Effect of Demonstration and Animation Videos in Flipped Classroom on Chemistry Students' Performance

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Abstract

The poor performance of students in chemistry has become a huge source of worry to education stakeholders in Nigeria and this is not unconnected to old-fashioned methodologies by teachers. In order to ameliorate this problem, we studied the effect of demonstration and animation videos in flipped classroom settings on students' performance in Niger State Nigeria. Adopting a pre-test posttest quasi-experimental design, purposive sampling technique was used to draw 144 students from three intact classes. The schools were randomly assigned into three experimental groups of demonstration and animation-based videos in flipped classroom settings and conventional method. A 20-item chemistry achievement test (CAT) and chemistry attitude questionnaire (CAQ) which were validated and pilot-tested (r=0.88 and 0.87 using test re-test and cronbach alpha respectively) were used to obtain data. Descriptive statistics was used to answer the research questions while inferential statistics involving ANCOVA, Sidak post-hoc and t-test were used to test the null hypotheses at 0.05 level of significance. Findings revealed a significant difference in the mean achievement ($F_{(2,140)} = 49.945$, P= 0.000, effect size =0.927) and retention ($F_{(2,140)} = 70.083$, P= 0.000, effect size =0.859) of students exposed to demonstration and animation-based videos in flipped classroom settings and conventional method. However, no significant difference was found in the attitude of students exposed to demonstration and animation videos in flipped classroom settings. The study has a number of implications for Chemistry teachers, policy makers and researchers in Nigeria to see the need to incorporate video learning flipped classroom in their instruction given that it is effective.

Key Words: Flipped Classroom, Animation videos, Demonstration videos, Chemistry Education, Video-based learning

Introduction

Chemistry is a subject taught at senior secondary schools in Nigeria and at the tertiary levels, it is offered as a course of study. Chemistry, as a central element in every facets of life, is the study of properties and composition of matter and its chemical reactions, structure and associated changes. It is specifically concerned with atoms and their interactions with other atoms particularly with the properties of chemical bonds (Nkiko, 2021). Furthermore, Chemistry occupies a central position in the field of science and provides basic concepts for understanding complex chemical reactions utilized in industries for production of numerous products for the benefit of man and technological development mostly in developing countries like Nigeria. Other Science field like medicine, engineering, and related courses depend on the knowledge of Chemistry for effective functioning of their profession (Sunday et al., 2019). The importance of Chemistry to national development is so enormous that it needs to be taught with modernized technology to arouse students' interests in order to contribute towards national development. Thus, in order to make Chemistry more relevant, easy and meaningful to students, technology can play a very vital role.

Technology has continued to change the way and manner teaching and learning takes place. Advancement in technology makes teaching and learning to be strictly student-centered so as to arouse the interests of students using different approaches to learning in order to suit learners' capabilities (Mohammed & Ogar, 2023). In view of this paradigm shift in the learning atmosphere propelled by technological headways, it becomes important to make teaching and learning student-centered by incorporating the appropriate technology in the realms of 21st century pedagogy (Falode & Mohammed, 2023b). With the advent of technology in modern learning, different techniques have continued to emerge and they are making meaningful contributions to teaching and learning (Khoo, 2020; Exposito et al., 2020; Mohammed et al., 2024a). One of the technological approaches used to enhance to teaching and learning is through the adoption of demonstration videos.

Demonstration videos have increasingly been incorporated into video-based learning where learners are presented with ample opportunities to see in practical terms what is expected of them and also to arouse several senses of learning. Padmavathi et al. (2019) noted that video-based strategy is advantageous when it comes teaching large number of students with uniformity and authenticity. Vrbik and Vrbik (2017) opined that video demonstration is tremendously interesting as a means of information transfer used during teaching and learning. It is widely known that people learn by mere observing others which enables them to cognitively construct their own meaning out of what they are taught. Several studies were conducted in the areas of video demonstration and the result has been very promising. For example, studies by Padmavathi et al. (2019); Ghahfarokhi (2022); Boyer et al. (2009); Maleki et al. (2010) all revealed the usefulness of demonstration videos towards enhancing students' achievement. Just like demonstration videos, animation videos are also deployed to enhance students' performance.

Animation is a video demonstration that comprises of motion graphics, audio-virtual, and content translation into words in order to ensure effective and meaningful learning. Animation videos provide additional information and gives external support for intellectual simulations, thus allowing learners to perform a higher amount of cognitive processing (Gambari et al., 2016). Animation videos can be viewed as movies with images that can capture children's attention and interest with the aim of improving learning and development (Aye et al., 2022). The use of animation videos help in smooth teaching and learning and it also improves retention of concepts because it is only when the concepts learned are stored and recalled in the long run that performance can improve (Faruk et al. 2022). When used in educational settings, students can watch educational videos created in the form of animation videos as many times as they feel is necessary and at their preferred place and time (Foster et al., 2022). Several studies conducted have revealed the potential of animation videos towards enhancing achievement and retention of learners (Aye, 2022; Lailatul & Efendi, 2022; Faruk et al., 2022; (Gambari et al., 2014; Olatunde-Aiyedun, 2021; Ahmed & Inti, 2021; Ridha et al., 2022). While these studies seem to have a unanimous conclusion in terms of findings, most of them were not conducted in chemistry. As a result of the foregoing, demonstration and animation videos can easily be incorporated in flipped classroom settings which is now occupying a very important place in the learning atmosphere due to its effectiveness toward enhancing learning outcomes.

