universal scholars
International Journal of Educational Excellence and Innovation
10.5281/zenodo.14899784 Vol. 02 Issue 02 Feb - 2025 Manuscript ID: #64

Effectiveness of Flipped Classroom Approach (FCA) on Students' Achievement and Retention in Chemical Equilibrium in High Schools in Jos, Plateau state – Nigeria

By
Dr Ephraim J. Gongden
Department of Science and Technology Education University of Jos
E-mail: gongdenej@unijos.edu.ng, estephephest@gmail.com

Abstract

This study investigated the effect of Flipped Classroom Approach (FCA) on students' achievement and retention in chemical equilibrium in Jos, Nigeria. It utilized a non-equivalent pretest-posttest control group design. The population comprised of the 22 public secondary schools with a sample of 77 students drawn from two secondary schools. 5 research questions and 5 hypotheses were formulated. The instrument for data collection was a 30 - multiple choice Chemical Equilibrium Achievement Test (ChEAT) with r = 0.79. The research questions were answered using mean and standard deviation while t-test and ANCOVA used to test the hypotheses at 0.05 level of significance. The results showed a significant difference in students' achievement in favor of those taught using FCA. The results also revealed no significant difference between the achievement and retention scores of male and female students thereby implying that the use of FCA does not discriminate based on gender. The study recommended the use of FCA by chemistry teachers and the training of such teachers through workshops, seminars and conferences.

Keywords: Flipped Classroom Aproach, Achievement, Retention

How to cite: *Dr Ephraim J. Gongden..... (2025). Effectiveness of Flipped Classroom Approach (FCA) on Students' Achievement and Retention in Chemical Equilibrium in High Schools in Jos, Plateau state – Nigeria. International Journal of Educational Excellence and Innovation, Volume-02 | Issue-02, Page 1 to 9, https://zenodo.org/records/14899784*

INTRODUCTION

Education is one of the most powerful tools that exist for the transformation, advancement and progress of people and societies. It is also an instrument for economic, political, social, technological and scientific development of nations. This may account for the huge investments by governments on the education sector and the various educational policies formulated by governments (Gongden, 2015). The purpose of education in today's society is to prepare students for the challenges of life in the career world (Robinson & Robinson, 2022). Science and technology education is particularly noted for its tremendous contribution as the driving force for the development of nations. Science has been seen as an organized system of explanations of nature through the process of experimentation. Such experimentations may be modified based on light shed by further empirical evidences by the scientists (Gongden, John &Gimba, 2019). Technology on the other hand, is the practical application of scientific knowledge to improve the living standards of mankind in its entire ramification. The development of new technology has been vital for human survival and progress throughout history as technology is seen as the primary vehicle through which humanity progresses. It serves to eliminate hunger, poverty and lack of access to education in the future. This accounts for the many developments in science and technology which have so greatly affected the lives of humans. It is interesting to know that several products of technology are also being used to enhance and improve the learning of sciences at different levels of study.

Chemistry stands out as the pivot on which the wheels of science rotates. It is the science that systematically studies compositions, structure, properties, interactions, transformations of organic and inorganic substances and various elementary forms of matter (Nnoli, 2011). Chemistry has been identified as a very important science subject and its importance in scientific and technological development of nations has been widely reported. Chemistry has helped in the development of modern technology through the application of its principle in modern invention. It fundamentally combines with other science subjects such as physics, and biology to guarantee learners admission into higher institutions as a prerequisite subject for offering most science-oriented courses such professions as, medicine, pharmacy, dentistry, agriculture, home economics, food science, engineering, among others, in the tertiary institutions (Nja, Orim, Neji, Ukwetang, Uwe&Ideba, 2022). Various chemical processes such as respiration and digestion are performed in all living things for their proper function and survival. The knowledge of chemistry is brought to bear in the manufacture of products that improves man's luxury such as herbicides, insecticides, plastic products, foams, drugs and clothing materials, just to mention a few (Ababio, 2017). Most industries rely on physical chemistry principles for their operations; hence the importance of chemistry in everyday life cannot be over emphasized.

