IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Human Journals
Research Article
January 2022 Vol.:20, Issue:3

Effects of Two Instructional Models on Senior Secondary II Students' Academic Performance and Retention in Chemical Equilibrium in Benue Education Zone C

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Submitted: 24 December 2021
Accepted: 30 December 2021
Published: 30 January 2022

Keywords: 4As, 5Es, Instructional Models, Academic Performance, Retention and Chemical Equilibrium.

ABSTRACT

The study investigated the effects of 4As and 5Es instructional models on senior secondary II students' performance and retention in chemical equilibrium in Benue State. Two research questions guided the study, while two hypotheses were formulated and tested. The study adopted quasi-experimental, non-randomized control group pretest and posttest design. The population of the study comprised 8,864 SSII Chemistry students. Samples of 194 SSII students from six Government grant aided secondary schools in Benue Education Zone C were selected using multistage sampling techniques. Chemical Equilibrium Performance Test (CEPT) with reliability coefficient of 0.87 and Chemical Equilibrium Retention Test (CERT) were used to collect data from students. Analysis using mean, standard deviation and mean gain scores were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The findings of the study revealed that there was a significant difference in the mean performance scores of students taught chemical equilibrium using 4As, 5Es instructional models and modified lecture method [$F_{2,193}$ = 89.995; P=0.000 < 0.05]. There was a significant difference in the mean retention scores of students taught chemical equilibrium using 4As, 5Es instructional models and modified lecture method [$F_{2,193}$ = 93.375; P = 0.000 < 0.05]. The study concludes that 5Es and 4As instructional models have greater effects on students' academic performance and retention in Chemical Equilibrium than Modified Lecture Method on SS II students in Benue Education Zone C. Based on the findings, it was recommended among others that Ministry of Education through Chemistry teachers should emphases the use of 5Es and 4As instructional models in teaching to enhance the academic performance and retention of students in Chemistry.

INTRODUCTION

The importance of science in advancing national goals and aspirations reveals to a large extent the huge commitment and support which nations make and give to Science and Technology advancement. It is an essential tool for a nation's progress and development (Ajayi, Achor, & Otor, 2020; Achor, 2019). Egbodo (2019) opined that as a result of the speed at which the world is changing technologically, the need and usefulness of teaching and learning Science should not be overlooked since education serves as a veritable tool for transmission of nation building skills and values. Students in various institutions are expected to be trained to discover, invent and be part of the scientific community and the teachers of science and technology are the channels or agents through which the skills and knowledge get to the learners.

Chemistry is most commonly regarded as the "Central Science" or the "mother of science" owing to its contribution and influence (Agogo, & Otor, 2015). Chemistry is an experimental science that systematically studies the composition, properties and activities of organic and inorganic substances and various elementary forms of matter (Senese, 2013). Chemistry is one of the science subjects taught at the senior secondary school levels of Nigerian education system. Chemistry teachers should endeavour to employ and utilize effective teaching strategies to increase the interest of students in Chemistry, which will subsequently improve performance in the subject in such external examinations as the Senior Secondary School Examination (SSCE), National Examinations Council (NECO), Unified Tertiary Matriculation Examinations (UT ME).

Chemistry is one of the science subjects taught at the senior secondary school levels of Nigerian education system. Chemistry teachers should endeavour to employ and utilize effective teaching strategies to increase the interest of students in Chemistry, which will subsequently improve performance in the subject in such external examinations as the SSCE, NECO, UT ME.

Instructional models that are strongly advocated include 4As and 5Es. These two instructional models may be preferred over others because of their effectiveness as reported in literature. This is as a result of the fact that traditional method of teaching science at the secondary school level has been widely implicated for being responsible for the undesirable state of science education in Nigeria by placing emphasis on examinations and certifications rather than understanding of

concepts that could lead to outstanding learning outcomes (Onanuga & Saka, 2018). Researchers have continued to search for appropriate methods and strategies that will enable Chemistry students to gain proper understanding and application of Chemistry concepts and principles that will enhance performance. According to (Achonye & Ajoku, 2013; Alamina, 2016), some methods, strategies and models as reported in literature are problem solving, project, field trip, concept mapping, played-way, discovery/inquiry method, Computer Assisted Instruction (CAl), collaborative approach, individualized, Jigsaw, 7Es, 5Es, 4As instructional models to mention but a few.