Flipped classroom is an instructional approach which occurs by assigning lectures outside of class and devoting class time to a variety of learning activities (DeLozier & Rhodes, 2017). Flipped classroom happens when the pedagogical activities usually traditionally undertaken by learners outside the classroom like homework and assignments are shifted into the classroom and that which was conventionally done in the classroom is carried out before

coming to class (Falode & Mohammed 2023a; Lag & Sæle, 2019). The flipped classroom enables students to gain first hand exposure to learning content outside the class, usually by reading or watching lecture videos, and then use class time to do the harder work of assimilating that knowledge through problem solving, discussion, or debates for a better learning outcome (Leo & Puzio (2016). The Flipped classroom technique bridges the inevitable individual differences that exist among students and this leads to improved achievement as boredom disappears while excitement and pleasurable learning increases. Students walk into the classroom environment full of confidence after they have reviewed learning contents and are ready to discuss what was previously studied at home (Nja et al., 2022). Ozyurt (2022) noted that during flipped classroom settings, the activities carried out in the classroom environs in orthodox learning is usually relocated to the home environment, and the happenings executed at home environment is moved to the classroom setting. Fung (2020) stated that the interaction of teachers with students in a flipped classroom can be more personalized and less didactic, and students are actively involved in knowledge acquisition and construction as they participate in and evaluate their learning. In a flipped learning environment, advancement in technology enables students to study pre-assigned learning contents in the form of recorded videos, readings materials and simple tasks so that the teachers will be able to conduct activities that build students' critical thinking skills in the face-to-face instructions. This is mostly done by necessitating learners to view videos outside of their class so that during face-to-face classes, students will be able to interface more with their students and instructors, instead of mere talks (Dong et al., 2019).

Studies in the field of flipped classroom have been very promising in terms of enhancing achievement, retention and attitude. For example, the study of Falode and Mohammed (2023a) revealed that while the students exposed to computer simulation and animation in flipped classroom performed better in achievement and retention in the post test, no significant difference was found in the achievement of the two groups, which indicates the equality of the two platforms in terms of their effectiveness. Studies by Leo and Puzio (2016); Balaban et al. (2016); Salas-Rueda (2022); Zhonggen and Guifang (2016); Ichinose and Clinkenbeard (2016); Aziz et al. (2019) all revealed that students' performance increased after exposure to flipped classroom environment. The aforementioned studies revealed that there seems to be a unanimous conclusion regarding the effectiveness of flipped classroom but most of these studies were not conducted in chemistry. Yet, there is need to further explore the potential of the model in different settings and circumstances to further unmask more literature in the field. As a result of the foregoing, we formulated this research question and hypothesis:

1. What is the difference in the mean achievement scores of students taught Chemistry using demonstration and animation-based videos in flipped classroom settings and conventional lecture method?

HO_1: There is no significant difference in the mean achievement scores of students taught chemistry using demonstration and animation-based videos in flipped classroom settings and conventional method

Similarly, studies by Falode and Mohammed (2023a); Foster et al. (2022); Oladimeji et al. (2021); Gambari et al. (2016); Adonu et al. (2021) revealed that students' achievement and retention significantly improved after exposure to flipped classroom instructional method. While there seems to be generalized conclusions regarding the effectiveness of flipped classroom, there is need to further explore the effectiveness of flipped classroom in different circumstances in order to advance the frontiers of knowledge and equally test the

effectiveness of the strategy in different disciplines. Thus, in view of the foregoing, we formulated the next research question and hypothesis:

2. What is the difference in the mean achievement scores of students taught Chemistry using demonstration and animation-based videos in flipped classroom settings and conventional lecture method?

HO_2: There is no significant difference in the mean retention scores of students taught chemistry using demonstration and animation-based videos in flipped classroom settings and conventional method

Furthermore, Studies by Singay (2020); Abolarinwa et al. (2022); Turra et al. (2019); Romero and Angeles (2023); Aburayash (2021); revealed that students have a positive attitude towards flipped classroom instructional approach after finding it useful towards their learning. On a similar vein, studies by Yang and Chen (2020); Nja et al. (2022); Bin-Hady and Hazaea (2020) revealed that students' achievement and attitude increased after exposure to flipped classroom instructional strategy. The foregoing review revealed that there seems to be a general conclusion regarding the attitude of students towards flipped classroom. However, there is need to also check students' attitude in different circumstances and disciplines in order to further reveal the influence of the model on students' attitude. In view of the foregoing discuss, if properly planned and executed, flipped classroom has the potential to improve students' achievement, retention and attitude towards Chemistry. In line with these, we formulated the next research question and hypothesis:

3. What is the difference in the mean attitude scores of students taught Chemistry using demonstration and animation-based videos in flipped classroom settings and conventional lecture method?