However, despite the numerous contributions of chemistry to national development, students' achievement in the subject over the years in both internal and external examinations have been poor. Researchers such as Philip (2023), Gongden (2022), Nja, Orim, Neji, Ukwetang, Uwe and Ideba (2022), Nja, Cornelius-Ukpepi and Ihejiamaizu (2019) and Nja, Cornelius-Ukpepi and Orim (2019) have all reported the poor achievement of students in the West African Senior School Certificate Examination (WASSCE) and the National Examination Council (NECO). The West African Chief Examiners' reports (2017-2020) also give a number of concepts that students found difficult and abstract, and so performed poorly to

include: chemical equilibrium, particulate nature of matter, chemical bonding, and periodicity of elements, chemical kinetics, energy changes, and nomenclature of organic compounds among others.

Chemical equilibrium is one of the most important concepts in physical chemistry. It is a state in which the rate of the forward reaction equals the rate of the backward reaction. In other words, there is no net change in concentrations of reactants and products (Chan &Alborzfar, nd). This kind of equilibrium is also called dynamic equilibrium. An example of such a reaction is:

$2SO_{2(g)} + O_{2(g)} \leftrightharpoons 2SO_{3(g)}$ + energy

A chemical reaction is in equilibrium when there is no tendency for the quantities of reactants and products to change. When a chemical reaction takes place in a container which prevents the entry or escape of any of the substances involved in the reaction, the quantities of these components change as some are consumed and others are formed. Eventually this change will come to an end, after which the composition will remain unchanged as long as the system remains undisturbed (Lower, nd). The system is then said to be in its equilibrium state, or more simply, at equilibrium". Various factors affect reactions that are in chemical equilibrium. These include temperature, concentration, catalyst and pressure (for gaseous reactions). The effects of altering any of the factors is summarized by Le Chatelier's principle that if a system at equilibrium is subjected to a change in temperature, volume, concentration, or pressure, the system readjusts to partially counter the effect of the change, resulting in a new equilibrium.

The principles of chemical equilibrium are applied industrially in the manufacture of ammonia by the Haber process and in the Contact process for the manufacture of sulphuric acid. Both products are important heavy chemicals that are used to produce other chemical products. In industrial processes, it is important to get the product as quickly and as efficiently as possible. The less expensive the process the better. The Haber process is a good example of an industrial process which uses the equilibrium principles. The equation is as follows:

$N_{2\,(g)} + 3H_{2\,(g)} \leftrightharpoons 2NH_{3\,(g)}$ + energy

It is used for making fertilizer, plastics, explosives, textiles, pesticides, dyes and other chemicals. There is the need to work towards ensuring that an important concept such as chemical equilibrium is well understood by students.

Another prominent reason why students performed poorly in chemistry examinations has to do with the mode of instruction. Adejo (2015) opined that the most important factor for effective learning to take place in science and especially in chemistry is an interesting instructional strategy. Osuafor and Okonkwo (2013) had earlier attributed the observed students' poor achievement in chemistry to the use of inappropriate or ineffective teaching strategy by chemistry teachers. They maintained that teaching strategy is a variable that can easily be manipulated by teachers to increase student's achievement and retention rate. A situation where teachers use the expository strategies such as the lecture and discussion

methods only does not enhance effective learning of chemistry in the senior secondary schools because they are teacher-centered strategies. Philip (2023) and Nja, Orim, Neji, Ukwetang, Uwe and Ideba (2022), reported that majority of Nigeria secondary school chemistry teachers use the lecture (conventional) method with the teacher dominating experiments which make students passive learners. This makes teaching of chemistry ineffective as special strategies needed for the teaching of chemical concepts are over looked. This problem led to the emergence and adoption of innovative instructional strategies that are student-centered such as inquiry, demonstration, discovery, cooperative and active learning. Educational institutions are required to adjust their system and learning environment to cater to the paradigm shift in the educational system. The researcher is of particular interest in the use of flipped classroom approach (FCA) – which is a form of active learning strategy for teaching.