There has been a growing concern among science education researchers about effective strategies for teaching and learning of scientific knowledge and skills so that students can learn science in a deep and meaningful way and be able to use scientific knowledge in solving problems that humans encounter in their lives. There has been a paradigm shift over the past decades as a result of influences from the constructivist learning theory which has revolutionised the manner in which teachers teach and how students learn science. Some of the new innovative teaching and learning strategies which define learning as an active process in which students are active learners and sense makers, who seek to build coherent and organised knowledge has emerged to include; the use of instructional models, assertive questioning, concepts mapping and prior knowledge (Otor, 2013).

4As model as one of the independent variable in this study, assumes that individuals construct knowledge by actively relating new information to their personal experience and their current frameworks for making sense of that experience. The four components are to: activate prior knowledge, acquire new knowledge, apply knowledge and assess knowledge. These broad categories, when narrowed down allow teachers to make sure students learn. By activating prior knowledge, students make important connections to past learning and prepare their brains for new content. New content is presented and taught, then applied to real-world or past situations. An assessment is given to determine students' understanding. Each of the four phases of the instructional model provides opportunities for formative and summative assessments of student. In each phase of the A's, teacher hears what students say and observes what students do, and in response to either form of evaluation, adjusts their instructional intentions. Vygotsky (1978) presupposed that in using 4As instructional model individuals construct their own knowledge,

develops social relation which provides opportunity to mix with others and it is accompanied through activities carried out socially.

On 5Es instructional model, the view that students are active thinkers who construct their own knowledge and understanding from interactions with the environment, concepts and other individuals is based on the theory of constructivism. A constructivist view of learning recognizes that students need time to; express their thinking, interact with objects, substances, and equipment to develop a range of experiences on which to base their thinking, reflect on their views by writing and expressing themselves and comparing what they think with what others think, and make links between their learning experiences and the real world.

This instructional model provides a built-in structure for creating a constructivist classroom. The 5Es model arranged learning experiences so that students have the opportunity to construct their own knowledge of a concept over time. The model leads students through five stages of learning that are easily described using words that begin with the letter E namely Engage, Explore, Explain, Elaborate, and Evaluate. According to Bybee and Pamela (2016), 5Es learning model was adopted for learning. The 5Es instructional model was designed to help students' learning by linking prior knowledge to new concepts. Adesoji &Idika (2015) that revealed from their study, that there is significant difference in chemistry achievement of students exposed to 7E learning cycle model and Case-based learning and those in the control group.

Performance as a variable in this study is the extent to which an educational goal is attained in terms of scores by a student. Poor performance in science as evident in various empirical studies has attracted the attention of researchers and other educational stakeholders. The persistent poor performance in science portends a serious danger to the nation's aspiration of becoming scientifically and technologically great in the near future. One of the serious issues at stake in education today is students' performance measures in relation to teaching and learning overall outcome. Academic Performance according to Wang and Degot (2016) is the observable and measurable behaviour of a student in a particular situation. For instance, the academic performance of a student in Chemistry is the observable and measurable behaviour of the student at any point in time in the subject. According to Muluku, Samba and Imoko (2020), effective instructional method could raise the performance of the students.

Retention is displayed through recognition or *via* recall; meaningful learning is explained in terms of retention. Retention is the term used to denote the demonstration that learning has taken place and maintained over time (Oloyede, 2011). Retention which is the preservation of memory traces of learned experiences affects the performance of students in a given subject. Ngwoke (2010) identified poor teaching and learning methods as one of the reasons for students' forgetfulness. Those teaching strategies that alienate the learners are teacher – centred and are responsible for forgetfulness. The ability to recall or repeat experience from memory traces or otherwise defines the remembering ability (retention) and forgetfulness of individual students respectively. This study therefore, seeks to determine the effects of 4As and 5Es instructional models on SSII students' academic performance, interest and retention in chemical equilibrium.

