



EFFECTS OF JIGSAW IV INSTRUCTIONAL STRATEGY ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN CHEMICAL EQUILIBRIUM

DR. IHEANYI O. IGWE ¹ | DR. EMMANUEL ETU ODO ² | DR. SYLVANUS IKWEN ADOR ³ | DR SAMBA MORIBA ⁴

¹ (FCON, FCAI & MSTAN), DEPARTMENT OF SCIENCE EDUCATION, EBONYI STATE UNIVERSITY, ABAKALIKI NIGERIA

² (MSTAN), DEPARTMENT OF CHEMISTRY, EBONYI STATE COLLEGE OF EDUCATION, IKWO NIGERIA

³ FEDERAL COLLEGE OF EDUCATION, OBUDU, CROSS RIVER STATE

⁴ FREETOWN POLYTECHNIC, JUI, KOSSOH TOWN, SIERRA LEONE

ABSTRACT:

The main purpose of this research was to determine the effect of Jigsaw IV Instructional Strategy on students' achievement in chemical equilibrium. Quasi-experimental research design, involving the pretest-posttest non-equivalent control group design was adopted. The sample for the study was 186 Senior Secondary 2 (SS 2) Chemistry students. 30-item multiple choice Chemistry Achievement Test (CAT) was used for data collection. The reliability coefficients of CAT were 0.83 and 0.95 using Product Moment Correlation and KR-20 respectively. Two research questions guided the study and two null hypotheses at 0.05 level of significance were tested in the study. The research questions were answered using the mean and standard deviation while the hypotheses were tested with Analysis Covariance (ANCOVA). It was found that Jigsaw IV Instructional Strategy yielded higher achievement mean scores than the lecture method; male students had higher achievement mean scores than female students. There was a significant difference in the achievement mean scores of those taught using jigsaw IV and those taught with the lecture method. There was no significant effect of gender on students' achievement mean score. The implications of the findings were considered and it was recommended that Chemistry teachers should use Jigsaw IV Instructional Strategy to improve achievement in Chemistry. Again, governments, ministries of education and professional bodies should organize workshops and seminars for teachers to improve on the use of Jigsaw IV Instructional Strategy by Chemistry teachers.

KEYWORDS:

CHEMICAL EQUILIBRIUM, JIGSAW IV, INSTRUCTIONAL STRATEGY, ACHIEVEMENT, GENDER.

BACKGROUND TO THE STUDY

Chemical equilibrium is a concept in physical Chemistry that is concerned with the study of the state of reversible reactions under the conditions of equal rates of forward and backward reactions. It is the study of the state of a chemical system in which the composition of reactants and products remains constant over time, provided there is no change in the material and energy composition of the container. Chemical equilibrium is characterized by no apparent change in chemical and physical composition of the system.

Ikwuka and Samuel (2017) noted that chemical equilibrium is very relevant to the study of Chemistry at the secondary school level. The concept is central to secondary school Chemistry and is relevant to the understanding of aspects of many topics in the Chemistry curriculum. Such topics as thermodynamics, dissociation of water, acids and bases, gas-phase reactions, neutralization reactions, solubility and kinetics have aspects of them that are linked to the knowledge of chemical equilibrium. It is also applicable in industrial processes like the Haber and Contact processes. The wide-range of relevance and applications of chemical

equilibrium to the study of Chemistry and to industries may account for the frequency of test items drawn from the concept in certificate examinations. Observations show that public examination bodies like West African Examinations Council (WAEC) show interest in chemical equilibrium because questions on chemical equilibrium appeared in West African Senior School Certificate Examination (WASSCE) conducted by it as in May/June, 2012, 2013 and 2017 as well as in November/December, 2010 and 2011 editions (source: WASSCE Chemistry Paper 2 past questions). It is therefore likely that students' achievement in chemical equilibrium would have substantial effect on students' achievement in Chemistry.

Achievement refers to performance outcome that indicates the extent to which a person has attained specific goals that were the focus of activities in instruction (Steinmayr, Meibner, Weidinger and Wirthwein, 2014). Levin (2013) defined achievement as an individuals' academic level of accomplishment or proficiency across subject areas. Achievement is measured in terms of test scores, grades, and overall academic ability. Achimugu (2016) stated that there is persistent poor achievement of secondary school students in Chemistry in public examinations. Opara and Waswa (2013) and Asabe (2014), independently observed

that despite the key role of Chemistry as the central science which forms the foundation of many professions and that Chemistry also improves the quality of life, poor achievement of students in Chemistry has for many years remained a matter of serious concern. Similarly, Edomwonyi-Otu and Ajayi and Ogbaba (2017) stated that despite the prime position Chemistry occupies in the educational system and the effort made by researchers to enhance performance in Chemistry, achievement is still poor.

