Influence of Method of Teaching on Secondary School Students Academic Achievements in Chemistry

Okiemute Ejedegbe
FCT Secondary Education Board Abuja, Nigeria

Abstract: This study investigated the influence of method of teaching on secondary school students academic achievements in chemistry. A total of seventy (70) students form the sample of the study. Two instruments, namely Chemistry Achievement Test (CAT) and Chemistry Attitude Questionnaire (CAQ) were used for data collection. The CAT was develop by the researcher and validated by experts in chemistry education and psychology. The reliability coefficient of CAT and CAQ were found to be r=0.785 and r=0.82 respectively. Analysis of data using t-test statistic and weight average revealed that the experimental group which was taught chemistry using inquiry teaching methods performed significantly better than the control group which was taught using the traditional lecture method. The study recommends, among others, that chemistry teachers should be encouraged to use inquiry method in the teaching of chemistry.

Keywords: Chemistry, Secondary School Students, Chemistry Achievement Test (CAT), Chemistry Attitude Questionnaire (CAQ), Inquiry Method

I. INTRODUCTION

The role of chemistry in the development of the scientific base of a country cannot be over emphasized and Nigeria is not an exception (Donald, 2010). Chemistry is one of the Science subjects taught at the senior secondary school level. It is one of the core science subjects that students are required to pass in order to qualify for admission into tertiary institutions to pursue science-based programmes e.g Medicine, Engineering, Pharmacy among others (Bunkure, 2007).

Chemistry is an experimental science which relies primarily on the harmony between theory and practical. It should therefore be taught as such. It follows therefore that, understanding of concept in practical chemistry will assist in enhancing student’s understanding of chemistry. Students have difficulty in making connections between the sub-disciplines of chemistry (which tend to be taught separately); the link between practical work and theory is often less than obvious; not enough emphasis is given to understanding of concepts in practical chemistry.

In chemistry teaching, the importance of harmonizing practical work with theory cannot be over-emphasized. Fraenkle and Wallen, (2009) states that; if the academic achievement of students is to be enhanced, learners must have deep understanding of basic concepts behind practical task they engage in. This is because the observations and experiments students carry out are meant to confirm some theories and the application of concepts.

In spite of this important position of chemistry among other science and science related disciplines, students’ academic achievement has consistently been below expectation and unimpressive (Jegede, 2008).

This study investigated the influence of method of teaching on secondary school students academic achievements in chemistry.

II. CHEMISTRY IN EVERYDAY LIFE

Chemistry is one of the three main branches of pure science, the others two being, biology and physics. Chemistry deals with the composition of matter and the changes matter undergoes. The world is made up of matter, we study chemistry to acquire and learn the skill of observation, recording and making an intelligent conclusion from our observation. Studying chemistry gives us training in scientific method and the knowledge of chemistry helps us to become scientists. Those that are trained in chemistry are known as chemists (Bashir, 2005).

Chemistry helps in improving the quality our life today. Studying chemical processes around us, such as lightening a match, cooking, burning of fire wood, rusting nails etc. allow man understand his environment and possible changes it may undergo under different conditions. All the house hold materials, such as soaps and detergents for washing, hair cream and perfumes and majority of cooking utensils, plastic materials for wide variety of uses are all products of chemical process, (Wong, Onyiruka & Akpanis, 2002).

Chemistry contributes towards providing our basic needs and improving the quality of our life in the following area:

(i) Agriculture, productions of different type of fertilizers and insecticides have been possible by chemical means, these increase food production greatly. The preservation of and storage of food for long periods is made possible as a result of chemicals prepared by chemist and also by means chemical process, so that the food can be exported to a distant places and made available to more people, to fight hunger and malnutrition. Many food substances today are enriched by addition of essential nutrients.

(ii) Man-made textile fibers produces as a result of intensive chemical researches has made available a wide range of clothing materials which supplement the scarce natural fibers. Building materials such as, cement steels bricks and tiles are produced by chemical industries. The chemical properties of the materials are known as a result of chemical researches, and these properties can be modified through chemical reaction to suit a certain purposes.

