

**EFFECTS OF PROGRAMMED INSTRUCTIONAL PACKAGE ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT IN ELECTROLYSIS**

**IHEANYI O. IGWE PhD.**

**Department of Science Education, Ebonyi State University,  
Abakaliki**

**And**

**NNEKA LUCY OKOYE**

**Department of Science Education, Ebonyi State University,  
Abakaliki**

**Article history:**

**Received: FEB 2022;**

**Received in revised form:**

**2 FEB 2022;**

**Accepted: 2 MARCH 2022;**

**Key Words:**

**Electrolysis, Programmed Instructional Package,  
Achievement, Chalk and Talk Teaching Method,  
Chemistry**

**Abstract**

There is the prevalence of poor achievement in Chemistry commonly noticed in secondary schools and among Chemistry students. This has been attributed to the use of inappropriate teaching methods by Chemistry teachers. In order to empirically substantiate this assertion and to possibly proffer lasting solution, this study sought to determine the effects of Programmed Instructional Package on Students' Achievement in Electrolysis. The study adopted a quasi-experimental design based on the pre-test post-test, non-equivalent control group approach. A total of 1,750 Chemistry SS II students from Port Harcourt Education Zone comprised the population for the study. The sample comprised 161 SS II Chemistry students. Four secondary schools were randomly selected out of twelve secondary schools. Two schools were assigned to the experimental group and the two to the control group. Intact classes were used in teaching. The experimental group students were taught Electrolysis using the Programmed Instructional Package while the control group students were taught using the Chalk and Talk Teaching Method. The instrument for data collection was the Electrolysis Achievement Test (EAT) which was face validated by three experts; two in Chemistry and one in Measurement and Evaluation. After item analysis, the reliability of Electrolysis Achievement Test (EAT) was determined using the Kuder-Richardson 20 and a reliability coefficient of 0.93 was obtained. Three research questions guided

the study and three null hypotheses were tested for significant difference at 0.05 alpha level. Adjusted mean and standard deviation were used to answer the research questions while the hypotheses were tested using Analysis of Covariance (ANCOVA) at  $p > 0.05$  level of significance. Results of the study showed that (i) mean achievement score of students in the Programmed Instructional Package group (the experimental group or treatment group) was higher than that of the students in the Chalk and Talk Teaching Method group (control group). (ii) Female students achieved higher mean score than the males. (iii). There was no interaction effect of teaching methods and gender on students' achievement mean score. (iv) there was a significant

### Background to the Study

Science and technology are recognized as basic tools of industrialization and national development that could bring economic and social satisfaction, provide employment and improve the welfare of citizens. Science has many branches such as applied science, social science and natural science among others. Courses in natural science include Biology, Physics and Chemistry which are taught in both senior secondary and tertiary institutions as single subjects (Gongden, 2016). It is the Chemistry aspect of science that this study dwells on.

Chemistry is one of the core subjects in the senior secondary school certificate examination and remains the most registered natural science after Biology (WAEC, 2013, 2014). Chemistry is a subject that deals with the composition, properties and uses of nonliving matter. It probes into the principles governing the changes that matter undergoes (Ababio, 2015). Igwe and Nwali, (2015) assert that Chemistry is preoccupied with the molecular transformation and manifestation of matter; implying that Chemistry is involved in some industrial set ups such as fertilizers, cement, plastics, medicine, engineering,

difference in achievement mean score of students taught Electrolysis using Programmed Instructional Package and those taught using Chalk and Talk Teaching Method at 0.05 alpha level. (v). achievement mean scores for gender was not significant. (vi). There was no significant interaction effect of teaching methods and gender on students' achievement mean score. Based on the results of the study, it was recommended that Programmed Instructional Package should be adopted by Chemistry teachers in teaching Electrolysis to secondary school students. Secondly, the method should be used to close the gap in achievement differences between male and female students.

---

agriculture and in improving the life of citizens.

As a result, Njoku and Ezinwa (2014) opined that Chemistry is perceived to be the fulcrum on which all other sciences and technology hinge for national development and emancipation. It is on this premise that Chemistry is considered as a precursor of science and technology and an indispensable element in modern societal development (Igwe and Okafor, 2016).

Chemistry also has many branches namely organic Chemistry, inorganic Chemistry and physical Chemistry. Electrochemistry is a topic in the physical Chemistry which has oxidation and reduction, electrochemical cell, electrode potential and electrolysis as subtopics. Electrolysis as a subject of this study is defined as the chemical decomposition of a component brought about by a direct current passing through it either in a solution of the compound, or the molten compound (Ababio, 2015).

It has been noted by West Africa Examinations Council (WAEC) Chief examiners' reports (2012, 2013, 2014) that questions in Electrolysis have continued to pose difficulty to candidates in external

examination. This poor achievement have been traced to the use of inappropriate method used in teaching the subject and

which may have contributed to the yearly poor achievement of st

Dents in Chemistry in public examination like WAEC as seen in the results shown in Table 1.

**Table 1: Students' achievement in Chemistry in senior secondary school certificate examination (SSCE) for 2012-2020**

Year	Number that registered for the examination	Number that sat for the examination	% that sat for the examination	Total credit 1 – 6	% grade	Total % pass Grade 7-8	Total % Fail F9
2012	496895	493397	99.30	14.26	19.40	66.34	
2013	513263	498378	97.10	21.40	20.50	58.10	
2014	565886	555361	98.14	24.35	26.67	48.98	
2015	639296	628748	98.35	28.12	18.20	53.68	
2016	639296	635844	99.46	20.16	22.40	57.44	
2017	666168	635844	98.15	28.14	31.20	40.66	
2018	658564	654086	99.32	20.10	14.10	65.80	
2019	667237	657762	98.58	21.17	18.30	60.53	
2020	704302	698668	99.20	23.30	15.20	61.50	

**Source:** West African Examination Council State Office, Lagos (2020).

The best results in the Table 1 are those of 2015 and 2017 which are not even up to 30%. However, the poor achievement has been traced to the use poor method of teaching adopted by the Chemistry teachers (WAEC, 2014, Odo, 2019).