Flipped classroom (FC) can be viewed as a student-centered approach to teaching and learning that emphasizes student engagement and active learning (Steen-Utheim&Foldnes, 2018). A flipped classroom is where typical in-class, informational activities are delivered as homework, and homework is done in-class. Guided notes, lectures, videos, are watched on a device at home, while homework assignments now done in class include practice problems, writing an essay, or creating a project. Flipping the classroom occurs when the teaching activities that were conventionally undertaken by the learner outside the class like, assignments and home works are shifted into the classroom, and that which was conventionally accomplished in class is achieved before coming to class. A typical example of a flipped classroom chemistry would be homework assigned as a Youtube video on balancing equations (Agnefo, 2017). Students come the following day to work on the problems in-class where the teacher and other students are accessible to help. In a flipped classroom, instead of students sitting in individual desks facing the front while their teacher lectures, students sit at tables or desks pushed together or are off by themselves doing work. Students get out of their seats, accessing books, computers and others students for information. Although a flipped classroom may appear chaotic, loud, or even messy at first glance, the action and collaboration taking place in this non-traditional classroom is a direct result of student learning. Proponents of the flipped classroom believe that it enhances the teacher-student relationship, enable deep learning utilizing effective classroom participation, enables students to comprehend their learning techniques and options, and bring about active involvement in learning (McLean et al, 2016). Newman et al,. (2016) discovered that learning improved without respect to age, sex, and students' educational levels. Studies indicated that students in the flipped classroom environment had higher academic achievement, had a positive attitude in learning (Strayer, 2012; Marlowe, 2012). Nja, Orim, Neji, Ukwetang, Uwe and Ideba (2022) reported the effectiveness of flipped classroom model. Their study revealed that students' academic achievement was significantly higher in the flipped classroom than those in the conventional group. There are many benefits to the flipped classroom. Flipped classroom is an appealing, innovative, and motivating pedagogical teaching approach (Abeysekera& Dawson, 2015). Students can practice the skills they are expected to learn in the presence of a teacher who can help them. Students are more likely to complete homework because failure to complete it will cause them to be completely lost during class. And students can re-watch the videos or other content whenever they like, including while studying for tests. Unlike lectures in class, it's always available to them. Parents also like it, because they can see your teaching style for themselves and feel more

involved. However, successfully implementing a FC in the elementary environment presents unique challenges and requires additional planning and preparation to truly improve student learning. The biggest one is that it takes a lot of work to prepare and set up. Although there is a growing interest in the FC method of instruction in the western world, little or not much has been done in Plateau state on its use. Empirical studies on the use of flipped classroom in chemistry classes are particularly lacking. This study, therefore, sought to find out the effects of flipped classroom on students' achievement and retention in chemistry (chemical equilibrium) in Jos metroplolis.

The following research questions were formulated to serve as guide for the study:
What are the pretest achievement mean scores of students taught using conventional method and those taught using flipped classroom approach - FCA?
What is the difference between the posttest achievement mean scores of thestudents taught using conventional method and those taught using FCA?
What is the difference between the posttest achievement mean scores of the male and female students in the class taught using FCA?
What is the difference between the retention mean scores of the students taught using conventional method and those taught using FCA?
What is the difference between the retention mean scores of the male and female students bin the class taught using FCA?

Hypotheses
There is no significant difference between the posttest achievement mean scores of thestudents taught using conventional method and those taught using FCA
There is no significant difference between the posttest achievement mean scores of the male and female students in the class taught using FCA
There is no significant difference between the retention mean scores of the students taught using conventional method and those taught using FCA
There is no significant difference between the retention mean scores of the male and female students bin the class taught using FCA

Methodology
A quasi-experimental design was used for this study. Specifically, a pretest-posttest-control group design was used. This was chosen because intact classes were used as experimental and control groups. Randomization was not possible because it could distract or disrupt the school's program and arrangement. Therefore the researcher made use of two intact classes from two secondary schools that have functional and accessible computers for students' regular use, power and internet connectivity. One of the classes was used as experimental class while the other was the control class. The study sample was 77 students offering chemistry in Senior Secondary Two classes with 32 students in the experimental class and 45 in the control. The instrument for data collection was a Chemical Equilibrium Achievement Test (ChEAT). This consisted of 30 multiple choice objective questions drawn from the concept of chemical equilibrium – reversible reactions, reactions in equilibrium, characteristics of reactions at equilibrium, equilibrium constant, factors affecting reactions at equilibrium, Le Chatelier's principle, industrial applications of chemical equilibrium, etc. The reliability coefficient of the test instrument was determined by subjecting it to Kuder Richardson's formular-20 analysis which yielded r = 0.79.