HO_3: There is no significant difference in the mean attitude scores of students taught chemistry using demonstration and animation-based videos in flipped classroom settings

Achievement is the outcome that shows the extent to which a student, teacher or instructor has achieved their educational goals (Ndako, 2017). Retention, on the other hand, is the ability to recall facts and previous information after undergoing a series of instruction. It's the ability to remember what has been previously stored (Falode & Mohammed, 2023a). Attitude is an individual's disposition to react with a certain degree of favorableness to an object, behavior, person, institution or event or any other discriminable aspect of the individual's words (Ajzen, 2014). Guido (2013) viewed attitude as a favorable or unfavorable evaluative reaction towards something, events and programs exhibited in an individual's beliefs, feelings, emotions or intended behaviors. Students' attitude toward school is a determining factor that predicts their academic achievement in any given subject. Thus, a positive attitude yields positive results while a negative attitude gives rise to a negative result (Marcela & Mala, 2016). In order to have a positive attitude, learners need to perform well, and that is easily achievable when technology is incorporated in classroom engagement.

Over the years, the poor performance of students in Chemistry remains a huge source of worry to educational stakeholders due to the abstract nature of the course worsened by teachers' inabilities to bring learning closer to students by making it interesting, engaging and arousing through the deployment of innovative technology during instruction. It has been observed that the performance of students in Chemistry in senior secondary schools in Niger State has alarmingly declined with many struggling to obtain a credit pass in the subject at SSS III examination. Nonetheless, this poor performance has been attributed to various

problems such as rote learning, overcrowded classrooms, shortage of qualified teachers, poor attitude and the deployment of traditional teaching methodologies largely considered to be old-fashioned for they only encourage one-way communication. Hence, in order to salvage the situation, several teaching approaches have been deployed by researchers but the problem seems to persist. Additionally, the conventional approach of teaching has proven to be ineffective and teacher-centered, therefore it fails to increase learning outcomes effectively (Gambari et al., 2016; Mohammed & Ogar, 2023; Falode & Mohammed, 2023a; Mohammed et al., 2023; Mohammed et al., 2024a; Adonu et al., 2021; Oladimeji et al., 2021). While several studies incorporated innovative approaches backed up by technology in the teaching of Chemistry, the potential of these technological innovations in flipped classroom settings has not been really explored especially in Chemistry. In this study, therefore, we attempted to check whether the use of demonstration and animation videos in flipped classroom settings can be used to enhance students' learning outcomes in Chemistry.

Methodology

The study adopted quasi-experimental design involving a pretest, posttest, control group research design. Quasi-experimental design, according to Armstrong and Sandeep (2017), is used to estimate the causal impact of an intervention on target population without random assignment, using a pretest, posttest control design. This research design sought to establish the cause-effect between the independent and dependent variables.

Research Design Layout

Group	Pre-Test	Treatment	Posttest	Retention
Experimental Group I	**O_1**	**X_1**	**O_1**	**O_1**
Experimental Group II	**O_2**	**X_2**	**O_2**	**O_2**
Control Group	**O_3**	**X_0**	**O_3**	**O_3**

Key:

X_1 = Treatment for experimental group on demonstration-based video package flipped model
X_2= Treatment for experimental group on animation-based video package flipped model
O_1: Pretest, posttest and retention of experimental group one
O_2: Pretest, posttest and retention of experimental group two
O_3 = Pre-Test, posttest and retention of control group
X_0 = Control group that was exposed to conventional lecture method with no treatment

Participants

The population of the study comprised of the entire 7432 Senior Secondary School Chemistry students of 2022/2023 academic session in Private Schools in Minna, Niger State, Nigeria. The targeted population was 2352 Senior Science II Students in Minna Metropolis. A sample of 144 SS II students out of 2352 drawn from the intact classes of three private selected schools was used in the study. Firstly, purposive sampling technique was used to select three equivalent secondary schools in Minna Metropolis based on the following criteria: equivalence (laboratories and manpower), school type (private boarding schools), availability

and accessibility of ICT facilities for learners and gender composition (co-educational schools). The schools were Himma International College, MYPA School Minna and Saint Clement Secondary School Minna. Thereafter, the three selected schools were randomly assigned to experimental group I (demonstration based-video), experimental group II (Animation based-video) and control group (traditional lecture method) respectively.

