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21st-Century laboratory instruction and students' academic achievement and anxiety level in acid-base titration in chemistry

Dr. AU Nwanekezi, Nwafor CL, Ndukwe UE
Department of Curriculum Studies and Educational Technology, Faculty of Education, University of Port Harcourt, Nigeria

Abstract
The study investigated 21st-century Laboratory instruction and Students' Academic Achievement and Anxiety Level in acid-base titration in chemistry. The area of the study was Port Harcourt Local Government Area in Rivers State. The population for the study consisted of all Senior Secondary School Two Students in Port Harcourt. The sample size consisted of 100 chemistry students in two intact classes. The students were randomly placed as experimental and control groups each with 50 students. A quasi-experimental pretest-posttest research design was used for the study. The students in the experimental group were taught using laboratory method while the control group was taught using demonstration method for the period of six weeks. Two instruments; Acid-Base Titration Achievement Test (ABTAT) and Students' Anxiety Scale Questionnaire (SASQ) with a reliability index of 0.79 was used to collect data for the study. Performances of the two groups were compared using their posttest mean scores. The major findings from the study are: Students taught using laboratory method recorded high academic achievement than those taught using demonstration method. The anxiety level of students taught using laboratory method tended to be low when compared with students taught using demonstration method. Based on the findings, the following recommendation was made: Chemistry teachers should be encouraged to use laboratory method of teaching so as to help students learn abstract concepts.

Keywords: Acid-Base Titration Achievement Test (ABTAT), SASQ, quasi-experimental

Introduction

Science is a body of empirical, theoretical and practical knowledge about the natural world produced by consistent and cumulative processes which emphasize observation, explanation and prediction of real-world phenomena using experiment (Mishra and Yadav, 2013) [14].

It is clear that science as a study of a systematic process, deals with nature and natural phenomena, employs observation and experimentation as tools kingdom-Aaron, (2012) [13] yet it cannot be limited to the classroom alone. Dienye and Gbamanja, (1990) [7] defined science education as the study of the interrelationships between science as a discipline and the application of educational principles to its understanding, teaching and learning. In the same vein, Obomanu (1999) [16] asserts that each country is striving towards the optimal production of sound scientists and technologists. Throughout the world, national education policies are geared towards creating generally scientifically literate citizens. Specifically, the National policy on education of Nigeria clearly stated in its aims and objectives that the learner would be given the opportunity to acquire basic practical skills for self-reliance and employment (FGN, 2004).

Within the context of science education, chemistry has been identified as a very important science subject and its importance in the scientific and technological development of any nation has been widely reported. It was as a result of the recognition given to chemistry in the development of the individual and the nation that it was made a core subject among the natural science and other science-related courses in Nigeria educational system. It has been the pre-requisite subject for offering any science-oriented course in the tertiary institution and this call for the need to teach it practically. Chemistry teaching is meant to be result oriented and student-centered and this can only be achieved when students are willing and the teachers are favourably disposed to using the appropriate methods and resources. Amadi (1993) [3] confirmed that chemistry students need to actively construct their own personal awareness and meaning. To substantiate the argument, Usman (2014) [20] remarked that the brain is not a passive consumer of information and to learn with understanding, a learner must actively construct the meaning of what to be learned.

Despite the prime position chemistry occupies in Nigerian educational system and the efforts made by researchers to enhance performance, students' performance in chemistry and sciences, in general, are still low. The senior secondary school chemistry curriculum according to Nigerian Educational Research and Development Council (NERDC, 2007) [10] is expected to enable students

a. Develop interest in the subject of chemistry
b. Acquire basic theoretical, practical knowledge and skills
c. Develop interest in science, technology and mathematics
d. Acquire basic S T M knowledge and skills
e. Develop a reasonable level of competence in ICT application that will engender entrepreneurial skills
f. Apply skills to meet societal needs of creating

employment and wealth

g. Be positioned to take advantage of the numerous career opportunities offered by chemistry and be adequately prepared for further studies in chemistry. In order to achieve the above objectives, the practical instructional approach has to be adopted.

Efficient teaching and learning of science subjects because of its process has to go beyond the four walls of a building. Research evidence has shown that students' lack of interest, poor attitude and underachievement in science-based subjects are as a result of some factors, vital among them is lack of practical (Observation, manipulation, data collection etc). The laboratory method of teaching which is an essential teaching approach to science has been accorded a central and distinctive role in science education and science educators have suggested that there are rich benefits in learning from using laboratory activities. Inadequate furnished laboratories can never enhance learning no matter how beautiful the buildings are. The laboratory is therefore defined as a room or space specifically built for teaching by demonstration of theoretical phenomena and the discovery of new facts in practical terms. The use of laboratory begets the saying "seeing is believing'' in the act of teaching and learning of science since understanding and recall are enhanced in students. Success achieved in any science-based subject is much more dependent on the provision and use of equipped-functional laboratories.