According to Ador (2019), students' poor achievement in Chemistry had been attributed to poor teaching method applied by Chemistry teachers which is also echoed by Samuel (2017).

A teaching method consists of the principles and means by which students are enabled in learning while teaching is a process of transferring knowledge from teacher to the learner (Samuel, 2018) in other to help the learner develop the required ability to make the right choices.

Therefore, teacher uses many different teaching methods in order to improve academic achievement of students. Some of the teaching methods used by Chemistry teachers include lecture method, demonstration method and discussion method among others. These

methods are said to be teacher-centered because there is no active interaction between the students and teacher during the knowledge transfer with them.

These teacher-centered methods of teaching are also referred to as conventional teaching methods (Ajayi, 2017) or traditional teaching methods and emphasize rote learning. Hence, they are considered by many researchers as poor methods of teaching. According to Dalgal and Adamu (2019), a teacher-centered method of teaching does not encourage initiatives, curiosity and creativity in learners.

In the same vein, Ajayi (2017) commented that poor students' achievement in Chemistry may be attributed to the use of conventional methods of teaching such as lecture, discussion and demonstration methods. Moreso, Okeke, (2015) posited that teacher-centered methods stifle students' understanding of contents taught. These disadvantages of teacher- centered

methods of teaching has resulted to the quest for a teaching method that will encourage students' active participation, enhance and sustain their zeal for knowledge transfer in order to improve their achievement in the subject. Hence, a student –centered teaching method is sought for in teaching Chemistry.

The student-centered teaching methods are methods of teaching where the teacher acts as the facilitator while the students take the responsibility for their learning. Student-centered teaching method can also be called child-centered teaching method (Audu, 2018). Some examples of student-centered teaching methods include simulation games, guided discovery, cooperative learning strategy, Jigsaw learning strategy and Programmed Instructional strategy among others. It is the Programmed Instructional Strategy that this paper is under studying to see how effective it will be in improving the achievement of Chemistry students in Electrolysis.

Programmed instruction is a method of presenting new subject matter to students in a graded sequence of controlled steps. Students work through the programmed materials by themselves at their own speed and after each step, test their comprehension by examination or fill-in-diagram (Molenda, 2017). Programmed instruction was formulated by B.F. Skinner as a student-centered teaching method which improves learning activities (Wangila, Martin and Ronald, 2015). There are two types of programmed instruction namely; linear and branching programmed instructions. It is the linear type that this study is exploring. Features of linear programmed lessons include: the material is broken down into small steps called

frames which are presented in logical sequence. Each frame has just minimal information, students are required to make frequent responses (one, two or three) in frame the responses being made promptly to ensure that correct answers are made, and linear programmed instruction provides immediate knowledge of results which act as a reinforcer.

In the face of gender stereotyping, Programmed instruction appears gender friendly, student-centered, encourages curiosity, active learning and mastery of content taught. Some researchers have reported the prevalence of significant gender differences in achievement of students, some in favor of males, and others in favor of females while some found no difference.

With the above inconclusive report on the interaction effect of gender and teaching strategies on students' achievement, the authors decided to use the Programmed Instructional Package in teaching Electrolysis. It is then imperative to investigate the efficacy of Programmed Instructional Package on secondary school students' achievement in Electrolysis sequel to the afore-mentioned qualities.

The theoretical framework of this study is centred on the hierarchical theory proposed by Robert Gagne. This theory states that meaningful learning takes place in a gradual step from simple to complex. To this end, he suggested that differences in which the learner already know i.e previously learned capabilities must therefore be placed on step one of the learning hierarchy. From where the individual can gradually in a step to step progression and from simple to complex learning capabilities master new capabilities

or new competences on his/her own at his/her own rate.

This theory has great implications to this study since the teacher must first carrying the analysis of what is to be learned by students, arrange them in sequence from simple to complex in small steps which conforms with the frames in Programmed Instruction strategy. This Gagne's hierarchical theory is the genesis of programmed instruction. These frames are arranged from simple to complex task based on what they had already known. This made learning very simple for the student.

### **Statement of the Problem**

Despite the enormous involvement of Chemistry in science and technology for national development, students' achievement in Chemistry especially in the aspect of Electrolysis has been persistently poor.

This observed poor achievement could be an indication of students' poor conceptual knowledge of the topic which might have been as a result of the teaching method used by the Chemistry teachers. It appears Electrolysis is mostly taught in secondary schools by lecture method, demonstration method or discussion method, all of which are teacher-centered. They do not encourage initiatives, curiosity and creativity in students.

Also, they stifle students' understanding of contents taught. There is therefore, the need to adopt a teaching method that is student-centered, which encourages students' active participation, enhances students' mastery of the subject taught to enhance achievement in the topic.

The poor achievement of the students have been a source of concern to

these researchers as these situation could lead to low scientific and technological development of the society and low standard of living if it persist. It is also on record that there is no known empirical evidence of the use of this strategy in teaching of Electrolysis.

The problem of this study in question form is "what is the effect of Programmed Instructional Package on secondary school students' achievement in Electrolysis"?

### **Purpose of the Study**

The purpose of the study was to determine the effects of Programmed Instructional Package on secondary school students' achievement in Electrolysis. Specifically, the study sought to determine.

- The effect of Programmed Instructional Package on secondary school students' achievement in Electrolysis.
- The effect of Programmed Instructional Package on male and female Chemistry students' achievement in Electrolysis.
- The interaction effect of teaching methods and gender on Chemistry students' achievement in Electrolysis.

### **Significance of the Study**

The results of the study would be beneficial to the following stakeholders: Chemistry students, science teachers, schools' authorities, Federal and State Ministry of Education, Local Government Education Authority, tertiary institutions especially institute of education, curriculum planners, and textbook authors.

