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Improving Secondary School Students' Academic Achievement In Chemistry Using 7Es Constructivist Instructional Strategy

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ABSTRACT

The study aimed to determine the effect of 7Es Constructivist Instructional Strategy (7ECIS) in the achievement of students in Chemistry. The study used quasi-experimental design. The experimental group was subjected to the use of 7ECIS while the control group was taught with the conventional guided discovery learning approach. From the total population of all students offering chemistry in public secondary schools in 2023/204 academic session in Jalingo Education Zone, Taraba State, Nigeria; a sample size of 200 students (146 males & 56 females) were drawn through purposive sampling. The instrument used in the study were the non-testing lesson plans, and testing teacher-made chemistry achievement test (CAT). The instrument (CAT) was validated by the pool of experts and were rated as very good with a reliability coefficient of 0.77 which was considered good and suitable for the study. The experimental and the control groups of participants were given pre-test, underwent different treatments and were given the post-test. Results showed that there is a statistical significant difference between the mean achievement scores of students taught Chemistry using 7ECIS and those taught using the conventional guided discovery strategy. However, the findings based on gender showed no statistical significant difference; also no significant interaction effect of method and gender using 7ECIS. It is evident from findings that the use of 7ECIS provides better strategy for students to learn and improve their achievement in chemistry. Thus, chemistry teachers may adopt 7Es constructivist instructional strategy for the development of student's higher achievement, creating gender-friendly classrooms, encouraging peer interaction and improving critical thinking skills.

Keywords: 7Es Constructivist Instructional Strategy, Secondary school students, Achievement in Chemistry, Redox reaction, Gender.

INTRODUCTION

Oxidation-reduction (redox) reaction is a type of chemical reaction that involves a transfer of electrons between two species in which the oxidation number of a molecule, atom, or ion changes by gaining or losing an electron; oxidation refers to the loss of electrons while reduction refers to the gain of electrons by a substance (Jack, 2023). Concepts in electrochemistry (such as oxidation-reduction reactions) are considered to be challenging to secondary (high) school students with associate alternative conceptions (Adu-Gyamfi et al., 2015; Adu- Gyamfi & Ampiah, 2019a; 2019b; Adu-Gyamfi, et al., 2020; Bong & Lee, 2016; Jack et al., 2017). And, as viewed by Jack (2023) there is need for more innovative and effective instructional strategies that could help students overcome their alternative conceptions of difficult concepts such as chemical (redox) reaction. This, leading to development competencies of conceptual understanding were students can construct knowledge of chemical concepts through active and meaningful learning.

Constructivism is activity–based, students' centered and interactive learning strategy which upholds the view that knowledge should be constructed by the learners through active mental developmental processes (Ekoh et al., 2017). The constructivist teacher poses a problem and monitors student exploration, guides student inquiry, and promotes new patterns of thinking. Constructivist instructional approaches can be applied across learners of all ages, including adults. Constructivist view of learning recognizes the fact that students need time to: express their current thinking; interact with objects, organisms, substances, and equipment to develop a range of experiences on which to base their thinking (Brooks & Brooks, 1993 in Mingren 2016). The research by Alan and Afriansyah (2017) showed that conceptual understanding is fundamental in science learning since concept mastery is the key to solve even the hardest problem. Though, many learners do not attain favourable learning outcomes since they are not aware of efficient and effective ways of learning methods that are students-centered because they only try to memorize lessons while Chemistry does not mean to be memorized as it requires reasoning and understanding of the concept (Lestari et al., 2019). As a result, if students are given a test, the learners will have difficulties (Yolanda et al., 2016). Therefore, conceptual understanding is highly required for the learners to get proper learning outcomes. Many researchers have conducted many ways to improve students' conceptual understanding; and one of which according to Balta and Sarac (2016) is through learning models; and one of the learning models that has been proven in improving students' conceptual understanding is the constructivism.