Instrument

Two research instruments were used to gather data for this study. They include: Chemistry Achievement Test (CAT) and Chemistry Attitude Questionnaire (CAQ). CAT consisted of 20 items multiple-choice questions with four options A-D with only one correct answer and three distracters. The test covered the following concepts: Periodic table, chemical equilibrium, rate of reaction and Acid and Base (pH Scale). The CAT contains two sections: the first section contained information on the demographic data of the students while the second section elicited information on the students' cognitive level based on periodic table, rates of reaction, chemical equilibrium and Acids and Base (pH Scale). It was used for both pretest and post-test respectively. In scoring the multiple-choice questions, each question was awarded one mark for a correct option chosen and later converted to percentage. Chemistry Attitude Questionnaire (CAQ) contained two segments, A and B. The first segment (A) contains information on the personal data of the respondent while segment 'B' consisted of information on the attitude of students towards chemistry. The Scale was used to measure students' attitude in learning of some basic principles such as periodic table, rate of reactions, chemical equilibrium and Acids- base (pH Scale) in chemistry. The questionnaire was administered to students in the experimental groups during the pretest and posttest. Attitude inventory test comprised of 20 statements based on five (5) point Likert scale in which Strongly Agreed (SA) was awarded 5 points, agreed (A) 4 points, Undecided (U) was 3 points, disagreed (D) was awarded 2 points and finally, Strongly Disagreed (SD) was 1 point. A mean of 3.00 was taken as acceptable mean for agreement as a result of 5-point Likert Scale rating.

Development of Treatment Packages

The demonstration and animation-based videos were developed with the help of experts in which chemistry laboratory was used to shoot the videos and the animation part was developed in the studio where the researchers performed cartoon part to motivate the learners and capture the student's attention. The steps involved were selection of content, preparation of a list of instructional objectives and designing activities that was based on specific learning outcomes and students' needs. The demonstration and animation-based videos consisted of different units. Each unit comprises the objectives of the lesson, main content and different activities carried out by the researchers. The packages had self-assessment exercises and was accompanied by periodic table, rates of reaction, chemical equilibrium and Acids and Base (pH scale), which enabled each student to practice and monitor their progress and understanding in the course of learning. The video applications were developed to suit classroom usage as well as made online and offline at home for Chemistry instruction. The videos were then installed in computer centers, phones and laptop of the sampled schools for the students to access at their convenient time. The students were allowed to explore the demonstration and animation-based videos package after school hours following the introduction of each concept in the class.

Experimental Procedure and Development of Flipped Classroom Model

The demonstration and animation videos comprising of several study units on periodic table, rates of reaction, chemical equilibrium and acids and base (pH scale) were installed in the various computers in the ICT laboratories of the various schools. The flipped classroom model was developed under pre-class, in-class and post-class activities. During the pre-class sessions, the teacher sent the lecture materials to the students with some guidelines on how to study them. The students would study the video and animation packages of the various concepts at their own pace after school hours in order to digest the contents. The packages required them to solve self-assessment tasks as well as end of module tasks. The videos have an introductory pane, objectives, main contents, self-assessment pane and tutor-marked assignment at the end of every module. During class activities, the teachers grouped the students and involved them in both group and individualized discussions in order to measure their own understanding of the concepts with the teacher serving as a facilitator. The students were allowed to watch, re-wind, pause and jot points from the pre-class videos at their own leisure time. After the experiment, during the post-class activities, the teachers have the students an achievement test to measure their achievement. Retention test was equally given after a period of two weeks to measure whether they have retained the information.

Validity and Reliability of Instruments

Chemistry Achievement Test (CAT) was validated by three educational technologists, one psychometrist, two chemistry lecturers and one chemistry teacher in Federal University of Technology, Minna, and Maryam Babangida Government Science College, Minna, Nigeria. The CAT was validated to ensure that the content of the test covered the curriculum or syllabus and the experts also suggested modification on the structure of the items, organization, choice of appropriate alternatives for the multiple-choice questions and clarity of the questions asked. The Chemistry Attitude Questionnaire (CAQ) was validated by two experts in counseling and educational psychology from Ibrahim Badamasi Babangida University, Lapai and one measurement and evaluation experts in Federal University of Technology, Minna. The face validation checked the instrument for clarity, arrangement, logical sequence and relevance to this study. Furthermore, the demonstration and animation-based videos in Chemistry were validated by two experts in educational technology and one instructional designer all in Federal University of Technology, Minna. The experts examined the face and content validity of the instrument using the following criteria: the simplicity of the format and its suitability for the level of students; the appropriateness of the graphics, video, text and colour separations; the sharpness, clarity and the subject matter covered; accuracy and logical presentation and verification of the content to determine the degree to which the concepts of each components was well thought-out for trying the topics they were meant to test. The experts checked also that a standardized instructional design model has been followed in the creation of the videos.

