

EFFECTS OF INQUIRY TEACHING STRATEGY ON SENIOR SECONDARY SCHOOL STUDENTS' RETENTION AND ACHIEVEMENT IN CHEMISTRY IN JALINGO**¹Jerusha Philip Danjuma and ²Mangut Mankilik****¹Department of Integrated Science, School of Sciences, College of Education, Zing. Taraba State, Nigeria, ²Department of Science and Technology Education Faculty of Education, University of Jos, Jos. Plateau State***E-mail: jpdanjuma@gmail.com***ABSTRACT**

The study investigated the Effects of Inquiry Strategy on Senior Secondary School Students' Retention and Achievement in Chemistry in Taraba State, Nigeria. It was based on the premise that over the years (2011-2021) students' achievement in secondary school Chemistry examinations in Nigeria and in Jalingo Education Zone have been poor. The fluctuating and poor results are due to teachers' use of inappropriate teaching strategy in most secondary schools that does not encourage active learning by students. The study employed the quasi-experimental of pretest-posttest non-equivalent control group research design. The target population consisted of 1,500 senior secondary two (SSII) students in 32 co-educational secondary schools. The sample consisted of 150 SSII intact group Chemistry students for the experimental and control groups. A 50 multiple-choice Periodic-Table Achievement Test (PTAT) with reliability value of $r = 0.91$ using Kuder-Richardson formula 20 was used to gather data for the study. Two research questions guided the study while two null hypotheses were tested at 0.05 levels of significance. The research questions were answered using mean and standard deviation while hypotheses were tested using Analysis of Covariance (ANCOVA). Findings from the study showed, amongst others, that Inquiry Teaching Strategy was more effective in facilitating students' retention and improved students' achievement in chemistry than the Lecture Teaching Strategy. Furthermore, the result revealed a significant difference of using ITS and LTS on SS II students' achievement and retention mean scores in Periodic-Table. Based on the findings, it was recommended among others, that Chemistry teachers should adopt Inquiry Teaching Strategy in teaching Chemistry in senior secondary schools. Stakeholders should organize workshops and seminars for in-service and pre-service Chemistry teachers on the use of Inquiry Teaching Strategy.

Key Words: Chemistry, Inquiry Teaching Strategy, Achievement, Retention, Periodic-Table

INTRODUCTION

Chemistry is the science that systematically studies compositions, structure, properties, interactions, transformations of organic and inorganic substances and various elementary forms of matter (Anaso, 2010). Nnaka (2006) opined that Chemistry deals with non-living matters. Ugwu (2014) reported that Chemistry has helped in the development of modern technology through the application of its principle in invention. It is also a necessary prerequisite and integral part of such professions as Medicine, Pharmacy, Dentistry, Agriculture, Home Economics, Food Science, Engineering and Science-related professions. With effective Chemical education, the natural resources which abound in Nigeria are harnessed, processed and converted to needed products for use by the society. Solid minerals such as coal, columbite, tin, iron ore, kaolin, limestone, gold, uranium, among others, and agricultural produce like hides and skins, rubber, palm produce, groundnut, cassava, among others would have been under-utilized without Chemistry (Eze & Egbo, 2010). Therefore, Chemistry education is one of the major bedrocks for the transformation of national economy and hence must be given adequate attention due to the gains of its learning and advancement in standard of living.

Despite the importance of Chemistry to the society, low achievement of students in Chemistry have been reported over the years in both internal and external examinations (WAEC, 2014, 2015, 2016, 2017, 2018) which indicated poor quality of Chemistry education at senior secondary school level in Nigeria and especially Taraba State (Anaso, 2010; Otor & Achor, 2015; Ajayi, Achor & Agogo, 2017). It is then a matter of necessity to think about what can be done to improve the situation as the poor achievement of students in the subject is a major concern of stakeholders in many developing country (Otor & Achor, 2015; Khan, Hussain, Ali, Majoka & Ramzan, 2011).