There are various types of constructivism learning models, such as problem-solving, mind mapping, and 7E learning cycle. In this research, the 7E Learning Cycle model is selected since it provides chances for learners to build their knowledge (Febriana at al., 2014). 7E Learning Cycle model is the improvement of the 5E Learning Cycle model (Ghaliyah et al., 2015). The cycles of the applied learning model are emphasized in the understanding of the scientific chemistry concepts and misconception correction. Furthermore, it is also expected to be able to improve the students' memorization process that is focused on the knowledge and knowledge transfer (Balta & Sarac, 2016). The learning cycle Approach is a model that is deemed adequate for Chemistry students (Olaoluwa & Olufunke, 2015); as it can help them to elaborate their understanding of certain aspects of scientific research (Hodson, 2014). One of the Chemistry topics as viewed by Sayyadi et al. (2016) that is considered quite difficult for students to understand is Redox reaction which may have resulted from the learning approaches.

The learning cycle in the classroom practice focuses on the experience and knowledge of the early learners (Ghaliyah et al., 2015).is sum, in attaining well-organized students' concept, an organized procedure is needed. The learning cycle model has been developed from 3E (Exploration, Explanation, Elaboration), 5E (Engagement, Exploration, Explanation, Elaboration, and Evaluation), and 7E (Elicit, Engage, Explore, Explain, Elaborate, Evaluate, and Extend). Some studies suggest that the 7Es learning cycle can foster motivation and learning achievement (Febriana et al., 2014; Sumiyati et al., 2016), improve language comprehension (Balta & Sarac, 2016), is sufficient to achieve goals quickly (Bozorgpouri, 2016), improve the ability of mathematical connections (Rawa et al., 2016), and foster conceptual understanding (Nurmalasari et al., 2014). More so, on the 7E constructivist instructional approach, these researchers (Abdullahi et al., 2021; Adak & Chatterjee, 2019; Adesoji & Idika, 2013; Adolphus et al., 2021; Balta & Sarac, 2016; Cherono, 2021; George, 2016; Khashan, 2016; Kosobameji, 2022; Libata et al., 2021; Maskur et al., 2019; Miadi et.al., 2018; Naade et al., 2018; Nilda, 2021; Turgut et al., 2017; Villacrusis & Beloy, 2021) attested to its effectiveness on students' academic achievement more than the traditional instruction approach; though there exists a serious gap in literatures in the present study area (Taraba State) which the study fits in to fill.

This study is also concerned with the alarming crisis in relation to the issue of ineffective teaching/learning strategies on students' achievement in chemistry; and gender-friendliness has been a burning issue mostly in difficult concepts in chemistry. This problem is even compounded by the fact that most science educations give masculine outlook to science subjects and some pointed out that gender has no influence rather they achieve equally when giving equal opportunity. Since constructivist strategy is acknowledged as one of the best innovative method for teaching, there is a need to try such innovative teaching strategy to see how gender will influence student's achievement in chemistry. More so, worried by the poor performance in chemistry and inabilities in conceptual understanding of some difficult concepts such as chemical (redox) reactions; and to help bridge the gap in literatures another innovative instructional enhancer was introduced using the 7E's constructivist instructional strategy (7ECIS). It is against this background that this research was conducted in order to establish the effectiveness of 7E's constructivist instructional strategy on students' academic achievement in Chemistry.

The purpose of this study is to investigate the effect of 7E's constructivist instructional strategy on students' academic achievement of redox reaction in Chemistry in Jalingo Education Zone, Taraba State, Nigeria. The specific objectives of this study are as follows:

i. To compare the effectiveness of instructions based on 7E's constructivist instructional strategy and guided discovery learning strategy.
ii. Find out the mean achievement scores of male and female students taught chemistry with 7E's constructivist instructional strategy.
iii. Determine the interaction effects of method and gender on students' mean achievement scores in Chemistry.

Research Questions

Based on the objectives stated, the following research questions were raised to facilitate the investigation.

i. What is the mean academic achievement scores of students taught chemistry with 7E's constructivist instructional strategy and guided discovery learning strategy?

ii. What is the mean achievement scores of male and female students taught chemistry with 7E's constructivist instructional strategy?

iii. What are the interaction effects of method and gender on students' mean achievement scores in Chemistry?

Hypotheses

From the research questions raised, the following null hypotheses were postulated and tested at 0.05 level of significance:

$H0_1$: There is no significant difference between the mean academic achievement scores of students taught chemistry with 7E's constructivist instructional strategy and guided discovery learning strategy.

$H0_2$: There is no significant difference between the mean achievement scores of male and female students taught chemistry with 7E's constructivist instructional strategy.

