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Effects of Flipped Learning on the Students' Academic Achievements in Physics Subject

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Abstract

The study objectively examined the effects of flipped learning on students' academic achievements in Physics, and on students' academic achievements in Physics based on gender. This study employed a quasi-experimental design involving forty-five experimental students and fifty control students from two secondary schools in Lagos state, who were randomly selected for Physics. The reliability coefficient (r) of the Achievement Test used as a research instrument for this study was 0.82. This study's data was analysed quantitatively to get ANOVA, t-test, standard deviation, mean, and frequency counts with interpretation at a $p < 0.05$ significance level. This study's results discovered that the flipped learning method had significant effects on students' achievement in Physics. Also, there is a significant difference between students' academic achievements in the control and experimental groups, and there is a significant difference in the academic achievements of students taught with the flipped learning method based on gender. It was therefore recommended that there should be provision for innovative, enriched technology-driven environments that will facilitate instructional activities proficiently for teachers and excellent performance for students based on the findings of this study.

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Background to the Study

Discoveries in science and technology every day innovatively transform the mode of instructional delivery. The advent of the internet and smart technology devices such as MOOCs, simulation, smartboards, dynamic visualisation, and mobile devices, among others, nowadays simplifies teaching and learning activities compared to 30 years ago. (Haleem et al. 2022 & U.S. Department of Education, 2017). Modification of learning styles towards students' needs and individual differences is presently at the top gear in advanced and developing countries. (Li et al. 2016). Effective instructional activities of science subjects entail multiple innovative teaching and learning styles that are technologically driven to suit both teachers' teaching competency and students' learning needs and interests. (California State Polytechnic University, 2017 & Brakhage et al., 2023). Mastery of science subject concepts by students usually needs diverse and innovative learning styles that will facilitate and simplify the learning task for them, wherever they might be at any time, with the appropriate usage of technology devices (Sunal et al., 2016). Thompson (2023) stated that excellent instructional activities in science subjects are guaranteed provided all necessary resource factors are available and appropriately utilised for students' exceptional performance and interest in the subject matter.

A new academic paradigm tends to arise whenever there is a need for instructional improvement to meet teachers' professional competency, students' academic performance, and society's demands (Ahmed, 2016). Successful integration of technology in instructional activities, as claimed by Thompson (2023) and Rymbai (2023), gives way to the emancipation of innovative teaching strategies (ITS) and technology-based learning (TBI). Oladejo (2023) emphasized that technology and culture have productive capacities to immensely transform the descriptions of physics learning in Nigerian secondary schools towards the emancipation of teachers' and students' self-efficacy and proficiency. Despite technological advancements and instructional resources in Lagos State secondary schools, physics learning remains challenging for students. Traditional approaches confine physics education to classroom-only interactions, denying students pre-class access to instructional materials and increasing cognitive load during lessons (Bergmann & Sams, 2012). This limitation creates emotional instability and disengagement from physics and related sciences. While flipped learning has demonstrated effectiveness in addressing preparation challenges and providing equitable access to instructional content in developed nations (Lo & Hew, 2017), its impact on physics achievement in Nigerian secondary contexts remains underexplored. Given the persistent learning difficulties students experience outside school environments, this study investigates flipped learning's effects on physics academic achievement, potentially offering solutions to traditional pedagogical constraints and improving student engagement in science education.

Literature Review

Concept of Flipped Learning:

One of the utmost innovative and technology-driven instructional methods is flipped learning. Thompson (2023) stated that flipped learning has been recognised as one of the

10 innovative teaching strategies that have recently emerged for better student engagement and excellent academic performance. According to Cam et al. (2022), flipped learning is one of the instructional strategies that tremendously boosts students' awareness, which was extensively utilised during the rapid spread and first time of the coronavirus disease-2019 (COVID-19) at all school levels. Flipped learning is also one of the innovative technology-driven learning instructional mediation approaches that transformed the education paradigm from teacher-centred to tremendously (Thompson, 2023 & Rymbai, 2023). Ahmed (2016) noted that the flipped learning model was raised due to the "flipped" of the whole classroom/homework paradigm.