One of the factors said to be responsible for the fluctuating achievement is the use of inappropriate instructional strategy (Achor & Ukwuru (2013; Adejo, 2015). They maintained that teaching strategy is a variable that can be manipulated by teachers to increase student's retention and achievement rate. A situation where teachers use the expository strategies (lecture, discussion and demonstration) that are basically teacher centred does not enhance effective learning of Chemistry. Fatokun, Egya and Uzoechi (2016) reported that 60 % of Nigeria secondary school Chemistry teachers use the conventional teaching method with teacher dominated experiments which make students passive learners. Inappropriate instructional strategy is therefore recognized as a major contributor to fluctuating achievement in Chemistry. This is the reason Nzewi (2010) suggested a shift from the lecture strategy in teaching science, technology and mathematics (STM) and adopt innovative strategies for better retention and achievement in secondary schools. This researcher feels that the use of Inquiry Teaching Strategy (ITS) would be a good innovation in teaching chemistry. The chemistry curriculum recommends the use of guided ITS also.

Adejo (2015) opined that Inquiry Teaching Strategy (ITS) requires students to describe objects and events, ask questions, construct explanations, test those explanations against current or prevalent scientific knowledge and communicate their ideas to others. The outline benefits include fostering curiosity as a habit of the mind, critical thinking, scientific reasoning skills used by scientists and providing teaching strategies for motivating learning. In ITS situations, students learn not only concepts but also self-direction, responsibility and social communication. All these permit students to assimilate and accommodate information.

Retention is the term used to denote that learning has taken place and maintained over time. It may be displayed through recognition or recall. Meaningful learning is explained in terms of retention. Okeke (2007) identified poor teaching methods as one of the reasons for students' forgetfulness in learning process; those teaching strategies that alienate the learners from active participation in the learning process are responsible for forgetfulness. Retention which is the preservation of memory traces of learned experiences can affect the achievement of students in a given subject. Retention also means the storage of information over some period of time called retrieval interval and if the information cannot be produced at the end, then forgetting has occurred. Thus, this study seeks to explore the effect of inquiry strategy on the retention and achievement of senior secondary two students in chemistry in Taraba State.

Statement of the Problem

Teaching and learning of Chemistry are noted by fluctuating results by students in several achievement tests, both teacher - made and national examinations. Likely sources of this development are located in the inappropriate strategies of teaching used by Chemistry teachers. This situation is worrisome and creates serious problems to students aspiring to be medical doctors, pharmacists, biochemists, chemical engineers and other Chemistry based professions. Therefore, this trend needs to be checked.

The situation is worsened by the paucity of appropriate teaching strategies that will be valid and reliable in enhancing students' retention and achievement in Periodic-Table. Already literature is replete with evidences of the inability of lecture teaching strategy (LTS) to deliver expected knowledge implying that this situation would remain as long as alternative students' centred teaching strategies are not found and used. The concept of Periodic-Table of elements

has been established as difficult to students. Activity oriented classes are needed to enhance better understanding of the arrangements, trends and properties of all the elements on the Periodic-Table. This activity based teaching strategy is lacking in the teaching of Chemistry causing poor achievement in examination resulting from low retention. Evidence also shows that retention is lacking in Chemistry students who learn it by rote memorization of concepts.

The need to stem the tide of fluctuating achievement and increase retention in Chemistry among senior secondary school students necessitated the exploration of the ITS. The problem of the study is: what are the effects of ITS on senior secondary school students' retention and achievement in chemistry in Taraba State, Nigeria?

Aim and Objectives of the Study

Specifically, the objectives of the study were to:

1. find out the pre-test and post-test achievement mean scores of SS II students taught chemistry using ITS and those taught without it.
2. establish the retention mean scores of SS II students taught chemistry using ITS and those taught without it.

Research Questions

The following research questions guided the study.

1. What is the difference in the pre-test and post-test achievement mean scores of senior secondary two (SS II) students taught chemistry using ITS and those taught using Lecture Teaching Strategy (LTS)?
2. What is the difference in the retention mean scores of SS II students taught chemistry using ITS and those taught using LTS?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 levels of significance.

