The Effect of Laboratory Teaching Method on Senior Secondary School Students' Academic Achievement in Inorganic Chemistry

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Abstract

This study investigated the effect of laboratory teaching method on the academic achievement in inorganic chemistry (acid-base titration) of senior secondary school studentsin Enugu Education Zone of Enugu State, Nigeria. The design for the study was a pre-test post-test non control group quasi-experimental design.The population for the study consists of 1,407 Senior Secondary School Two (SS2) chemistry students from twenty (20) public co-educational schools in the education zone. The instrument used for data collection was Inorganic Chemistry Achievement Test (ICAT). The statistical tools used for data analysis in the study were mean and standard deviation for research questions and Analysis of Covariance (ANCOVA) for testing the null hypotheses at 0.05 significant level. The findings of this study showed that laboratory teaching method had much more effect on Chemistry students' achievement. The study showed that males and females benefited significantly from the teaching method since it is activity oriented which made them engage in in-depth critical thinking and process skills. Chemistry teachers should therefore incorporate it into the teaching-learning process since it developed students' scientific and practical skills motivated the students and fostered the spirit of competitiveness among them. Its effectiveness is also not limited by gender.

Keywords: Chemistry education, laboratory teaching method, inorganic chemistry achievement score,Senior Secondary School Two (SS2) chemistry students, gender and achievement score

Introduction

Science is an area of learning in the world today through which the development and progress of any nation are based. It is viewed generally as a systematic study of nature. Bradford (2015) defined science as a systematic and logical approach to discovering how things in the universe work. The knowledge of science has a link with that of technology. Acquisition of scientific and technological knowledge can enhance the development of any nation.

The degree of scientific and technological advancement of a nation is a function of its strength, politically, economically, socially, among others. In view of this, Aniodoh (2008) noted that science and technology have become dominant cultural factors and any nation that is not alive to this fact is either dead or dying. The truth is that any nation that is not deeply involved in the knowledge of science and technology is retrogressing. In realization of the critical role of science, many developing countries like Nigeria are making frantic efforts to improve on the study of science and science-related subjects in their various schools. For instance, the adoption and effective implementation of 6-3-3-4 system of education which focuses on acquisition of entrepreneurship and technological development is built around science and technology (Uwaifo, 2009). For this reason, the major aim of science education is viewed as a means of producing scientists needed for national development as contained in the National Policy on Education (Federal Republic of Nigeria (FRN), 2013). One of these science subjects is chemistry which can be defined as the study of the composition, properties and uses of all forms of matter (Ababio, 2013).

Effective study of chemistry lays a solid foundation for the scientific and technological development. Irshad (2014) stressed that chemistry is geared towards equipping the learner with specific knowledge, skills and attitude which enables him to become useful to himself and the society at large. The importance of chemistry to man cannot be overemphasized, as its knowledge is used in our daily lives within and outside school. Research evidences have proved that chemistry's contribution to quality of life and nation building is enormous in all aspects of human endeavour (Olorukooba, 2007; Olorundare, 2011). Reiterating the importance of chemistry, Ezinwa (2011) opined that no nation can be scientifically and technologically developed without adequate level of chemistry education.

Chemistry is divided into organic and inorganic branches at secondary school level. The National Policy on Education (FRN, 2013) defined secondary school education as the type that is received after primary education and before the tertiary stage. Effect of laboratory teaching on secondary school students' achievement, interest and retention is on inorganic chemistry. This is because inorganic chemistry forms about 70% of the entire secondary schools chemistry curriculum as contained in the revised edition of Senior Secondary Schools Curriculum (Federal Ministry of Education (FME), 2007). Inorganic chemistry is the study of the structures, properties and reactions of chemical elements and their compounds apart from carbon compounds and their derivatives. Sanderson (2011) stated that inorganic chemistry covers a broad range of the subject which deals mostly with non-carbon compounds.