Chemical equilibrium is a theory which explains chemical reactions based on three ideas: incomplete reactions, reversibility and dynamism (Quilez, 2019). The theory maintains that in a closed system, reactants are not completely used up to form products; but that as products are formed, they decompose to form back reactants. The two opposing reactions occur continuously, even when at the observable level no reaction seems to be happening. Studies on students' understanding of Chemical equilibrium worldwide have revealed a number of limitations to learning of chemical equilibrium. These limitations include students' alternative conception relating to the nature of chemical equilibrium and poor understanding of equilibrium law, confusion between rate and equilibrium and poor understanding of the effects of catalysis, temperature and concentration on equilibrium reactions (Ozmen, 2018).

Statement of the Problem

The Nigerian educational sector has a lot of challenges as there are consistent poor performance of students in chemistry in external examinations such as the West African Examinations Council (WASSCE), National Examinations Council (NECO), General Certificate Examinations (GCE), and UTME. Prominent among the contributing factors to poor performance in science and chemistry in particular is the method of teaching the students, abstractness of the subject, and misconceptions in chemical equilibrium (Upelle, Ukwuru, Enuma, & Eru, 2019). Students' poor performance, low retention ability, learning difficulties and misconceptions in chemical equilibrium are indications of the likelihood of a deficiency in instructional strategies used in

chemistry instruction. It has been observed that the conventional teaching methods such as lecture and discussion methods adopted in the classroom have not provided the varied activities or stimulated students' learning. Currently, the conventional method of instruction being used in chemistry teaching has not yielded considerable improvements in the quality of students' performance and retention in the subject. The problem posed as a question therefore is, would the use of 4As and 5Es instructional models improve students' academic performance and retention in chemical equilibrium?

Research Questions

The following research questions will guide the study:

1. What are the mean academic performance scores of students in Chemical equilibrium when taught using 4As, 5Es instructional models and those taught using modified lecture method?

2. What are the mean retention scores of students in Chemical equilibrium when taught using 4As, 5Es instructional models and modified lecture method?

Hypotheses

The following null hypotheses will be tested at 0.05 level of significance.

1. There is no significant mean difference in the academic performance scores of students in chemical equilibrium taught using 4As, 5Es instructional models and those students taught using modified lecture method.

2. There is no significant mean difference in retention scores of students in chemical equilibrium when taught using 4As, 5Es instructional models and those students taught using modified lecture method.

Research Method

The research design adopted for this study was quasi-experimental design, particularly the non-randomized pre -test post-test control group design. The design involves three groups (two experimental groups and one control group) where subjects were not randomly assigned to the

groups by the researcher instead intact classes were used. The target population of this study is 8,864 SSII students from 99 government grant-aided secondary schools in Benue Education Zone C that offer chemistry as one of the core subjects. The government grant-aided secondary schools are preferred because their mode of establishment and operation is in line with the State Ministry of Education operational guidelines. The choice of SSII students is based on the assumption which has been confirmed that they have covered chemical equilibrium concepts in chemistry and should understand the concepts better using different instructional models such as 4As and 5Es.

The sample size for this study comprised 194 (84 male and 110 female) senior secondary school students in the intact classes to be selected from six co-educational schools. The sample for experimental group I comprise 63 students with (27 males and 36 females), and 64 students (28 males and 34 females) for the experimental group II while the control group has 67 students (30 males and 37 females) respectively. The sample of 194 is considered adequate because in experimental designs fewer subjects are often used as it is easier to observe change within the subjects than differences between groups. It is also argued that in experimental studies less emphasis is placed on large sample size but on the treatment and control of extraneous variables.

Multi-stage sampling was adopted in this study. The large population of the schools was divided into stages to make the sampling process more practical. Purposive sampling technique also referred to as judgmental sampling was used to sample the required schools based on the nature of this study and six schools were assigned randomly to two experimental and control groups. Sampled schools were designated as A, B, C, D, E and F. A & B was assigned to experimental group I, C & D was assigned as experimental group II, while school E and F was assigned as control group III. The experimental group I was treated with 4As, experimental group II was treated with 5Es while the control group was not treated but taught with modified lecture method.

Two instruments were used for data collection, namely, Chemical Equilibrium Performance Test (CEPT) and Chemical Equilibrium Retention Test (CERT) is a reshuffled version of CEPT. CEPT was used for pre-test and post-test to determine the extent of performance, while CERT was used to determine the retention.