To the students the result would: make the concept of Electrolysis in such a way that it would no longer be abstract and difficult to understand as it enhances achievement. It would help the students to

understand other chemistry concepts that are related to Electrolysis to improve their achievement in chemistry examinations.

To the teachers, the result would help them to plan and develop classroom practices that would enable students to develop higher knowledge domain, enhance their problem-solving skills and become confident learners.

To the school authorities, the result would sensitize them on the use of Programmed Instructional Package and its extension to other subjects in order to improve students' achievement.

To Federal and State Ministry of Education and Local Government Education Authorities; the result would enable them to liaise with Institute of Education to conduct in-service training for teachers through organizing seminars and workshops to understand this strategy.

To the curriculum planners the result would enable them to construct curriculum that enhances intellectual substance with Programmed Instructional Package in view. It would help to form a basis for the review of weak areas of Chemistry curriculum appropriately especially as it affects pedagogy, specifies the activities that are learner-centered and enhances interest in the students.

### Scope of the Study

The study was delimited to determining the effects of Programmed Instructional Package on secondary school students' achievement in Electrolysis in Port Harcourt Education Zone of Rivers State. It explained also the interactive effect of Programmed Instructional Package and Chalk and Talk method on gender with respect to achievement in Electrolysis. The study made use of secondary school two

(SSII) students who offer Chemistry as one of their subjects in WAEC and Electrolysis as a topic in secondary school (II) Chemistry syllabus.

### Research Questions

The study was guided by the following research questions.

- What is the achievement mean score of students taught Electrolysis with Programmed Instructional Package and those taught with Chalk and Talk Teaching Method?
- What is the achievement mean score of male and female students taught Electrolysis with Programmed Instructional Package?
- What is the interaction effect of teaching methods and gender on the achievement mean score of students in Electrolysis?

### Hypotheses

The following hypotheses were tested at 0.05 alpha levels:

- HO<sub>1</sub>:** There is no significant difference in the achievement mean score of students taught Electrolysis with Programmed Instructional Package and those taught with the Chalk and Talk Teaching Method.
- HO<sub>2</sub>:** There is no significant difference in the achievement mean score of male and female Chemistry students taught Electrolysis with Programmed Instructional Package.
- HO<sub>3</sub>:** There is no significant interaction effect of teaching methods and gender on the achievement mean score of Chemistry students on Electrolysis.

## Methodology

The procedures adopted by researchers in carrying out this study are stipulated here:

### Research Design

The research design adopted was pretest-posttest, non -equivalent control group quasi-experimental design. The design is represented symbolically thus:

$$\begin{array}{cccc} E & O_1 & X_1 & O_2 \\ \hline C & O_1 & X_2 & O_2 \end{array}$$

### Where

$O_1$  and  $O_2$  represent pretest and posttest respectively,  $X_1$  is the Programmed Instructional Package group and  $X_2$  is the Chalk and Talk Teaching Method. E is Treatment or Experimental group and C is Control group.

### Area of the Study

The study was carried out in Port Harcourt education Zone of Rivers State, Nigeria. Rivers state is bounded on the South by the Atlantic Ocean, to the North by Anambra, Imo and Abia States, to the East by Akwa Ibom State and to the West by Bayelsa and Delta States. Rivers State is currently made up of 23 Local Government Areas.

The Local Government Areas are Abua/Odua, Ahoada-East, Aboada-West, Akuku-Toru, Asari Toru, Andoni, Bonny Degema, Eleme, Emohua, Etche, Gokana, Ikwerre, Khana, Obio/Akpor. Ogba/Egbema/Ndoni, Ogu/Bolo, Okrika, Omuoma, Opobo/Nkoro, Oyigbo, Port Harcourt and Tai.

Port Harcourt Local Government Area is located 52 kilometers southeast of Ahaoda and about 40 kilometers Northwest of Bori. It is bounded to the South by Okrika, to the East by Eleme, to the North

by Obio/Akpor and to the West by Degema. The choice of the area for this study is due to the fact that despite Port Harcourt being a capital city with good and well equipped secondary schools, presence of highly qualified Chemistry teachers; students still perform poorly in Chemistry in public examinations.

### Population of the Study

The population of the study comprised 1,750 senior secondary (II) Chemistry students from Port Harcourt Education Zone of the State. The population comprised 763 male and 987 female Chemistry students. The choice of this topic was guided by the fact that Electrolysis was taught in SS2 of the senior secondary school in Nigeria. The zone has twelve secondary schools that consistently offer students for WAEC Examinations.

### Sample and Sampling Techniques

The treatment group had 40 males and 25 females, while the control group had 35 males and 61 females, giving a total sample of 161 students. Purposive sampling technique was used to select four (4) out of the twelve (12) senior secondary schools offering Chemistry. Random sampling was adopted to select the two secondary schools that were in experimental group and two secondary schools in the control group respectively. The intact classes were used in each case of the secondary schools chosen for the study.

### Instrument for Data Collection

The instrument used to collect the data for the study was the Electrolysis Achievement Test (EAT). EAT was adapted from West African Examination Council (WAEC) past question papers. The EAT covered such topics as electrochemical cell, mechanism of electrolysis, preferential

discharge of ions, Faraday Laws of Electrolysis and uses of electrolysis. Model answers to EAT were provided to guide the markers. The items tested the students on the understanding of the topics taught. EAT was used as both the pre-test and the post-test instrument to determine the students' achievement. EAT had thirty three (33) question items initially

### **Validation of the Instruments**

The instrument, EAT was given to three experts; two in Chemistry and one in Measurement and Evaluation for face validation, all from University of Port Harcourt. The validators were required to vet EAT instrument based on language clarity to students, content coverage of the items on the achievement test, relevance of the items to stated specific objectives and correctness of item options for the achievement test. Some of the items of EAT were restructured but none was dropped.