Despite the importance of chemistry to human lives and to society at large, students' achievement in chemistry has been persistently low. The Chief Examiner's reports on WAEC (2010, 2011, 2013, 2014, & 2015) and even NECO (2014) showed that students' performance in chemistry has been

persistently poor. The effect of these problems on the chemistry students is enormous as their achievement is being hampered (Adepoju & Oluchukwu, 2011). Hence, there is the need for this topic of study.

Subsequently, efforts have continuously been made to improve on chemistry teaching and learning especially at the senior secondary level so as to ensure a sound foundation for future studies. However, Okebukola (1999), Njoku (2007) and Olorundare (2014) lamented that students' failure in chemistry at Secondary School Certificate Examination (SSCE) can be traced to their poor achievement in the practical examination which has frequently been attributed to the inadequacy of laboratory practice. Academic achievement is the learning outcome of students which may emanate from the teaching methods the teacher may adopt during teaching (Onowa, 2015). The issue of gender effect on students' achievement is inconclusive. Researches of Njoku (2007, 2016, & 2018) revealed that there was significant difference in students' achievement in chemistry. Such being the case gender as a variable is considered in this study. Practical chemistry is always done in the chemistry laboratory. The laboratory teaching method can be explained as a procedure involving first hand experiences with materials or facts derived from investigations or experimentation (Dushi, 2013). Laboratory teaching method helps students to develop their critical thinking, skills and scientific concepts efficiently as they make use of science process skills whereas demonstration method involves mere showing the students how to perform an experiment.With respect to science teaching and learning, demonstration method is defined as a practical teaching where one person (probably a teacher) performs the experiment while others observe the experiment and record what they see (Ezeano, 2012).

Considering the benefits derivable from laboratory activities and the prevailing poor students' achievement in chemistry in external examinations, there is need to ascertain the effect of laboratory methods of teaching on SS11 students'achievement in chemistry.

Statement of Problem

The prevalent negative trends in academic output and dispositions of students towards science subjects in general and chemistry in particular have been the concern of science educators and all those who care about the subjects. The students' achievement in external examinations like WASSCE and NECO has been persistently poor, especially in chemistry. Several attempts have been made to find out some science teaching methods that can stimulate the students' interest to learn and achieve better in chemistry. In this regard, many researchers have noted that science teachers predominantly make use of ineffective teaching methods in teaching secondary school chemistry which might have led to deteriorating students' achievement in chemistry. Therefore, there is every need to involve the use of other teaching methods and approaches which have been found effective in some subject areas and countries. One of such is the laboratory teaching method which has proved to be effective in improving students' achievement and interest in mathematics.

The issue is whether the laboratory teaching method may lead to improvements in students' achievement in chemistry especially when the content involves inorganic chemistry (acid-base titration).

Available studies have shown that gender influences students' achievement in secondary school chemistry. How would gender interact with laboratory teaching method in influencing students' achievement especially when the content is acid-base reaction? Hence, the problem of this study framed in a question form is; would there be interaction effect of gender and laboratory teaching method on the mean achievement scores of chemistry students in Enugu Education zone of Enugu State, Nigeria?

Purpose of the Study

The main purpose of this study was to determine the effect of laboratory teaching method on senior secondary school students' achievement in inorganic chemistry. Specifically, the study determined;

i. students' achievement in inorganic chemistry;
ii. students' achievement in inorganic chemistry in respect of gender;

Research Questions

The following research questions were raised to guide the study;

1. What are the mean inorganic chemistry achievement scores of SS 11 chemistry students in experimental (LTM) and control (DM) groups in both pretest and posttest ICAT?
2. What are the mean achievement scores of male and female chemistry SS II students taught inorganic chemistry using laboratory teaching method?

Research Hypotheses

The following null hypotheses which were tested at 0.05 level of significance ($P<0.05$) guided the study.

Ho_1: There is no significant difference between the mean inorganic chemistry achievement scores of senior secondary school (SSS II) chemistry students in experimental and control groups.

Ho_2: There is no significant difference between the mean achievement scores of male and female students taught inorganic chemistry using laboratory teaching method.