1. There is no significant difference in the pre-test and post-test achievement mean scores of senior secondary two (SS II) students taught chemistry using ITS and those taught using LTS.
2. There is no significant difference in the retention mean scores of SS II students taught chemistry using ITS and those taught using LTS.

METHODOLOGY

This study employed the quasi-experimental non-equivalent pretest posttest control group design. The design allows the use intact classes and does not allow randomization of subjects in the experimental and control groups (Lawal, 2003). The pretest was used to take care of the initial differences in the intact group. One SS II arm in each of the two schools was used for the study. From the two schools, one was used as control group and the other was used as experimental group. The design is represented symbolically as shown below:

$$\begin{array}{l} \text{EG} \rightarrow \text{O}_1 \rightarrow (\text{AC}) \rightarrow \text{X}_1 \text{O}_2 \rightarrow (\text{AC RT}_1) \\ \text{CG} \rightarrow \text{O}_3 \rightarrow (\text{AC}) \rightarrow \text{X}_0 \text{O}_4 \rightarrow (\text{ACRT}_2) \end{array}$$

Source: Nworgu (2015)

Where:

EG = Experimental group 1; CG = Control group; X_1 = Experimental treatment (Inquiry Teaching Strategy); X_0 = Control (Exposed to lecture method); O_1 & O_3 = Pretest for the EG and CG; O_2 & O_4 = Posttest for the EG, and CG; RT_1 = Retention Test for EG; RT_2 = Retention Test for CG; AC = Achievement

The population of the study was 1,500 senior secondary two (SSII) students that were currently offering Chemistry as a school subject. This comprised 1,200 male and 300 female Chemistry students spread in 32 co-educational public senior secondary schools in Jalingo

Education Zone of Taraba State for the 2019/2020 academic session (Education Resource Center, 2019).

Sample and Sampling Techniques

One hundred and five (105) SS II Chemistry students (70 males and 35 females) from two sampled co-educational secondary schools were used as sample for the study. Out of this, the experimental group had 35 males and 20 females while the control group had 35 males and 15 females. The sample distribution of the students is as shown in Table 1.

Table 1: Summary of Sampled Schools and Number of SSII Students

S/N	School	Group	Gender		Total
			Male	Female	
1.	A	EG1	35	20	55
2.	B	CG	35	15	50
	Total		70	35	105

The multi-stage sampling technique was used. First, simple random sampling procedure was used to obtain the zone used for the study. Purposive sampling procedure was used to obtain two secondary schools with comparable characteristics as: school type (public schools); school composition (co-educational schools in order to remove sex bias); the school had an SS II population of not less than 30 Chemistry students per class since intact classes would be used.

Instrument for Data Collection

Periodic-Table Achievement Test (PTAT) was developed by the researcher and used to collect data for the study. PTAT comprised two sections: A and B. Section A consisted of demographic data which elicited information on respondent's name of school, time allowed, date and gender. Section B consisted of 50-item multiple-choice questions on students' achievement and retention in secondary school Chemistry concepts of Periodic-Table. Each item had four options labeled A-D. Periodic-Table Achievement Test (PTAT) was developed using table of specification based on SSCE syllabus and scheme of work on the concept of Periodic-Table; and in conjunction with the behavioural objectives of the lesson plans for both experimental and control groups. The model answers for PTAT were provided.

Validation of the Instrument

Face and content validity of Periodic-Table Achievement Test (PTAT) were done by three experts, one from Chemistry Education Unit, the second from Test and Measurement Unit both of Faculty of Education, University of Jos and the third (a seasoned Chemistry teacher) from a secondary school in Jalingo Education Zone of Taraba State, Nigeria. A copy of PTAT was given to each of the above mentioned experts for the validation alongside the objectives of the study, research questions and hypotheses. All the experts adjudged the instrument of good quality, comprehensive, adequate, relevant and suitable for the study.