Teaching the concept of chemical equilibrium in the experimental class was done using the flipped strategy while non-flipped (conventional) strategy was used to teach the control group. In each case, a lesson plan guided the presentation. For the experimental class, the researcher made simple recordings of lectures, high-quality video presentation with graphics, stock images, footage, and animation to illustrate the points of each topics to be covered. Other contents and activities to keep the learning flowing were also documented for use. These materials can be shared and played over and over by students. Prior to the commencement of flipped classroom instruction, the teacher gave an orientation to students as regards what is expected of them. Before the first lesson, the teacher assigned a video to students, recorded lecture and some short quiz on the topic to be considered for students to listen and go through. In the class, the students engaged in various activities, discussing, doing the assignment given while the teacher checks in on their progress. The teacher plays the role of an active observer, able to spend more time with each student, aiding when necessary and offering suggestions and modifications to those that need more support. The teacher at the end of each lesson, released the videos and other materials for the next lesson so students can watch and interact with at home. So students come to each lesson already instructed on the day's topic. To help ensure students do their homework each time, an incentive was provided for them. All the video and recorded lectures, and animations were kept short. At the end of four weeks of instruction, the experimental and control group were given posttest and the scores compared with the pretest scores. The retention test was administered to the control and experimental groups four weeks after the posttest. This consisted of the same test items on the ChEAT but with the numbers reshuffled. The research questions were answered using mean and standard deviation while the hypotheses were tested using t- test and ANCOVA.

Results

Research Question One:

What is the pretest achievement mean scores of students taught using conventional method and those taught using FCA?

Table 1: Results of the Analysis on Students' Achievement in the Experimental and Control Groups

Group	**N**	**PretestSD**	$\bar{x}$ **Difference**	
mean				
Experimental	32	20.66	4.021	0.47
Control	45	21.13	5.26	

Table 1 reveals that the pretest mean achievement scores of students taught using conventional method (control class) and those taught using FCA (experimental class)were 21.33 (SD=5.26) and 20.66 (SD=4.021) respectively. This means that at the pre-test, students in both groups had poor performance and were at the same level.

Hypothesis One:

There is no significant difference between the pretest achievements mean scores of the students taught using conventional method and those taught using FCA.

Table 2: Summary of t-test Result on Difference between the pretest mean scores of students in Experimental and Control Groups

Group	**N**	**Mean**	**SD**	**df**	**t-value**	**p-value**	**Decision**
Experimental	3220.66	4.021	75	0.431	0.668	Accept Ho	
Control	45	21.13	5.26				

P>0.05

Table 2 shows the result on the difference between the pretest mean scores of students taught chemical equilibrium using conventional methodand those taught using FCA (experimental class). The result yielded t(75) = .431 and P = 0.668. Since P > 0.05, the null hypothesis was retained. It was concluded that there is no significant difference between the pretest mean scores of students taught Chemistry using FCA and the students taught without.

Research Question Two:
What is the difference between the posttest achievement mean scores of the students taught using conventional methodand those taught using FCA?

Table 3: Results of the Analysis on Students' Posttest Mean Achievement Scores of the Experimental and Control Groups

Group	**N**	**PosttestSD**	$\bar{x}$ **Difference**	**mean**
Experimental	32	64.53	8.773	14.55
Control	45	49.98	6.323	

Table 3shows that the posttest mean achievement scores of students in the experimental and control groups were 64.53 (SD = 8.773) and 49.98 (SD = 6.323) respectively. The mean difference was 14.55 in favor the experimental class. It can be deduced that FCA does improve students' achievement in Chemical equilibrium (chemistry).

Hypothesis Two:
There is no significant difference between the posttest achievements mean scores of the students taught using conventional method and those taught using FCA.

Table 4: Summary of ANCOVA result on Difference between Posttest Mean Scores of Experimental and Control Groupsin Chemistry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3981.346[a]	2	1990.673	35.715	.000	.491
Intercept	11303.373	1	11303.373	202.795	.000	.733
pretest	20.345	1	20.345	.365	.548	.005
Group	3979.451	1	3979.451	71.396	.000	.491
Error	4124.602	74	55.738			

Total	249802.00	77
Corrected Total	8105.948	76

a. R Squared = .491 (Adjusted R Squared = .477)

Analysis of Covariance (ANCOVA) conducted shows that $F(1, 74) = 71.396$, $p < 0.05$, since the p-value of 0.000 is less than 0.05 level of significance. The null hypothesis was rejected, indicating that there was a significant effect of the FCA on students' achievement in Chemistry. The result further reveals an adjusted R squared value of .477 which means that 47.7 percent of the variation in the dependent variable which is students' achievement in Chemistry is explained by variation in the treatment, while the remaining is due to other factors not included in this study. Hence, we can say that FCA does improve students' achievement in Chemistry.

Research Question Three:
What is the difference between the posttest achievement mean scores of the male and female students in the class taught using FCA?

