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Impact of Prior Exposure to Laboratory Apparatus on the Acquisition of Science Process Skills Andacademic Achievement among Chemistry Students in Secondary Schools

BABAFEMI ADENIYI JOHNSON[1] and ILIYA JEREMIAH MAKARAU[2]
[1, 2] Department of Chemistry, School of Sciences, Federal College of Education Zaria, Kaduna State Nigeria.
+2348038243178 and +2347036121865. Corresponding author email id : adedara04@gmail.com [1]
email id : makarauij@gmail.com [2]

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***Abstract* – This work investigates the impact of prior exposure to laboratory appreciation on the acquisition of science process skills and academic performance among secondary school chemistry students. Some of the research questions formulated to guide the study include; what is the difference in the mean academic performance of senior secondary school chemistry students' prior exposure to laboratory apparatus in comparism to those not exposed? What is the difference in the acquisition of process skills among senior secondary school chemistry students who had prior exposure to laboratory apparatus and those not exposed? To answer these questions, some hypotheses were developed. There is no significant difference in the mean academic performance of chemistry students' prior exposure to laboratory apparatus and those not exposed. There is no significant difference in the acquisition of science process skills between chemistry apparatus and those not exposed. Various literatures were reviewed by the researchers. The study is a pre-test, post-test, quasi experimental and control group design. A total of sixty (60) students forms the sample of the study. Three instruments, namely; Chemistry Achievement Test (CAT), Science Process Skills, Achievement Test (SPSAT) and Chemistry Retention Test (CRT) were used for data collection. The CAT was developed by the researcher and validated by experts in chemistry education. The data was analyzed using t-test and the results from testing the hypotheses above were both found to be 0.000 at 0.05 level of significance. This revealed that the experimental group taught chemistry using prior exposure to laboratory apparatus strategy performed significantly better in their process skills acquisition and academically than the control group taught using the traditional lecture method. The study recommends among others that chemistry teachers should be encouraged to use prior exposure to laboratory apparatus strategy in teaching of chemistry.**

***Keywords* – Prior-exposure, Laboratory, Apparatus, Skill-Acquisition and Achievement.**

I. INTRODUCTION

The role of chemistry in our daily and national life as well as in the industry is undaunted many of our day-to-day activities revolve around chemistry. Chemistry is everywhere; chemistry is life; chemistry is the oracle and crown prince of wonder in science (Oloyede, 2010; Opara and Wasagu, 2013).Despite the key role of chemistry as the central science that forms the basic foundation to many disciplines and in improving the quality of life, the performance of Nigeria secondary school students in the subject has for many years remained a matter of a serious concern (Jegede, 2010, Oloyede, 2010).

Efforts made through research to discover the causes of the persistent failure revealed among others that secondary school chemistry teachers, mainly adopt the lecture method in teaching and learning of chemistry (Udoh, 2008). Lovat (2003) posit that "teaching is not an accidental craft to follow naturally from mastery of subject content, but a highly complex blend of theoretical understanding and of practical skill. "Emphasis on traditional approaches and coverage of content mapped out in the school syllabus and scheme of work for the three years of senior secondary education (Nigeria runs 6 – 3 – 3 – 4 system of education although with the recently introduced 9 – 3 – 4 system; the senior secondary school position has not changed). In Nigeria have resulted to students teaching chemistry without conceptual understanding (Bennet, 2003; Jodi, 2010). Recent studies done in Nigeria (Eze, 2002; Egbo, 2005; Oludipe and Awokoya, 2010; Ameh and Dantani, 2012; Opara and Wasagu, 2013 and Muhammad, 2014) suggests that teachers are in a hurry and tend to rush through the scheme of work to enable them cover the topics in the curriculum within the given period pay by little or no time on the use of the laboratory and its resources.