Reliability of the Instrument

To ascertain the reliability of PTAT, a pilot study was carried out in two public senior secondary schools in Takum Education Zone, Taraba State, Nigeria. The choice of these schools was because they were not part of the main study. Moreover, the schools have the same characteristics in terms of learning and quality of Chemistry teachers as the schools for the main study. The reliability coefficient of PTAT was computed as 0.91 using Kuder-Richardson formula 20 (KR-20).

Procedures for Data Collection

The researcher employed the services of two research assistants comprising one qualified Chemistry teacher from each of the two sampled schools to be used. The Chemistry teacher for the experimental group was trained for five days by the researcher using a training guide before the commencement of the treatment. The research assistant for the control group was also exposed to the details on the training schedule on how to use the lesson plans provided to him by the researcher on Lecture Teaching Strategy.

Prior to the treatment on the experimental groups, the Periodic-Table Achievement Test (PTAT) was administered as pre-tests to all the students in the two groups. Treatment was provided to the experimental groups for a period of four weeks while the control group was also engaged during the same period of weeks. The experimental group was taught the concept of Periodic-Table using Inquiry Teaching Strategy while students in the control group were engaged by being taught the same concept of Periodic-Table using Lecture Teaching Strategy (LTS) in the same period. The researcher monitored the research assistants at the different locations since the periods for the Chemistry lessons differed in the sampled schools. After the treatment period of four weeks, the posttests were administered to the students in the fifth week to both the experimental and control groups using PTAT.

The retention test was administered to the experimental and control groups after an interval of two weeks from the post-test administration. The retention test was to indicate the extent to which the students had retained the Periodic-Table concept they had learnt when taught using the Inquiry Teaching Strategy and Lecture Teaching Strategy according to their groups.

Mean and standard deviation were used to answer the research questions while the hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. ANCOVA was considered appropriate because the test was for analyzing differences between variables in the experimental and control groups using pre-test scores as covariates.

Results

Research Question One

What is the difference in the pre-test and post-test mean achievement scores of Senior Secondary Two (SS II) students taught Periodic-Table using Inquiry Teaching Strategy (ITS) and those taught using Lecture Teaching Strategy (LTS)?

Table 2: Means and Standard Deviations of Pre-test and Post-test Achievement Scores of SS II Students Taught Chemistry Using ITS and those Taught Using LTS

Group	Pre-test			Post-test	
	N	Mean	SD	Mean	SD
ITS	55	22.25	5.93	61.96	10.73
LTS	50	23.72	7.98	47.28	9.09

From the result in Table 2, those taught using ITS had a pretest mean score of 22.25 while their counterparts taught using LTS had a pretest achievement mean score of 23.72. However, the posttest achievement mean scores of students in the ITS was 61.96, while that of their counterparts in LTS was 47.28 respectively. The findings showed that students in the ITS had a higher achievement mean score in Chemistry than their counterparts in the LTS.

Hypothesis One

There is no significant difference in the pre-test and post-test achievement mean scores of SS II students taught chemistry using ITS and those taught using LTS

Table 3: ANCOVA Results of Pre-test and Post-test Achievement Mean Scores of SS II Students Taught Chemistry Using ITS and those Taught Using LTS

Source	Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6047.970 ^a	2	3023.985	31.267	.000	.380
Intercept	20157.816	1	20157.816	208.425	.000	.671
PRETEST	401.063	1	401.063	4.147	.044	.039
GROUP	5903.911	1	5903.911	61.044	.000	.374
Error	9864.944	102	96.715			
Total	333208.000	105				
Corrected Total	15912.914	104				

a. R Squared = .163 (Adjusted R Squared = .147)

Result in Table 3 shows that $F(1,102) = 61.04$, $p < 0.05$, and since the p value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of ITS on students' achievement in chemistry. Hence, ITS does increase students' achievement scores in Chemistry compared to LTS.