The face validated EAT was administered to thirty- three (33) SS II Chemistry students from non- target school in Ahoada Local Government for trial testing. Scores from students on EAT were used for item analysis based on the item discrimination and item difficulty index. Only item of difficulty index of 0.40–0.60 and discrimination index 0.40–1.00 were retained. By this analysis five (5) items (10, 17, 28, 29 and 35) were not accepted. This brought the number of items of EAT to thirty (30) for use. The remaining 30 items were used to establish the Test-Blue Print.

### **Reliability of the Instrument**

The data collected from the remaining 30 items of EAT after trial testing were subjected to a test of reliability through the application of Kuder-Richardson-20 for internal consistency. It

gave a reliable coefficient index of 0.93 which showed that EAT had a very high internal consistency and was suitable for the study.

### **Experimental Procedures**

This was done in two stages; training of the research assistants (regular chemistry classroom teachers of the class in the sampled schools) in the experimental group, and treatment to the experimental and control groups. The researchers introduced themselves to Principal of the schools, who took them to meet the research assistants. The researchers introduced themselves to the research assistants who were the regular Chemistry teachers in the sampled schools for that class. The researchers explained vividly the objective of the research to the research assistants and introduced the method as Programmed Instructional Package. They took time to explain to the research assistants how to use the Programmed Instructional Package. The training lasted for one week.

The Chalk and Talk Teaching Method was used for the control group. No training was given to the two research assistants in this group because they were to use the Chalk and Talk Teaching method they were conversant with. The researchers provided the experiment group research assistants the website for Programmed Instructional Package and the lesson plans for the research assistants for the control groups which guided them during the teaching-learning process.

Before the experiment began, the EAT was administered to both students of experimental and control groups as pre-test. The scripts were marked by the researchers, and the scores recorded as pre-test scores to be used to; determine the



students' initial knowledge of the material they learned later, and determine the comparability of the two groups (experimental and control) with respect to their achievement in the pre-test scores.

### **Experimental Procedure for the Programmed Instructional Package (Treatment)**

The implementation of the study involved the study of subtopics in electrolysis using Programmed Instructional Package. The experimental group was subjected to Electrolysis Achievement Package (EAP) on the website which contained the objectives of each subtopic clearly spelt out, the short comprehension passage on the topic in electrolysis with the corresponding questions in form of fill-in-the blank spaces in a frame. The student studied the short comprehension passage and clicked on the bottom to supply the correct answer(s) and then clicked on the submit button to upload their answer(s).

Correctly answered question(s) by the student, automatically sent him/her to the next frame. Wrong answer(s) gave a feedback that sent the student back to the passage for thorough understanding. Each student connected to the website to access the EAP and required to study electrolysis using it. The research assistant only attended to the students' problems when necessary but not to teach them.

### **Procedure for the Chalk and Talk Method**

The Chalk and Talk Teaching Method was used to teach students (research subjects) in the control group in the sample schools. The research assistants (their classroom teachers) used verbalization for relevant concepts and principles in electrolysis during the knowledge transfer using the lesson plan prepared by the

researchers. The students watched and listened attentively during the teaching-learning process and took down notes. The teaching lasted for the same period of six weeks as for the treatment group.

During the period of this study, the researchers monitored the schools used to ensure that the research assistants (their classroom teachers) adhered strictly to the instructions given to them.

### **Post-test**

After the treatment, EAT was reshuffled and administered to both students in experimental and control groups. This was the post-test. The scripts of the post-test were also marked by the researchers, and the scores were recorded. The procedures for the training were summarized as follows:

**1<sup>st</sup> week:** visiting the participating schools used in the study to see the Chemistry teachers used for the study and to carry out the training of the research assistants on the use of Electrolysis Achievement Package.

**2<sup>nd</sup> week:** Administration of EAT to both the experimental and control groups by research assistants (their SS-2 classroom teachers) involved in the study. Marking and recording of the pre-test scripts scores by the researchers.

**3<sup>rd</sup> – 8<sup>th</sup> week:** Six weeks of students of the experimental group being exposed to EAP (Electrolysis Achievement Package) while students in the control group were taught by the research assistants (their classroom teachers) using the lesson plans prepared by the researchers.

**9<sup>th</sup> week:** Post-test administration of EAT

**Control of Extraneous Variables/Conditions**

The researcher took the following steps to checkmate the effects of the extraneous variable which might affect the experimental result.

1. **Experimental bias:** To avoid experimental bias regular classroom teachers in the participating secondary schools who used to teach the student Chemistry in SS II classes were used. The teachers (research assistant) administered the pretest and posttest as class test. The researchers came in as external observers.
2. **Teacher Variability:** Normal Chemistry SS II teachers in each of the schools under study were used. The classroom teachers involved in administering the instruments were properly trained by the researcher for the experimental group in order to ensure homogeneity of instruction across the group. Both the lesson plans and the programmed software on Electrolysis were prepared by the researchers. Students in the experimental group were exposed to programmed software on Electrolysis Achievement Package, while the lesson notes prepared by the researchers were used by the teachers to teach the control group. The researchers supervised the exercise.
3. **Experimental factor:** Each school did not have both experimental and control groups in order to avoid interferences. Different schools that were far apart were used in the experiment.
4. **Inter group variable:** It was not possible to assign participants at random to both experimental and control groups. Intact classes were

used for the study, which meant that the initial equivalence was not achieved in the two groups. Hence the researchers employed Analysis of Covariance (ANCOVA) for data analysis in order to eliminate the error of non-equivalence. This controlled the initial differences of the participants in the intact classes.

5. **Hawthorn effect:** This effect was controlled by using intact classes and their Chemistry teachers as research assistants, who were trained for the experimental classes.

#### **Method of Data Collection**

The EAT was administered to both experimental and control group as pre-test before the beginning of the treatment. This provided the pre-test scores as covariates. After the treatment, the post-test was administered to both experimental and control groups using EAT (reshuffled) as instrument.

The scores generated from the administration of pre-test and post-test from (subject assistants) Chemistry students using Electrolysis Achievement Test (EAT) was used as the data collected for the research work.