The instruments were validated by three experts, one expert in Science Education, and one in Mathematics Education, Benue State University, Makurdi, and an experienced B.SC (Ed) Chemistry teacher at the Senior Secondary School level. A request for validation of instruments was given to the validators and validation forms respectively. The experts' advice was sought in terms of adequacy of instruments in soliciting the desired response, relevance of instruments to the purpose of the study, structure and grammatical construction of the instruments. Their comments were that the instruments are appropriate and capable of achieving its objectives; items conform to the subject matter, readable, not ambiguous and address the scope of the study. The researcher also used their suggestion to compute the psychometric indices of the research instrument after which only 40 items scaled through out of the initial 45 items.

Lesson plans developed by the researcher for the study are based on the use of 4As and 5Es instructional models for the experimental groups and modified lecture method for the control group were also assessed by these same validators. Their advice was sought in terms of content relevance, clarity of terms, study duration, and logical presentation. Their criticisms, comments and suggestions were used to adjust the lesson plans for the study.

A trial test was carried out on 89 subjects from three senior secondary schools that offered chemistry, which were not part of the sampled schools for the main study. The students were trial- tested and their scores recorded and used to calculate the reliability coefficient. Kuder-Richardson (KR-21) formula was used to test internal consistency of CEPT which gave a reliability value of 0.87. Three chemistry teachers from selected schools for trial testing were trained to teach the two experimental and a control groups respectively. The lesson plans prepared by the researcher based on the concepts of chemical equilibrium were used for teaching by the research assistants for four weeks before the test. The experimental groups were taught using 4As and 5Es instructional models while the control group was taught in the class with charts and chalkboard illustrations. The students were assessed using CEPT and CERT that are multiple choice instruments of 40 items each after the treatment.

The scores obtained were used to calculate the reliability coefficient of the instruments using Kuder-Richardson formula (KR-21). KR-21 was used to calculate the reliability of CEPT since the items have correct / wrong answers nature of the multiple choice test instruments used.

Ogbeba (2009), Eriba and Iyekekpolor (2016) explained that for intelligence and achievement test, a reliability coefficient value of 0.80 is the required minimum. This research work involved six intact classes for two experimental groups and one control group. Research assistants were trained to help with data collection. The research assistants were teachers selected from those sampled schools, four assistants for the experimental groups and two assistants for the control group. The data collected were subjected to statistical analysis in order to answer the research questions and test the research hypotheses. The data to answer the research questions and test the research hypotheses were obtained from the scores of the CEPT and CERT.

The pre-test was first administered to the two experimental groups and control group to determine the entry level of the students who participated in the study. The experimental group I were taught using 4As instructional model, experimental group II were taught using 5Es instructional model while the control group were taught using modified lecture method. At the end of the six weeks of teaching the concept of chemical equilibrium, the three groups were post-tested to determine the effects of the two instructional models (4As and 5Es) and the modified lecture method. Two weeks after the post-test, CERT was administered to determine the knowledge retention of the SSII students in chemical equilibrium.

The CEPT contains forty items and the CERT contains forty items which is a reshuffled version of the CEPT. Each correct response to a CEPT and CERT question attracts 2.5 totalling 100 marks in all. The results of the data analysis and interpretation are presented according to the research questions and hypotheses formulated for the study.

RESULTS

Research Question One

What are the mean academic performance scores of students in chemical equilibrium when taught using 4As, 5Es instructional models and those taught using modified lecture method?

Table 1: Mean Academic Performance and Standard Deviation Scores of Students Taught Chemical Equilibrium Using 4As, 5Es Instructional Models and Modified Lecture Method.