Theoretical Framework

Prior exposure to laboratory apparatus is based on Gagnes (1965) theory of learning state "that any piece of knowledge can be acquired by students who possess certain pre-requisite piece of knowledge which have their own pre-requisite in turn". According to this theory, prior knowledge determines what further learning may take place and Gagne (1965) believes that this type of learning structure is particularly important for subject like the nature of science and that the meaningfulness of instructional material can be achieved through the shift from concrete operation to abstract operation when students are exposed to appropriate teaching instructional materials. Piaget (1968) Gagne (1965) system for categorizing learning a very useful framework for instruction. However, Ausubel's theory of learning (1965) distinguishes between rote and meaningful learning of science on the one hand and how prior knowledge affects one learning process of science on the other hand. According to Ausubel's (1965) "Meaningful learning occurs when there is interaction between the student's appropriate elements in the knowledge that already exists and new materials to be learnt." Where such interaction does not take place, rote learning occurs. Those parts of the learner's cognitive structure (organization of knowledge) which can provide for the interaction necessary for meaningful learning called "sub-summers."

Statement of the Problem

This century is witnessing rapidly changing developments in information, science and technology in all walls of life; to cope with these developments, proper teaching methods for applied subjects requiring laboratory scientific experiments need to be adopted. This perspective should be firmly established in the mind of curriculum designers and educational decision-makers, especially when they design, develop the curricula and consider activities and experiments related to the teaching material. Some educationist believe that science topics cannot be effectively taught without experiences. Therefore, modern educational trends in education emphasize laboratory activities and experimenters, because the laboratory is physically associated to science topics that entail practical laboratory experiments, on the one hand and the accomplishment of the objectives of science teaching on the other (El-Qumeizi, 2002).

The American chemistry student project emphasized the laboratory work in teaching chemistry, likewise, the British National Field Project showed great interest in using laboratory experimentally in teaching chemistry in order to develop the students' manual skills, designing experimental activities can enhance the students' knowledge through certain processes such as analysis, synthesis, demonstration and prediction.

Science teaching has the following objectives to achieve;

- Acquiring the proper functional information
- Developing the students' scientific thinking and problem-solving abilities

- Fostering students' proper functional attitudes
- Developing certain functional scientific skills
- Fostering functional scientific trends
- Fostering appreciation of scientific attitudes and enhancing recognition of scholar efforts (Salameh, 2007).

These objectives cannot be properly attained without effective rise of the science laboratory and experimentation. This attainment can be realized through the teachers' readiness to effectively use the laboratory in teaching science. But, failure to achieve the objectives of science teaching is the upper basic stage is mainly due to the fact that lots of teachers evade laboratory work and science activities though they can easily use the school laboratory (Zaytoun, 1987). Researchers like Akubuilo (2004) for example have shown that when learners are actively involved in the process of learning, they are able to retain what they have learnt.

Therefore, the study seeks to elucidate the impact of students' prior exposure to laboratory apparatus on the acquisition of process skills, the achievement and retention ability among secondary school students.

The objectives of the study were to:

i. Ascertain the impact of prior exposure to laboratory apparatus on the academic achievement among secondary school chemistry students.
ii. Investigate the acquisition of science process among secondary school chemistry student's prior exposure to laboratory apparatus and those not exposed.

Research Questions

The following research question were generated for the study:

i. What is the difference in the mean academic achievement of senior secondary school chemistry students' prior exposure to laboratory apparatus in comparison to those not so exposed?
ii. What is the difference in the acquisition of process skills in senior secondary school chemistry students who had prior exposure to laboratory apparatus and those not so exposed?

Research Hypothesis

Based on the research questions, the following hypotheses stated in the null form were formulated and tested at $P \leq 0.05$ level of significance.

i. There is no significant difference in the mean academic achievement of chemistry students' prior exposure to the laboratory apparatus and those not exposed.
ii. There is no significant difference between the acquisition of process skill of chemistry students that have prior exposure to laboratory apparatus and those not exposed.

II. Methodology

Research Design

The design adopted for this study was quasi experimental in nature, using a pretest, post - test and post - post - test, experimental group and control group design. The experimental group and control group were pre - tested using CAT and SPSAT to determine their group equivalence at the start of the experiment and to test that there is no significant differences between the two groups ability level before the treatment. This was to enable the researcher measure student's level of understanding of the use of laboratory apparatus prior to teaching of chemistry concepts and to see their acquisition of process skills level before and after the administration. Later a post-post-test treatment was given two weeks after the post-test to measure the retention ability of the experimental and control groups.