Acts of flipped classroom activities, according to the Derek Bok Centre for Teaching and Learning (2025), give students opportunities to learn subject content ahead of and after the face-to-face school activities. Bergmann and Sams (2012) specified that flip classrooms are different from traditional classrooms because they permit students to carry out instructional activities like notetaking, virtual practical and quizzes, among others, outside the normal classroom setting. Also, Smallhorn (2017) highlighted that during flipped learning utilization, teachers usually shared related subject contents of instructional activities like internet videos and other e-material links with students at least a week ahead of the face-to-face classroom activities to prepare students exceptionally. Also, Boise State University (2024) and Harvard University (2024) claimed that flipped learning gives students freedom and control over their learning, encourages student-centred learning and collaboration, and makes subject content more easily accessible for students than traditional methods.

Philosophy of Physics Curriculum in Nigeria

At Nigerian Senior Secondary Schools, as noted by Aderonmu and Obafemi (2015), Physics is a fundamental science core subject and gateway to the achievement of essential scientific skills and knowledge. Science and Mathematics field of study by the NERDC (2019) and the Federal Republic of Nigeria (FRN) (2013) consisted of Physics, Chemistry, Computer Studies, Further Mathematics, Agriculture, Health Education, and Physical Education subjects. The discovery of Physics in the field of science as an international resourcefulness that focuses on the incorporation study of matter, energy and their interactions toward human present and future progress in all ramifications (Britannica, 2024, Montclair State University, 2024, Science, 2024 & International Union of Pure and Applied Physics, IUPAP, 1999). The Nigerian Educational Research Development Council (NERDC) (2019) stated that the Physics curriculum for Nigerian Secondary Schools comprises the Interaction of Matter, Conservation Principles, Space and Time, Energy Quantisation and Quality of Matter; Field at Rest and in Motion; and Physics in Technology, respectively. NERDC (2019) further stated that the themes were student activity concerned with prominence on experimentation, discussion, questioning, and problem-solving, among other technology-driven innovative strategies that provide an opportunity to meet individual learners' needs and interests with modern technology.

Empirical Studies of flipped learning related to the students' academic achievement

In terms of student understanding and engagement improvement in physics, due to the utilisation of flipped learning where students are encouraged to voluntarily engage with instructional content at home through teacher-prepared and recommended videos or other learning resources for physics experiments, problem-solving, and collaborative activities. Kim, Kim, Khera, & Getman's (2014) study demonstrated that flipped learning led to excellent students' performance in Physics tests, which signified that students exposed to the flipped classroom displayed an improved acquisition of physics content compared to control group students in traditional settings. Regarding students' higher academic achievement and test scores, O'Flaherty & Phillips' (2015) study proved that students subjected to flipped Physics classrooms exhibited excellent academic performance in their examinations and problem-solving abilities. Also, Chen, Wang, & Chen (2014) study found that students who had undergone flipped learning in Physics classes achieved higher on post-tests than peer students in traditional lecture-based classrooms. The O'Flaherty & Phillips (2015) and Chen, Wang, & Chen (2014) studies are attributed to the lively learning environment where students are involved in real practical applications of Physics concepts. Regarding students' collaborative learning and peer interactions, Fulton's (2012) study disclosed that Physics students who collaboratively worked in flipped classrooms outclassed those in traditional classrooms, simply because students had opportunities to support one another's learning via direct interaction that relieved their workloads and challenging subject concepts more effectively.

Regarding applications of flipped learning in Physics, Amanah, Wibowo, and Astra (2021) confirmed that students exposed to flipped learning had exceptional achievement when compared with students taught in traditional classrooms. Putri and Purwaningsih (2021) reconfirmed that the flipped classroom motivates students to learn physics, influences students to learn flexibly and independently, and improves students' metacognition in outward show. Mokuolu and Ojo's (2023) study was carried out to observe learning interest, students' academic achievement, learning retention, and physics based on the utilisation of flipped classrooms and traditional lectures. Koray, Çakar, & Koray's (2023) studies discovered that the effects of the flipped classroom's utilisation improved through digital content and educational events for the Physics lessons on students' problem-solving skills and academic performance in Physics instructional activities. Koray, Çakar, & Koray's (2023) study findings revealed that the students' physics lesson performance and students' attitude scores in the students exposed to experimental instruments were significantly more advanced than the students' scores in the control group. No significant difference was found in the students' problem-solving skills scores between the control group students and the experimental group.