Table 5: Results of the Analysis on Students' Achievement in the Experimental Group based on Gender

Gender	**N**	**Posttest mean**	**SD**	$\bar{x}$ **Difference**
Male	17	63.41	7.779	2.39
Female	15	65.80	9.901	

Table 5 reveals the result on the achievement mean scores of male and female students taught chemistry using FCA. From the result, in the experimental group male students had a achievement mean score of 63.41 and a standard deviation of 7.78, while female students had a mean score of 65.80 and a standard deviation of 9.90 with a mean difference of 2.39. This means that in the experimental group there was a difference in the achievement of male and female students, in favor of female students.

Hypothesis Three:
There is no significant difference between the posttest achievement mean scores of the male and female students in the class taught using the FCA

Table 6: Summary of ANCOVA Result on Achievement Mean Scores of Experimental Group in Chemistry based on Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	105.660[a]	2	52.830	.672	.519	.044
Intercept	3282.236	1	3282.236	41.742	.000	.590
Pretest	60.209	1	60.209	.766	.389	.026
Gender	81.147	1	81.147	1.032	.318	.034
Error	2280.308	29	78.631			

Total	135643.000	32
Corrected Total	2385.969	31

a. R Squared = .044 (Adjusted R Squared = -.022)

Table 6 is the summary of the ANCOVA result of the achievement mean scores of the experimental group (students taught chemical equilibrium using FCA based on gender). The data were subjected to analysis of covariance (ANCOVA) having experimental group (male & female). The mean score of males yielded (M = 63.41; SD = 7.78 and female (M = 65.80; SD = 9.90); F (1, 29) =1.03, P > 0.05. Since the p-value of .318 is greater than the 0.05 level of significance, the null hypothesis was retained. This indicates that the achievement mean score of male students do not significantly differ from that of the female students when they are taught using FCA. The strategy is gender friendly, influencing male and female students equally.

Research Question Four:
What is the difference between the retention mean scores of the students taught using conventional method and those taught using FCA?

Table 7: Results of the Analysis on Students' Retention in the Experimental and Control Groups

Group	**N**	**Retention mean**	**SD**	$\bar{x}$ **Difference**
Experimental	32	61.59	9.231	12.77
Control	45	48.82	6.383	

Table 7 reveals the result on retention mean scores of students taught Chemistry in the experimental and control groups. From the result, the experimental group had a retention mean score of 61.59and a standard deviation of 9.23, while the control group had a mean score of 48.82 with a standard deviation of 6.38. The mean difference between students taught Chemistry using concept mapping strategy and the students taught without FCA was 12.77. This means that after the intervention, the experimental group had a higher retention mean score than the control group. It can be deduced that flipped classroom strategy does increase student's retention in Chemistry.

Hypothesis Four:
There is no significant difference between the retention mean scores of the students taught using conventional method (control class) and those taught using FCA (experimental class)

Table 8: Summary of ANCOVA result on Difference between Retention Mean Scores of Experimental and Control Groupsin Chemistry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3052.971[a]	2	1526.485	25.489	.000	.408
Intercept	11732.688	1	11732.688	195.910	.000	.726

pretest	2.566	1	2.566	.043	.837	.001
Group	3034.089	1	3034.089	50.663	.000	.406
Error	4431.731	74	59.888			
Total	233098.000	77				
Corrected Total	7484.701	76				

a. R Squared = .408 (Adjusted R Squared = .392)

Analysis of Covariance (ANCOVA) conducted and recorded in Table 8 shows that $F(1, 74) = 50.66$, $p < 0.05$. Since the p-value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of FCA on students' retention in Chemistry. The result further reveals an adjusted R squared value of .392 which means that 39.2 percent of the variation in the dependent variable which is students' retention in Chemistry is explained by variation in the treatment, while the remaining is due to other factors not included in this study. Hence, we can say that FCA does improve students' retention in Chemistry.

Research Question Five:
What is the difference between the retention mean scores of the male and female students bin the class taught using FCA (experimental class)?

Table 9: Results of the Analysis on Students' Retention in the Experimental Group based on Gender

Gender	**N**	**Posttest mean**	**SD**	$\bar{x}$ **Difference**
Male	17	60.88	9.43	1.52
Female	15	62.40	9.26	

Table 9 reveals the result on the retention mean scores of male and female students taught chemistry using FCA. From the result, in the experimental group male students had a retention mean score of 60.88 and a standard deviation of 9.43, while female students had a mean score of 62.40 and a standard deviation of 9.26 with a mean difference of 1.52. This means that in the experimental group there was a slight difference in the retention of male and female students in favor of female students.