$H0_3$: There is no significant difference between the interaction effects of method, gender on students' mean achievement scores in Chemistry.

The 7E Constructivist Instructional Model

The 7E constructivist instructional model adopted for this study is a comprehensive model that accommodates various methods, such as cooperative learning, group work, lectures, laboratory investigations and direct instruction which enables students to explore their beliefs and allow them to construct new knowledge, while discarding their misconceptions. The model is a student-centered, inquiry learning strategy that lays the foundation for proper conceptualization by students through various activities, spread across seven phases (Elicit, Engage, Explore, Explain, Elaborate, Evaluate and Extend) proposed by Eisenkraft, (2003) as shown in Figure 1.

Fig 1: The 7E constructivist instructional model by Eisenkraft (2003)

The phases of the 7E constructivist instructional model as applicable in redox reaction concepts in the study are briefly explain as follows:

Elicit: The objective of the first phase of the learning cycle is to determine what the students already know about the concept to be taught. The teacher can access the prior knowledge of the students through questioning, KWL chart or graphic organizer, incomplete concept maps, concept cartoons, activity sheets etc. The KWL chart tracks what a student knows (K), wants to know (W), and has learned (L) about the topic (redox reaction). The teacher also tries to track down if there is any misconceptions and find out students' previous knowledge on the topic, by asking: What is the meaning of redox reaction? What chemical reaction occurs during the process of photosynthesis, whereby green plants manufacture its food? Can you identify the substances that are oxidized and reduced respectively from its equation? Answers coming from students will disclose their knowledge about redox reaction.

Engage: The motive of this phase is to get the students mind focused on the topic. The teacher arouses interest and stimulates the curiosity of the students towards learning the subject matter so that they become ready to give all their attention on the contents taught. For example, to gain the students' attention on the topic - "Redox reaction", the teacher can tell a story or show students a video or diagram or a small science activity on redox reaction (e.g. Photosynthesis, combustion, extraction of metals) and can ask a few questions based on the material presented. This way students will get to know the importance of redox reaction and will be naturally motivated to learn.

Explore: The purpose of this phase is to provide the students with a common experience. The students get involved (active) in the topic directly, explore the concept themselves which help them build their own understanding and realize the unsatisfactory explanations in their minds. They share their experiences, observations and findings with their peer group; and this helps to develop teamwork, cooperative learning skills and helps them in the process of sharing and communicating. For example, the teacher can divide the students in three groups:

Group-I will explore the different definitions of redox reaction,

Group-II will explore the substances that are oxidizing agents and those that are reducing agents in the chemical reactions.

Group-III will explore ways to calculate the oxidation numbers of the central atoms in the compounds and write the IUPAC names of the compounds.

After sometime each group can be asked to give a brief presentation of their topics before the remaining two groups. Each presentation can be further followed by peer group discussion. The teacher will encourage the students to ask questions based on the information presented to know their understanding and to reveal if there are any misconceptions they have related to the concept.

Explain: In this phase, students discuss and express their conceptual understandings with the teacher and their classmates. Both teacher and the students actively participate in this phase. The teacher needs to question based on the information provided while explaining the subject matter to examine students' understanding, to induce their thinking and to ensure that the concepts are correctly formed in students' minds. The teacher explains the whole concept by making connections between students' understanding and examples from the living world. For example, the teacher encourages the students to explain the concept of water pollution in their own words to know their level of understanding of the concepts. The students are asked questions on previous topic water pollution; and connects it to the present concept of redox reaction, as oxidation and reduction reaction, defines oxidation, reduction, describe oxidizing agent and reducing agents and also calculation of oxidation number by connecting students‟ explanations with scientific clarifications and examples from the nature.

Elaborate: In this phase students gets the opportunity to apply the information learned in the 'Explain' phase. Students' previous understanding helps them ask more questions, arrive at solutions, and draw conclusions. During this phase students will get the opportunity to enhance their understanding of redox reaction concepts aside the ones giving during the exploration stage, identify and balance half reactions in a given redox reaction, write and balance redox equation, and conduct redox titration. This can be done by the teacher dividing the students into three groups;