Putri and Purwaningsih (2021) and Talan & Gulsecen (2019) studies focus on the students' response to the relevance of flipped classrooms in learning Physics at high schools. Putri and Purwaningsih's (2021) study revealed that flipped classrooms transform students to be effective active learners and support students in alleviating their cognitive load. Also, flipped classrooms have the potential to influence students to be self-reliant and encourage students to learn Physics content ahead of and after the normal classroom sessions. Sirakaya and Özdemir's (2018) study was carried out to examine the flipped classroom model's effect on self-directed learning of students' instructional readiness, academic achievement, and motivations. The study's findings displayed that in terms of students' academic achievement, motivation, and retention, there was a significant difference between the control and experimental groups. However, in terms of self-directed instructional readiness, there was no significant difference between the control and experimental groups. Zainuddin and Halili's (2016) study claimed that the ancient instructional cultures have transformed from lecturer-centred to student-centred due to the application of flipped learning classrooms, and students have been able to oversee their skill and knowledge acquisition without limitations.

Concerning students' gender differences in achievement, Jugović (2017) and Bergmann & Sams (2012) study noted that flipped learning environments have the potential to inspire a more equal involvement from all students, which has been revealed to help female students in Physics practical and classes improve their academic achievements. Baepler, Walker, & Driessen (2014) therefore proposed that flipped learning could be advantageous to decrease the gender gap in Physics and science education in general, due to female students in flipped classrooms outperformed and were more engaged compared to their peers in traditional learning settings. Mokuolu and Ojo's (2023) study findings reflected that flipped classrooms improved male physics students' academic achievement exceptionally than their female students taught with flipped classrooms without no significant difference between male and female students; flipped classrooms significantly heightened students' interest in learning Physics and academic achievements in Physics remarkably than the traditional lecture; and flipped classrooms stimulate students' exceptional learning retention in Physics better than the traditional lecture without significant difference between the experimental and control groups.

Theoretical Framework

The theoretical framework for this study was constructed based on the constructivist learning theory, self-regulated learning theory, active learning theory, and Community of Inquiry (CoI) that support active learning, self-regulated learning, and engagement, which might influence student achievements in Physics due to the intervention of flipped learning. The constructivist learning theory connects through variables measuring student knowledge construction, where flipped learning enables students to build understanding through pre-class video engagement and active classroom problem-solving rather than passive lecture absorption. The Self-Regulated Learning Theory relates to variables assessing student autonomy, time management, and metacognitive strategies. Flipped learning requires students to regulate their own pace during pre-class preparation and monitor comprehension independently. The Active Learning Theory corresponds to variables measuring classroom engagement levels, peer interaction frequency, and hands-on physics experimentation time. The flipped model transforms classroom time from lecture-based to activity-centered learning. The Community of

Inquiry (CoI) framework connects through variables examining social presence, cognitive presence, and teaching presence. Variables might include peer collaboration quality, instructor-student interaction patterns, and collective problem-solving effectiveness. Academic achievement variables (test scores, conceptual understanding, problem-solving skills) serve as dependent measures influenced by these theoretical constructs, creating a comprehensive framework for examining how flipped learning impacts physics learning through multiple pedagogical lenses. The following are the key theoretical perspectives that have potential for the foundation for a study on flipped learning's impact on students' academic achievement in physics:

The Constructivist Learning Theory advocated by Piaget and Vygotsky underscores that learning is an active procedure where all learners build on their prior skills, knowledge, and experiences. In a flipped learning instructional technique, students interact with the subject's content materials, such as videos and reading materials outside of class, and afterwards apply the knowledge and skills acquired in active, collaborative manners during the class period. The focus of flipped learning is on student-centred learning where students connect with the subjects' content extensively, repeatedly through problem-solving, experiments, or peer discussions. The flipped learning, according to the O'Flaherty & Phillips (2015) and Chen, Wang, & Chen (2014) studies, are perfectly aligning with constructivist principles due to its potential to reposition the role of the teacher from the primary knowledge source and authority to a facilitator who properly guides students through collaborative activities. Significantly, students have opportunities to engage in more hands-on activities and important learning experiences in Physics, which comparatively enhances their understanding and retention.

Self-regulated Learning Theory, postulated by Barry Zimmerman and Albert Bandura, explains the ultimate processes in which students can embark to take control of their learning with the inclusion of setting goals, monitoring progress, selecting strategies, and reflecting on their progressive learning outcomes. Concerning the flipped classrooms, as revealed by the Derek Bok Centre for Teaching and Learning (2025) and Ahmed (2016) studies that the students are naturally required to engage and interact with learning materials independently and creatively before coming to class, which in turn fosters their development of self-regulation skills and competency. According to Thompson's (2023) and Rymbai's (2023) studies, the flipped learning technique encourages students to oversee their learning by preparing for class ahead of the classroom activities session. Eventually, this procedure promotes students' self-regulation as they must master their time, seek clarification, and identify areas of difficulty during class activities, especially in Physics, where multifaceted problem-solving and relativity are often required.