Ho_3: There is no significant interaction effect of laboratory method and gender, on students' mean achievement scores in inorganic chemistry.

Methodology

The design of the study was quasi-experimental research design. Specifically, pre-test, post-test non-randomized control group design was used because the subjects were not randomized into group; intact classes could not allow randomization. This study was carried out in Enugu Education Zone of Enugu State. Enugu Education Zone consists of three local government areas which are

Enugu East, Enugu North and Isi-Uzo. The population for the study consists of 1,407 Senior Secondary School Two (SS2) chemistry students from twenty (20) public co-educational schools in Enugu Education Zone (Source: Statistics Unit, PPSMB Enugu zone, February 2017). The sample size for this study was two hundred and fifty six (256) SS2 from three intact classes drawn from six senior secondary schools sampled for the study. Finally, the experimental group comprised 131 students with 62 males and 69 females, while the control group was made of 125 students (59 males and 66 females).

Inorganic Chemistry Achievement Test (ICAT) was used for this study's instruction for data collection. This instrument underwent face and content validation by three experts and the experts' corrections and modifications were used in preparing the final draft of the instrument. The instrument was trial tested in Army Day Secondary School, Awknanaw and its reliability was determined using the Kudar Richardson Formula 20. Hence, the instrument was found to be reliable with the reliability coefficient of 0.70. Mean and standard deviation were used to answer research questions while ANCOVA was used to test the research hypotheses at 0.05 levels of significance.

Results

Research Question 1:

What are the mean inorganic chemistry achievement scores of SS II chemistry students in experimental (LTM) and control (DM) groups in both pretest and posttest (ICAT)?

Table 1: Mean Achievement Scores and Standard Deviations of SS II Chemistry Students in Experimental and Control Groups in both Pretest and Posttest

Groups	Number (N)	Pre-test Mean ($\bar{x}$)	Pre-test Standard Deviation (s)	Post – test Mean ($\bar{x}$)	Post – test Standard Deviation
Experimental Group (LTM)	131	12.44	4.20	23.49	4.91
Control Group (DM)	125	13.79	4.84	21.98	4.93
Total	**256**				

Table 1 above displayed the results of Mean Achievement Scores and Standard Deviations of SS II chemistry students taught inorganic chemistry with laboratory teaching method (Experimental Group) and those taught inorganic chemistry with demonstration method (Control Group) in both Pretest and Posttest. From the results of the analyses, the pre-test mean achievement score and

standard deviation for the experimental group were **12.44**and **4.20**respectively, while the post-test mean achievement score and standard deviation were **23.49**and **4.91**respectively. On the other hand, for the control group, pre-test mean achievement score and standard deviation were **13.79**and **4.84**respectively, while the post-test mean achievement score and standard deviation were **21.98**and **4.93**respectively.

From the analyses, it showed that learning took place in both experimental control groups. This is because the two groups achieved higher mean scores in their posttests than their pretests. However, the posttest mean achievement score of the experimental group was higher than that of the control group by 1.51. This indicated that students that were taught Inorganic chemistry with laboratory teaching method recorded higher achievement more than those taught with demonstration method.

To establish whether or not the observed difference in achievement between the two groups was significant, hypothesis one was tested.

H_{O1}: There is no significant difference between the mean inorganic chemistry achievement scores of senior secondary school (SSS II) chemistry students in experimental and control groups.

Table 2: Analysis of Covariance (ANCOVA) on the Mean Achievement Scores of Students in Experimental and Control Groups.

Source	Type II sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected mode	142.16[a]	1	142.16	5.88	.02	
Intercept	10325.94	1	10325.94	427.09	.00	
Group	142.16	1	142.16	5.88	.02	Rejected
Error	5995.96	248	24.18			
Total	135597.00	250				
Corrected total	6138.12	249				

In Table 2 above, both groups (experimental and control) as main effect, gave an f-value of 5.88 and this is significant at .02. Since .02 is less than .05, at .05 level, the f-value of 5.88 is significant. Therefore, hypothesis 1 is rejected as stated, indicating that there was a significant difference between the mean achievement scores of the experimental and control groups. Also, the sum of squares arising from both groups (142.16) is highly significant in comparison with the sum of squares arising from error (5995.96). This indicates that the observed difference in achievements of the experimental and control groups is due to the treatment administered to the subjects.