Hypothesis Five:
There is no significant difference between the retention mean scores of the male and female students bin the class taught using FCA (experimental class)

Table 10: Summary of t-test Result on Difference between the Retention mean scores of Male and Female students in the Experimental Class

Group	**N**	**Mean**	**SD**	**df**	**t-value**	**p-value**	**Decision**
Experimental	17	60.88	9.43	43	-.577	7.56	Accept Ho
Control	15	62.40	9.26				

P>0.05

Table 10 reveals the t-test result on the retention mean scores of male and female students taught chemistry using FCA. Male students had a retention mean score of 60.88 (SD = 9.43), while female students had a mean score of 62.40 (SD = 9.26). The mean difference 1.52. The result yielded t (43) = -.577, P > 0.05, since the P-value of 0.567 is greater than 0.05 level of significance, the null hypothesis was retained. Therefore there is no significant difference between the retention mean scores of male and female students taught Chemistry using FCA.

4.2 DISCUSSION OF RESULTS

One of the findings of the study is that there was a significant difference between the posttest achievements mean scores of the students taught using conventional method (control class) and those taught using FCA in favor of the experimental class. There was a significant effect of flipped classroom strategy on students' achievement in Chemistry. This result agrees with the results of Gopalan (2018) and Busebaia and John (2020) who found out in their separate studies that studies that FCA increased students' academic performance in chemistry. The result is also in consonance with that of Nja, Orim, Neji, Ukwetang, Uwe and Ideba (2022) who reported that students' academic achievement was significantly higher redox reaction test in the flipped classroom than those in the conventional group. Contrary to this finding, Covil and Cook (2019), observed that learning outcomes of traditional lecture and flipped method classes were similar in their study. The finding does not support the report of Memler (2017) who found out that there was no statistically significant difference in the achievement of students taught physics using the flipped classroom strategy and those in the control class. There was also, no a significant difference in gains between genders for the different methods. The trend is similar for the retention test as there was a significant difference between the retention mean scores of the students taught using lecture (conventional) method and those taught using flipped classroom strategy. This means that the use of FCA enhanced the academic retention of students that were taught chemical equilibrium. This collaborates with earlier findings of Naik (2023) that Students exposed to the FCA demonstrate improved academic achievement, increased engagement, enhanced critical thinking skills, and better retention of course content taught them.

Another finding of the study was that the posttest achievements mean scores of the male students in the class taught using FCA did not differ significantly from that of the female students taught in the same class. This means that learners of both sexes that utilized the FCA benefited equally from the treatment. Therefore, the use of FCA is gender friendly. The result here supports the finding by Enekwechi and Okeke (2017) who found out that there was no significant effect of FCA on both male and female students' interest, participation and academic achievement in chemistry. Both were enhanced equally with the use of FCA. The finding also agrees with that of Egara and Mosimege (2023) that the achievement and interest scores of male and female learners who received mathematics instruction using FCA were the same. The finding supports earlier reports by Makinde and Yusuf (2017) and Kutigi,Gambari, Tukur, Yusuf, Daramola, and Abanikannda (2022) who found out the effects of FCA in mathematics and English language respectively. The finding however, disagrees with that of Chebotib, Too and Ongeti (2022) who investigated the impact of the FCA on students' achievement in biology and discovered that female students achieved much more when the strategy was employed than their male counterparts. The finding in the retention scores based on gender followed the same trend with the achievement. There was no significant difference between the retention mean scores of the male and female students in the class taught using

FCA. This finding supports the report by Kutigi, et al. (2022) that the retention level of male and female students taught Oral-English using FCA was high without discrimination.

Conclusion

The inferences drawn from the findings of this research are connected to the positive effect of the FCA on students' academic achievement and retention with respect to gender. The study revealed that FCA significantly enhanced students' achievement and retention in chemical equilibrium (a concept in chemistry). This was evident by the mean achievement score of the chemistry students taught using the FCA which significantly differed from that of students in the control. The experimental class achieved higher than the control class. Similarly, the retention scores of students in the experimental group were higher than their counterparts in the control group. This could have been because; students in the flipped classroom had reviewed learning materials at home and were ready to harness what was previously learned at home. The study discovered that the retention scores of male and female students who were taught chemical equilibrium using FCA were the same. Both male and female students benefited equally from the treatment with the FCA. From a social perspective, the FCA has the potential to address educational inequalities, promote inclusivity, and prepare students for the demands of the 21st-century workforce. This study contributes to the existing literature in chemistry education by providing a comprehensive report on the effects of FCA on students' achievement and retention in chemical equilibrium, taking into consideration their gender. It is the first to explore the FCA's effect on students' achievement and retention in chemical equilibrium in Plateau state, Nigeria, and it explains how the FCA can help secondary school students enhance their achievement and retention in chemistry, particularly in chemical equilibrium.