The low achievement in Chemistry can be traced to low achievement in chemical equilibrium. The WAEC Chief Examiner's Report (2015) observed that questions on chemical equilibrium were not popular among students while most of those who attempted the questions performed poorly in them. This means that the achievement of students in questions on chemical equilibrium was low. Generally, poor achievement in Chemistry has been traced to some factors, among which are socioeconomic status, demographic factors, gender, environment and method of teaching (Levin, 2013; Akinsola in Okeke, 2015; Omiko, 2015; Achimugu, 2016). However, this study concentrated on the effect of Jigsaw IV Instructional Strategy as a method of teaching male and female Chemistry students. The findings will apply to achievements in specific contents such as chemical equilibrium. It is important, therefore, that research should seek for appropriate strategies to teach the contents. This is why this study sought to determine the effect of Jigsaw IV Instructional Strategy on students' achievement in chemical equilibrium.

Akinsola in Okeke (2015) stated that most teachers still believe that the most effective means of communicating knowledge is via the conventional approach (lecture method). Omorogbe and Ewansiha (2013) stressed that the teaching of science has been reduced to descriptive exercises, using mainly expository methods (lecture method), and this has reduced efficiency. The lecture method is characterized by talking, writing and issuing notes by the teacher while the learner listens passively. When used the focus is on the teacher and his knowledge base as the centre of teaching (Barirani, 2014). Also, teaching is regarded as a process of transferring stored knowledge, cultural values and vital skills into the new generation (Gelisli, 2009). The learner learns by committing the information into memory (rote learning). The use of lecture method in teaching Chemistry concepts worsens students' understanding of Chemistry concepts already perceived difficult, one of which is chemical equilibrium. Based on this conviction, the opinion of Uzoechi (2013) that science education programmes must focus attention on innovative teaching methods that can promote creative, critical and reflective thinking in scientific problem-solving is relevant to the teaching of chemical equilibrium for students to achieve better in the concept and transfer same to related concepts and the industry. Innovative approaches used in teaching Chemistry concepts include co-operative learning

strategies, peer tutoring strategies, collaborative instructional strategies and Jigsaw instructional strategies. However, this research is set to determine the effect of Jigsaw IV Instructional Strategy on students' achievement in chemical equilibrium.

Jigsaw is a strategy that involves students working in groups to become experts on specific topics (Trent, 2013). It is a learning strategy in which the members of the class are organized into groups, and then rearranged in new groups to share their learning. In practice, a jigsaw class is divided into several small groups (home groups) of the same or related subtopics/segments of the topic to be learnt. After preparation of the subtopics/segments, the class then re-groups into new groups (expert groups), with a member from each of the home groups with corresponding subtopics/segments forming part of the expert group. Students in the expert group interact and become 'experts' in the respective subtopics. Each member will then go back to his 'home group' to interact, with the experts in each subtopic taking turns to teach their respective home groups the aspect of the topic in which they are experts. This is followed by a class assessment. The procedures according to Turacoglu, Alpat and Ellez (2013:19) are outlined in steps as follows:

STEP 1: Groups of 3-7 are formed and different subtopics of the topic are distributed to members to work on. This is the home group.

STEP 2: Members leave their home groups to form specialization groups with other students responsible for the preparation of the same subtopic with them.

STEP 3: Back to their home groups each student teaches the subtopic which he studied in the specialization groups.

STEP 4: All the students are then assessed on the topic.

There are types of Jigsaw strategies available for use in the classroom (Sahin, 2010; Fini, Zainalipour and Jamiri, 2012; Timayi, Bolaji and Kajuru, 2015). They include: Jigsaw (I) developed by Aronson and Shelley in 1978, Jigsaw (II) developed by Slavin in 1986, Jigsaw (III) developed by Stahl in 1994, Jigsaw (IV) developed by Holliday in 1995.

The Jigsaw IV derives its root from the Social Learning Theory, which according to Tran (2013) was developed by Albert Bandura in 1971. According to the theory, much learning occurs by observing, modelling and imitating models. The major premise of the theory is that learners can improve their knowledge and retention by observing and modelling the desired behaviours, attitudes and reactions of others (Schunk, 2007). The theory presupposes that learning environment should provide opportunities for social interaction that would facilitate observation and modelling of desired behaviour. As observed by Schunk (2007) and Tran (2013) most learning occurs in a social environment through triangular reciprocal interactions: person, behaviour, and environment. The implication is that the three interactions influence each other mutually to effect learning goals. These interaction patterns characterise Jigsaw IV Instructional Strategy. According to Sahin (2010) Jigsaw

strategy is based on group dynamics and social interactions. Problems of social interaction were the primary motivators of the Jigsaw instruction. Timayi, Bolaji and Kajuru (2015:15) stated that the Jigsaw learning technique was developed by Elliot Aronson and his colleagues in 1978 "with the goals of reducing conflict, enhancing positive educational outcomes, helping students realize they are essential components of a whole and encouraging cooperation in a learning environment".

There is a dichotomous factor in students' achievement, which is gender. Nzewi (2013) and Ifamuyiwa (2013) independently stated that achievement depends on gender. Evans, Schweingruber and Stevenson (2002) also found significant gender differences in the achievement of students. Research findings on the pattern of dependence of achievement on gender are still controversial. Atomatofa (2014) found that there was no significant difference between the overall achievement of male and female students taught Basic Science using inquiry, demonstration and lecture methods. Ezenwosu and Nworgu (2013) conducted an achievement test and found that males achieved better than females. This pattern may as well be the same with chemical equilibrium. On the contrary, Ukozor (2011) stated that students' achievement by gender depend on the strategy used by the teacher. This agreed with the finding by Uhumuavbi and Mamudu (2009) that the difference in achievement of male and female students in science depends on the strategy used by the science teacher. Mari in Fatokun, Egya and Uzoechi (2016) maintained that teaching strategy is a variable that can easily be manipulated by teachers to increase performance and reduce or eliminate sex-related differences in science. This research therefore, sought to determine the effect of the Jigsaw IV Instructional Strategy on students' achievement in chemical equilibrium based on gender.