Group 1- Identify and balance half reactions in a given redox reaction
Group II- Write and balance redox equation
Group III- Conduct quantitative redox reaction analysis.
Each group will represent how to Identify and balance redox reactions. To begin the investigation, the teacher will provide them a "Redox chart" containing reduction potential table and standard oxidation potential table. The first group will use the redox chart to identify the substances that can undergo oxidation and reduction in reactions. The second group will use the same chart to learn to write and balance a chemical or redox reaction; and the third group will be done to carry out to find the concentration of the charged species present in the solution of Iron (II) tetraoxosulphate (VI) and potassium tetraoxomanganate (VII). After few minutes each group will share their experiences with other two groups and with the teacher. This activity will encourage the students to think critically on how substances are oxidized, reduced, learn how to balance redox reaction, identify oxidizing and reducing agents, and calculate oxidation numbers of elements

Evaluate: Both process as well as product of student learning are examined through this phase. The teacher uses rubrics, checklist, observation sheets, self-assessment, peer-assessment, writing assignments, and other formative as well as summative evaluation techniques to guide students learning. The teacher assesses if the students' have attained an understanding of concepts or not. The teacher will use questioning throughout the lesson to reveal the student understanding. The teacher can give the students a short-written quiz consisting of open ended questions on redox reaction to determine the extent to which the students have learned the concepts.

Extend: In this phase, students apply the concepts learned in real-world situations. Transfer of learning to a new context enhances their conceptual understanding. The teacher gives the students an activity to make a list of "Redox reaction" examples which are real life reaction in our immediate environment. The teacher will divide the students into five groups and tells them to write the equations involve in each reaction and identify substances that are oxidized, reduced and list their importance to living. From this activity, the students will be able to make some discoveries by developing critical thinking, task orientation, team work and social skills.

RESEARCH METHODOLOGY

The quasi-experimental design was used for the study. The population of the study consisted of all the 2,223 (1,601 males and 622 females) students offering chemistry from the 53 public secondary schools in 2023/2024 academic session in Jalingo Education Zone, Taraba State, Nigeria. The sample of the study was 200 (146 males and 54 females) SSII students offering chemistry drawn from two (2) intact classes in two public secondary schools through purposive sampling.

The testing instrument used for data collection was a Chemistry Achievement Test (CAT), a 40-items multiple choice questions adopted from standardized test conducted by West African Examination Council (WAEC) 2019-2022. The correct option was scored two marks while wrong option was zero mark. While, the non-testing instrument was two sets of 4 weeks lesson plans which entailed the ages and gender of the students, duration of the lesson (40 minutes), as well as the behavioral objectives in relation to the topic ⁄ lesson. One set of lesson plans was based on 7ECIS (experimental group), and the other set was on guided discovery (control group). Both sets of lesson plans were prepared on oxidation and reduction reaction (Redox reaction) topics contained in the recent secondary schools chemistry curriculum by Nigerian Education Research development Council, (NERDC).

The instrument (CAT) was validated (content and face validation) by three experts. The content validation has to do essentially with the systematic examination of the test content, to determine whether it covers a representative sample of the behavioural domain to be measured, while face validation was to ensure the extent to which the instrument appear to deal with relevant content in the considered subject area of the study. The validators assessed the instrument in terms of content relevance, clarity and simplicity of language; and based on the comments and suggestions of the experts, corrections and modifications were made on the instrument.

The reliability of the instrument (CAT) was conducted to determine the appropriateness of the instrument with a sample size of 40 SS2 students offering chemistry in a secondary school outside the study area. The aim is to estimate the reliability and workability of the research instrument, design and procedures. The internal consistency reliability of CAT was determined to be 0.77 using the Kuder- Richardson's formula- 20 (K-R20). This formula is considered appropriate as it is applied to item that have multiple choice options. In addition, since the CAT was subjected to psychometric or item analysis, the forty (40) initially constructed items were reduced to twenty-eight (28) items; which was used for the study. The value (0.77) obtained from the trial testing indicate the suitability and reliability of the instrument for the study.

In the administration of the instrument, the CAT instrument was administered in two phases. The first phase was the administration of pre-test (Pre-CAT) to the student of experimental and control groups; which took place a week before treatment. After pre-test administration, the students were taught (treatment stage) the topics in the unit redox reaction for four (4) weeks in the same intact classes using 7ECIS (experimental group) and guided discovery learning strategy (control group) by the trained research assistants (teachers). The second phase was the administration of a Post-test (Post- CAT) to the same set of students of both groups; which was after the treatment, to determine students' achievement.