Active Learning Theory, proposed by Richard Mayer and David Perkins, emphasises the significance of students who are actively engaging with the instructional materials through hands-on activities that stimulate them to apply, analyse, and synthesise knowledge appropriately in their educational process. Flipped classrooms, as opined by Ahmed (2016), generate and supply a leading and radiant environment for students' active learning because of shifting subject content outside the classroom and complementing class time for collaborative activities such as experiments and problem-solving that intensively engage students with the subject's content. Therefore, the acquisition of physics concepts, knowledge and practical skills with flipped learning will promote students' active participation in class and invariably improve their academic achievements in Physics.

The Community of Inquiry Framework advocated by Garrison, Anderson and Archer emphasises the instructional significance of three elements in learning. The three elements in learning comprise cognitive presence based on students' engagement with content, a social presence based on students' interaction with peers, and a teaching presence based on students' guidance from teachers and instructors. The Community of Inquiry Framework is frequently applied in blended and online learning environments and can be important to flipped classrooms, which combine in-class and out-of-class instructional activities. Boise State University (2024) and Havard University (2024) noted that flipped learning granted students the freedom to engage in both social and cognitive learning that promotes their interactions with peers and the teachers/instructor towards the application of knowledge and skills (social and teaching presence) for the promotion of greater understanding and sound academic achievement.

Statement of the Problem

Despite the availability of instructional resources at most Lagos State secondary schools and innovative learning devices, effective learning of Physics is still a challenge for students. Learning Physics theory and practical activities was limited only to the school and lesson environment. Moreover, non-access to teachers' instructional materials before school hours increases students' emotional instabilities and cognitive workloads during and after school hours. Students only interact with teachers' notes, quizzes, and practical demonstrations during school sessions. Learning Physics theory and practice constantly becomes a nightmare for secondary students, which causes students to disengage from Physics and other science subjects. Upon the emergence of various innovative technology-driven learning methods like flipped learning, students were still experiencing learning difficulties away from the school environment. Flipped learning has been confirmed as a solution to the challenges related to students' preparation and equitable access to instructional activities ahead of school hours, among others, in advanced countries. Therefore, this study examines the effects of flipped learning on the academic achievements of students in Physics.

Purpose of the Study

This study objectively was carried out to examine the effects of flipped learning on the academic achievements of students in Physics. Specifically, this study examines the:

1. Effects of flipped learning on students' academic achievements in Physics.
2. Effects of flipped learning on students' academic achievements in Physics based on gender.

Research Questions

The following were the research questions postulated to conduct this study:

1. What are the effects of flipped learning on students' academic achievement in Physics?
2. What are the effects of flipped learning on students' academic achievement in Physics based on gender?

Research Hypotheses

The following were the research hypotheses that were postulated to guide this study:

H_{O1}: There is no significant difference between the academic achievements of students taught with the flipped learning method and those taught with traditional methods.

H_{O2}: There is no significant difference in the academic achievements of students taught with the flipped learning method based on students' gender.

Significance of Study

This study's findings have the potential to benefit the following recipients productively:

Learners; this study will encourage all categories of learners to discover and appreciate flipped learning as an innovative and excellent way to motivate themselves to learn excellently and develop an interest in learning Physics productively, enhance their engagement in learning Physics, address their learning inequalities, and prepare them for real-world challenges and opportunities.

Science Teachers; this study's findings professionally enhance teachers' instructional flexibility, promote their active learning with the latest instructional technology, foster their collaborative learning community, and contribute to their professional growth and development.

School Administrators; this study's findings would expose school administrators to the advantages of varied, productive, differentiated instructional approaches and maximisation of instructional time. This study would offer solutions to the poor alignment of instructional activities to educational goals and standards. Additionally, the findings of this study will enlighten school administrators about the collaboration of teachers with technology-driven instructional devices and maximize instructional time in their respective schools.

Governments; this study's findings would encourage Governments at all levels to provide necessary instructional technology resources in all schools within their districts. Also, it will promote innovative instructional practices, a digital economy, students' equal learning outcomes, and address educational inequalities in their respective secondary schools.

Examination Bodies and Curriculum Planners; this study's findings would keep examination bodies and curriculum planners informed about the alignment of the instructional system with 21st-century skills, the promotion of metacognitive skills in the subjects' curriculum, preparation for performance-based assessments, and adaptation to technological advances in Nigerian secondary schools.