Evidence from empirical reports showed that Jigsaw IV Instructional Strategy has been employed to enhance students' achievement in many subject areas and concepts. Fini, Zainalipour and Jamri (2012) carried out investigation into the effect of jigsaw technique on the academic achievement of 2nd-grade middle school students in Bandar Abbas City of Iran. The study adopted semi-experimental (quasi-experimental) pre-test, post-test experimental control group design. A total of 153 students (89 girls and 64 boys) were used from two randomly selected schools to represent a population of 4126 2nd-grade students (1961 girls and 2165 boys). The researchers used two intact classes from each sample school (one experimental treatment and one lecture method as control).

The pre-test and post-test scores from the tests were analyzed using the Analysis of Variance (ANOVA). The results showed that Jigsaw technique significantly improved academic achievement as compared with the mean scores gained by the control group. The research was however, limited by the use of two groups (experimental and control) from the same school which is

prone to experimental errors. The sample was gender dichotomized, the analysis failed to take account of possible gender effects. The research report also failed to indicate the topics or subject taught. The study is relevant to the present study because it investigated the effect of jigsaw technique on achievement as was the case in the present study. Intact classes were used and data collected as pretest-posttest scores.

In summary, literature is vivid on the evidence of poor and declining achievement of students in Chemistry in general. Inappropriate methods of teaching have been identified as a major cause of the low and declining achievement. In particular, the predominant use of lecture method the delivery of Chemistry concepts has been found to hinder meaningful students' achievement. Innovative strategies such as jigsaw strategies have produced better results in many subject areas and concepts. It is believed similar better results would replicate when Jigsaw IV Instructional Strategy is used to teach chemical equilibrium concepts. This research therefore determined the effect of Jigsaw IV Instructional Strategy on students' achievement in Chemical Equilibrium.

STATEMENT OF THE PROBLEM

There have been evidence-based reports of poor performance of secondary school students in Chemistry in public examinations. Chief examiners' reports on senior school certificate examinations in Chemistry organized by the West African Examinations Council are replete with consistent observation of poor achievement of students in these examinations. The persistent students' poor achievement in Chemistry is of serious concern.

Poor achievement in Chemistry has been blamed on some factors, and particularly on method of teaching and learning of the subject. Research reports have linked the low achievement to predominant use of teacher centred approaches like the lecture method. Specifically, lack of active involvement of students seems to be responsible for the poor achievement of students taught using the lecture method. If this scenario continues, the achievement of students will continue to be poor and economic development of Nigeria would be low.

The problem of this study therefore, when put in question form is: "what will be the effect of Jigsaw IV Instructional Strategy on students' achievement in chemical equilibrium"?

PURPOSE OF THE STUDY

The general purpose of the study was to determine the effect of Jigsaw IV Instructional Strategy on the achievement of secondary school Chemistry students. In specific terms, the study determined the

1. Effect of Jigsaw IV Instructional Strategy on secondary school Chemistry students' achievement in chemical equilibrium.
2. Effect of Jigsaw IV Instructional Strategy on male and female secondary school students' achievement in chemical equilibrium.

SCOPE OF THE STUDY

This study was delimited to determining the effects of Jigsaw IV Instructional Strategy on the interest of secondary school students. The subjects (students) of the study were SS II Chemistry students in selected senior secondary schools in Onueke Education Zone of Ebonyi State. The schools used were those where the regular SS II Chemistry teachers hold at least B.Sc (Ed)/B.Ed in Chemistry Education. The aspects of Chemical Equilibrium taught were: concept of equilibrium; law of mass action and equilibrium constant; Le Chaterlier's Principle and Factors affecting chemical equilibrium; and industrial applications of Le-Chatelier's Principle (Haber and Contact Processes).

RESEARCH QUESTIONS

The researcher sought to answer the following research questions:

1. What is the effect of Jigsaw IV Instructional Strategy on secondary school Chemistry students' achievement mean scores in Chemical Equilibrium?
2. What is the effect of Jigsaw IV Instructional Strategy on male and female secondary school students' achievement mean scores in Chemical Equilibrium?

HYPOTHESES

The following hypotheses were tested at 0.05 alpha level:

HO₁: There is no significant difference in achievement mean scores of students taught chemical equilibrium using Jigsaw IV Instructional Strategy and those taught using the Lecture Method.

HO₂: There is no significant difference between the achievement mean scores of male and female secondary school students when taught chemical equilibrium using Jigsaw IV Instructional Strategy.

METHODOLOGY

The research adopted quasi-experimental, pre-test, post-test non-equivalent control group design. This design is appropriate for this study because the subjects were made up of one treatment group and one control group where each group had subjects from intact classes.