Population of the Study

The population of the study comprised of SS1 science students in five (5) selected public senior secondary schools that offered chemistry in Sabon Gari local government educational area of Kaduna State. The population comprised of single sex and coeducational schools. There were one (1) male school, two (2) female schools and two (2) coeducational schools in the population.

Table 1. Enrollment in Local Colleges, 2005.

NAME OF SCHOOL	**SEX**		**TOTAL NUMBER OF STUDENTS**
	M	**F**	
GSS Chindit (boys)	350	-	350
GSS DogonBauchi (girls)	-	350	350
GSS Chindit (girls)	-	235	235
GSS Aminu (coeducation)	1198	98	296
GSS Muchiaa (coeducation)	157	99	256
Total			**1487**

(*Source:* Ministry of Education, Kaduna State 2015)

Sample and Sampling Techniques

Sixty students served as sample for the study from two of the public schools (GSS Aminu and GSS Muchia) within SabonGari local government educational area of Kaduna State. These schools were randomly selected and grouped into experimental (GSS Aminu) and control (GSS Muchia) groups respectively. Thirty students from each school sample of SS1 chemistry students were selected by random sampling. This technique was used because, according to Freankle and Wallen (2000), it ensures that all key characteristics of individual in the population were included in the same population and it increased the likelihood of the sample being a true representation of the population.

Instrument for Data Collection

Three instruments were used for the study. This was the Chemistry Achievement Test (CAT), Science Process Skills Achievement Test (SPSAT) and Chemistry Retention Test (CRT) respectively. A multiple-choice achievement test in science (chemistry) was developed by the researcher and standardized by lecturers in chemistry department for the CAT. These tests were developed in accordance with the curriculum objectives. It comprised of 20 multiple choice items. The face and content validity of the test was determined through expert opinion. The instruments were validated by specialists in chemistry and science education. SPSAT was also developed to test the students' science process skills.

Validity of the Test

The tests were validated by three lecturers in chemistry department with at least master degree. The instrument was subjected to this process for the purpose of standardization. The validators critically examined and assessed all the items of the instrument which was aimed at;

(a) Determining the appropriations of the instruments with reference to the purpose of the study.

(b) 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.

(c) Determining whether the test item test what they were designed to test.

(d) Determining whether the questions match the ability of the students.

(e) Determining whether the questions are clear, precise and free from ambiguity.

Pilot Testing

A pilot study was conducted on a small group to determine the effectiveness of the instrument. This was preceded by the pre-test given to the students from two schools (divided into experimental and control groups). After the treatment, the post-test was administered. Two weeks after the post-test was administered, the post-post-test was administered which was in line with Tuckman's recommendations of the use of two weeks interval for the test-retest procedure. The instruments consist of twenty (20) multiple choice questions with clear instructions on how to answer the questions. The reliability coefficient of CAT was when determined using Pearson product moment coefficient statistic and r = 0.79 and that of the SPSAT recorded was found to be 0.77.

III. Results

The results were presented below according to the sequence of the research questions and hypotheses which guided the study. The research has three research questions.

Pre-Test Analysis of Schools Results

Below is the t-test analyses of the pre-test scores of experimental group (students who had prior exposure to laboratory apparatus) for each of the schools before the commencement of the treatment to ensure that all the groups were of equal academic strength.

Table 2. T-Test Analysis of Pre-Test Scores of Experimental Groups.

Group	N	Mean	S.D	S.E	df	t-value	p-value
Experimental	30	7.13	1.907	0.348	58	-0.061	0.952
Control	30	7.17	2.379	0.434			

*significant level ($p \leq 0.05$)

From the table 2, the p-value of the CAT was found to be 0.952, which is above the 0.05 level of significance. This shows that the two groups (experimental and control groups) had equal academic strength in their knowledge of chemistry before the commencement of the treatment.

Table 3. T-Test Analyses of Pre-Test (Spsat) Scores of Experimental and Control Groups.