(iii) The healthy life many of us are enjoying today is due to the variety of medicines that are available as a result of advanced chemical researches in chemistry. These researches are financed by pharmaceutical firms, governmental and non-governmental organization, and conducted by chemists. These researches will continue to find new drugs and also meet the challenges of time. Modern transportation is an essential feature of today’s civilization the rapid development from carts pulled by animals to the latest air craft was made possible by chemists producing suitable fuels and structural materials like alloys which are light, strong and heat resistant.
(iv) Career in Chemistry, Nigeria is a developing nation with an increasing demand for skilled manpower. Many job opportunities are available for students with knowledge of chemistry in the public and private sectors; these opportunities are more prevailing in the following areas:

Teaching Service, chemistry teachers and lectures in secondary schools, polytechnics, colleges of education and universities, laboratory assistants in schools and universities are always of increasing demand.

Health Services, pharmacists, nurses medical assistant and laboratory assistants are all students of chemistry, that is to say, they must to have studied chemistry before being able to be what they are.

A. Instructional Strategies in the Teaching of Chemistry

There are so many instructional strategies used in the teaching of chemistry. Some of these strategies include inquiry method, traditional lecture method, problems solving approach, cooperative learning and project method among others.

Inquiry teaching method has been described as problem solving, critical thinking, reflective inquiry and deductive thinking. It is a method of teaching that involves probing, finding out investigating, analyzing, synthesizing, discovering, evaluating, questioning and thinking (Muhammad, 2007). In another development, inquiry method is defined as teaching method which heavily depends upon the learner’s involvement with the leaning task. The method is based on the assumption that the subject is to learn actively by fully participating in the learning task. It is a method that leads to effective learning outcomes which will be meaningful to the learner.

In this method of teaching, students are encouraged to behave like scientists in the process of their investigation. Therefore, for the students to meaningfully engage in inquiry there is the need for teacher to practically involve the students from the planning stage to the evaluating stage. This could be done or achieved by the students and the teacher in locating and gathering information from many sources like reading materials, specimens and community resources.

Inquiry teaching method is one way of making sense out of what we experience and therefore requires thinking, (Blair and Simon 1998). This implies that the method requires putting learners into situation in which they must to be engaged in intellectual operation that constitutes finding out (Muhammad, 2007). Kyle and Gadsden (1996), viewed inquiry teaching method as a strategy of teaching where students examine ideas, existing issues, probe and question them freely, and practice on their own or with little guidance from the teacher. The students seek for information to answer or solve their problems. Therefore, inquiry teaching is educative and experimental and produces a lot of fun and joy as students learn by doing activities.

An ancient Japanese proverb says: “give a man a fish and he will not be hungry for a day, teach a man how to fish, he will not be hungry for life time”, (Matthias, 1973). By this proverb it means that teaching people how to tackle and solve problems by themselves, becomes an asset which is what the inquiry approach stands for, while solving problems for people, which is what tradition lecture method is known for, is a temporary.

Although, the inquiry teaching method has been described by many educators as effective approach, it is not without some shortcomings and many people have expressed one thing or another against the inquiry reaching method. One of such critiques is Bredderman (1985) who pointed out some disadvantages of inquiry approach to include its time consuming nature. Time is needed to plan inquiry activities. It may not be possible to use the inquiry approach in all situations and some authors like Agboola & Oloyede (2007) maintained that, inquiry approach is more suitable for “intuitive and creative children who are full of enthusiasm and active”.

German (1989), in his own view concerning the competency of the teacher, said: “if the method is used by a competent teacher it has great deal to offered but if used incompetently as fashion it is probably more disastrous to leaning than exclusive reliance of the former methods.

The lecture method is known as the traditional method of transmission of knowledge; it is characterized as a one way flow of information from the lecturer, who is always active to the learners who are always passive. The method is the most frequently used method of instruction. The lecture method is indeed an oral presentation intended to present information or teach people about a particular subject. Lectures are used to convey critical information, historical background, theories and equation. According to Donald (2000) Lecture method is the most frequently used method in teaching.