THE DESIGN IS REPRESENTED THUS:

O_1	X_1	O_2	(E)
O_3	X_2	O_4	(C)

Where O_1 and O_2 are pre-tests for Jigsaw IV Instructional Strategy and Lecture Method respectively. X_1 is the treatment (Jigsaw IV Instructional Strategy) and X_2 is the Control condition (Lecture Method). E is the treatment group while X_2 is the control condition

The study was carried out in Onueke Education Zone of Ebonyi State Nigeria. Onueke Education Zone covers Ezza North, Ezza South, Ikwo and Ishielu Local Government

Areas of Ebonyi State. Ebonyi State is bounded in the North by Benue State, in the South by Abia State, East by Cross River State, and in the West by Enugu State. It is divided into three education Zones (Abakaliki, Onueke and Afikpo Education Zones). Ebonyi State is one of the States of Nigeria designated as educationally disadvantaged.

The population of the study comprised 1,498 Chemistry students in SS 2 in public schools in Onueke Education Zone of Ebonyi State (source: Secondary Education Board, Onueke Zonal Headquarters, Onueke, 2017). The choice of this target population was informed by the fact that chemical equilibrium was taught in SS 2 of the secondary school programme.

Purposive sampling technique was used to choose the schools. The criteria used were that the schools must have up to 20 Chemistry students in SS II and the Chemistry teacher must possess at least B. Sc./B. Ed in Chemistry education. The final list of schools used was arrived at through simple ballot with replacement of schools that met the criteria after the purposive sampling. Through this process, six schools were selected.

The six schools were grouped into two clusters, with three schools per teaching group. Each group was made up of schools that were closer to one another to avoid students in one treatment group communicating with students in the other group on the content of the topic taught. Simple ballot was used to assign clusters to treatment and control groups. The treatment group was made up of 49 male and 42 female students from three secondary schools in the Zone while the control group was made up of 43 male and 52 female students, giving a total sample size of 186 students.

The instrument used to collect data for the study was researchers' made test entitled: Chemistry Achievement Test (CAT). The instrument was divided into two sections: section A and section B. Section A required information on the bio-data of the subjects. Section B contained thirty multiple choice questions, each with four options (a, b, c and d) where the subject was required to choose the correct answer from the options. The items tested the research subjects on the understanding of the topics taught. CAT was used as pre-test and post-test instrument to determine students' achievement.

Initial draft of CAT contained 35 items and was face-validated by three experts; one in Chemistry, one in Psychology and the third in measurement and evaluation, all from Ebonyi State University, Abakaliki, Nigeria. The validators were requested to vet CAT instrument based on:

- Content coverage for the achievement test items;
- Relevance of the drafted items to stated specific purposes of the study;
- Clarity of the level of language to the students.

Some of the items of CAT were restructured but none was dropped. Then the face validated CAT was administered to thirty (30) SS 2 Chemistry students for trial testing. The test (answering of CAT) lasted for 45 minutes.

The first scores for CAT were used for difficulty index analysis of the items (where accepted values were between 0.40 – 0.60) and discriminating power (whose accepted values were 0.40 and above). By this analysis, five (5) items were not accepted. This reduced the number of items of CAT to 30, which was used to establish the test-blue print.

The CAT was subjected to test-re-test to determine its reliability using Pearson Product Moment Correlation. This analysis gave a reliability coefficient of 0.83. The data from the trial test was also subjected to another test of reliability through Kuder-Richardson-20, which gave a reliability coefficient of 0.95 showing very high internal consistency.

EXPERIMENTAL PROCEDURES

The researchers used the permanent Chemistry teachers in the sample schools to teach the Chemical equilibrium topics in their respective intact classes.

(i) Procedure for Jigsaw IV Instructional Strategy

The following steps were followed in the implementation of the Jigsaw IV Instructional Strategy. The steps formed the framework. Adjustments were made by respective Chemistry teachers to accommodate environmental realities. The researchers explained to the research assistants the procedures for the experimental treatment and group.

THE STEPS WERE AS FOLLOWS:

1. Administration of Chemistry achievement test to the students as the pretest.
2. How the model worked and why it was used in teaching and how the students could benefit from its implementation were explained to students; highlighting specifically, the role of the students in their groups.
3. Students divided into 5–6 person Jigsaw IV groups (**home groups**) and one student from each group appointed as a leader.
4. A subtitle/subtopic/segment of the day's lesson was assigned to each student in the group to learn; using codes for subtitles across groups as shown below:

A1, B1, C1, D1, E1, F1, G1, H1,(n)1:
subtitle/subtopic/segment 1.

A2, B2, C2, D2, E2, F2, G2, H2,(n)2:
subtitle/subtopic/segment 2

A3, B3, C3, D3, E3, F3, G3, H3,(n)3:
subtitle/subtopic/segment 3.

A4, B4, C4, D4, E4, F4, G4, H4, ... (n)4:
subtitle/subtopic/segment 4.

A5, B5, C5, D5, E5, F5, G5, H5, (n)5:
subtitle/subtopic/segment 5

Where 1, 2, 3, 4, 5 stand for subtitles of the lesson.