#### **Method of Data Analysis**

Mean and standard deviation was used to answer the research questions while the Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

The results of the hypotheses were interpreted thus: where  $p < 0.05$ , the result of the hypothesis was rejected and where  $p > 0.05$ , the result of hypothesis was not rejected.

## Results

The results of data analysis are presented in Tables according to the research questions and hypotheses.

### Research Question One

What is the achievement mean score of students taught electrolysis with Programmed Instructional Package and

those taught with the Chalk and Talk Teaching Method?

Data collected using the achievement test (pre and posttest) for both the treatment and control groups for male and female students were used to answer this research question.

Summary of the result is shown in Table 2.

**Table 2: Achievement Mean Score Based on Teaching Methods**

Method	Number	Adjusted mean $\bar{X}$	Standard Deviation
Programmed Instructional Package	65	68.15	13.22
Chalk and talk Teaching Method	96	39.93	6.65

As shown in Table 2, the achievement mean score of students taught Electrolysis using the Programmed Instructional Package is 68.15 with 13.22 as standard deviation. The Table also shows that the achievement mean score for the students taught using Chalk and Talk Teaching Method is 39.93 with standard deviation of 6.65. This implies that Programmed Instructional Package yields greater achievement mean score than the Chalk and Talk Teaching Method.

### Research Question Two

What is the achievement mean score of male and female students taught electrolysis with Programmed Instructional Package?

The data collected on achievement (pre and posttest) for the treatment group only were used to answer this research question. Summary of results is shown in Table 3.

**Table 3: Achievement Mean Score Based on Gender**

Method	Male			Female		
	N	Adjusted mean $\bar{X}$	Standard deviation	N	Adjusted mean $\bar{X}$	Standard deviation
Programmed Instructional Package	40	67.75	12.29	25	68.80	14.80

The results in Table 3 show that the mean achievement score and its standard deviation for male are 67.75 and 12.29 respectively. The Table also reveals that the mean achievement score for female students is 68.80 with its standard deviation as 14.80. From the results, female students taught Electrolysis using Programmed Instructional Package have higher

achievement mean score than the male students taught using the same method.

### Research Question Three

What is the interaction effect of teaching methods and gender on the achievement mean score of students in electrolysis?

Data collected using the achievement test (pre and posttest) for

both treatment and control groups for both male and female students were used to test

for interaction. Summary of results is shown in Table 4.

**Table 4: Achievement Mean Score of Students Based on Interaction Effect of Teaching Methods and Gender**

Method	Male		Female	
	N	Adjusted mean score $\bar{x}$	N	Adjusted mean score $\bar{x}$
Programmed Instructional Package	40	67.75	25	68.80
Chalk and talk Teaching Method	35	39.26	61	40.34

The summary of the results in Table 4 shows that the female students have higher achievement mean score in both the Programmed Instructional Package group and the Chalk and Talk Teaching Method group, hence, there is no interaction effects between the teaching methods and gender on achievement mean score of students in Electrolysis.

#### Test of Hypotheses

The null hypotheses (HOs) were tested at 0.05 level of significance.

#### Test of Hypotheses One and Three

**HO<sub>1</sub>:** There is no significant difference in the achievement mean score of

students taught Electrolysis with Programmed Instructional Package and those taught with the Chalk and Talk Teaching Method.

**HO<sub>3</sub>:** There is no significant interaction effect of teaching methods and gender on the achievement mean score of Chemistry student on electrolysis.

Data collected using the achievement test (pre and posttest) for both treatment and control groups for male and female students were used to test these hypotheses. Summary of the results are shown in Table 5.

**Table 5: ANCOVA Results of Achievement Mean Scores Based on Methods of Teaching**

Source of variation	sum of squares	DF	Mean square`	F	Sig of F	Alpha level
Covariates	39142.851	1	39142.851	1069.781	0.000	
Pretest	39142.851	1	39142.851	1069.781	0.000	
Main effects	1269.741	2	634.871	17.351	0.000	
Methods	1246.719	1	1246.719	34.073	0.000	0.05
Gender	23.022	1	23.022	0.629	0.429	
2-way interactions	99.318	1	99.318	2.714	0.101	
Method X gender	99.318	1	99.318	2.714	0.101	0.05
Explained	40511.911	4	10127.978	276.799	0.000	
Residual	5707.977	156	36.590			
<b>Total</b>	<b>46219.888</b>	<b>160</b>	<b>288.874</b>			

For HO<sub>1</sub>, results in Table 5 show that the F-ratio for methods is 34.073 with significance of F (p-value) as (0.000) which is less than 0.05 the alpha level. Hence, HO<sub>1</sub>

is rejected. This means that there is a significant difference in the achievement means scores of students taught Electrolysis using Programmed Instructional Package

and those taught using Chalk and Talk Teaching Method.

As was found in research question one, the Programmed Instructional Package group had a higher achievement mean score than the Chalk and Talk Teaching Method group. The fact is that the significant difference in the achievement mean scores was systematic and not a chance occurrence. The difference can be rightly attributed to the effects of the treatment. This also means that the two methods cannot be used in the same class.

For  $H_{O3}$ , and still on Table 5, the results show that the F-ratio with regard to interaction between methods and gender is 2.714 with significance of F ( $p > 0.05$ ) as 0.101. The significance of F (0.101) is greater than the alpha level (0.05), hence,  $H_{O3}$  is not rejected. This means that the

interaction effect of methods and gender on students' achievement mean score in Electrolysis is not significant. This is in line with the finding in research question 3 that showed that there was no interaction effects of methods and gender on students' achievement mean score.

### Test of Hypothesis Two

There is no significant difference in the achievement mean score of male and female Chemistry students taught Electrolysis with Programmed Instructional Package.

The data collected using the achievement test (pre and posttest) for the treatment group only were used to test this hypothesis. Summary of results is in Table 6.