Methodology

Research Design

The quasi-experimental research design that involved pre-test/post-test assessments of students and analysis of students' academic performance was utilised for this study. The design involved intact classes of an experimental group that was exposed to the flipped learning method and a control group that was exposed to the traditional learning method. The study was quantitatively carried out to collect data from both groups. The pre-test and post-test designs are symbolically illustrated as follows in Figure 1:

Figure 1

Pre-test and Post-test Design.

Experimental	O_1	X	O_2
Control	O_3	—	O_4

Effect of the experimental treatment = (O2 – O1) – (O4 – O3)

The independent variables (flipped learning vs. traditional classroom instruction) were manipulated with control variables (prior academic achievement, student demographics, and frequency of the flipped learning intervention) to bring out dependent variable results (academic achievements of students in Physics). The academic achievement of students' data from both control and experimental groups was collected at the end of the study. The framework of activities of Zain and Sailin's (2020) study, which comprises pre-class, in-class, and post-class phases, was adopted for this study as shown in Figure 2. Learning activities were simultaneously done in control and experimental groups in schools between week 1 and week 6 of the school's instructional periods. At the experimental group school, the Physics teacher.

Figure 2: Framework of Activities

Phase	Flipped Learning Activities (WEEK 1-WEEK 6)		Traditional Learning Activities (WEEK 7-WEEK 12)	
	Instructor's role	Students' role	Instructor's role	Students' role
Pre-class	• Create video • Share with students	• Watch lecture • Take note and jot down questions for the instructor		
In-class	• Facilitate discussion	• Group discussion • Game-based learning • Peer review • Role playing	Instructor directed instruction	• Lecture • Presentation
Post-class	Check students' understanding	Students extend their learning through reflection	Check students' understanding	Do homework

Area of Research Study and Population

The research was carried out at Yaba and Lagos Mainland Local Government Areas of Educational District IV of Lagos State. The study covered all government senior secondary schools in the Yaba and Mainland Local Government Areas. There are 9 government senior secondary schools in the local government. (Lagos State Government Ministry of Education, 2019).

Sample and Sampling Technique

The intact class of SS 2 students offered Physics at the Mainland Senior High School (MSHS), Jibowu, and Federal College of Education (Tech.) Secondary Schools in Akoka are used as samples for this study. Fifty (50) SS 2 students were used as a control group at the Mainland Senior High School (MSHS), and forty-five (45) students were used as an experimental group at the Federal College of Education (Tech.) Secondary Schools. The two SSS 2 schools selected for this study possessed the same characteristics concerning an equal number of Physics teachers, and a lack of flipped learning methods to teach Physics, and both schools have been offering Physics since the year 2000 to date. There was no interference between the groups used for this study during fieldwork exercises because the control and experimental groups' schools were in educational districts 2 and 4 of Lagos State. A purposive sampling technique was utilised for this study.

Research Instrument

Only the Physics Achievement Test (PAT) was used as a research instrument to obtain quantitative data for the research questions for this study. The PAT consists of twenty questions drafted from force, electricity, waves, motion, and measurement topics of the S.S.S. 2 Physics curriculum and thirty minutes were allotted for the students to answer all questions. The PAT was validated and pilot-tested at a senior secondary school other than the schools used for the study, with Guttman Split-Half coefficient results of 0.82.

Data Collection Techniques

The consent of the experimental group and control group schools' students and physics teachers to participate in this research activity was sought through their schools' authority permission, and they were guaranteed that all their identities and test results would be kept confidential. Learning activities at the experimental group school took place for six weeks and three phases (pre-class, in-class & post-class phases), while the traditional learning activities at the control group school took place for a duration of 4 weeks and two phases only (in-class & post-class phases) as shown in Figure 2. At the experimental group school, the physics teachers created an instructional video and shared with the students, while students watch an instructional video, take notes, and jot down questions for their physics teachers during the pre-class phase; physics teachers facilitate students' discussions, while students engage in group discussion, peer review, and role-playing during in-class phase; and physics teachers check students' understanding, while students extend their learning through reflections during post-class phase appropriately.

Also, at the control group school, physics teachers directed instruction, while students listened to the instruction and presentation during the in-class phase; and physics teachers checked students' understanding, while students did homework during the post-class phase. The pre-test was conducted for experimental groups at the beginning of the pre-class phase, and the pre-test was conducted for control groups at the beginning of the in-class phase to measure students' prior knowledge in Physics. Also, a post-test was conducted for both experimental and control groups at the end of the post-class phase to measure their learning achievement in physics after the flipped learning intervention.