To determine the reliability of the demonstration and animation-based videos, a pilot test was carried out to test the consistency of the CAQ and CAT instruments. The study was carried out in Bahago Secondary Schools, Minna. The school was within the population but not part of the schools chosen for the research. This was based on the environmental conditions (ICT centres, facilities and manpower) in order to establish the uniformity of the Chemistry Achievement Test and CAQ instruments. The internal consistency of the items in the CAQ instrument was tested using Cronbach alpha which revealed a reliability coefficient of 0.87 while Zarumai Model School was used to test the reliability of CAT instrument using test-retest reliability method. Test re-test method of reliability entails the issuance of the same

instrument twice in order to check for any form of linearity in terms of relationship (Mohammed et al., 2024b). Thereafter, Pearson Moment Correlation (PPMC) was used to find the reliability coefficient of the instrument which was determined to be 0.88.

Data Collection Procedure Analysis

One week before the experiment, the selected schools were visited in order to obtain official permission from the school management. Ethical approval was waved based on national regulations even though the study entails the use of human subject (Federal Ministry of Education, 2007). Cooperation from staff, especially the computer teacher and the subject teacher was sought for. One week was used for the administration of the pretest on CAT and CAQ. This was done in order to determine the previous knowledge and the equivalent level of both the experimental and control groups. An extensive teaching was carried out for three (3) weeks by means of dual period of eighty (80) minutes per day in each school. The experimental groups were exposed to three contents units based on flipped classroom settings and likewise the control group with conventional lecture method. This exercise lasted for five (5) weeks at contact period of once a week. At the end of each unit, a self-assessment test activity was given to evaluate the level of performance of students in the experimental groups. The control group was also evaluated towards the end of each lesson. After three weeks of an intensive teaching, both the control and experimental groups underwent revision and were post tested with CAT and CAQ for a period of one week. Data collection lasted for five weeks. The Chemistry Achievement Test (CAT) was used as pretest, to establish the group equivalence of the experimental and control groups and also used as posttest to ascertain achievement and retention level.

The data collected was analyzed using inferential and descriptive Statistics of mean and standard deviation. All the research questions were answered using mean and standard deviation. Inferential statistics of independent samples t-test was used to test hypothesis 3. Analysis of covariance (ANCOVA) was used to test hypotheses 1 and 2. Sidak post-hoc test was used to determine the direction of difference where a significant difference. Normality test was conducted using Kolmogorov-Smirnov and Shapiro-Wilk and the dataset were confirmed to be normally distributed ($P>0.05$) which satisfies the requirement for the adoption of parametric inferential statistics. Statistical package for social sciences (SPSS) version 25 was used to compute the result.

Results

Research Question 1: What is the difference in the mean achievement score of students taught Chemistry using demonstration and animation-based videos in flipped classroom settings and conventional lecture method?

Table 1: Pretest, Posttest scores of Chemistry students taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method

		Pretest		Posttest		
Groups	N	Mean	SD	Mean	SD	Mean gain
Demonstration	70	34.30	11.89	78.70	15.99	44.40
Animation-based	20	35.45	8.92	78.20	20.99	42.75
Conventional	54	35.02	10.85	50.66	15.73	15.64

Table 1 shows the mean and standard deviation of the pretest and posttest scores of

Chemistry students taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method. The result revealed that the students taught using demonstration had a mean score of 34.30, with standard deviation of 11.89 at pretest, and the mean score of 78.70 with standard deviation of 15.99 at posttest. This gives a mean gain of 44.40 for students taught using demonstration. Similarly, the results also revealed that the students taught using animation-based videos had 35.45 as the mean score with 8.92 as the standard deviation at pretest, and 78.20 as the mean with standard deviation of 20.99 at the posttest. This gives a mean gain of 42.75 for students taught using animation-based videos. Also students taught using conventional lecture method had a mean score of 35.02, with standard deviation of 10.85 at pretest, and the mean score of 50.66 with standard deviation of 15.73 at posttest. This gives a mean gain of 15.64 for students taught using conventional lecture method. From the result, it can be deduced that there is difference between the pretest and posttest mean scores which accounted for mean gain scores for the three groups in favors of the posttest. This implies that the students of the three groups performed better at posttest than pretest. Meanwhile, students taught using demonstration-based video had the highest posttest mean score and mean gain score than those taught using animation-based videos in flipped classroom settings and conventional method respectively.

Research Question 2: What is the difference in the mean retention scores of students taught Chemistry using demonstration and animation-based videos in flipped classroom settings and conventional lecture method?