**Table 6: ANCOVA Results of Achievement in Electrolysis Based on Gender**

Source of variation	Sum of squares	DF	Mean square`	F	Sig of F	Alpha level
Covariates	7985.375	1	7985.375	156.114	0.000	
Pretest	7985.375	1	7985.375	156.114	0.000	
Main effects	21.733	1	21.733	0.425	0.517	
Gender	21.733	1	21.733	0.425	0.517	0.05
Explained	8007.108	2	4003.554	78.270	0.000	
Residual	3171.353	62	51.151			
<b>Total</b>	<b>11178.462</b>	<b>64</b>	<b>174.663</b>			

Results in Table 6 show that the F-ratio with regard to gender is 0.425 with significance of F (p-value) as 0.517. The significance of F (0.517) is greater than the Alpha level (0.05), hence,  $H_{O3}$  is not rejected. This means that there is no significant difference between the achievements means scores of male and female Chemistry students who were taught Electrolysis using Programmed Instructional Package.

The implication is that though the female students had higher achievement mean score than male students, this was

not by systematic process but by chance occurrence.

### Summary of Findings

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

- The achievement mean score of students taught Electrolysis using Programmed Instructional Package is higher than the achievement mean score of students taught using Chalk and Talk Teaching Method. The difference is statistically significant at  $p < 0.05$ .

- Female students have higher achievement mean score than male students. The difference is however, statistically non-significant at  $p < 0.05$ .
- There is no interaction effect of teaching methods and gender on students' achievement mean score and the interaction effect is not statistically significant at  $p < 0.05$ .

### Discussion

The results of the research are discussed as follows:

#### Effect of Programmed Instructional Package on Students' Achievement Mean Score in Electrolysis

It was found that students who were taught electrolysis using Programmed Instructional Package had higher mean achievement score than those taught using Chalk and Talk method of teaching. This means that the disparity in the achievement mean score was systematic rather than a chance occurrence. As long as both methods resulted to achievement in Electrolysis, the difference can be attributed to the effectiveness of the Programmed Instructional Package.

The higher achievement mean score of the Programmed Instructional Package implies that most members of the class scored relatively higher score, individually. This may be due to the fact that the Programmed Instructional Package provided activities that attracted the attention of the students and motivated them to learn. It also provided a learning environment which reduced anxiety, undue stress and embarrassment as each student participates actively at his/her own pace without a threat of being exposed to humiliation in a heterogeneous class. Also,

the teaching-learning materials being in frames facilitated the recall of information which enhanced their achievement.

Similarly, the Programmed Instructional Package provided the students opportunity to learn independent of the teacher, this many have facilitated the construction and reconstruction of the knowledge acquired by them. The implication of this is that what they learned is internalized and retained by them; and could be easily recalled when needed, to enhance their achievement. These activities that are embedded in the Programmed Instructional Package, were not found in the Chalk and Talk method of teaching, and may have accounted for higher achievement mean score in Programmed Instructional Strategy.

The finding of this study agreed with Falode et al, (2016); Agwu and Eze (2018); Udeh, Edeoga and Okpube (2017); and Laleye (2019) where student-centered innovative strategies improved achievement mean score just as Programmed Instructional Package has done here.

The test of significance of hypothesis 1 which stated that there is no significant difference in the achievement mean scores of students taught Electrolysis using Programmed Instructional Package and those taught using Chalk and Talk Teaching method was rejected. This means that the difference between the achievement mean scores of students taught using Programmed Instructional Package and those taught using Chalk and Talk method of teaching was statistically significant at  $p < 0.05$ .

#### Effect of Programmed Instructional Strategy Package on Male and Female

### **Secondary School Students' Mean Achievement in Chemistry**

The research question 2 sought to find out what the achievement mean score of male and female students taught electrolysis with Programmed Instructional Package was. The result in Table 3 showed that the females had higher achievement mean score than the male students. The implication of this is that the female student having higher achievement mean score than the male student was not systematic.

This may be due to the ability of Programmed Instructional Package function as a strategy to present teaching learning materials step by step, from known to unknown to both male and female students which made it easy for them to internalize the topic which facilitates the recall of the information when needed to enhance their achievement almost equally. Also, the Programmed Instructional Package creates a gender free environment that reduces anxiety, undue stress and embarrassment in a heterogeneous class. As a result, the male and female benefits equally. The absence of the teacher in the teaching and learning process using Programmed Instructional Package reduces some negative demotivating factors like, shyness and psychological insecurity which is present during teaching using Chalk and Talk method of teaching. Programmed Instructional Package helps to create a learning environment of equal benefits to both male and female students for meaningful learning activities. In general, Programmed Instructional Package does not discriminate between genders when used during learning process in electrolysis.

The finding in this study is consistent with that of Okorie and Eze (2016) who

reported that mean achievement score of female students in chemical bonding was greater than these of the male student. Ajiboye (2015) found that female students achieved better than their male counterparts when taught Chemistry using inquiry role instructional model. Ajai and Imoko (2015) found out that female students achieved better than their male counterparts when mathematics was taught using problem-based learning method.

On the contrary, Ajayi and Ogbeba (2017) found that male students achieved slightly higher than female counterpart in Chemistry when taught with hand-on-activities. Igwe (2016) found that male student achieved higher than the female in Chemistry when taught with digital game based instructional strategy.

However, the test of significance of hypothesis 2 which states that there is no significant difference in the achievement means scores of male and female Chemistry students taught Electrolysis with Programmed Instructional Package was not rejected. This means that there is no significant difference between the achievements means scores of male and female students who were taught using Programmed Instructional Package.

The finding of no significant difference between the mean achievement scores of male and female Chemistry students is in agreement with Odinko and Arikpo, (2015), Godpower-Echie and Ihenko, (2017); Ogonnaya, et al, (2016). The finding is also in line with the views of some researchers (for instance Aniodoh and Egbo (2013), Ajai and Imoko (2015), Okorie and Eze (2016) who reported that female students achieved higher mean scores in Chemistry than their male counterparts and the achievement was statistically

equivalent. This further shows that Programmed Instructional Package produced the same effect on the male and female students' achievement mean scores.