Recommendations:

Based on the findings and conclusions of this study, the researcher recommended that chemistry teachers should adopt the FCA because it is a student-centered learning strategy that engages the students rather than spoon-feed them. Chemistry teachers should seekfor more knowledge on the utilization of FCA for instruction because is a technology-driven. Therefore there is the need for them to attend workshops, seminars and conferences during which they will be taught and trained on how to implement flipped classrooms in their teaching and learning process. There should be a resource base in schools where videos and hand out for teaching chemistry be kept for all chemistry teachers to work cooperatively. Teachers' training institutions should provide the student teachers with activities to get them to participate in flipped classroom practices in order to equip them with the expertise to implement flipped classrooms in their teaching.

References

Ababio, Y.O. (2017). *New Schools Chemistry for Senior Secondary Schools3rd edition.* Nigeria: Africa first publishers Ltd

Abeysekera, L., & Dawson, P. (2015). Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research. High Educ Research Developmnt . 34(1), 1-14

Adejo, L. O. (2015). *Effects of inquiry method on academic performance of chemistry students in senior secondary schools in Kaduna State, Nigeria*. An unpublished M.Ed. Thesis, Department of Educational Foundations & Curriculum, Ahmadu Bello University, Zaria, Nigeria.

Agnefo, H. (2017). *Encouraging Positive Learning Outcomes in Flipped Classrooms.* Retrieved from https://study.com/academy/lesson/encouraging-positive-learning-outcomes-in-flipped-classrooms.html.

Ali, R., Mondal, M., Das, T. (2018). Pedagogy and the role of teachers in the teaching learning process. *Journal of Emerging Technologies and Innovative Research,* 5(5), 803-808. www.jetir.org (ISSN-2349-5162) JETIR1805554

Busebaia T.J.B. & John B. (2020). Can flipped classroom enhance class engagement and academic performance among undergraduate pediatric nursing students? A mixed-methods study. *Research and Practice in Technology Enhanced Learning. (RPTEL),* 15(4), 1-16

Chan, V. &Alborzfar, L. (nd). *Principles of chemical equilibrium.* Retrieved from https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_TextbookMaps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Equilibria/Chemical_Equilibria/Principles_of_Chemical_Equilibria/Principles_of_Chemical_Equilibrium

Chebotib, N., Too, J., &Ongeti, K. (2022). Effects of the flipped learning approach on students' academicachievement in secondary schools in Kenya. *Journal of Research and Method in Education*, *12*(6), 1–10. https://doi.org/10.9790/7388-1206030110.

Covill L., Cook J. Comparison of academic performance in traditional and flipped classrooms and students' attitudes of the flipped experience. *Allied Health Spring.* 2019;48(1):17

Egara, F. O. &Mosimege, M. (2023). Effect of flipped classroom learning approach on mathematics achievement and interest among secondary school students.*Education and Information Technologies*https://doi.org/10.1007/s10639-023-12145-1

Enekwechi, E. E., &Okeke, S. O. C. (2017). *Effects of flipped classroom instruction on secondary school students' interest, participation and academic achievement in chemistry* [Unpublished doctoral dissertation]. NnamdiAzikiwe University. https://phd-dissertations.unizik.edu.ng/repos/81192823200_144523225296.pdf.