On the method of data analysis, the data collected was subjected to analysis at two different levels; descriptive and inferential statistics. At the descriptive levels, mean and standard deviation were used to answer the questions. While at the inferential level; the Analysis of Covariance (ANCOVA) was used to test the hypotheses ($H0_I$-$H0_3$) at $p<0.05$ level of significance.

RESULTS

Answering Research Question One: *What is the mean academic achievement scores of students taught chemistry with 7E's Constructivist Instructional strategy (7ECIS) and students' taught using guided discovery learning strategy?*

Table 1 was used to answer research question one.

Table 1: Mean Achievement and Standard Deviations of Pretest and Posttest of Experimental and Control Groups

Group		Pretest		Posttest		Mean
	n	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Gain**
7ECIS	140	14.99	3.47	35.16	6.22	20.17
GDLS	60	15.80	4.01	30.67	7.07	14.87
Mean Difference		0.81		4.49		5.30

Results in Table 1 shows that the post-test mean achievement scores of students taught Chemistry using 7Es constructivist instructional strategy (7ECIS) is 35.16 with standard deviation of 6.22, while that of those taught using Guided discovery learning strategy (GDLS) is 30.67 with standard deviation of 7.07. The mean difference between the pre-test and post-test mean scores of 7ECIS is 20.17 and that of GDLS is 14.87; these differences show the achievement by the two groups. There is also a difference of 4.49 between the post-test mean scores of the two groups and the mean gained by the experimental group is 5.30. The implication is that the students taught Chemistry using 7ECIS gained in achievement more than those taught Chemistry using GDLS. But, to verify if the difference is significant, this was tested with $H0_1$.

Testing Hypothesis One ($H0_1$)

$H0_1$: There is no significant difference between the mean academic achievement scores of students taught chemistry with 7E's Constructivist Instructional strategy (7ECIS) and students' taught same Chemistry using Guided discovery learning strategy.

Table 2 was used in testing hypothesis one ($H0_1$).

Table 2: One-way Analysis of Covariance of Mean Achievement Scores of the Experimental and Control Groups

Source of Variation	Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	1134.068[a]	2	567.034	13.896	.000	.124
Intercept	8046.342	1	8046.342	197.187	.000	.500
Pretest	287.164	1	287.164	7.037	.009	.034
Group	**941.541**	**1**	**941.541**	**23.074**	**.000**	**.105**
Error	8038.712	197	40.806			
Total	237796.000	200				
Corrected Total	9172.780	199				

Table 2 is one-way ANCOVA between groups analysis of covariance to compare the effect of 7Es constructivist instructional strategy (7ECIS) and Guided discovery learning strategy (GDLS) on students' achievement in Chemistry. The result $F(1, 197) = 23.074$, $P = .000 < 0.05$ shows that the two groups differ significantly. Thus, the null hypothesis is not retained. Therefore, there is a significant difference between the mean achievement scores of students taught chemistry with 7ECIS and students taught with GDLS. The effect size (eta square =.105) which indicates that 10.5% of the difference in the mean score is based on the strategy used.

Answering Research Question Two: *What is the mean achievement scores of male and female students taught chemistry with 7E's Constructivist Instructional strategy (7ECIS) and students' taught using guided discovery learning strategy?*

Table 3 was used to answer research question two.

Table 3: Mean Achievement and Standard Deviations of Pretest and Posttest Based on Gender of Experimental and Control Groups

Group		Pretest		Posttest		Mean
	n	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Gain**
EXP Male	97	14.80	3.50	35.01	6.84	20.21
EXP Female	43	15.40	3.42	35.49	4.56	20.09
Mean Difference		0.60		0.48		0.12
Ctrl Male	49	15.88	4.01	30.53	7.04	14.65
Ctrl Female	11	15.45	4.20	31.27	7.50	15.82
		0.43		0.74		1.17

Results of Table 3 shows that the mean gain for male students is 20.21 and that of the female students is 20.09 for experimental group (7ECIS) with a mean gain difference of 0.12; which is quite negligible. While for the control group, the mean gain of the male students is 14.65 and that of the female students is 15.82; with a mean gain difference of 1.17; which is not too high. But, to verify if the difference between both strategies is significant, this was tested with $H0_2$.