However presentation of lecture without pausing for interaction with students can be ineffective regardless of the skill of the lecturer. The use of pauses during the lecture for interaction or questions create an interaction between instructor and students, the lecture method is used primarily to introduce students to a new subject, but it is also a valuable method for summarizing ideas, showing relationship between theory and practice and re-emphasizing certain points.

A lecture/demonstration method is a teaching technique that combines oral explanation with doing to communicate, processes concepts and facts. It is particularly effective in teaching a skill that can be observed (Sola and Ojo, 2005). A skill-full educator may wish to both tell and show what steps to take in an educational process. A demonstration is usually accompanied by explanation which is essentially a lecture.

On the other hand the demonstration performance method of teaching is based on simple but sound principle that we learn by “doing". The lecture method is a traditional method of transmission of knowledge. It is characterized by a one way flow of information from the teacher who is always active to the learners who are always passive. It is characterized by large class size which may range from 25-100. It is more suitable for high secondary school students and tertiary institutions. It has the following characteristics:

i. The students are absolutely passive listeners and passively assimilating Information given to them by the teachers.

ii. It may be supported with visual aids, films, lecture media and handouts.

iii. Students are responsible for making their own notes.

iv. It is teacher- centered; the teacher or the lecturer does the major activities, i.e. talking illustrating or presenting the films or other aids.
Though lecture method is generally considered to be a weak pedagogy, schools have not yet found practical alternative teaching methods for large majority of their courses (Adedoyin, 1990). The lecture method is also known to have merits, e.g. knowledge, factual information are carefully transmitted to allow students gain a good understanding of a subject; it is less expensive compared to the inquiry methods. The lecture method has several short comings which include the following:

i. Passive learning by the students which make them weak and disinterested.
ii. Immediate evaluation provision of what has been learnt may not be possible
iii. It is one way method of communication that does not involve significant students’ participation.

Cooperative learning is another teaching method which provides opportunities for students to develop skills in group interactions and working with others which is needed in today’s world. According to Johnson and Johnson (1990), cooperative learning experiences promote positive attitudes toward the instructional experience than competitive or individualistic methodologies.

Other teaching methods include interactive multimedia (IMM) which is a relatively new educational innovation. It is used in primary, secondary and tertiary level. Interactive multimedia is defined as a powerful combination of early technologies that constitutes an extraordinary advancement in the capability of machine to assists the educational process (Mohsen, 1998). Interactive multimedia combines computer hardware, software and peripheral equipment to provide a rich mixture of text, graphics, sound animation, full-motion video, data and other devices to effectively convey information to students.

The assumption that multimedia information facilitates learning process has led to an increasing use of IMM computer assisted instruction. The interactive nature of multimedia makes it especially attractive in youth education because interactive encourages children to take an active role in learning process. Research shows that children are much more attentive to programs where animation and narrative are used. Inquiry method of teaching enable students to interact with the leaning materials and the students are responsible for their own leaning.

III. METHODOLOGY

A. Research Design

The design for this study is quasi experimental in nature. It is a pre test, post-test and post-posttest experimental group and control group design. The control and experimental groups were pre-tested to determine their group equivalence at the start of the experiment. Experimental group was given an attitude pre-test this is to determine the attitude of experimental group towards chemistry before they were exposed to treatment. The control group was taught the same chemistry concept using traditional teaching strategy. The design is illustrated as follows:

Where;
EG = experimental group
CG = control group
O1 = pre-test
OA1 = pre-test attitude
XI = inquiry method
XO = lecture method
O2 = post test
OA2 = post test attitude
O3 = post- posttest

This design is recommended by Fraenkle and Wallen, (2009) for a study of this nature.

B. Population of the Study

The Population of the study consisted of all SS3 Science Students of Oboro Secondary School in Abia State. This category of students offered chemistry in SS3 Secondary School in Abia State. The students are of average age of 18 years. Details of the population are given in Table 1.