Group		Pre CEPT	Post CEPT	Mean Gain
	Mean	41.54	63.17	21.63
4As Instructional Model	N	63	63	
	Std. Dev	3.17	4.22	
	Mean	42.73	69.67	26.94
5Es Instructional Model	N	64	64	
	Std. Dev	3.08	4.76	
	Mean	40.75	58.28	17.53
Modified Lecture Method	N	67	67	
	Std. Dev	4.25	4.89	

The analysis of data on table 1 shows the mean academic performance scores of students taught chemical equilibrium using 4As, 5Es instructional models and modified lecture method. The table reveals that the mean academic performance scores of students taught chemical equilibrium using 4As instructional model is 41.54 with standard deviation of 3.17 during the pre-test and 63.17 with standard deviation of 4.22 in the post-test. The mean academic performance scores of students taught chemical equilibrium using 5Es instructional model is 42.73 with standard deviation of 3.08 during pre-test and 69.67 with a standard deviation of 4.76 in the post-test. While the mean academic performance scores of students taught chemical equilibrium using modified lecture method is 40.75 with standard deviation of 4.25 during pre-test and 58.28 with standard deviation of 4.89 in post-test. The mean gain in academic performance scores of students taught chemical equilibrium using 4As is 21.63; 5Es instructional model is 26.94 and 17.53 for those taught using modified lecture method respectively**.**

Research Question Two

What are the mean retention scores of students in Chemical equilibrium when taught using 4As, 5Es instructional models and modified lecture method?

Table 2: Mean Chemical Equilibrium Retention Test scores and Standard Deviation of Students taught Chemical Equilibrium Using 4As, 5Es instructional model and Modified Lecture Method

Group		Pre-CERT	Post-CERT	Mean Gain
	Mean	41.54	60.51	18.97
4As Instructional Model	N	63	63	
	Std. Dev	3.17	2.63	
	Mean	42.73	66.22	23.49
5Es Instructional Model	N	64	64	
	Std. Dev	3.08	4.71	
	Mean	40.75	57.03	16.28
Modified Lecture Method	N	67	67	
	Std. Dev	4.25	3.46	

The analysis of data on table 2 shows the mean chemical equilibrium retention test of students taught chemical equilibrium using 4As instructional model, 5Es instructional model and those taught using modified lecture method. The table reveals that the mean chemical equilibrium retention scores of students taught chemical equilibrium using 4As instructional model is 41.54 with standard deviation of 3.17 during pre-test and 60.51 with standard deviation of 2.63 in post-test. The mean retention scores of students taught chemical equilibrium using 5Es instructional model is 42.73 with standard deviation of 3.08 in pre-test and 66.22 with standard deviation of 4.71 in post-test while the mean retention score for those taught using modified lecture method is 40.75 with standard deviation of 4.25 in the pre-test and 57.03 with standard deviation of 3.46 in post-test. The mean gain in chemical equilibrium retention test scores of students taught using 4As instructional model is 18.97, 23.49 for students taught using 5Es instructional model and 16.28 for those taught using modified lecture method.

Hypothesis One

There is no significant mean difference in the academic performance scores of students in chemical equilibrium taught using 4As, 5Es instructional models and those students taught using modified lecture method.

Table 3: Two-Way ANCOVA for Mean Academic Performance Scores of Students Taught Chemical Equilibrium using 4As, 5Es instructional models and Modified Lecture Method.

Dependent Variable: PostCEPT						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4419.001[a]	6	736.500	35.195	.000	.530
Intercept	4464.945	1	4464.945	213.367	.000	.533
PreCEPT	57.888	1	57.888	2.766	.098	.015
Groups	3766.473	2	1883.236	89.995	.000	.490
Gender	75.771	1	75.771	3.621	.059	.019
Groups *Gender	10.930	2	5.465	.261	.770	.003
Error	3913.185	187	20.926			
Total	795040.000	194				
Corrected Total	8332.186	193				
a. R Squared = .530 (Adjusted R Squared = .515)						

Table 3 presents the summary of two-way ANCOVA result for mean academic performance scores of students taught chemical equilibrium using 4As, 5Es instructional models and Modified Lecture Method (MLM). The data in Table 10 revealed that the mean difference in the performance scores among the groups was significant [$F_{2, 193} = 89.995$; $P = 0.000 < 0.05$]. The null hypothesis which that stated that there is no significant difference in the mean academic performance scores of students taught chemical equilibrium using 4As, 5Es instructional models and MLM was rejected. This implies that there was significant difference in the mean performance scores among the groups. Meanwhile, the effect size was showed to be 0.490 by the corresponding partial eta squared value which is considered as large effect size. This implies that, 49% of the difference in the performance scores was explained by the treatments among the groups. Hence, the difference in the academic performance scores among the groups has a large statistical effect size.