Method of Data Analysis

Quantitatively, the Statistical Package for Social Sciences (SPSS) software was used to calculate the descriptive statistics of frequency counts, standard deviation, mean, t-tests and ANOVA that are perfectly useful to determine the level of students' academic achievement, and the level of relationship between the variables for this study. The ANOVA statistical technique at a 0.05 significance level was used to test for hypothesis 1, while the t-test statistical technique at 0.05 significance level was used to test for hypothesis 2.

Results and Discussion

Item-by-Item Analysis of the Research Questions

Table 1: Distribution of Students in schools based on gender

S/N	Name of Schools	Students		
		Male	**Female**	**Total**
1.	Mainland Senior High School (MSHS), Jibowu.	32.0	18.0	50.0
2.	Federal College of Education (Tech.) Secondary School, Akoka.	29.0	16.0	45.0
	Total	61.0	34.0	95.0

Table 1 shows that 95 students were used for this study. 50 students were available as the Physics intact class at the Mainland Senior High School (MSHS), Jibowu, and 45 students were available as the Physics intact class at the Federal College of Education (Tech.) Secondary School, Akoka. Out of the two schools sampled, only 34 (35.79%) female students, while 61(64.21%) were males.

Research Question One

What are the effects of flipped learning on students' academic achievements in Physics?

Table 2: Analysis of Mean Differences and Standard Deviation of Students' Pretest and Posttest Scores in PAT for Control and Experimental Groups

Groups	N	Pretest Scores		Posttest Scores		Mean Gain
		Mean	**SD**	**Mean**	**SD**	
Experimental	45	06.00	01.91	17.22	02.19	11.22
Control	50	05.80	01.87	13.12	02.00	07.32

Table 2 shows the values of standard deviations and average pre-test and post-test mean scores. The table revealed that the experimental group had 06.00 as the pre-test mean score, while the control group had 05.80 as the pre-test mean score. An experimental group had 17.22 as the post-test mean score, while the control group had 13.12 as the post-test mean score. The mean gain for the experimental group is 11.22, and the mean gain for the control group is 07.32. This implies that the group taught with the flipped learning method outperformed the group taught with the traditional method.

Research Question Two

What is the effect of flipped learning on students' academic achievements in Physics concerning gender?

Table 3: Analysis of Experimental Group's PAT Results Based on Gender

S/N	Gender	No	%	Pretest Mean ($\bar{x}$)	Posttest Mean ($\bar{x}$)	S. D.
1.	Male	33.00	73.33	05.91	17.12	2.446
2.	Female	12.00	26.67	06.25	17.50	1.314
	TOTAL	45.00	100	12.16	24.62	3.760

Table 3 shows the analysis of the experimental group's PAT pretest and posttest results based on gender. The table revealed that the male students have a pretest mean score of 05.91 and a posttest mean score of 17.12, while female students have a pretest mean score of 06.25 and a posttest mean score of 17.50 in the PAT. Therefore, based on the Table 3 results, the female students achieved better academically than the male students in the PAT.

Hypothesis Testing

Hypothesis 1

H_{O1}: There is no significant difference between academic achievements of students taught with the flipped learning method and those not taught with traditional methods.

Table 4: ANOVA analysis showing the difference in the achievements of students in experimental group and control group

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	16.553	11	1.505	17.515	.000
Within Groups	7.131	83	.086		
Total	23.684	94			

Table 4 displays the F-calculated value of 17.515, and the p-value of 0.000 is the result of the differences in the achievements of students in the control and experimental groups. Since the calculated p-value is less than the alpha level of 0.05 of significance, the null hypothesis, which predicted that there was no significant difference between the achievements of students in the experimental group and control group, is not accepted. Therefore, there is a significant difference between the achievements of students in the experimental group and the control group.

Hypothesis 2

H_{O2}: There is no significant difference in academic achievements of students taught with the flipped learning method based on students' gender.

Table 5: Independent t-test analysis showing the differences in the achievements of students in the experimental group based on students' gender

Gender	NO.	Mean	SD	Df	t-value	p-value
Male	33	17.12	2.446		-48.54	0.00
Female	12	17.50	1.314	44		

Table 5 reveals the calculated t-value of -48.54 and p-value of 0.00 is the result of the difference between the students' achievements in the experimental group based on gender. Since the calculated p-value is less than the 0.05 level of significance, the null hypothesis that predicted there was no significant difference between the achievements of students in the experimental group based on gender was not accepted. Therefore, there is a significant difference between the experimental group's achievements based on gender.