5. Students were given time to study their own subtitle in details.
6. Students then moved to '**expert groups**' where each expert group had at least a member of each 'home group' who were assigned the same subtitles. The students in the expert group, led by a leader chosen by them, discussed the main points of their subtitle, ensuring active participation of each 'expert'. Each member took note, ready to present the subtitle in his or her 'home group'.
7. The students then moved back to their respective home groups where they took turns to teach their groups what they learnt from the expert groups.
8. At the end of the group interactions, the students return to the class for general review and assessment by the teacher.

(ii) Procedure for the Lecture Method

The CAT was administered on the students as pre-test. The regular Chemistry teachers used the lesson plans for Lecture method which was prepared by the researchers. The teacher taught chemical equilibrium using the lecture approach for the same period as for the treatment group. At the end of the teaching, the teacher administered the instrument again as post-test.

METHOD OF DATA COLLECTION

Before the treatment, CAT was administered on the subjects as pretest. Respondents were given 45 minutes to respond to CAT. At the end of the treatment CAT was administered again on the subjects for the same durations as post-test. Before using the instrument as post-test, the items were reshuffled to ensure that the pre-test did not influence the responses in the post-test that might result from familiarity with the items.

METHOD OF DATA ANALYSIS

Each item in CAT was scored 3.33 and total score for each student collated for both pre-test and post-test. Similarly, each item in CIS was weighted and total value collated. The mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) statistic was used to test the hypotheses at 0.05 alpha levels.

RESULTS

The results of data analysis are presented in Tables

according to the research questions and hypotheses.

RESEARCH QUESTION 1: What is the effect of Jigsaw IV Instructional Strategy on secondary school students' achievement mean score in Chemical Equilibrium?

TABLE 1: ACHIEVEMENT MEANS SCORE OF CHEMISTRY STUDENTS BASED ON TEACHING METHODS

Teaching Method	N	Adjusted Mean \bar{X}	Standard Deviation
Jigsaw IV Instructional Strategy	91	63.41	5.98
Lecture Method	95	45.53	4.30

As shown in Table 1, the achievement mean score of students taught Chemical Equilibrium using the Jigsaw IV Instructional Strategy was 63.41 while the standard deviation is 5.98. The Table also shows that the achievement mean score for the students taught Chemical Equilibrium using lecture method was 45.53 with standard deviation of 4.30. The results show that Jigsaw IV

Instructional Strategy yielded greater achievement mean score than the lecture method.

RESEARCH QUESTION 2: What is the effect of Jigsaw IV Instructional Strategy on male and female secondary school students' achievement mean score in Chemical Equilibrium?

TABLE 2: ACHIEVEMENT MEANS SCORE OF STUDENTS BASED ON GENDER

Gender	N	Adjusted Mean \bar{X}	Standard Deviation
Male	49	63.73	6.61
Female	42	63.02	5.21

The results in Table 2 show that the achievement mean score and its standard deviation for male were 63.73 and 6.61 respectively. The Table also reveals that the achievement mean score for female students in the group was 63.02, with its standard deviation as 5.21. From the results, male students taught Chemical Equilibrium using the Jigsaw IV Instructional Strategy had higher

achievement means score than female students taught using the same method.

HO₁: There is no significant difference in achievement mean scores of students taught Chemical Equilibrium using Jigsaw IV Instructional Strategy and those taught using the lecture method.

TABLE 3: ANCOVA RESULTS OF ACHIEVEMENT MEAN BASED ON METHODS OF TEACHING

Source of variation	Sum of Squares	DF	Mean Square	F	Sig. of F
Covariates	76.408	1	76.408	2.854	0.093
Pre-test	76.408	1	76.408	2.854	0.093
Main Effects	14887.638	2	7443.819	278.047	0.000
Methods	14734.558	1	14734.558	550.376	0.000
Gender	3.404	1	3.404	0.127	0.722
2-Way Interactions	5.271	1	5.271	0.197	0.658
Methods X Gender	5.271	1	5.271	0.197	0.658
Explained	14969.317	4	3742.329	139.786	0.000
Residual	4845.699	181	26.772		
Total	19815.016	185	107.108		

Method: Significant at $p < 0.05$;

Table 3 showed that the significance of "F" as 0.000. Since the significance of F (0.000) is less than alpha level of 0.05, HO₁ was not accepted. This means that there is a significant difference in the achievement means scores of students taught Chemical Equilibrium using Jigsaw IV

Instructional Strategy and those taught using the Lecture Method.

HO₂: There is no significant difference between the achievement mean scores of male and female students when taught Chemical Equilibrium using Jigsaw IV

Instructional Strategy.

TABLE 4: ANCOVA RESULTS OF STUDENTS' ACHIEVEMENT IN CHEMICAL EQUILIBRIUM BASED ON GENDER

Source of variation	Sum of Squares	DF	Mean Square	F	Sig. of F
Covariates	75.618	1	75.618	2.123	0.149
Pre-test	75.618	1	75.618	2.123	0.149
Main Effects	7.938	1	7.938	0.223	0.638
Gender	7.938	1	7.938	0.223	0.638
Explained	83.556	2	41.778	1.173	0.314
Residual	3134.400	88	35.618		
Total	3217.956	90	52.75		

Interaction is not Significant at $p > 0.05$

Table 4 showed that the significance of "F" with regard to gender was 0.638. Since the significance of "F" (0.638) is greater than the alpha level (0.05), H_0 was accepted. This means that there is no significant difference between achievements means scores of male and female students who were taught Chemical equilibrium using Jigsaw IV Instructional Strategy.