Gongden, E. J.,*Comparative effects of two metacognitive instructional strategies on gender and problem solving abilities in selected chemistry concepts in Plateau state, Nigeria.*Doctoral dissertation, AbubakarTafawaBalewa University, Bauchi, 2015

Gongden, E. J., John, D. P., and Gimba, E. M. (2019). Effects of jigsaw cooperative learning strategy on senior secondary two chemistry students' understanding of chemical kinetics in Jos South LGA of Plateau state, Nigeria. *East African Scholars Journal of Education, Humanities and Literature,2(5),* 280-288

Gongden, E. J. (2022). Improving chemistry students' achievement and retention in chemical kineticsusing blended learning strategy in Jos -Plateau state, Nigeria. *International Journal of Education and Evaluation.* 8(6), 33-42, E-ISSN 2489-0073 P-ISSN 2695-1940

Gopalan C. (2018). Effect of flipped teaching on student performance and perceptions in an Introductory Physiology course. *Adv. Physiol. Educ. J.* 43(1), 28-33

Kutigi, U., Gambari, I., Tukur, K., Yusuf, T., Daramola, O., &Abanikannda, O. (2022). Gender differentials in the Use of flipped Classroom Instructional Models in enhancing achievement and Retention in oral-english contents of senior secondary School in Minna, Niger State, Nigeria. *International Journal of Advanced Humanities Research*, *2*(1), 1–21. https://doi.org/10.21608/ijahr.2022.256372.

Lower, S. (nd). *Introduction to Chemical Equilibrium.* Retrieved from https://chem.libretexts.org/Bookshelves/General_Chemistry/Chem1_(Lower)/11%253A_Chemical_Equilibrium/11.01%253A_Introduction_to_Chemical_Equilibrium#:~:text=Chemical%20equilibrium%20When%20a%20chemical%20reaction%20takes%20place,as%20some%20are%20consumed%20and%20others%20are%20forme

Makinde, S., & Yusuf, M. O. (2017). The flipped classroom: Its effects on students' performance and retention in secondary school mathematics classroom. *International Journal of Innovative Technology Integration in Education, 1*(1), 117–126. https://ijitie.aitie.org.ng/index.php/ijitie/article/view/43.

Marlowe, C. (2012) *The Effect of the Flipped Classroom on Student Achievement and Stress* Unpublished Master's Thesis, Montana State University; Bozeman

McLean S., Stefanie M., Attardi L., Faden, Goldszmidt M. (2016). Flipped classrooms and student learning: not just surface gains. *Adv. Physiol. Educ.*;40:47–55.

Memler, J. (2017). *The effect of a flipped classroom on student academic achievement and the gender gap in high school physics*. Ph.DDissertation, University of Georgia

Naik, M. (2023). Assessing the effectiveness of flipped classroom strategy on student performance. *European Chemical Bulletin.* 12(8). 2883-2896

Newman G., Kim J.−H., Lee R.J., Brown B.A., & Huston S. (2016). The perceived effects of flipped teaching on knowledge acquisition. *Journal of Effect. Teach.* 16(1): 52–71.

Nja, C. O. Cornelius-Ukpepi, B. U. and Orim, R. E. (2019) Effect of Simulation instructional method on undergraduate Chemistry Education students academic performance in Sodium reactions. *European Journal of Scientific Research.* 155(1), 6-12.

Nja, C. O., Orim, R. E., Neji, H. A., Ukwetang, J. O., Uwe, U. E. &Ideba, M. A. (2022). Students' attitude and academic achievement in a flipped classroom. *Heliyon,* 8(1): e08792.doi: 10.1016/j.heliyon. 2022.e08792

Nnoli, J. N. (2011). *Chemistry pivot for students' empowerment and realization of vision 20:20:20. National agenda: Implication for science teaching.* Paper presented at the School Science, NwaforOrizu College of Education, Nsugbe.

Osuafor, A., &Okonkwo, I. (2013). Influence of family background on the academic achievement of secondary school Biology students in Anambra State. *African Research Review. An International Multidisciplinary Journal,7*(3), 156-167.

Philip, J. (2023). *Effects of guided inquiry and demonstration strategies on senior secondary two (SS II) students' retention and achievement in chemistry in Taraba State, Nigeria*. Unpublished Ph.D Dissertation, University of Jos

Pappas, C. (2013). *The Flipped Classroom Guide for Teachers*. Retrieved on September 15, 2023 from https://elearningindustry.com/the-flipped-classroom-guide-for-teacher

Robinson, K. & Robinson, K. (2022). *Four core purposes of education*. Retrieved from http://www.edutopis.org/article/what-education on 28/06/2023

Steen-Utheim, A. T., &Foldnes, N. (2018). A qualitative investigation of student engagement in a flipped classroom. *Teaching in Higher Education, 23*(3), 307–324. https://doi.org/10.1080/13562517.2017.1379481

Strayer, J.F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learn. Environ. Res.*15(2):171–193

West African Examination Council. (2015-2021). *Chief examiners reports* (Lagos: Megavons, W.A Ltd, 2017-2020)