Discussion of Findings

Physics is a fundamental science subject/course that needs the utilisation of an enriched environment and innovative learning methods that have the potential to boost students' academic achievements in Physics. Therefore, the discussion of the findings based on this study's research questions and research hypotheses goes thus: Regarding research question 1, the results on the effects of flipped learning on students' academic achievements in Physics are presented in Table 2. The means scores show that the group of students taught with the flipped learning method outperformed the group of students taught with the traditional method. Therefore, this indicated that the usage of flipped learning classrooms at the experimental group school influences students' academic achievements in Physics than the control group students.

Concerning research hypothesis 1, the results on the effects of flipped learning on students' academic achievements in Physics are presented in Table 4. The result from Table 4 expressions shows that there was a significant difference between the achievements of the group of students taught with the flipped learning method and the group of students taught with the traditional method. These results were supported by Thompson (2023), Thompson (2023), Rymbai (2023), Ökmen and Kılıç (2021), Putri and Purwaningsih (2021), Sirakaya and Özdemir (2018), Zainuddin and Halili (2016) studies' findings that flipped learning is a game-changer method that transforms teaching methods completely from teacher-centred to student-centred, reduces students' cognitive loads and motivates students to learn school subject content without stress and worries at all academic and training institutions where the flipped learning is reasonably adopted and utilised.

The result of the effects of flipped learning on students' academic achievements in Physics concerning gender is presented in Table 3. The result shows that the female students achieved better academically than the male students in the PAT. Therefore, this indicated that the usage of flipped learning classrooms at the experimental group school for this research study influences female academic achievements in Physics than their male counterparts. Research hypothesis 2, the results on the effects of flipped learning on students' academic achievements in Physics concerning gender, were presented in Table 5. The result from Table 5 shows that there was a significant difference in the achievements of students taught with the flipped learning method based on gender, which was in line with Baepler, Walker, & Driessen's (2014) study. These results strongly contradict Jugovi's (2017) findings, who discovered that female students had inferior self-concept of ability and lower expectations of achievements in Physics compared to male students in his study. Also contradicts Mokuolu and Ojo's (2023) findings that discovered that the flipped learning method improved male students' academic achievements in physics better than their female colleagues taught using traditional learning methods. Therefore, the right utilisation of flipped learning in this study has shown that any class of students can excel in any subject as long as they are taught with innovative and technology-driven methods that have the potential to liberate students from failure enslavement wisely.

Conclusion and Recommendations

This study has educationally demonstrated the fact that the flipped learning method has an encouraging influence on the academic achievements of students in Physics. The findings showed that the flipped learning method had an effective significance on students' academic achievements in Physics. This study has now remarkably concluded that state-of-the-art technology-driven instructional approaches can profitably empower students' academic achievements, and boost students' readiness to learn Physics subjects fearlessly beyond the four walls of academic and training institutions effectively. Efficiently, technology-driven instructional approaches like flipped learning remove students' learning disparities irrespective of their gender, parental social-cultural, religious influence, and other individual differences.

Based on the research discoveries of this study, the following recommendations were made for instructional and administrative implementations:

1. School teachers should be periodically trained in innovative technology-driven teaching methods and empowered with enriched instructional environments that will facilitate their official school activities proficiently.
2. Great priority should be given to the availability and usability of innovative teaching techniques that have the potential to foster the learning of science subjects by students.
3. Technology-driven learning methods that will enhance students' understanding, thinking, production and problem-solving should always be encouraged by schoolteachers, administrators, and parents.
4. There is a need for the science (particularly Physics) inspectorate division of the Ministry of Education and the head of the Department of Physics to conduct regular inspections of the public schools to see that the innovative technology-driven instructional methods are used for the purposes they are meant for.

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APPENDIX

UNIVERSITY OF LAGOS
FACULTY OF EDUCATION
DEPARTMENT OF SCIENCE EDUCATION
PHYSICS ACHIEVEMENT TEST (PAT)

Dear Student,

I am a master's degree student at the above university carrying out a study on "Effects of flipped learning on the academic achievement and interest of students in Physics." Kindly respond to this test's questions as correctly and honestly as possible.

All information supplied will be treated confidentially. Please tick (√) the most appropriate response to you for each Statement. Thank you.