SUMMARY OF FINDINGS

The following is the summary of the findings of the research:

1. Secondary school students taught Chemical Equilibrium using Jigsaw IV Instructional Strategy had higher achievement mean score than students taught using the Lecture method.
2. Male students taught Chemical Equilibrium using the Jigsaw IV Instructional Strategy had higher achievement mean score than female students in the group.
3. There was a significant difference between achievement mean scores of students taught Chemical Equilibrium using Jigsaw IV Instructional Strategy and those taught using the lecture method.
4. There was no significant difference between the achievement mean score of male and female secondary school students taught Chemical Equilibrium using Jigsaw IV Instructional Strategy.

DISCUSSION

It was found that students who were taught Chemical Equilibrium using the Jigsaw IV Instructional Strategy had higher achievement mean score than those taught using the lecture method. Also, H_0 which stated that there is no significant difference in the achievement mean scores of students taught Chemical Equilibrium using Jigsaw IV Instructional Strategy and those taught using lecture method was not accepted. This means that there was a significant difference between achievement mean scores of students taught Chemical Equilibrium using Jigsaw IV Instructional Strategy and those taught using the lecture

method.

The greater effect of the Jigsaw IV Instructional Strategy on the achievement mean scores may have been due to active participation, interaction and cooperation of students in the teaching and learning process used in the Jigsaw IV Instructional Strategy class. The strategy is believed to have provided conducive teaching and learning environments which promoted active involvement of students in a collaborative manner. These findings make the Jigsaw IV Instructional Strategy a useful strategy in teaching Chemical Equilibrium. The findings agree with Abbas (2009), Timayi, Bolaji and Kajuru (2015) and Okeke (2015) that Jigsaw instructional strategy improved achievement mean scores very highly. The specific contribution of this particular finding of the present study is that it has shown that Jigsaw IV Instructional Strategy may equally be effective in enhancing students' achievement in other Chemistry concepts in general.

Table 2 revealed that the achievement mean score for male students (63.73) was slightly greater than the achievement mean score of female students (63.02). This means that male students had slightly higher achievement mean score than the female students. This result could mean that male students achieved higher because of the students' greater interest in Chemical Equilibrium when taught using the Jigsaw IV Instructional Strategy. The finding agrees with the long held view that male students perform better than the female students in science. The finding agrees the critical view of the assertion by Oludipe (2012) that gender differences in science achievement is fast disappearing.

H_0 was not rejected, meaning that there is no significant difference between achievements means scores of male and female secondary school students when taught chemical equilibrium with Jigsaw IV Instructional Strategy. Therefore the Jigsaw IV Instructional Strategy does not discriminate between genders when used to teach Chemical Equilibrium. In terms of achievement mean scores, the finding agrees with that of Ezenwosu and Nworgu (2013) that male students achieved better than female students in achievement test. However, the result

disagrees with Okorie and Eze (2016) that the achievement mean score of female students in chemical bonding was greater than that of male students.

Similarly, Shaibu and Mani in Nworgu, Ugwuanyi and Nworgu (2013) found that female students achieved higher in science processes. The finding that there was no significant difference between the achievement mean scores of male and female secondary school students when taught Chemical Equilibrium using Jigsaw IV Instructional Strategy is consistent with Ibiri (2012), Godpower-Echie and Amadi (2013), Richman (2014) and Godpower-Echie and Ihenko (2017) who independently reported no significant difference between achievement mean scores of male and female students.

EDUCATIONAL IMPLICATIONS OF THE FINDINGS

If used by Chemistry teachers, Jigsaw IV Instructional Strategy will result to high students' achievement. Secondly, if curriculum planners incorporate Jigsaw IV Instructional Strategy into curriculum implementation guides, Chemistry teachers will make use of Jigsaw IV Instructional Strategy more effectively and that will increase students' achievement in chemical equilibrium and related concepts.

Also if Jigsaw IV Instructional Strategy is incorporated into Chemistry teachers training programmes it will prepare teachers for better use of the strategy in teaching Chemistry. It also implies that failure to use the strategy by teachers or to incorporate the strategy into curriculum plans and Chemistry teacher training programmes will deny Chemistry education the benefits of Jigsaw IV Instructional Strategy, that of enhancing students' achievement.

If the Chemistry teacher uses the Jigsaw IV Instructional Strategy it will result to no discrimination in achievement based on gender. Also when the strategy is used it will make the female students to realize their potentials in Chemistry, hence increase their confidence in Chemistry resulting to higher achievement. On the contrary, if Jigsaw IV Instructional Strategy is not used in teaching Chemistry these benefits due to the use of the strategy may have been lost.