Table1: SS3 Science Students of Oboro Secondary School in Abia State

<table>
<thead>
<tr>
<th></th>
<th>Morning</th>
<th>Afternoon</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>45</td>
<td>51</td>
<td>96</td>
</tr>
<tr>
<td>Female</td>
<td>70</td>
<td>40</td>
<td>110</td>
</tr>
<tr>
<td>Total</td>
<td>115</td>
<td>91</td>
<td>206</td>
</tr>
</tbody>
</table>

Source: Office of the principal Oboro Secondary School in Abia State

C. Sample and Sampling Procedure

A sample of 70 chemistry students was selected by random sampling. This technique was used because, according to Freankle Wallen (2009), it ensures that all key characteristics of individuals in the population are included in the same proportion and it increases the likelihood of the sample being a true representation of the population. Also the sample size (70 students) was sufficiently large enough for an experimental study of this nature as it conformed to Freankle and Willen (2009) who reported that the recommended minimum numbers of subjects is 30 in each experimental and control group for an experimental study of this type. Two hundred and six 206 students were considered. The list was then divided in two substrata, boys and girls and then control and experimental groups respectively. The experimental group was from the morning session and the control group from the afternoon session. This was to avoid interaction of the two groups during administration of the treatment. In the experimental group there was 17 male and 18 female while in the control group there were 20 male and 15 female. The number of the samples in both experimental group and control group was 35 each.
The instruments were validated by psychologists, specialists in chemistry and science education, based on the following terms of reference:

i. to determine the appropriateness of the instruments with reference to the purpose of the study.

ii. grammatical structure of the questions the clarity and the content area. All the corrections and suggestions pointed out were effected to enhance the validation of the instruments.

**E. Validation of CAT and CAQ**

The instruments were validated by psychologists, specialists in chemistry and science education, based on the following terms of reference:

i. to determine the appropriateness of the instruments with reference to the purpose of the study.

ii. grammatical structure of the questions the clarity and the content area. All the corrections and suggestions pointed out were effected to enhance the validation of the instruments.

**F. Reliability of Chemistry Achievement Test (CAT)**

A pilot study was conducted to establish reliability of the instrument Twenty SS3 Science Students of Oboro Secondary School in Abia State were randomly selected for the pilot study. The test contains appropriate instructions on how to answer the questions. The test was administered at first and second occasion within an interval of fourteen days under the same conditions as the first one. On each occasion of the test administration, it took the students 60 minutes to answer the questions. The scores of the students were recorded in term of their overall performance on the test and retest administered. The reliability coefficient of the test and re-test scores were computed by means of Pearson Product Moment Correlation Coefficient (PPMCC).

This statistics was used to ascertain if there is any correlation between the first and second test of the study sample. The reliability coefficient r was found to be 0.78

**G. Administration of Treatment**

It is important to distinguish between inquiry and traditional instructional strategies used in his study. According to Flowers (1987) inquiry – based teaching is emphasizing observation and interpretation of data. Inquiry based instruction in this current study similarly emphasizes hands-on minds- on activities that involve gathering data and information critically to examine the data for relationship and interprete the data.

The experimental group which consists of 35 students which are from the morning session were subjected to six weeks teaching (each week 2hrs) using inquiry-based method using acid, base and salt concepts where all materials needed was provided to the students. These materials include different types of acids strong and weak acids and different types of bases and salts litmus paper and even an internet facility. All other materials that would make an inquiry method instruction a success were provided. During the lessons the students carried out different activities and investigation under the supervision of the teacher.

The most important characteristic of the lesson was that, the lesson was “students-centered”. Activities were designed to encourage students to become more adapted to using science process skills and more knowledgeable about acid, base and salt concept.

The control group which consists of the same number of students as in the experimental group and which were in the afternoon season, were taught the same concept for the same period of time using the traditional lecture method. A number of variables were held constant so that statistical comparison between experiment and control group could be made. The constant variables were SS3 science students, the same school environment, same participating teacher and same duration. The only variable that changed was the teaching method.

**H. Data Collection Procedure**

Two instruments were used for data collection namely Chemistry Achievement Test (CAT) and Chemistry Attitudes Questionnaire (CAQ). CAT was used as pre-test and post-test, and post post-test. While CAQ was only given to the experimental group as attitude pre test and attitude posttest.