Studies of Tobias, (1999) [19] and Elliot, (2000) [8] have shown that test anxiety affects the performance of science students. Anxiety is defined as an unpleasant sensation that is usually experienced as feelings of apprehension and general irritability accompanied by restlessness, fatigue and various somatic symptoms such as headaches and stomachaches (Chiss and Hassibi, 1998) [6]. Anxiety may affect the academic performance of students. According to (Elliot, 2000) [8] this is called test anxiety. In other words, test anxiety is a reaction to examination stress that is the stress caused by testing conditions such as examination. For the concepts in chemistry to be taught effectively to chemistry students especially acid-base titration in the senior secondary school, laboratory method of teaching has been considered relevant and fruitful (Kearsley 1999) [12]. Okere, (2014) [17] observed that the use of laboratory method in teaching practical concepts enhances students' manipulative skills. This study, therefore, looks at 21st-century laboratory instruction and students' academic achievement and anxiety level on SSS chemistry students.

Statement of the problem

Research has shown that most science teachers adopt conventional teaching methods which are teacher-centred and subsequently result in poor learning outcomes, Halladyna and Shanghnessy, (1982) [11], Achunonye and Ajoku, (2003) [1]. This has raised doubts among educators about the efficacy of teaching methods and approaches adopted over the years. Students' interest and academic performance in chemistry depends on many factors and stands out to show how well the subject is being taught. Festus and Ekpete (2012) [9] contended that students' cognitive achievement becomes more positive after being exposed to science problem base instruction like laboratory teaching method. The adoption and use of this method in teaching and learning of science-based subjects is essential, mostly when the expected results have not been achieved in students internal and external examination, as well as in this era which is characterized with most teachers laying emphasis on the cognitive aspect of teaching and learning thereby neglecting the psychomotor and affective domains.

It is in line with these problems such as poor academic achievements, difficulties in learning certain chemical concepts like acid-base titration and high anxiety level that the study sought to investigate 21st-century laboratory instruction and students' academic achievement and anxiety in an acid-base titration at SSS level to see what the result will be.

Objective of the study

The objectives of the study are to:

1. Determine the effect of using laboratory method of teaching on chemistry students' academic achievement in an acid-base titration at SSS 2 level.
2. Determine the effect of using laboratory method of teaching on anxiety level of students in an acid-base titration at SSS 2 level.

Research questions

The study is guided by the following questions.

1. Is there any difference in academic achievement of senior secondary school 2 chemistry students when exposed to laboratory method of teaching and those exposed to demonstration method in acid-base titration?
2. What is the difference in anxiety level of senior secondary school 2 chemistry students when exposed to laboratory method of teaching and those exposed to demonstration method in acid-base titration?

Research hypotheses

The following null hypotheses guided the study

Ho_1: There is no significant difference in academic achievement of SSS 2 chemistry students exposed to laboratory method of teaching in acid-base titration and those exposed to demonstration method of teaching.

Ho_2: There is no significant difference in the anxiety level of senior secondary school chemistry students exposed to laboratory method of teaching in acid-base titration and those exposed to demonstration method of teaching.

Significance of the study

The findings of the study will certainly uplift the standard of chemistry education in the following ways.

1. Through enhancing the academic achievement of chemistry students
2. Through minimizing/reducing chemistry students' anxiety level.

Methodology

In this study, quasi-experimental control groups design involving pre-test and posttest was used. The study involved control group and an experimental group consisting of both male and female students**.** A pretest was administered to the groups, before the treatment to determine the group

comparability of experimental and control groups' ability level. The experimental group was taught the concept of acid-base titration using laboratory method of teaching. The control group was taught the same concept using the demonstration method. At the end of the treatment period, a posttest was administered to both groups of students in order to determine the effectiveness of the treatment on acid-base titration.