SECTION A: BIOGRAPHY DATA

General Information:

(I) Name of the school: ____

(ii) School Local Government: Somolu ( ) Mainland ( )

(iii) Sex: Male ( ) Female ( )

(iv) Class: SSS 1 ( ) SSS 2 ( ) SSS 3 ( )

SECTION B: OBJECTIVE TEST

1. The inner diameter of a test tube can be measured accurately using a
A. Measuring Tape
B. Pair of dividers
C. Metre rule.
D. Vernier callipers

2. What is the principle of conservation of energy?
A. Energy cannot be created or destroyed, only transformed.
B. Energy is created when needed.
C. Energy is destroyed during transformations.
D. Energy is constant in a closed system.

3. Particles of mass 10^{-2} kg are fixed to the tip of a fan blade which rotates with an angular velocity of $100rad^{-1}$. If the radius of the blade is 0.2m, the centripetal force is
A. 2N
B. 20N
C. 200N
D. 400N

4. In nuclear reactions, what is the term used to describe the combining of atomic nuclei?
A. Fission
B. Fusion
C. Decay
D. Radioactivity

5. A car of mass 800kg attains a speed of 25m/s in 20sec.The power developed in the engine is
A. 1.25×10^4
B. 2.50×10^4
C. 1.25×10^6
D. 2.50×10^6

6. What is the function of the lens in the human eye?
A. Control the amount of light entering the eye.
B. Focus light onto the retina.
C. Change the colour of the light.
D. Control the pupil size.

7. If the stress on a wire is $10^7 Nm^{-2}$ and the wire is stretched from its original length of 10.00cm to 10. 05cm.The young's modulus of the wire is
A. $5.0 \times 10^4 Nm^{-2}$
B. $5.0 \times 10^5 Nm^{-2}$
C. $2.0 \times 10^8 Nm^{-2}$
D. $2.0 \times 10^9 Nm^{-2}$

8. Which law of thermodynamics states that energy cannot be transferred from a colder body to a hotter body without the addition of energy?
A. Zeroth Law
B. First Law
C. Second Law
D. Third Law

9. The lowest note emitted by a stretched string has a frequency of 40Hz. How many overtones are there between 40hz and 180Hz?
A. 4
B. 3
C. 2
D. 1

10. What is the function of the ozone layer in the Earth's atmosphere?
A. Generate oxygen.
B. Absorb ultraviolet radiation.

C. Regulate temperature.
D. Reflects sunlight.

11. A man stands 4m in front of a plane mirror. If the mirror is moved 1m towards the man, the distance between him and his new image is.
A. 3m
B. 5m
C. 6m
D. 10m

12. A circuit has a resistance of 20ohms and a current of 2 amperes. What is the voltage across the circuit?
A. 10 V
B. 40 V
C. 2 V
D. 80 V

13. Which of the following electromagnetic waves is least energetic?
A. Infra-red rays
B. X-rays
C. Ultra-violet rays
D. Gamma rays

14. Calculate the work done when a force of 30 N is applied to move an object 15 m.
A. 450 J
B. 2 J
C. 0.5 J
D. 15 J

15. A 3000W electric cooker is to be used on a 200V mains circuit. Which of the fuses below can be used safely with the cooker?
A. 2A
B. 5A
C. 10A
D. 20A

16. A pully system is used to lift a load of 200 N. If the effort force is 100 N, what is the mechanical advantage of the system?
A. 2
B. 0.5
C. 1
D. 1.5

17. In Fleming's right-hand rule, the thumb, the forefinger, and the middle finger if held mutually at right angles represents respectively, the
A. Motion, the field and the induced current.
B. Induced current, the motion and the field.
C. Field induced current and the motion.
D. Induced current, the field and the motion.

18. Calculate the total resistance in a series circuit with resistors of 8 ohms, 12 ohms, and 20 ohms.
A. 40 ohms.
B. 5 ohms.
C. 16 ohms.
D. 32 ohms.

A body of mass 200g moving at $15.0ms^{-1}$ is accelerated to $25.0ms^{-1}$ in a time of 10.0s. use the given data to answer questions 19 and 20

19. Determine the magnitude of the accelerating force.
A. 0.2N
B. 2.0N
C. 20.0N
D. 200.0N

20. The lens has a focal length of 15 cm. If an object is placed 20 cm from the lens, calculate the image distance.
A. 12 cm.
B. 30 cm.
C. 10 cm.
D. 24 cm.