Research Question 2

What are the mean inorganic chemistry achievement scores of male and female SS II chemistry students taught inorganic chemistry using laboratory teaching method (LTM)?

Table 3: Mean Achievement Scores and Standard Deviations of Male and Female SS II Chemistry Students taught Inorganic Chemistry Using Laboratory Teaching Method in both Pretest and Posttest

Group	N	Pre – test		Post – test	
		$(\bar{x})$	SD	$(\bar{x})$	SD
Male (Experimental)	62	12.90	4.63	25.97	4.35
Female (Experimental)	69	12.03	3.77	21.24	4.28
Male (Control)	59	13.81	4.86	22.76	4.51
Female (Control)	66	13.76	4.87	21.28	5.22

From the results presented on table 3 above, male students in the experimental group had pre-test mean achievement score and standard deviation of **12.90** and **4.63** respectively, while their post-test mean achievement score end standard deviation were**25.97**and **4.35**respectively. Female students in the experimental group had pre-test mean achievement score and standard deviation of **12.03**and **3.77**respectively while their post-test mean achievement score and standard deviation were **21.24** and **4.28** respectively.

For the control group, the pre-test mean achievement score and standard deviation for the male students were **13.81**and **4.86**respectively while their post-test mean achievement score and standard deviation were **22.76**and **4.51** respectively. The female students in this group had pre-test mean achievement score and standard deviation of **13.76**and **4.87** respectively as well as post-test mean achievement score and standard deviation of **21.28**and **5.22** respectively. The results indicate that male students recorded higher achievement than their female counterparts in the treatment.

In order to establish whether or not the observed effect of LTM on the male and female students' achievement, the null hypothesis two was tested:

H_{O2}: There is no significant difference between the mean achievement scores of male and female SS II chemistry students taught inorganic chemistry using laboratory teaching method (LTM).

Table 4: Analysis of Covariance (ANCOVA) on the Mean Achievement Scores of Male and Female Students taught Inorganic Chemistry using LTM

Source	Type II sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected mode	757.78	2	378.89	17.39	.00	
Intercept	8193.38	1	8193.38	376.14	.00	
Gender	615.62	1	615.62	28.26	.00	Rejected
Group	141.48	1	141.48	6.50	.01	
Error	5380.34	247	21.78			
Total	135597.00	250				
Corrected total	6138.12	249				

Table 4 showed the Analysis of Covariance (ANCOVA) on the mean achievement scores of male and female students in the treatment. In table 4 above, gender as main effect gave an f-value of 28.26 and was significant at 0.00. Since .00 was less than 0.05 and at 0.05 level of significance, the f-value was significant. Therefore, hypothesis 2 is rejected as stated, indicating that there was significant difference between the mean achievement scores of male and female students taught inorganic chemistry using laboratory teaching method. In addition, the sum of squares arising from gender (615.62) is highly insignificant in comparison with the sum of squares arising from error (538034). This indicates that any observed difference is as a result of extraneous variables, hence the insignificance in the differences in the mean scores.

$H0_3$: There is no significant interaction effect of laboratory teaching method and gender on students' mean achievement scores in inorganic chemistry.