The area of the study was Port Harcourt Local Government in Rivers State. The population for this study consisted of all senior secondary school two chemistry student (SSS2) in Port Harcourt. A sample size of 100 students was selected using stratified random sampling technique. Two instruments were used for data collection: Acid-Base Titration Achievement Test (ABTAT) and Students Anxiety Scale Questionnaire (SASQ). Both the instruments were validated by experts in science education and measurement and evaluation. The reliability coefficient of ABTAT was found at 0.79. The questionnaire was divided into two sections; section A which comprises of students' personal data response while section B consist of a 4-point Likert scale response (Strongly Agree, = SA, Agree = A, Disagree = D, Strongly Disagree = SD) rated 4, 3, 2, and 1 which is on students anxiety level. The reliability of the instrument was estimated by a split-half method using Pearson product moment correlation coefficient (PPMCC) statistics. This formula yields a reliability of 0.78. For effective data collection, the two groups experimental and control groups were taught separately for five weeks. The instruments developed by the researcher were administered both at the beginning i.e pretest and after the treatment as posttest and students responded to the items in the presence of the researcher. Students' Anxiety Scale Questionnaire (SASQ) was also administered to both experimental and control group, before and after the treatment. After the students have completed their responses the questionnaire was collected and subjected to the analysis. The data generated from Acid-Base Titration Achievement Test (ABTAT) were analyzed using t-test unrelated sample. The other data which was generated from the students' anxiety scale questionnaire (SASQ) was coded before applying t-test unrelated sample to analyze the data. The significant level of rejection or acceptance of the hypotheses is $P \leq 0.05$.

Results analysis and discussion

Hypothesis 1: There is no significant difference in the academic achievement of SSS chemistry students exposed to laboratory method of teaching in acid-base titration and those exposed to demonstration method the results are presented in Table 1.

Table 1: t-test Analysis of Difference in Achievement of the Experimental and control groups.

Groups	N	X	80	df	t-valuecal.	t-critical	Value P	Remark
Experimental	50	67.34	13.12	98	6.02	1.67	0.000	significant
Control	50	52.84	10.86					

Significant at $P \leq 0.05$

From Table 1 above, it is evident that the calculated t-value of 6.02 is greater than the t-critical value of 1.67 at df (98). In addition, the calculated p-value of 0.000 is less than 0.05 level of significance. Therefore, the null hypothesis of no significant difference is rejected. This implies that students' exposure to laboratory method of teaching has produced significant difference among the experimental and control groups. Thus, there is the statistically significant difference in the academic achievement of SS II chemistry students exposed to laboratory method of teaching in acid-base titration and those exposed to demonstration method.

The significant effect was in favour of the experimental group. The findings of the study affirmed the earlier findings of studies by Bajah and Bello (1990) [5], Adetula (2000) [2] and Oyoleye (2001) [18] who noted that students taught using Laboratory method of teaching tend to record significantly high academic achievement when compared with those taught using lecture method.

Hypothesis 2: There is no significant difference in the anxiety level of SSS chemistry students exposed to laboratory method and those exposed to lecture method. The SASQ result was coded to enable the researcher to convert the data from ordinal scale to Interval scale, (Awotunde and Ugodulunwa, 2002) [4] Based on the result obtained after coding the result, the t-test was applied to find a significant difference between Anxiety level of Chemistry students and their Academic achievement in the acid-base titration.

Table 2: t-test comparative Analysis of Students' Anxiety Level between Experimental and Control in an acid-base titration

Groups	N	X	SD	df	t-valuecal.	P	Remark
Experimental	50	47.50	15.13	98	4.68	0.000	significant
Control	50	62.00	15.82				

Significant at $P \leq 0.05$

At df 98 the calculated t-value and p-value at an alpha level of 0.05 are repetitively 4.68 and 0.000 (Table 2). This means that there is a significant difference on the anxiety level between those students in the experimental group and those in control group. By extension, it implies that students taught using laboratory method tend to have low anxiety than those taught with lecture method in the acid-base titration. Therefore, the null hypothesis of no significant difference in students' anxiety level is rejected. This supports the assertion of Tobias (1999) [19], Elliot, (2000) [8] that the anxiety level of SSS students is affected (lowering) by the influence of induced activity based.

Conclusion

From the findings, the following conclusions are drawn

A laboratory method of teaching has helped in improving the academic achievement of senior secondary school chemistry students, as well as their anxiety level. Therefore, laboratory method of teaching is viable and has the potential of enhancing senior secondary school chemistry students' academic achievement in the acid-base titration.

Recommendation

Based on the findings, the following recommendations are made:

1. In terms of academic achievement, this study shows that laboratory method of teaching enhanced the academic achievement of the students in chemistry as compared to lecture method. The use of laboratory method of teaching by chemistry teachers should, therefore, be encouraged in Nigeria secondary schools.
2. Apart from the use of laboratory method of teaching in improving academic achievement, the findings of this study also showed that anxiety level of students taught using laboratory method is lower than the anxiety level of the students taught using demonstration method. In education, it is hard to think of any goal for which lowering an anxiety level is not important. The implication of this is that the use of laboratory method of teaching should be encouraged in the science learning because of its efficiency in lowering the anxiety level of the students.

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