Research Question Two

What is the difference in the retention mean scores of SS II students taught chemistry using ITS and those taught using LTS?

Table 4: Means and Standard Deviations of Retention Scores of SS II Students Taught Chemistry Using ITS and Those Taught Using LTS

Group	N	Mean	SD	X-diff.
ITS	55	65.05	8.13	18.73
LTS	50	46.32	20.47	

From the result in Table 4, those taught using ITS had a retention mean score of 65.05 while their counterparts taught using LTS had a retention mean score of 46.32 after exposure to treatment. The findings showed that students in the experimental group (ITS) had a higher retention mean score in chemistry than their counterparts in the control group (LTS) who were taught chemistry using the LTS. This means that students in the ITS had a higher retention mean scores than those in the LTS.

Hypothesis Two

There is no significant difference in the retention mean scores of SS II students taught chemistry using ITS and those taught using LTS.

Table 5: ANCOVA Results of Retention Mean Scores of SS II Students Taught Chemistry Using ITS and Those Taught Using LTS

Source	Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	9445.030 ^a	2	4722.515	56.187	.000	.524
Intercept	22224.565	1	22224.565	264.421	.000	.722
PRETEST	252.613	1	252.613	3.006	.086	.029
GROUP	9412.429	1	9412.429	111.986	.000	.523
Error	8573.103	102	84.050			
Total	348868.000	105				

Corrected Total	18018.133	104
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a. R Squared = .524 (Adjusted R Squared = .515)

The results in Table 5 showed that $F(1,102) = 26.32$, $p < 0.05$, and since the p-value of 0.000 is less than 0.05 level of significance, the null hypothesis was rejected, indicating that there was a significant effect of ITS on students' retention in chemistry.

Discussion of Findings

Difference in Achievement Mean Scores of Senior Secondary Two (SS II) Students in Chemistry using Inquiry Teaching Strategy and Lecture Teaching Strategy

The summary of results of research question 1 as shown in Table 2 indicated that students in the ITS performed better than the students in the LTS. Therefore, the ITS is more facilitating than the LTS in teaching the periodic table aspect of Chemistry.

The positive result of the ITS on the students was promoted by the nature of learning environment the students had through self-assessment which involves freedom to express doubts and feelings of success. This means active participation of students in the learning process through asking questions and getting feedback is very effective. It is possible that the students employed the techniques of survey whereby learners collected information on specifics of the topic from other persons of the school or from textbooks, magazines or newspapers to enrich themselves; used opinion pool of people within the school or community to predict the outcome of questions they were to answer; made use of interviews to prepare questions in advance for revision; and used questionnaire to extract certain facts from a certain group of people knowledgeable in periodic table. All these are in consonance with ITS based instructions where students become engaged in many of the activities and thinking processes that students use to produce new knowledge.

The result agrees with Sylvanus and Eke (2017) who investigated the effect of ITS on academic achievement of senior secondary school Chemistry students in Okrika Local Government Area and found that the method enhanced academic performance in Chemistry more than the conventional lecture method. In buttressing the low achievement in the control strategy, Adejo (2015) and Njoku (2009) criticize the ineffectiveness of LTS in promoting higher achievement in students' learning in science due to lack of active involvement. Therefore, the positive result on the students in the ITS group is attributable to active participation by the students in the ITS learning process.

The results of the test of significance for hypothesis 1 as shown in Table 3 reveals that the p-value of 0.000 is less than 0.05 level of significance, hence, the null hypothesis is rejected, indicating that there is a significant effect (difference) of ITS on students' achievement in periodic table. This test proves that ITS indeed does increase the achievement scores of students in the study of periodic table.

The significance in the result is in agreement with Pandey, Nanda and Ranjan (2011) who investigated the effectiveness of ITS training model over conventional teaching method on academic achievement of physical science students at secondary level in India. The result shows that the students cannot be taught using the two strategies together if achievement must be high. The students must be separated and the more facilitating used, in which case the ITS because the model is more effective than the LTS at the senior secondary school level.