### **Interaction Effect of Teaching Methods and gender on Secondary School Students' Mean**

#### **Achievement Score in Electrolysis**

The research question 3 sought to determine the interaction effect of teaching methods and gender on the achievement mean scores of students in Electrolysis. The results in Table 4 show that female students have higher mean scores than the male students in both the Programmed Instructional Package and the Chalk and talking Teaching method. This means that there is no interaction. The lack of interaction effect may be due to the fact that Programmed Instructional Package is a gender friendly teaching-learning package which enabled equal participation of students and an active interaction of the logically sequenced programme which was tailored to their level for easy of comprehension, mastery and recall which enhanced their achievement in Electrolysis.

On the test of significance of  $H_{03}$  the ANCOVA results in Table 5 show that there is no significant interaction effect of teaching methods and gender on the achievement mean score of Chemistry students on electrolysis. This finding is consistent with that of Danjuma (2015), Akintade (2017); Okotocha (2018); Ador (2019) who found no significant interaction effect between teaching methods and gender on students' achievement score in Electrolysis.

#### **Recommendations**

Based on the findings the researchers recommend as follows:

- Chemistry teacher should use Programmed Instructional Package in teaching Electrolysis and other aspects of Chemistry in secondary schools as it improves achievement mean scores.
- The curriculum for teacher-training programme in Institutes and Faculties of Education could be reformed and enriched with adequate ICT courses that will enable teachers develop and use educational software packages to enhance achievement.
- Workshops, conferences and seminars should be organized by Ministry of Education, Profession bodies like STAN and TRCN to popularize effectiveness of Programmed Instructional Package in teaching Chemistry.
- Curriculum planners should incorporate this instructional package into the secondary school curriculum.
- Publishers and professional bodies should develop Chemistry textbooks in line with the Programmed Instructional Package format.

#### **Educational Implications of the Findings**

The findings of this study have many implications for Chemistry education. Those implications are discussed below.

The Programmed Instructional Package led to higher mean achievement score than the Chalk and talk Teaching method. The difference between the mean achievement score was found to be statistically significant. These findings have important implications for Chemistry education in that with the use of Programmed Instructional Package, result



will be higher among the students' achievement.

Secondly, with the incorporation of Programmed Instructional Package into curriculum implementation guides, Chemistry teachers will make use of the method to help increase students' achievement in Chemistry. It also implies that failure to use the instructional package by teachers or incorporate the instructional package into the curriculum will deny Chemistry education the benefit of Programmed Instructional Package of enhancing students' achievement in Chemistry.

The mean achievement score of female students was slightly higher than that of male students, but the difference was not significant. The implication is that if the Chemistry teacher uses the Programmed Instructional Package it will result to no discrimination in achievement based on gender. Also, when the instructional package is used it will make the female students to realize their potentials in Chemistry by increasing their confidence in the Chemistry topics resulting to higher achievement. On the contrary, if Programmed Instructional Package is not used in teaching electrolysis these benefits due to the use of the instructional package may have been lost.

There was no interaction effect of methods and gender on students mean achievement score. It follows that Programmed Instructional Package does not discriminate on basis of gender. The implication is that when Chemistry teachers use the Programmed Instructional Package to teach Chemistry, it will lead to higher achievement of students irrespective of gender or mix genders in the class as that would not significantly affect achievement.

If however the Chemistry teachers do not use the instructional package, the students will not benefit from its non-discriminating effects on achievement on the basis of gender.

### **Limitations of the Study**

The following constraints were encountered as limitations of the study:

1. The number of schools that had ICT facilities was small and this made it difficult for the researchers to use more schools.
2. There was sometimes epileptic supply of electricity from the national grid the schools used which cut down the length of time the students interacted with the package.
3. Some research subjects were not ICT literate and had initial problem of assessing the lesson online. This limited the use of the package which may have affected the results.

### **Conclusion**

Research evidences show that students have poor achievement in Electrolysis which is especially evident in students' performance in the topic in public examinations in Chemistry. The persistent poor achievement in Electrolysis has been of great concern to Chemistry educators and these researchers. The implicating factor in this poor achievement is the teaching method used by the Chemistry teachers.

This research therefore sought to find the effects of Programmed Instructional Package on secondary school students' achievement in Electrolysis with the intention of proffering solutions to improve the achievement in Electrolysis. The findings of the study showed that the

use of Programmed Instructional Package can enhance students' achievement in Electrolysis significantly. The Instructional Package was also capable of bridging the gap between male and female students' achievement in Electrolysis.

There was no interaction effect of method and gender on achievement. The researchers therefore are of the view that with the effective use of Programmed Instructional Package in teaching Chemistry, the problem of poor achievement in the subject will be drastically reduced if not totally eliminated.

### References

- Ababio, Y.O. (2015). New school Chemistry for senior secondary school (6<sup>th</sup> ed) Nigeria African first publishers.
- Ador, S.I. (2019). Effects of collaborative instructional strategy on students' achievement and interest in stiochiometry. *Unpublished Ph.D Thesis*. Ebonyi State University, Abakiliki.
- Agwu, U.D. and Eze, C.U. (2018). Utilization of learning activity package in the classroom, impact on senior secondary school students' academic achievement in organic Chemistry. *African journal of Chemistry education (AICE)* 8 (2)
- Ajai, J.T. and Imoko, B.T. (2015). Gender differences in mathematics achievement and retention scores. A case of problem-based learning method. *International Journal of Research in Education and Science (IJRES)*, 1 (1): 45-50
- Ajayi, O.V. (2017). Effects of hand-on-activity based method on interest of senior secondary students in organic Chemistry. *Scholarly journal of education* 6 (1) : 1-5
- Ajayi, V.O. and Ogbeba, J. (2017). Effect of gender on senior secondary school Chemistry students achievement in stiochiometry using hands-on activities *American Journal of Educationall Research*. 5 (8): 839-842
- Ajiboye, M. M. (2015). Effects of two methods of teaching on students' interest on Basic Science and Technology. *Greener Journal of Education Research*. 3(3): 12-18
- Akintade, C.A. (2017). Effect of computer assisted instruction on students' achievement and attitude toward Latitude and longitude in Ogun State, Nigeria. University of South African, Pretoria. Retrieved 19/07/17  
<http://hdl.handle.net/10500/23613>
- Aniodoh, H.C.O. and Egbo, J.J. (2013). Effect of gender on students' achievement in Chemistry using inquiry role instructional model. *Journal of Educational and Social Research*. Retrieved from [www.meser.org.php/jesi/article/download/1715-1719](http://www.meser.org.php/jesi/article/download/1715-1719). Accessed on 20/12/2016. 3(6): 17-21.
- Audu, C.T. (2018). Influence of teaching styles on student's achievement and interest among Biology students in secondary school in Taraba State, Nigeria. *Advancer in Social Science Research Journal*. 5(5): 164-172.
- Dalgal, R.G.M. and Adamu, U, (2019). Effects of guided discovery method