Table 5: Analysis of Covariance (ANCOVA) on the interaction effect of laboratory teaching method and gender on students' mean achievement scores

Source	Type II sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected mode	136.66	1	136.66	5.65	.02	
Intercept	27440.20	1	27440.20	1133.92	.00	
Group * Gender	136.66	1	136.66	5.65	.02	Rejected
Error	6001.45	248	24.20			
Total	135597.0	250				
Corrected total	6138.12	249				

Table 5 above showed the interaction effect of method and gender on students' achievement in inorganic chemistry. The results indicate that the main interaction effect gave an f-value of 5.65 and this is significant at .02. Since .02 is less than 0.05, it means that at .05 level, the f-value of 5.65 is significant. Therefore, hypothesis 3 is rejected as stated, indicating that there is a significant interaction effect of gender and method on students' achievement in inorganic chemistry.

Summary of Findings

Results of the analysis presented in this chapter revealed the following:

1. Students taught inorganic chemistry using the laboratory teaching method achieved higher than those with demonstration method. Hence, there was significant difference between the mean achievement scores of students taught inorganic chemistry with laboratory teaching method (Experimental group) and those taught with demonstration method (control group).
2. The male students taught inorganic chemistry using the laboratory teaching method recorded higher achievement than their female counterparts. Hence, there was significant difference between the mean achievement scores of male and female students in experimental and control group. There was significant interaction effect of method and gender on students' achievement in inorganic chemistry.

Discussion of Findings

The findings of this study were discussed and hereby presented according to the major variables investigated in this work.

Effect of LTM on students' achievement in inorganic chemistry;

Table 1 showed that there is significant difference between the mean achievement scores of experimental and control group. Research question one from Table 1 sought to know the mean achievement scores of the chemistry students in experimental (LTM) and control (DM) groups in both pretest and posttest. From the analyses, the posttest mean achievement score of the experimental group was higher than that of the control group. This is an indication that students taught inorganic chemistry with laboratory teaching method (experimental group) achieved better than those taught with the demonstration method (control group). This implies that chemistry teachers should try to employ laboratory teaching method in order to enhance chemistry students' achievement in chemistry. The finding of the study was in consensus with Ahmad (2014) who stated that field trip teaching strategy (an activity based teaching method) is a good tool in teaching science concepts at secondary school level. In the same vein, Omiko (2015) found out that the use of the laboratory teaching method (an activity based method) helps to develop scientific attitudes in the students towards the learning of chemistry, develop scientific skills for problem solving in students among others.

Effect of gender on students' achievement

The study showed in Table 2 that male students had higher mean achievement scores than their female counterparts. This can be seen from the mean gain in the posttest achievement scores which is 13.07 and that of the female counterparts which is 9.21. From the differences in the mean gain scores, it then indicated that there is significant difference between the achievement scores of male and female chemistry students in favour of the male students. This was in agreement with the findings of Neboh (2009) which stated that male students achieved higher than their female counterparts when taught using LAP on the unit life in Biology. On the other hand, Egbo (2014) found out that female students achieved significantly better than their male counterparts once activity based teaching methods are employed. Meanwhile, Eneh (2015) and Iwuji (2012) pointed out that gender was not a significant factor in the mean achievement scores in science teaching.

Table 5 shows the data displaying the interaction effect of gender and the method on the students' achievement in inorganic chemistry. The data indicate that there was a significant interaction effect of gender and method on students' achievement. This finding was in line with Eneh (2015) who stated that there was no significant interaction effect of teaching method and gender on the subjects in achievement in chemistry.

Conclusion

The findings of the study showed that laboratory teaching method can help students achieve better in chemistry. From this study it has been proved that LTM is a better teaching method than demonstration method in the learning of chemistry.

Recommendations

Based on the findings, the following recommendations were made;

i. Chemistry teachers should therefore incorporate laboratory teaching method into the teaching-learning process since it develops students' scientific and practical skills. Also it motivates the students and fosters the spirit of competitiveness among them.
ii. For the fact that chemistry is a practical oriented subject, the government should help in equipping the laboratory in all schools, so as to make the teaching of chemistry and other science subjects more comprehensive. The teacher should try to improvise the equipment that are difficult to get and should not wait for the government to provide everything.
iii. The Federal Ministry of Education should organize seminars and workshop at least twice a year to enable science teachers update their knowledge.

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