Testing Hypothesis Two ($H0_2$)

$H0_2$: There is no significant difference between the mean achievement scores of male and female students taught chemistry with 7E's Constructivist Instructional strategy (7ECIS) and students' taught same Chemistry using guided discovery learning strategy

Table 4 was used in testing hypothesis two ($H0_2$).

Table 4: Two-way Analysis of Covariance of Mean Achievement Scores of Male and Female of the Experimental and Control Groups

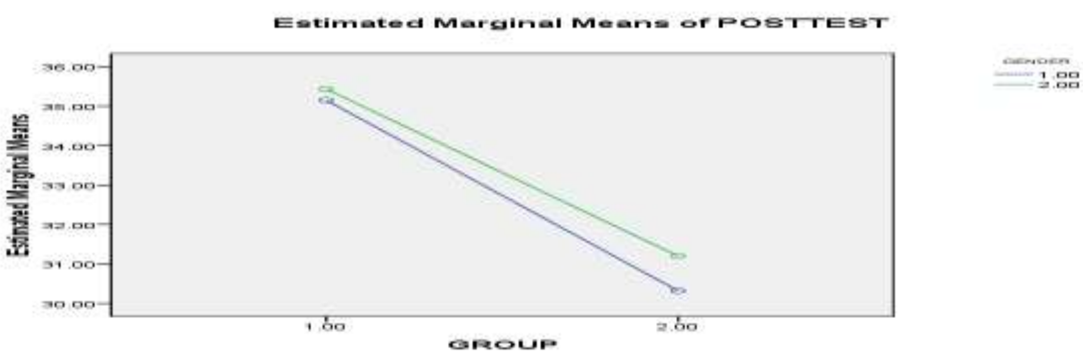
Source of Variation	Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	1143.436[a]	4	285.859	6.942	.000	.125
Intercept	7870.514	1	7870.514	191.143	.000	.495
Pretest	284.775	1	284.	6.916	.009	.034
Group	**565.789**	**1**	**7222.060**	**13.741**	**.000**	**.066**
Gender	**9.361**	**1**	**9.361**	**.227**	**.634**	**.001**
Group* Gender	**2.468**	**1**	**2.468**	**.060**	**.807**	**.000**
Error	8029.344	195	41.176			
Total	237796.000	200				
Corrected Total	9172.780	199				

Table 4 is two-way ANCOVA between groups' analysis of covariance to assess the effect of 7Es constructivist instructional strategy (7ECIS) and Guided Discovery Learning Strategy (GDLS) on male and female students in Chemistry. After adjusting the mean for the pre-test scores, the result F (1,195) = **.**060, P = .807 > 0.05 shows that the mean achievement scores of male and female students' taught Chemistry using 7ECIS and GDLS of male and female students do not differ significantly. Hence, the null hypothesis two is not rejected. Also, the effect size (eta square = **.**000) is low; hence the effect size is insignificant. The effect size indicates zero difference in the mean score is based on the strategy used**.**

Answering Research Question Three

What are the interaction effects of method and genders on students' mean achievement scores in Chemistry?

Figure 1 was used to answer research question three.



Key on Gender: 1=Male; 2=Female

Fig 1: Interaction effect of method and gender on students' mean achievement score in Chemistry

In Figure 1, the profile plot/graph shows the interaction effect of method and gender on students' achievement in Chemistry. The interaction pattern shows that the plots for males and females do not intercept, and the lines are apart, though not parallel to each other. This indicates that there is likelihood of an interaction between method and gender in Chemistry for 7ECIS and Guided Discovery Learning Strategy. But when the plot is extrapolated the intersection could only be at infinity, which means that the interaction effect between method and gender may be tenable in this case. But, to determine if the interaction effects of method and gender on students' mean achievement score is significant, was tested with $H0_3$.

Testing Hypothesis Three ($H0_3$)

$H0_3$: There is no significant difference between the interaction effects of method and gender on students' mean achievement scores in Chemistry.

Table 5 was used to test hypothesis three ($H0_3$).