Group	N	Mean	S.D	S.E	df	t-value	p-value
Experimental	30	5.08	2.665	0.487	58	-0.240	0.981
Control	30	5.10	2.440	0.446			

*significant level (p≤0.05).

From the table 3, the p-value of the SPSAT was found to be 0.981, which is above the 0.05 level of significance. This shows that the two groups (experimental and control groups) had equal academic strength in science process skills before the commencement of the treatment.

Testing Hypotheses

Hypothesis H_{01}

The first hypothesis in this study states that:

H_{01}: There is no significant different in the mean academic achievement of chemistry students' prior exposure to laboratory apparatus and those not exposed.

The post test data of the experimental and control groups were generated Chemistry Achievement Test (CAT) and were subjected to t-test statistical analysis to determine if there is any significant different in academic achievement of students in the experimental and their counterparts in the control groups. Summary of the analysis is presented in Table 4.

Table 4. Summary of the Mean Scores, Standard Deviation and Mean Differences of Experimental and Control Group's Post-Test (Cat) Scores.

Group	N	Mean	S.D	Mdf
Experimental	30	13.400	2.608	2.000
Control	30	11.400	1.993	

*significant level (p≤0.05).

From Table 4, it shows that there is difference in in the academic strength of those students exposed to laboratory apparatus and those not so exposed.

To test if there is a significant difference in their mean score, the data is subjected to to-test statistical analysis which is summarized in table 5 below.

Table 5. T-Test analyses of Post-test (Cat) Scores of Experimental and Control Groups.

Group	N	Mean	S.D	S.E	df	t-value	p-value
Experimental	30	13.400	2.608	0.476	58	4.033	0.000
Control	30	11.400	1.993	0364			

*significant level (p≤0.05)

The p-value = 0.000, this value is less than 0.05 at 5% alpha level with df = 58. This means that there is a significant difference between the CAT mean scores of the experimental and the control groups in favour of the experimental group. Thus, the null hypothesis is rejected. This implies that the experimental group taught chemistry using prior exposure to laboratory apparatus achieved significantly higher than the control group taught same concepts using lecture method. This answered the first research question that is "there is a significant difference in the mean scores of the students' academic achievement taught chemistry concepts using prior exposure to laboratory apparatus and those taught the same concept using traditional lecture method.

Hypothesis H_{02}

H_{02}: There is no significant difference between the acquisition of process-skill of chemistry students that have prior exposure to laboratory apparatus and those not exposed.

The post test data of the experimental and control groups were generated via Science Process Skills Achievement Test (SPSAT) and were subjected to t-test statistical analysis to determine if there is any significant different in the acquisition of science process skills of students in the experimental and their counterparts in the control groups. Summary of the analysis is presented in table 6 - 7 below.

Table 6. Summary of the Mean Scores, Standard Deviation and mean Difference of Experimental and Control Group's Post-Test (Spsat) Scores

Group	N	Mean	S.D	Mdf
Experimental	30	14.53	-	5.50
Control	**30**	**9.030**	**2.977**	

From Table 6, it shows that there is difference in the mean score of those students exposed to laboratory apparatus and those not exposed.

To test if there is a significant difference in their mean score, the data is subjected to t-test statistical analysis which is summarized in table 7 below.

Table 7. Test of Degree of Significance Deference between Experimental and Control (T-Test).

Group	N	Mean	S.D	S.E	df	t-value	p-value
Experimental	30	14.530	2.515	0.459	58	9.669	0.000
Control	**30**	**9.030**	**2.977**	**0.543**			

*significant level ($p \leq 0.05$)

The p-value = 0.000, this value is less than 0.05 at 5% alpha level with df = 58. This means that there is a significant difference between the SPSAT mean scores of the experimental and the control groups in favour of the experimental group. Thus, the null hypothesis is rejected. This implies that the experimental group taught chemistry using prior exposure to laboratory apparatus acquired more science process skills that the control group taught same concepts using lecture method. This has answered the second research question, that is, there is a significant difference in the acquisition of science process skills of the students taught chemistry concepts using prior exposure to laboratory apparatus and those taught the same concept using traditional lecture method.