Table 4: Bonferroni Post Hoc Comparison for Mean Academic Performance Scores of Students taught Chemical Equilibrium using 4As, 5Es instructional models and Modified Lecture Method.

Dependent Variable: PostCEPT

(I)Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
5Es	MLM	4.635 *	.809	.000
4As	MLM	10.844 *	.819	.000
4As	Es	-10.844*	.819	.000

Table 4 shows Bonferroni post-hoc comparison for mean academic performance scores of students' taught chemical equilibrium using 4As, 5Es instructional models and Modified Lecture Method (MLM). The result revealed that the mean difference (I-J) between 5Es instructional model and MLM is 4.635* and this is significant at $p = .000 < 0.05$. This implies that there is a significant difference in the mean academic performance scores between the students taught chemical equilibrium using 5Es instructional model and those students taught using MLM in favour of students in 5Es instructional model group. The result in Table 11 revealed that the mean difference (I-J) between 4As instructional model and MLM is 10.844* and is significant at $p = .000 < 0.05$. This implies that there is a significant difference in the mean performance scores between the students taught chemical equilibrium using 4As instructional model and those students taught using MLM in favour of students in 4As instructional model group. Likewise, the result in the table revealed the comparison between 4As and 5Es instructional models mean difference of -10.844* and this is significant at $p = .000 < 0.05$. This shows a significant difference in the mean academic performance scores between students taught chemical equilibrium using 4As and 5Es instructional models in favour of students in 5Es instructional model group. This implies that there is significant difference between students' academic performance taught chemical equilibrium using 4As, 5Es instructional models and MLM.

Hypothesis Two

There is no significant mean difference in retention scores of students in chemical equilibrium when taught using 4As, 5Es instructional models and those students taught using modified lecture method.

Table 5: Two- Way ANCOVA for Mean Retention Scores of Students Taught Chemical Equilibrium using 4As, 5Es Instructional Models and Modified Lecture Method.

Dependent Variable: PostCERT						
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
CorrectedModel	2874.736[a]	6	479.123	34.311	.000	.524
Intercept	4805.940	1	4805.940	344.162	.000	.648
PreCEPT	4.503	1	4.503	.322	.571	.002
Groups	2607.819	2	1303.909	93.375	.000	.500
Gender	33.593	1	33.593	2.406	.123	.013
Groups *Gender	2.992	2	1.496	.107	.898	.001
Error	2611.305	187	13.964			
Total	731514.000	194				
Corrected Total	5486.041	193				
a. R Squared = .524 (Adjusted R Squared = .509)						

Table 5 presents the two-way ANCOVA result for mean retention scores of students taught chemical equilibrium using 5Es instructional models and MLM. The data in Table 14 revealed that the mean difference in the retention scores among the groups was significant [$F_{2,\ 193}$, = 93.375; P = 0.000 < 0.05]. Hence, the null hypothesis which stated that there is no significant difference in the mean retention scores of students taught chemical equilibrium using 4As, 5Es instructional models and MLM was rejected. This implies that there is a significant difference in the mean retention scores among the groups. Meanwhile, the effect size was 0.500 as indicated by the corresponding partial eta squared value is considered a large effect size. This showed that 50% of the difference in the retention scores among the groups was explained by the treatments.

Hence, the difference in the retention scores among groups taught chemical equilibrium has a large statistical effect size.

Table 6: Bonferroni Post Hoc Comparison for Mean Retention Scores of Students Taught Chemical Equilibrium using 4As, 5Es Instructional Models and Modified Lecture Method.

Dependent Variable: PostCERT

(I)Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
5Es	MLM	3.451*	.665	.000
4As	MLM	8.968*	.663	.000
4As	5Es	-8.968*	.663	.000