**1. Pre-test administration**

Before the Administration of the treatment the subjects of the study that is the experimental group and the control group were subjected to pretest to determine the level of their performances for the purpose of comparison.
The means scores of the two groups were calculated and subjected to a t-test statistic to determine group equivalence between experimental group and control group at the start of the experiment. The experimental group were then given a pre - attitude questionnaire to determine the attitude of the students before they were exposed to inquiry teaching method refers to appendix 8a. The two groups were then exposed to chemistry instruction on acid, base and salt concept for six weeks. The experimental group was taught using inquiry teaching method while the control group was taught using traditional lecture method.

2. Posttest Administration

At the end of six weeks, a posttest was administered to both control and experimental groups this was to determine the means scores of the two groups. The experimental group was also given an attitude post-test after the treatment to determine whether there was a change in attitude before and after the experiment.

3. Post-posttest

Two weeks later, a post-posttest was administered to both experimental and control groups to determine if there was any significant difference in the mean scores of the post test and post-post test. This according to Harry and Newcomb (1990), two weeks is enough to test retention level of the students.

4. Data Analysis

The data collected were analyzed using t-test statistic to answer the research question as well as test the null hypotheses.

H01: There is no significant difference between the means scores of students taught chemistry concepts using inquiry methods and those taught the same concept using lecture method. This hypothesis was tested using t-test.

H02: There is no significant difference between the means scores between male students taught chemistry concept using inquiry method of teaching and their female counterparts taught same concept using the same teaching strategy. This hypothesis was tested using t-test.

H03: There is no significant difference in the retention of learned concepts between students taught chemistry concepts using inquiry method and those taught same concept using lecture method. A t-test statistic was used to test this hypothesis.

H04: There is no significant change in students’ attitude towards chemistry before and after exposed to inquiry teaching method. The data collected were analyzed by using weighted average to find the means of the scores before and after the treatment. The result was then subjected to t-test analysis to test the null hypothesis.

IV. ANALYSIS, RESULTS AND DISCUSSION

The research has four research questions.

A. Hypotheses Testing

The first hypothesis in this study is that:

HO1: There is no significant difference between the mean scores of students taught chemistry concepts (acid, base and salt) using inquiry methods and those taught the same concept using traditional lecture method.

The post test data of the experimental and control groups were generated via CAT and were subjected to t–test statistical analysis to determine if there is any significant difference in academic achievement of students in the experimental and their counterparts in the control groups.

Table3: t-test analysis of the Post Test Mean Scores of the Experimental Group (EG) and the Control Group (CG)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
<th>DF</th>
<th>t-calculated</th>
<th>t-critical</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>35</td>
<td>22.25</td>
<td>2.45</td>
<td>34</td>
<td>2.25</td>
<td>1.54</td>
<td>Significant</td>
</tr>
<tr>
<td>Control</td>
<td>35</td>
<td>21.56</td>
<td>2.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant (P =0.05)

From Table 3, the calculated t-value is 2.25. This value is greater than the t value critical which is 1.54 at 5% alpha level with df = 34. This means that there is a significant difference between the post test mean scores of the experimental and the control groups in favor of the experimental group. Thus the null hypothesis is rejected. This implies that the experimental group taught chemistry using inquiry method of instruction achieved significantly higher than the control group taught same concepts using lecture method. This had answered the first research question that is there is a significant difference in the mean scores of the students taught chemistry concepts using inquiry teaching method and those taught the same concept using lecture method.

B. Testing HO2

HO2: There is no significant difference in academic performance between male students taught acid, base and salt concepts using inquiry method of teaching and their female counterparts taught same using the same teaching strategy.

To test this hypothesis, the post test achievement scores of the experimental and control group were split according to sex of the students taught the same concept. The mean scores of the male and female students who were exposed to the inquiry method of instructions were subjected to t-test statistical analysis. The results obtained are shown in Table 4.