Table 2: Mean retention scores of Chemistry students taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method

		Posttest		Retention		
Groups	N	Mean	SD	Mean	SD	Mean Difference
Demonstration	70	78.70	15.99	69.94	16.30	8.76
Animation-based	20	78.20	20.99	68.95	12.89	9.25
Conventional	54	50.66	15.73	40.93	11.06	9.73

Table 2 shows the mean retention scores of Chemistry students taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method. The result revealed that the students taught using demonstration had a mean score of 78.70 with standard deviation of 15.99 at posttest and a retention score of 69.94 with standard deviation of 16.30. This gives a mean difference of 8.76 for students taught using demonstration. Also, the results also revealed that the students using animation-based videos had 78.20 as the mean with standard deviation of 20.99 at the posttest and 68.95 as the mean with 12.89 as the standard deviation. This gives a mean gain of 9.25 for students taught using animation-based videos. Likewise students taught using conventional lecture method had a mean score of 50.66 with standard deviation of 15.73 at posttest and a retention mean score of 40.93 with standard deviation of 11.06. This gives a mean gain of 9.73 for students taught using conventional lecture method. From the result, it can be deduced that there is a difference between the posttest and retention mean scores in favour of the posttest in the three groups which accounted for mean loss. This indicates that the students of the three groups performed better at posttest than retention. However, students taught using demonstration retained better than those taught using animation-based video in flipped classroom settings and conventional lecture method.

Research Question 3: What is the difference in the mean attitude scores of students taught Chemistry using demonstration and animation-based videos in flipped classroom settings?

Table 3: Mean attitude score of secondary school students towards Chemistry when taught using demonstration and animation-based videos in flipped classroom settings

Groups	N	Mean	SD	Mean Difference
Demonstration	70	3.20	0.51	
				0.01
Animation-based video	20	3.21	0.44	

Table 3 shows the mean attitude scores of secondary school students towards Chemistry when taught using demonstration and animation-based videos in flipped classroom settings. From the result, the mean and standard deviation of demonstration were 3.20 and 0.51 respectively while the mean and standard deviation of animation-based videos were 3.21 and 0.44 respectively with a mean difference of 0.01 in favour of animation-based videos. This shows that secondary school Chemistry students taught using animation-based videos had higher mean attitude score than those taught using demonstration in flipped classroom settings.

Testing of Hypotheses

HO_1 There is no significant difference in the mean achievement scores of students taught Chemistry using demonstration and animation-based videos in flipped classroom settings and conventional lecture method.

In order to test hypothesis one, the result was analyzed using ANCOVA as shown on Table 4a.

Table 4a: ANCOVA result of achievement scores of students in Chemistry when taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method

Source	Type III Sum of Squares	df	MS	F	Sig.	Partial Eta Squared
Corrected Model	28368.301a	3	9456.100	35.704	.000	.324
Intercept	83214.636	1	83214.636	314.198	.000	.561
Pretest (Covariate)	1691.343	1	1691.343	6.386	.013	.082
Treatment (Achievement)	26455.490	2	13227.745	49.945	.000*	.927
Error	37078.692	140	264.848			
Total	733617.000	144				
Corrected Total	65446.993	143				

***Significant at 0.05 level**

Table 4a is the ANCOVA analysis of achievement scores of students in Chemistry when taught using demonstration and animation-based videos in flipped classroom settings and

conventional lecture method. From the table, $F_{(2,140)} = 49.945$, P = 0.000 with an effect size of 0.927. Since the p-value value is less than 0.05. Hence, hypothesis one is rejected. This implies that there is a significant difference in the mean achievement scores of students taught Chemistry using demonstration and animation-based videos in flipped classroom setting and conventional lecture method. Additionally, the partial eta squared effect size of 0.927 means that 92.7 % of the total variance in students' overall achievement can be linked to demonstration and animation videos. This means that the use of demonstration and animation videos in flipped classroom improved students' performance by 92.7% which represents a large effect (Cohen, 1988). However, in order to identify the direction of the significant difference among the treatment groups, Sidak post-hoc analysis was done as shown on table 4b.

Table 4b: Sidak Post-hoc analysis of students' achievement scores taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method

Treatment	Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Demonstration	Animation	-.8643	3.57130	.993	-9.4941	7.7655
	Conventional	28.1241*	3.68700	.000	19.2147	37.0335
Animation	Demonstration	.8643	3.57130	.993	-7.7655	9.4941
	Conventional	28.9884*	2.55114	.000	22.8237	35.1530
Conventional	Demonstration	-28.1241*	3.68700	.000	-37.0335	-19.2147
	Animation	-28.9884*	2.55114	.000	-35.1530	-22.8237

***Significant at 0.05 level**

Table 4b shows the sidak post-hoc analysis of students' achievement scores when taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method. The multiple comparisons revealed that there is no significant difference in the achievement scores of students in Chemistry when taught using demonstration and animation-based videos in flipped classroom settings. However, a significant difference was observed between achievement scores of students in Chemistry taught using demonstration and conventional method. Furthermore, a significant difference was observed between achievement scores of students in Chemistry when taught using animation-based videos in flipped classroom settings and conventional method.

HO_2: There is no significant difference in the mean retention scores of students taught Chemistry using demonstration and animation-based videos in flipped classroom settings and conventional lecture method.

In order to test hypothesis one, the result was analyzed using ANCOVA as shown in Table 5a.