- on students' attitude and achievement in Biology in senior secondary school, Bauchi State. *International Journal of Research and Statistics Innovation (IJRSI)*. 6 (7): 105-110.
- Danjuma, G.S. (2015). Effects of collaborative and competitive learning strategies on Upper Basic II students' interest and achievement in Basic Science. *Unpublished Ph.D. Thesis. Department of Science Education*. University of Nigeria, Nsukka.
- Falode, O.C.; Sobowale, M.F.; Salu, R.M.; Usuman, H. and Falode, M.E (2016). Effectiveness of computer animation Instructional Package on academic achievement of senior secondary school Agricultural Science students' in animal psychology in Minna, Nigeria. *Bulgarian, Journal of Science and Education Policy (BJSEP)*. 10(1): 18-22.
- Godpower-Echie, G. and Ihenko, S. (2017). Influence of gender on interest and achievement of students' in Integrated Science in Obio-Akpor Local Government Area of Rivers State. *European Scientific Journal*. 13(10):272-279
- Gongden, E.J. (2016). The effects of analogy of male and female Chemistry student's problem-solving abilities in electrolysis. *International Journal of Scientific Research in Education* .9 (1): 1-6.
- Igwe, I.O and Nwali, D. (2015). Effects of simulation model of instruction on junior secondary school class III students' in Basic Science in Ebonyi State. *Journal of Educational Research and Development*. 9(1): 73-85.
- Igwe, I.O. (2017). Students interest, attitude and achievement as correlates of Chemistry teacher's classroom management behavior in senior secondary schools. *International Journal of Current Research*. 9(5): 50062-50066
- Igwe, I.O. and Okafor, G.A. (2016). Relationship between student's attitude interest and achievement in Chemistry in senior secondary school Nigeria. *Journal of Curriculum Studies* 23(1):60-70.
- Laleye, A.M. (2019). Effect of a computer package instructional strategy on Basic Science students' learning outcome in two instructional setting in Ondo State, Nigeria. *International Journal of Scientific Research*. 7(2): 869-876.
- Molenda, M. (2017). *Programmed instructioned.tech.wiki*. Retrieved September 2019.
- Njoku, Z.C. and Ezinwa, U.S. (2014). Comparative effects of peer teaching and lecture on students' achievement and interest in some difficult concept in Chemistry. *Journal of Science Teachers Association of Nigeria*. 49(1): 60-73.
- Odinko, M.M. and Arikpo, O.U. (2015). Effects of gender on primary five (5) pupils' achievement a Basic Science using computer assisted instruction in Ibadan. Oyo State, Nigeria. *British journal of Psychology Research*. 3(4): 25-45.

- Odo, E.E. (2019). Effect of Jigsaw instructional strategy on secondary school students' interest and achievement in Chemistry. *Unpublished Ph.D. Thesis Ebonyi State University Abakiliki.*
- Ogonnaya, U.F.; Okafor, G.; Abonyi, O.S. and Ugama, J.O. (2016). Effect of concept mapping instruction approach on students' achievement in Basic Science. *Journal of Education Practice* 7(8).
- Okeke, A.M. (2015). Effect of Jigsaw instructional strategy on students' achievement and interest in quadratic equation in Nsukka Education Zone. *Unpublished M.Ed Thesis.* University of Nigeria, Nsukka.
- Okorie, E.U. and Ezeh, D.N.(2016). Influence of gender and location on students' achievement in chemical bonding. *Mediterranean Journal of Social Science.* 1(3): 309-318.
- Okotocha, E.N. (2018). Effects of a Constructivist Based Instructional Model on Students' Conceptual Change in Chemistry. *Journal of the Department of Science Education,* University of Nigeria, Nsukka. 4(1)
- Samuel, I.R. (2017). Assessment of Basic Science teachers' Pedagogical practice and student's achievement in Keffi. Education Zone, Nasarawa State, Nigeria. *An Unpublished Master Dissertation.* Nasarawa State University of Keffi Nigeria.
- Samuel, I.R. (2018). Effect of simulation instructional package on Upper Basic Science students' interest achievement and rotation on body system. *International Journal of Scientist Research in Education (IJSRE).* 11(4):716-724.
- Udeh, I.J.; Edeoga, B.O. and Okpube, N.M. (2017). Programmed instruction method of teaching on students' achievement in mathematics. *Journal of Engineering Science and Mathematics.* 6(6).
- W.A.E.C (2012). Chief examiners report on May/June West African Senior School Certificate examination Abuja. Federal ministry of education. Publication
- W.A.E.C (2013). Chief examiners report on May/June West African Senior. Federal Ministry of Education Publication.
- W.A.E.C (2014). Chief examiner report on May /June West African Senior School Certificate Examination. Abuja. Federal ministry of education publication.
- Wangila, M.J.; Martin, W. and Ronald, M. (2015). Effect of programmed instruction on students' attitude towards structure of the atom and the periodic table among Kenyan Secondary School. *Science Education International.* 26(4) :488-500.