IV. Discussion

From all the information and data recorded, the experimental group had significantly higher mean scores in chemistry achievement and science process skills achievement test than the control group. It may be that student exposed to the treatment has the opportunity to observe, and interpret data on their own during hands on investigative activities.

From the analysis of data, it is empirically confirmed that experimental/laboratory 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. This observation reflects Eze (2002) who observed that the teacher should train the students to recognize problems, since individual thinking, though not easy, should be encouraged because it fostered interaction and that the science class becomes alive as students get involved and pursue answers to their own problems. The statistically significant difference between the two means suggests laboratory method of teaching led to effective learning outcome than the traditional lecture method. This finding is also in agreement with Bichi (2002) who compare the effectiveness of problem-solving strategy and that of traditional lecture method on students' retention level of concepts and found that problem solving teaching strategy enabled the learners to have effective learning and higher retention level than the traditional lecture method.

According Leonard, Dfrense and Mester, (1998), laboratory exposure produces significantly greater educational gains than traditional methods and appeared to work equally well for college students of all ability levels, not just the very academically talented, but also for the low performing among them who appear to be the majority of the students. This is in line with this work as the pre-test and post-test score comparison shows that difference which explains that exposure to laboratory apparatus level weaker students achieve better. Akubuilo (2004) further stressed that when learners are actively involved in the process of learning, they are able to achieve better and retain what they have learned. Nwosu and Okeke (1995) investigated the effect of laboratory and demonstration methods of teaching process skills acquisition. The results revealed that students taught using the laboratory method performed significantly better than those taught through demonstration and conventional methods. This is due to the fat that the laboratory method of teaching challenge students to be involved in the classroom. This is very much in line with the findings of this research.

Akubuilo (2004) opines that experimental method elicits adequate students' participation and promotes understanding and retention of concepts. Experimental method concretizes and elucidates difficult and abstract concepts thereby reducing students' problem of comprehension and application of concepts in problems solving situations (Njoku, 2004). Yadav and Mishra (2013), opines that students taught by prior exposure to laboratory apparatus show better academic performances than those taught using conventional methods. Morgil, Gungor, Seyhan and Seeken (2009) opines that laboratory practices generally improves the students' science process skills, cultivate interest in chemistry, develop team workability in problem solving and help students understand complex and ambiguous empirical work. According to Babafemi 2014 (unpublished thesis), students taught using experimental method achieve better academically and acquire more science process skills than those taught using lecture method. This is in line with the findings above.

V. Conclusions

From the findings of this study, it was concluded that the teaching method a teacher use in teaching chemistry and other science related courses has a direct effect on the students' academic achievement, process skills acquisition and retention ability. Experimental method of teaching science increases students' acquisition of process skills, academic achievement and retention ability.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. The teaching of chemistry should be concluded in such a way that students effectively learn and retain the concepts presented to them. The use of experimental/laboratory method seems to be appropriate in this respect. It should, therefore be incorporated into the main stream of pedagogy in the teaching of chemistry in secondary schools and higher institutions.
2. The use of traditional lecture method of teaching has been found to be less effective in teaching science in this study, with respect to the academic performance, science process skills acquisition and retention ability in the learning of chemistry concepts. For this reason, experimental teaching method should be encouraged and lecture method should be used with caution.

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AUTHORS PROFILE'

JOHNSON ADENIYI BABAFEMI Held from Kogi State Nigeria Studied at the famous Ahmadu Bello University Zaria (B..Sc ed, M.ed) Currently studying PhD Science Education at same university. He is presently a lecturer at the Department of Chemistry, School of Science Federal College of Education Zaria, Kaduna State Nigeria
Phone: +2347036121865, email id: adedara04@gmail.com

MAKARAU JEREMIAH ILIYA Held from Kaduna State Nigeria, Studied at the famous Ahmadu Bello University Zaria (B.SC, PGDE, MSc), currently studying his PhD Analytical chemistry at the same university. He is presently a lecturer at the Department of Chemistry, School of Sciences Federal College of Education Zaria, Kaduna State Nigeria, Phone: +2348038243178, email id: makarauij@gmail.com