Table 5a: ANCOVA result of retention scores of students in Chemistry taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	28085.002[a]	3	9361.667	46.998	.000	.281

Intercept	49383.018	1	49383.018	247.914	.000	.495
Achievement (Covariate)	86.982	1	86.982	.437	.510	.682
Treatment (Retention)	27920.268	2	13960.134	70.083	.000*	.859
Error	27887.158	140	199.194			
Total	555939.000	144				
Corrected Total	55972.160	143				

***Significant at 0.05 level**

Table 5a shows the ANCOVA results of the retention scores of students in Chemistry taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method. From the table, the $F_{(2,140)} = 70.083$, $P = 0.000$. Since the p-value value is less than 0.05. Hence, hypothesis two is rejected. This implies that there is a significant difference in the mean retention scores of students taught Chemistry using demonstration and animation-based videos in flipped classroom settings and conventional lecture method. Additionally, the partial eta squared effect size of 0.859 means that 85.9 % of the total variance in students' overall retention can be linked to the treatment of demonstration and animation videos. This basically means that the use of demonstration and animation videos in flipped classroom improved students' retention by 85.9% which represents a large effect (Cohen, 1988). Meanwhile, in order to identify the direction of the significant difference among the treatment groups, Sidak post-hoc analysis was done as shown in table 5b.

Table 5b: Sidak Post-hoc analysis of students' retention scores taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method

Treatment	Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Demonstration	Animation	-.6643	3.57130	.993	-9.4941	7.7655
	Conventional	23.1641*	3.68700	.000	19.2147	37.0335
Animation	Demonstration	.6643	3.57130	.993	-7.7655	9.4941
	Conventional	23.1641*	2.55114	.000	22.8237	35.1530
Conventional	Demonstration	-23.1641*	3.68700	.000	-37.0335	-19.2147
	Animation	-23.1641*	2.55114	.000	-35.1530	-22.8237

***Significant at 0.05 level**

Table 5b shows the sidak post-hoc analysis of students' retention scores when taught using demonstration and animation-based videos in flipped classroom settings and conventional lecture method. The multiple comparisons revealed that there is no significant difference in the retention scores of students in Chemistry when taught using demonstration and animation-based videos in flipped classroom settings. However, a significant difference was observed between retention scores of students in Chemistry when taught using demonstration and conventional method. Furthermore, a significant difference was observed between retention scores of students in Chemistry when taught using animation-based videos in flipped classroom settings and conventional method.

HO_3: There is no significant difference in the mean attitude of students towards Chemistry when taught using demonstration and animation-based videos in flipped classroom settings

In order to test hypothesis three, independent samples t-test was used to analyze the mean attitude of students towards Chemistry taught using demonstration and animation-based videos in flipped classroom setting as presented in Table 6.

Table 6: Independent samples t-test on mean attitude of students towards Chemistry when taught using demonstration and animation-based videos in flipped classroom setting

Groups	N	Df	Mean	SD	t-value	p-value
Demonstration	70		3.203	0.505		
		88			0.017	0.986 ^{ns}
Animation	20		3.205	0.436		

Not Significant: P>0.05

Table 6 shows the independent samples t-test results on mean attitude of students towards Chemistry when taught using demonstration and animation-based videos in flipped classroom setting. From the table, t = 0.017, p = 0.986. The p-value is greater than the level of significance, hence hypothesis two was accepted. This shows that there is no significant difference in the mean attitude of students towards Chemistry when taught using demonstration and animation-based videos in flipped classroom settings. This implies that students have positive attitude towards Chemistry when taught using demonstration and animation-based videos in flipped classroom settings.

Discussion

The main aim of the study was to check the effect of demonstration and animation videos in flipped classroom settings on chemistry students' performance. The result revealed that the use of demonstration and animation videos in flipped classroom settings enhanced chemistry students' achievement and retention. The result of hypothesis one was rejected and this shows a significant difference in the achievement of students exposed to demonstration video, animation-based video and conventional method. The partial eta squared effect size of 0.927 revealed that the use of demonstration and animation videos in flipped classroom improved students' performance by 92.7% which, according to Cohen (1988), represents a very large effect. When the post-hoc pairwise analysis (table 4b) was done in order to determine where the significant differences lie, the result revealed that the students exposed to the duo of demonstration video and animation videos in flipped classroom settings all outperformed the conventional method, however, the students in the demonstration group performed better for they slightly had a higher mean. While no significant difference in achievement was found in the post-hoc test between the demonstration and animation video groups in flipped classroom settings, indicating that the two of them are equal in their effectiveness and are equally both better than conventional method, the demonstration videos slightly had a higher mean. This is possible because with demonstration videos in flipped classroom settings, students get to construct their own meaning through mere observation and replication of techniques, procedures and body movements at their own leisure time at home and this is very vital towards enhancing performance especially during chemistry experiments. Also, demonstration videos used in flipped classroom settings promote observational and individualized learning which enables students to pause, replicate, replay and repeat a given task countless times at

home before coming to discuss in the class with the teacher to attain mastery. Demonstration videos also have what it takes to stimulate various senses which facilitate learning easily. Thus, this finding agrees with the studies of (2023); Leo and Puzio (2016); Balaban et al. (2016); Salas-Rueda (2022); Zhonggen and Guifang (2016); Ichinose and Clinkenbeard (2016); Nja et al. (2022); Aziz et al. (2019); Foster et al. (2022); Oladimeji et al. (2021); Gambari et al. (2016); Adonu et al. (2021) whose findings revealed that students' performance increased tremendously after exposure to flipped classroom settings.