Difference in Retention Mean Scores of Senior Secondary Two (SS II) Students in Chemistry using Inquiry Teaching Strategy and Lecture Teaching Strategy

The summary of results as shown in Table 4 indicated that students in the ITS group had a higher retention mean score than the students in the LTS group. Therefore, the ITS is a better teaching strategy than the LTS in teaching the periodic table for retention.

The result obtained with the ITS on the students' retention was due to the interactive nature of learning environment that guaranteed students thorough inquisition, self-assessment and freedom of expression on the concepts of teaching, which further motivated their learning. This means active participation by students in the learning process through asking questions and getting feedback helped their retention of facts. The ITS may have made information provided familiar and meaningful thereby increasing the level of motivation of students at the time of learning to enhance retention. The provision of feedback in the ITS helped the learners to link relatively meaningful information with prior schema making it easier for the materials to be learned, retained and remembered (Mergel, 2008).

The result is in line with the study carried out by Achor and Ukwuru (2013) on the effect of Computer-assisted Instruction (CAI) on students' retention in senior secondary schools Chemical Reaction and Equilibrium (CRE) in Oju Local Government Area, Benue State. In that study, the retention mean scores of students taught CRE using CAI was more than those taught using conventional strategy. The result of this research question agrees with Fatokun, Egya and Uzoechi (2016) who investigated the effect of games teaching approach on Chemistry students' retention and achievement in periodicity from public secondary schools in Keffi Local Government Area of Nassarawa State and found that the students taught periodicity using games teaching approach retained and achieved more than those taught without it.

The results of the test of significance as summarized in Table 5 reveals that the p-value of 0.000 is less than 0.05 level of significance; hence, the null hypothesis is rejected, indicating that there is a significant difference of ITS on students' retention in periodic table. This result means that the two groups of students cannot be taught using the same strategy in the same class; they have to be separated.

The significance in the retention result is in agreement with Achor and Ukwuru (2013) who studied the effect of Computer-assisted Instruction (CAI) on Students' Retention in Senior Secondary Schools Chemical Reaction and Equilibrium (CRE) in Oju Local Government Area, Benue state and found that there is a significance difference between teaching methods and retention. The result is also supported by Achor, Ogbeba and Amadu (2014) who examined the effect that school outdoor activities (ITS) on senior secondary two students' retention in Ecology in Jalingo Metropolis of Taraba State and found that there was statistically significant difference in the retention mean scores of student by the effect of teaching strategies and retention.

CONCLUSION

This study determined the effects of inquiry teaching strategy on students achievement on periodic table, an aspect of Chemistry in senior secondary two (SS II) in Taraba State. This was prompted by evidences which showed that senior secondary school students have low and fluctuating achievement in chemistry and, this has been attributed to the use of the conventional lecture strategy by chemistry teachers in secondary schools in Taraba State. In order to address this issue, the inquiry teaching strategy (ITS) was adopted to teach periodic table to determine its effects on the retention and achievement in the periodic table aspect of Chemistry in senior secondary (SS II) schools in Taraba State. The study showed that the ITS improved students' achievement much more than the LTS. This was possible due to the strategy's potencies for engaging students in active learning. This implies that when chemistry teachers use ITS in teaching Chemistry contents, students' retention and achievement will improve considerably.

RECOMMENDATIONS

Based on the results, the following recommendations are made:

1. The use of ITS should be adopted by senior secondary school chemistry teachers for the teaching of periodic table and other topics in chemistry in order to enhance students' retention and achievement.

2. Stakeholders like Ministries of education, Private school owners, science and technology teachers and professional bodies like Nigerian Educational Research and Development Council (NERDC), Science Teachers association of Nigeria (STAN) and Curriculum Organization of Nigeria (CON) should create awareness by incorporating into their workshops, the training of chemistry teachers on the use of ITS in chemistry classrooms.
3. The teacher training institutions should include the use of ITS in their chemistry method course contents to ensure the training of pre-service chemistry teachers.

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