Table 5: Two-way Analysis of Covariance of interaction effect of method, gender on students' mean achievement scores in chemistry

Source of Variation	Sum of Squares	df	Mean Square	F	Sig	Partial Eta Squared
Corrected Model	1143.436[a]	4	285.859	6.942	.000	.125
Intercept	7870.514	1	7870.514	191.143	.000	.495
Pretest	284.775	1	284.	6.916	.009	.034
Method	**565.789**	**1**	**7222.060**	**13.741**	**.000**	**.066**
Gender	**9.361**	**1**	**9.361**	**.227**	**.634**	**.001**
Method* Gender	**2.468**	**1**	**2.468**	**.060**	**.807**	**.000**
Error	8029.344	195	41.176			
Total	237796.000	200				
Corrected Total	9172.780	199				

Table 5 is two-way ANCOVA between groups' analysis of covariance to assess the effect of 7ECIS and Guided discovery learning strategy (GDLS) on male and female students in Chemistry. After adjusting the mean for the pre-test scores, the result F (1,195) = **.**060, P = .807 > 0.05 shows that the mean achievement scores of male and female students' taught Chemistry using 7ECIS and GDLS of male and female students do not differ significantly. Hence, the null hypothesis three ($H0_3$) is not rejected. Also, the effect size (eta square = **.**000) is low; hence the effect size is insignificant. The effect size indicates zero difference in the mean score is based on the strategy used**.**

DISCUSSION OF FINDINGS

The findings of this study are summarized thus:

i. Students taught Chemistry using 7Es constructivist instructional strategy achieved higher than their counterparts taught Chemistry using more than their guided discovery learning strategy counterparts.

ii. Male students taught Chemistry with 7Es constructivist instructional strategy gained in achievement more than their female counterparts while female students taught Chemistry with Guided discovery learning strategy acquired gained more in achievement than their male counterparts though their differences is statistically insignificant

iii. There is no interaction effect of method and gender on students' achievement in Chemistry.

On the effect of 7ECIS on students' achievement in Chemistry; showed that a significant difference exists among the mean achievement scores of students taught chemistry using 7ECIS and guided discovery learning strategy. This means that 7ECIS adopted in teaching of chemistry is significant in enhancing students' achievement in Chemistry. This therefore implies that the two strategies are not of equal strength. The finding on effectiveness of 7CIS based on achievement agrees with that of Kosobameji (2022) in Lagos State whose results showed that the 7ECIS is superior to the traditional (lecture) method and the difference was significant. The study by Abdullahi et al. (2021) in Nigeria also showed a significant difference between 7E model and the traditional approach. Adolphus et al. (2021) in Delta State revealed among others that there was statistical significant improvement in student's achievement in chemical equilibrium after exposure to 7E's instructional approach. Cherono (2021) in Kenya also revealed that students in the experimental group (7E Learning Cycle Model) performed better than students in the control group (traditional method). Also, on the effectiveness of 7E, Libata et al. (2021)

revealed that the experimental group students evidenced more learning achievements than the control group students. This shows that the 7ECIS is an effective way of improving students' academic achievement. Nilda (2021) in Masapang also revealed that there was a significant difference between the academic achievement of learners who used 7E model and traditional approach; and the students performed and developed critical thinking skills better with 7E model. Also, Villacrusis and Beloy (2021) revealed that there was a significant difference between the posttest and pretest mean scores of the experimental (7Es Instructional Mode) and control (Traditional method) groups; and the category: Explore, Explain, Elaborate and Extend promote high scores in the Science Achievement Test.

The finding based on students improved achievement also agrees with the study by Adak and Chatterjee (2019) in India revealed that the students exposed to the 7ECIS significantly achieved better than traditional method; since it was capable of improving student's mastery of content at the higher order levels of cognition. The finding also agrees with Maskur et al. (2019) who revealed that the use of the 7ECIS is sufficient to improve the learners' understanding of temperature and heat concepts. And, this was seen from the success of the learning process that integrated the whole seven stages with the seven indicators of conceptual understanding. Thus, the7ECIS could be effectively applied and can increase the students' conceptual understanding; and by implication enhances students' achievement in Chemistry.

The finding based on achievement agrees with that of Naade et al (2018) in Rivers State that showed that the mean score of the experimental group (7Es) was higher than the mean score of the control group. The study by Naade et al also revealed that there was statistically significant difference between mean scores of those exposed to 7ECIS and those exposed to the traditional method. It also agrees with Miadi et.al. (2018) that found out that the student's cognitive abilities also improved with the application of the 7E model. More so, the finding agrees with Turgut et al (2017) who observed that the students taught with the 7E model perceived the lessons more enjoyable.