RECOMMENDATIONS

Based on the findings the researcher recommended as follows:

1. Chemistry teachers should use Jigsaw IV Instructional Strategy in teaching Chemistry in secondary schools as it enhances achievement as seen in Chemical Equilibrium concepts.
2. Chemistry teacher training programmes should incorporate the development of skills of using Jigsaw IV Instructional Strategy by pre-service Chemistry teachers.
3. Ministries of Education and Boards in charge of secondary education should organize workshops for serving Chemistry teachers on the use of

Jigsaw IV Instructional Strategy.

4. Professional bodies like Science Teacher Association of Nigeria (STAN) should incorporate in their workshops, the training of Chemistry teachers on the effective use of Jigsaw IV Instructional Strategy in Chemistry classrooms.
5. Governments and agencies that finance educational research should encourage and finance research to further develop and improve on effective and innovative teaching strategies such as Jigsaw IV Instructional Strategy.

CONCLUSION

Research evidences have shown that students' achievement in Chemistry has been poor in public examinations. The persistent poor achievement in Chemistry has been of great concern to Chemistry educators and researchers. Among the factors responsible for the poor achievement was the use of inappropriate teaching methods especially the lecture method.

This research was aimed at finding the effects of Jigsaw IV Instructional Strategy on secondary school students' achievement in Chemical Equilibrium in order to determine the effectiveness of the strategy in improving students' achievement. The findings of the study showed that Jigsaw IV Instructional Strategy improved students' achievement in Chemical Equilibrium tremendously. Recommendations were proffered which the researchers believed that when they are implemented, poor achievement in Chemistry in public examinations will significantly be reduced in Ebonyi State.

ACKNOWLEDGEMENTS

The authors very highly appreciate the kind gesture of the Management of Ebonyi State College of Education, Ikwo for financially sponsoring the Doctor of Philosophy (Ph.D) programme that yielded this research paper. The authors are also grateful to the Heads of secondary schools used for the field work of this study. The researchers hereby state unequivocally that there is no conflict of interest between them or the sponsoring Institution in the entire work carried out.

REFERENCES

1. Abbas D. (2009). The effect of jigsaw instructional strategy on senior secondary school class one students' achievement and interest in geometric construction. *African Research Review*, 7(3), 156-167.
2. Achimugu, L. (2016). Factors affecting the effective implementation of senior secondary education Chemistry curriculum in Kogi State, Nigeria. *International Journal of Scientific and Research Publication*, 6(5), 562-566.

3. Ajayi, O. V. & Ogbeba, J. (2017). Effect of gender on senior secondary Chemistry students' achievement in stoichiometry using hands-on activities. *American Journal of Education Research*, 5(8), 839-842.
4. Asabe, M. B. (2014). Impact of conceptual instructional method on students' academic achievement in practical Chemistry among secondary school students in Zaria Education Zone, Kaduna State Nigeria. *Journal of Education and Human Development*, 3(2), 351-360.
5. Atomatofa, R. O. (2014). Effects of instructional techniques and gender on Basic Science students' achievement in Nigeria. *Academic Journal of Psychological Studies*, 3(3), 207-217.
6. Barirani E. (2014). Technology and student-centred learning. Retrieved From http://etec.ctlt.ubc.ca/510wiki/Technology_and_Student-Centred_Learning 20th February, 2017.
7. Edomwonyi-otu, L. & Aava, A. (2011). The challenge of effective teaching of Chemistry: A case study. *Leonardo Electronic Journal of Practices and Technologies*, 10 (18), 1-8.
8. Evans, E. M., Schweingruber, H. & Stevenson, H. W. (2002). Gender Differences in Interest and Knowledge Acquisition: The United States, Taiwan, and Japan. *Sex Roles*, 47(3/4). Retrieved from www-personal.umich.edu/~evansem/Sex_Roles.pdf on 20th April, 2016.
9. Ezenwosu, S.U. & Nworgu, L. N. (2013). Efficacy of peer tutoring and gender on students' achievement in Biology. *International Journal of Scientific and Educational Research (IJSER)*, 4 (12), 944-950.
10. Fatokun, K. V. F., Egya, S. O. & Uzochi, B. C. (2016). *Effect of game instructional approach on Chemistry students' achievement and retention in periodicity*. *European Journal of Research and Reflection in Educational Sciences*, 4(7), 29-40.
11. Fini, A. A., Zainalipour, H. & Jamri, M. (2012). An investigation into the effect of cooperative learning with focus on jigsaw technique on the academic achievement of 2nd-grade middle school students. *Journal of Life Science & Biomed*, 2(2), 21-24. Retrieved from jjesb.science-line.com/attachments/articles/10/JLSB-2012-B4.pdf on 12th February, 2017.
12. Gelisli, Y. (2009). The effect of student centred instructional approaches on student success. *Procedia Social Sciences* 1, 467-473. Retrieved from www.sciencedirect.com on 20th February, 2017.
13. Godpower-Echie, G. & Amadi, J. (2013). Attitude and gender differences on students' achievement in Chemistry. *New Era Research Journal of Human Education and Sustainable Development*, 6(3), 64-68.
14. Godpower-Echie, G. & Ihenko, S. (2017). Influence of gender on interest and academic achievement of students of Integrated Science in Obio Akpor L. G. A. of Rivers State. *European Scientific Journal*, 13(10), 272-279.
15. Ibiri, T. I. (2012). Influence of cultural differences on educational choices of students in modern times. *Journal of Modern Educational Advancements*, 3(5), 16-21.
16. Ifamuyiwa, A. S. (2013). Gender differences in secondary school students' computer anxiety, knowledge and utilization in B. Akpan (ed.), *Science Education: A Global Perspective*. Abuja: Next Generation Education Ltd.
17. Ikwuka, O. I. & Samuel, N.N.C. (2017). Effect of computer animation on Chemistry academic achievement of secondary school students in Anambra State, Nigeria. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS)*, 8(2), 98-102.
18. Levin, H. (2013). Measuring what matters in education: Broader measure of success in people for education. Retrieved from <http://www.peopleforeducation.ca/broader-measures-of-success-2013.pdf> on 7th July, 2017.
19. Nworgu, B. G., Ugwuanyi, C. S. & Nworgu, L. N. (2013). School location and gender as factors in senior secondary school students' conceptual understanding of force and motion. *International Journal of Educational Research and Technology*, 4(4): 71-76.
20. Nzewi, U.M. (2013). Gender issues in STEM education: The way forward in B. Akpan (ed), *Science Education: A Global Perspective*. Abuja: Next