Source: Field Survey, 2021

Table 6 presents the Bonferroni post-hoc comparison for mean retention scores of students taught chemical equilibrium using 4As, 5Es instructional models and MLM. The result in the table revealed that the mean difference (I-J) between 5Es instructional model and MLM is 3.451* and this is significant at $p = .000 < 0.05$. This implies that, there is a significant difference in the mean retention scores between the students taught chemical equilibrium using 5Es instructional model and those taught using MLM in favour of students in 5Es instructional model group. Likewise, the results revealed that the mean difference (I-J) between 4As instructional model and MLM is 8.968* and this is significant at $p = .000 < 0.05$. This implies that, there is a significant difference in the mean retention scores between the students taught chemical equilibrium using 4As instructional model and those taught using MLM in favour of students in 4As instructional model group. Similarly, the paired comparison between 4As and 5Es instructional models revealed a mean difference of -8.968* and this is significant at $p = .000 < 0.05$. This implies that, there is a significant difference in the mean retention scores between the students taught chemical equilibrium using 4As and those taught using 5Es in favour of students in 5Es instructional model group. Hence, there is statistical difference in the mean

retention scores between students taught chemical equilibrium using 4As, 5Es instructional models and MLM in favour of students in 5Es instructional model group.

DISCUSSION

Finding of this study showed that there was significant difference in performance between the students taught using 4As instructional model, 5Es instructional model, and MLM was statistically significant. The post-hoc comparison for the performance scores among the groups revealed that students taught chemical equilibrium using 5Es instructional model had significantly higher performance scores than those taught using modified lecture method. The post-hoc comparison for the performance scores also revealed among the groups that students taught chemical equilibrium using 4As instructional model had significantly higher performance scores than those students taught using discussion method.

This finding agrees with Umahaba (2018) who found that students taught chemistry using 5Es learning model as experimental group performed significantly better than the conventional group. The finding is also inconsonance with Adesoji &Idika (2015) that revealed from their study, that there is significant difference in chemistry achievement of students exposed to 7E learning cycle model and Case-based learning and those in the control group. The post-hoc comparison for the performance scores among the groups further showed that the difference in the academic performance scores between students taught chemical equilibrium using 5Es and those students taught using 4As instructional model was found not to be statistically significant. There was scarcity of literature on comparison between 4As and 5Es instructional models on students' academic performance in science subjects. Possible explanation for none statistical significant difference could be due to the fact that both 4As and 5Es instructional model provide enabling environment for meaningful learning as students cognitive structure are developed.

The finding of this study revealed that students taught chemical equilibrium using 5Es instructional model retained better than those students taught using 4As instructional model. It was discovered that male students taught chemical equilibrium using 5Es instructional model retained more chemical equilibrium concepts than their counterpart taught using 4As instructional model. Likewise, female students taught chemical equilibrium using 5Es instructional model retained more chemical equilibrium concepts than female students taught

using 4As instructional model. The use of 4As and 5Es instructional models are approach that involves students in knowledge construction, thinking, interaction with others and materials, and creating meaning from their experience. The finding also agrees with that of Muluku, Samba & Imoko (2020) who reported that, an effective method is expected to raise students' achievement scores in the subject and retain what is learnt in the class. The finding of this study showed that 5Es instructional model tends to enhance students' retention in chemical equilibrium concepts than 4As instructional model, and 4As instructional model than modified lecture method.

CONCLUSION

Based on the findings, the following conclusions were drawn:

The use of 5Es and 4As instructional models had positive effects on students' academic performance and retention in chemical equilibrium. The post test results revealed that 5Es and 4As instructional models has significant effect on students' academic performance and retention in chemical equilibrium concepts which had already been confirmed by different studies cited in the study. Thus, greater attention should be given to the use of 5Es and 4As instructional models as teaching strategies.

The effect of these instructional models is not dependent on gender. This implies that academic performance in chemical equilibrium is a function of method rather than gender. Both male and female students are capable of interacting, collaborating in classroom activities and finally construct their own knowledge since student interest, performance and retention are the focus of teaching chemistry. These instructional models are effective, learner-friendly and allow active participation of students than MLM which is passive and teacher–centered.

Recommendations

The following recommendations are made based on the findings of the study:

1. Government through the Ministry of Education should emphasize the use of 5Es and 4As instructional models in schools through regular supervision.

2. Ministry of Education Science and Technology and professional bodies such as Science Teachers Association of Nigeria (STAN) should on a continuous basis arrange workshops,

seminars and symposia to popularize and sensitize Chemistry teachers on the integration of 5Es and 4As instructional models in teaching chemical equilibrium and Chemistry in general.

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