Table 4: t-test Analysis of post-test Mean Scores of Male and Female Students in the Experimental Groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>N</th>
<th>Means</th>
<th>SD</th>
<th>DF</th>
<th>t-Calculated</th>
<th>t-Critical</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male students</td>
<td>17</td>
<td>22.29</td>
<td>2.44</td>
<td>34</td>
<td>0.21</td>
<td>1.645</td>
<td>*Not Significant</td>
</tr>
<tr>
<td>Female students</td>
<td>18</td>
<td>22.18</td>
<td>2.45</td>
<td></td>
<td></td>
<td></td>
<td>*Not Significant (P=0.05)</td>
</tr>
</tbody>
</table>
From Table 4, the calculated t-value is 0.21. This value is less than the value of t-critical which is 1.645 at 5% alpha level with df = 16. The null hypothesis is therefore retained. This means there is no significant difference between the mean scores of the male students and their female counterparts of the experimental group exposed to inquiry teaching method.

This implies that both male and female students performed equally well after exposure to Inquiry teaching method, and it is concluded that Inquiry teaching method is gender friendly. This also answered the second research question that is inquiry teaching method had no effect on the gender of the students.

D. Testing H03

HO3: There is no significant difference in retention ability between students taught acid, base and salt concepts using inquiry method and those taught the same concept using lecture method.

The data analyzed to test this hypothesis were post-posttest achievement scores of the experimental group (EG1) and control group (CG). The mean scores were subjected to t-test statistical analysis. The results are shown in Table 5.

Table 5: t-test analysis of the Post-post-Test Mean Scores of the Experimental Group (EG) and the Control Group (CG)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>DF</th>
<th>T-Calculated</th>
<th>T-Critical</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>21.54</td>
<td>2.94</td>
<td></td>
<td>34</td>
<td>1.645</td>
<td>*Significant</td>
</tr>
<tr>
<td>Control</td>
<td>18.6</td>
<td>2.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant (P = 0.05)

The result of Table 5 shows that the t-value calculated 7.17 is higher than the t-critical 1.645 at alpha level of 0.05 with df= 34. This means that there is a significant difference in post post-test result of the experimental group and control group in favor of the experimental group. Thus the hypothesis is rejected. This shows that the experimental group taught using inquiry method of instruction retained the taught concepts better than those taught using traditional lecture method. This answered the third research question, that is inquiry teaching method result in greater retention of the learn concepts (acid, base and salt)

E. Summary of Findings

(i) Analysis of data to test HO1 shows that there is a significant difference in the means scores of the experimental group and control group in favor the experimental group which implies that inquiry teaching method was more effective instructional strategy than traditional lecture method.

(ii) Analysis of data used to test HO2 indicates that the performance of male and female students is the same when exposed to inquiry teaching method in Chemistry, which means that inquiry teaching method is gender friendly.

(iii) Analysis of post-posttest, data used to test H03 indicates that the retention level of students taught using inquiry method of instruction is higher than that of students taught using lecture method.

(iv) Analysis of data to test the HO4 shows that students developed positive attitude toward chemistry after exposure to inquiry method of instruction via the CAT.

F. Discussion of Results

After six weeks of the inquiry-oriented instruction, the experimental group had significantly higher means scores in chemistry achievement test than did the control group. It may be that pupils exposed to the treatment had the opportunity to observe, record, and interpret data on their own during hands on investigative activities.

From the analysis of data it is empirically confirmed that inquiry method of instruction significantly improved students’ performance. This finding is in line with that of Campbell (1966), who reported that practical exploration and experimentation leads to a constant interplay between students and teachers, which leads to effective learning. Similarly Basaga (1994) observed that the lecture method would be declared obsolete and relegated like all old models to a resting place in a science museum.

CONCLUSIONS

From the finding of this study, the research concludes that Instructional strategies which the teachers use in the teaching of science have significant effects on the students’ achievement. Inquiry teaching method facilitates effective learning of acid, base and salt. Students that were taught chemistry concept using inquiry teaching method retained the learned concepts better than those taught using traditional lecture method. Neither male nor female students performed better than other when taught chemistry concept using inquiry teaching method.

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Unpublished Msc. (Ed) thesis Department of Science Education A.B.U. Zaria