Generation Education Ltd.

21. Okeke, A. M. (2015). Effect of jigsaw instructional strategy on student's achievement and interest in quadratic equation in Nsukka education zone. *Unpublished M. Ed thesis, university of Nigeria, Nsukka Educational Zone.*
22. Okorie, E. U. & Ezeh, D. N. (2016). Influence of gender and location on students' achievement in chemical bonding. *Mediterranean Journal of Social Science, 1*(3), 309-318.
23. Oludipe, D. I. (2012). Gender difference in Nigerian junior secondary students' academic achievement in science. *Journal of Education and Social Research, 2*(1), 93-99.
24. Opara, F. & Waswa, P. (2013). Enhancing students' achievement in Chemistry through piagetian model. *The learning cycle. International Journal for Cross-Disciplinary Subjects in Education, 4*(4), 1270-1278.
25. Omiko, A. (2015). Laboratory teaching: Implication on students' achievement in Chemistry in senior secondary schools in Ebonyi State of Nigeria. *Journal of Education and Practice, 6*(30), 206-213.
26. Omorogbe, E. & Ewansiha, J. C. (2013). The challenge of effective science teaching in Nigeria secondary schools. *Academic Journal of Interdisciplinary Studies (AJIS), 2* (7), 181-188.
27. Richman, E. I. (2014). *Career guide for the young school leavers.* Mbaise Nigeria: Hero Publishers.
28. Sahin, A. (2010). Effect of Jigsaw II technique on academic achievement and attitudes to written expression course. *Educational Research and Reviews, 5*(12), 777-787.
29. Schunk, D. H. (2007). *Learning theories: An educational perspective (4th ed).* New Jersey: Pearson Education.
30. Steinmayr, R. Meibner, A. Weidinger, A. F. & Wirthwein, L. (2014). Academic achievement. Retrieved from DOI: [10.1093/obo/9780199756810-0108](https://doi.org/10.1093/obo/9780199756810-0108) on 5th April, 2017.
31. Timayi, J. M., Bolaji, C. & Kajuru, Y. K. (2015). Effects of Jigsaw IV cooperative learning strategy (J4CLS) on academic performance of secondary school students in Geometry. *International Journal of Mathematics Trends and Technology, 28* (1), 12-18
32. Tran, V. D. (2013). Theoretical perspectives underlying the application of co-operative learning in Classrooms. *International Journal of Higher Education, 2*(4), 101-115. Retrieved from <http://dx.doi.org/10.5430/ijhe.v2n4p1010> on 20th January, 2017.
33. Trent, K. S. (2013). The effects of the peer instruction technique think-pair-share on students' performance in Chemistry. Unpublished thesis, Louisiana State University and Agricultural and Mechanical College. Retrieved on 10th January, 2017 from <http://etd.lsu.edu/docs/available/etd-07022013-45716/unrestricted/Thesiseditorsfixes.pdf>.
34. Turacoglu, I., Alpat, S., & Ellez, A. M. (2013). Effects of Jigsaw in teaching chemical nomenclature. *Education and Science, 38* (167), 256-272.
35. Ugwu, T. U. (2014). Effect of guided inquiry methods on students' achievement and interest in Basic Science. *Unpublished M. ED dissertation, Department of Science Education, University of Nigeria, Nsukka.*
36. Uhumuavbi, P. O. & Mamudu, J. A. (2009). Relative effects of programme instruction and demonstration methods on students, academic performance in science. *College School Journal, 43*(2), 658-668.
37. Ukozor, F. I. (2011) Effect of constructivist strategy on senior secondary students' achievement in physics. *Journal of Science Technology and Mathematics Education, 1*(1), 141-160.
38. Uzoechi, B. (2013), Effective delivery of science lessons in large classes in B. B. Akpan (ed) *Science education: Global perspective.* Abuja: Next Generation Education Ltd.
39. West African Examinations Council (WAEC) (2015). Chief examiner's reports: Chemistry (2009-2014). Retrieved from <http://waeconline.org.ng/e-learning/Chemistry/chem219me.html> on 6th October, 2016.