.*

Theme 4 Increased collaboration with classmates

Students were able to collaborate with their classmates in the use of the Flipped classroom and this had a greater impact on their studies and retention of electronics concepts. Collaborative activities made use of the benefits of social interaction and active participation, creating a dynamic and supportive learning environment that improved the retention of electronics concepts. For example, three students made the following assertions:

Student 7 *As a result of the opportunity to interact and collaborate with our classmates I had a misconception identified and cleared of certain concepts, especially about the mechanism of conduction in intrinsic semiconductors and extrinsic semiconductors. It was from my friends that I had a better understanding and could score it all in the second test that you conducted. Meanwhile, I could not understand it on my own when I watched the video, nor did I learn it better when I was first taught by my Physics teacher."*

Student 8 *Collaborating with my classmates in the house as we watched the video together and had discussions as well as allowing us to interact among ourselves based on what we are studying during lesson periods has made me remember the topics better. I had a clear understanding of concepts that would have taken me days or weeks to comprehend. This is the reason why I scored an excellent mark on your last test.*

Student 9 *I barely receive help even from my classmates. However, you gave us the chance to discuss and share ideas among ourselves concerning what we had been taught. This helped me to voice out my challenge on the role of a capacitor in the amplification of signals to my classmates, and I received an eye-opening explanation from two of them that neither my teacher nor the video you sent to us could not explain to my understanding.*

From their feedback, it was found that students generally had positive feedback on the use of the FLP in teaching and learning electronics. These themes are in line with the findings of Strohmyer (2016) and Stratton et al. (2020), who stated that students' perceptions of flipped classrooms have always been positive. Stratton et al. added that students who experience a flipped classroom take more responsibility for their education, which improves their perceptions and may help them perform better academically.

Conclusion

The initial interaction with the SHS Physics students used for the study showed that the majority of them had difficulties teaching and learning electronics concepts, which affected their retention of learned electronics concepts. However, FLP has proven to be effective more than the conventional teaching approach, in teaching and learning electronics concepts in high schools in Old Tafo Municipality, Ghana, in terms of maintaining the retention of learned electronics concepts and developing positive feedback towards electronics concepts. The reason for this improvement in student retention is that much attention was paid to studying at their own pace and collaborating with their peers both outside and in the classroom, coupled with the effective use of technological resources that made concepts real to the students. However, in the conventional classroom as used in this study, students missed the opportunity to apply technological resources which could have helped them learn at their own pace, thus leading to lower retention of electronics concepts. It can be concluded that SHS physics students within Old Tafo Municipality, Ghana, retained learned concepts better and developed positive feedback on the study of electronics concepts when instructed with FLP. The finding of this study is beneficial for SHS physics teachers within Old Tafo Municipality to maximise the use of technology in their electronics lessons. Specifically, teachers and students can take advantage of vacation periods with the Ghanaian government's initiative to provide SHS students with tablets for academic work, given the limited time that students and teachers have to complete the syllabus.

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APPENDIX
WEEKLY SCHEME OF LEARNING AND LEARNING OUTCOMES DURING IN-CLASS ACTIVITIES

WEEK 1	
Topic:	Electronic Semi-conductors
Lesson Objectives:	Mechanism of conduction in intrinsic and extrinsic semi-conductors Formation of P-type and N-type semi-conductors
Sample video links:	https://youtu.be/AhLATP5rYPs https://cdn.kastatic.org/ka-youtube-converted/Ekm2hhcrgCw.mp4/Ekm 2hhcrgCw.mp4#t=0

Summary of videos: The above videos explained the mechanism of conduction in intrinsic and extrinsic semi-conductors as well as the formation of P-type and N-type semi-conductors

WEEK 2

Topic: Bipolar Junction Transistor (BJT)

Lesson Objectives: Definition of bipolar transistor.
Description of construction and action of the bipolar junction transistor.

Sample video links: https://www.youtube.com/watch?v=0Z8tslPvU0o
https://youtu.be/J4oO7PT_nzQ
https://youtu.be/7ukDKVHnac4
https://youtu.be/gWM90gZuro

Summary of videos: These videos presented how BJT is constructed with 3 doped semiconductor regions separated by 2 p-n junctions.

WEEK 3

Topic: Bipolar Junction Transistor (BJT)

Lesson Objectives: Description of transistor biasing.

Description of the various transistor configurations

Sample video links: https://youtube.com/clip/Ugkx_DmCMzSMNkNZ_IybXixe0Nia4fwBiVgh?si=hbzolFH7Luzfy59D
https://youtu.be/fn0qngFjKSM
https://youtu.be/Z48BMO05Gf4
https://youtu.be/pZoU7Nn5FXE

Summary of videos: The concept of transistor biasing the various transistor configurations using NPN or PNP transistors was explained in the above videos

WEEK 4

Topics: Bipolar Junction Transistor (BJT)

Lesson Objectives: Description of the operation of a transistor as a switch.

Description of the operation of a transistor as an amplifier.

Sample video links: https://youtu.be/Sod_5y7ZBlk
https://youtu.be/oE1_CO4bpHI
https://youtu.be/Sod_5y7ZBlk

https://youtu.be/AhLATP5rYPs
https://cdn.kastatic.org/ka-youtube-converted/Ekm2hhcrgCw.mp4/Ekm2hhcrgCw.mp4#t=0

Summary of videos: The above videos explained how a transistor can behave as a switch and an amplifier, as well as the mechanisms of conduction in both intrinsic and extrinsic semiconductors.