The findings of the present study also agrees with Balta and Sarac (2016) who attested that since the effect of 7ECIS in science teaching is so high, teachers should be encouraged to incorporate this strategy into their teaching, and to gradually customize it into their own personalized teaching style. The finding of this study agrees with George (2016) who also revealed that the Constructivist 7-E model is more effective than the traditional method; and the result by Khashan (2016) in Saudi Arabia also showed that the students' scores on the mathematics achievement tests indicated that the 7E's Learning Cycle is more effective than the traditional method. The results Adesoji and Idika. (2013) in Ibadan, Oyo state, also showed that there was a significant main effect of treatment (7Es) on students' achievement in Chemistry.

On the effect of gender on students' achievement in Chemistry showed that the male students taught Chemistry with 7ECIS gained in achievement more than their female counterparts though the difference was statistically insignificant. The findings of this study agreed with Kosobameji (2022) in Lagos State, showed the achievement difference of both male and female students taught using 7ECIS was not significant and affirmed that that gender has no effect on students' academic achievement. But, disagrees with Adolphus et al. (2021) who also revealed that male students performed better than female students exposed to 7ECIS when compared to other traditional method.

On the interaction effect of method and gender on students' achievement in Chemistry, the 7ECIS had significant effects on the students' achievement. However, the students' gender did not have effect on students' achievement in Chemistry. The implication is that there is no significant effects of gender and method on students' achievement in Chemistry. The findings agrees with Adewale and Effiong (2015) who revealed that interaction effects of teaching strategy and gender have no significant effect on students' achievement. This could be why Rahman and Chavhan (2022) attested that 7E Model is an effective instructional approach for teaching and learning

In the practical implication of the effectiveness of 7ECIS; it encouraged peer interaction in which students collaborated and discussed concepts (redox reaction) with a view to meaningfully understand them. This may have helped in increasing conceptual understanding among students, which may have resulted from the gains in understanding during discussions among the peer groups. The peer collaboration helped the students to interact, collaborate and discuss in trying to meaningfully understand redox reaction concepts which showed in the increased achievement of students of various intellectual abilities. This being a student-centered pedagogic approach, the 7ECIS significantly improved students' satisfaction, self-reported engagement, and critical thinking; which reflected in the increase of students' achievement in chemistry more than the conventional guided discovery used in most chemistry lessons.

CONCLUSION

From the results of the findings, it is evident that the use of 7Es constructivist instructional strategy (7ECIS) could provide a good way for students to learn concepts of redox reaction and chemistry in general. It is therefore concluded that the use of 7ECIS would enhance students' achievement in Chemistry more than the conventional more than the conventional guided discovery used in most chemistry lessons. Furthermore, the strategy is gender friendly and as well increases achievement of students in Chemistry; therefore the strategy could be used to address the present trend of poor academic achievement among secondary school students in Chemistry.

The practical implication of the findings of the study is that it has added to the existing body of knowledge and provided additional empirical evidences that 7ECIS is an effective strategy with more meaningful and result-oriented learning in imparting skills and acquiring a better understanding of redox reaction concepts. Hence, it was evidenced in higher increase in students' achievement in chemistry more than the conventional guided discovery method.

RECOMMENDATIONS

The implication of this study and the associated recommendations as it borders on chemistry education are as follows:

1. Chemistry teachers (and other science teachers) may adopt constructivist /inquiry methods like 7Es constructivist instructional strategy for the development of student's higher achievement at secondary level. Teachers may also make teaching and learning of chemistry gender-friendly and collaborative (peer interaction); and may also engage students in constructing their own ideas and information to help improve their critical thinking skills.
2. With the introduction of 7Es constructivist instructional strategy, there was more effectiveness in teaching of chemistry and enhancing student's achievement. Hence, the Ministries of Education may ensure that textbook authors incorporate this innovative, effective and efficient strategy in secondary schools when designing and redesigning the curriculum in other to enhance students' achievement in Chemistry.
3. The 7Es constructivist instructional strategy may be encouraged and integrated in Chemistry lessons as it exposes students to dynamics and richness of the subject; and helps to stimulate their curiosity and brainstorming for meaningful learning.

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