The result of hypothesis two was rejected and this indicates the existence of a significant difference in the retention of the students exposed to demonstration videos, animation-based videos and conventional method. The partial eta squared effect size of 0.859 revealed that the use of demonstration and animation videos in flipped classroom improved students' retention by 85.9% which, according to Cohen (1988), represents a large effect. When the post-hoc analysis (table 5b) was conducted in order to determine where the observed difference lies, it was revealed that while the duo of demonstration and animation video groups in flipped classroom settings performed equally in the retention test with no observed significant differences, their performance in the retention test outperformed those in the conventional group. The post-hoc test also revealed that the students in the demonstration video group had a slightly higher mean in the retention test. This is possible because in a typical flipped classroom involving demonstration videos, students get to study a given content at home multiple time times before coming to classroom and this increases mastery and removes boredom for they have ample time to see, rewind, replay and replicate activities at home and at their own convenience which can facilitate mastery and by extension retention. This also increases interests for learning is made interesting, flexible and student-centered. This finding, therefore, agrees with the studies of Falode & Mohammed (2023a); Foster et al. (2022); Oladimeji et al. (2021); Gambari et al. (2016); Adonu et al. (2021) whose findings revealed that the deployment of flipped classroom instructional model increases students' retention.

The result of hypothesis three was accepted and this indicates that there is no significant difference in the attitude of students exposed to demonstration and animation videos in flipped classroom settings. The students' attitude in the demonstration and animation-based video groups in flipped classroom really increased after the experiment during the post-test. This is because when learning is made interesting, flexible and student-centered in order to arouse the interests of learners using a given technology tool, students tend to develop a positive attitude to learning due to the fact that they do derive satisfaction through good performance in what they do. The more students develop positive attitude, the more their performance and the less students develop poor attitude, the poor their performance. This finding agrees with the studies of Singay (2020); Abolarinwa et al. (2022); Turra et al. (2019); Aburayash (2021); Romero and Angeles (2023) whose result revealed that the use of flipped classroom instructional strategy increased students' attitude by making learning interesting and also meeting the individual expectation of students. The finding also agrees with Yang and Chan (2020); Nja et al. (2022); Bin-Hady and Hazaea (2020) whose studies revealed that students' achievement and attitude increased after exposure to flipped classroom instructional strategy.

Finally, these findings further validate the constructivist learning theory which states that students learn best when they construct their own knowledge. The use of demonstration and animation videos in flipped classroom have proven to validate the constructivist theory such that when students learn through watching video elements and in flipped classroom settings, they will be able to construct their own understanding and plan their learning in accordance with their own pace as proven in this study.

Conclusion

The use of demonstration and animation-based videos in flipped classroom settings has proven to have the potential to tackle the poor performance of students in chemistry by improving student's achievement and retention more than conventional approaches even though the demonstration video group had a higher mean in both retention and achievement. The use of demonstration and animation-based videos also increases students' attitude to learning which is very vital towards enhancing learning.

Implication of Findings for Research, Practice and Theory

The study has a number of implications for chemistry teachers in Nigeria. The findings have exposed teachers, researchers and policy makers to the effectiveness of using demonstration and animation-based videos in flipped classroom settings which will go a long way towards tackling the problems of poor performance of students in Chemistry. The findings have added more literature to the field of flipped learning in an attempt to advance the frontiers of knowledge. In terms of practice, this finding has provided empirical evidence regarding the effectiveness of animation and demonstration videos in flipped classroom towards enhancing students' performance thereby leading to the failure of students especially in chemistry. Theoretically, this finding has advanced the constructivist learning theory such that when students learn at their own pace using flipped classroom model, they can be able to construct their own knowledge and develop their self-paced, individualized learning.

Limitation and Further Research Direction

This study has a number of limitations. First, it was conducted on a very few sample therefore its generalizability is not guaranteed; thus, there is need to conduct same on a much larger sample. Secondly, it was conducted on secondary school students, therefore similar studies should be conducted on other students like tertiary institutions and those at the lower levels in order to a further advance the frontiers of knowledge in the field of flipped classroom.

Recommendation

In light of the findings of this research, the following recommendations are hereby made:

1. Chemistry teachers should deploy the use of demonstration and animation videos in flipped classroom settings to enhance the performance of students.
2. Proper training and workshop should be conducted in order to train teachers on how to plan flipped classroom environment for effective instructional delivery.

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