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An Investigation Into The Effects Of Laboratory, Guided-Unguided Discovery (Inquiry) And Lecture-Demonstration Teaching Methods On Senior Secondary Students' Achievement In Acid-Base Titration Practical Test In Selected Secondary Schools In Giwa Local Government Area Of Kaduna State, Nigeria

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Abstract: *The relative effectiveness of three methods of teaching and conducting experiment in acid-base titration in practical chemistry was investigated in some selected Nigerian secondary schools. A pre-test, post-test experimental design with a control group was used. A total sample of 123 students within an average age 17 years in SSII & SSIII of four (4) senior secondary schools were randomly selected from Giwa local government area of Kaduna state, Nigeria. The research instruments developed were twenty four item supply/select response including objectives and essay questions used for the pre-test and post-test tagged acid-base achievement test (ABAT). Students were divided into three experimental and one control group. Students in the three experimental groups were subjected to treatment using laboratory, inquiry (guided-unguided discovery) and lecture-demonstration method respectively while students in the control group were taught using traditional method of teaching. The pre-test was administered to students in all the four (4) groups before teaching commenced and after the teaching and the experiment, a post-test was then administered. The data was analyzed using mean, standard deviation, t-test and one way analysis of variance (ANOVA). The result of ANOVA of the difference in the scores of the post-test of the laboratory, inquiry, lecture-demonstration method and control group showed a significant difference between the groups (Fc= 188.38 > Ft= 3.92 at p<0.05, df =3.144). Students taught with laboratory method performed better in the acid-base achievement test (ABAT) than the students taught with lecture-demonstration method (t_c=16.24 > t_t= 1.67 at p<0.05, df=69) while those students taught with the laboratory method performed better than those taught with inquiry (guided-unguided) method (t_c=11.84 > t_t=1.67 at p<0.05, df=71). Students taught with inquiry (guided-unguided discovery) method performed better than students taught with lecture-demonstration method (tc=13.59 > tt=1.67 at p<0.05, df=70). The study concluded that the laboratory method enhanced better performance in acid-base titration in practical better than either inquiry or lecture-demonstration method. The implication of the study was highlighted and recommendations made based on findings.*

Keywords: **Laboratory,***Lecture- demonstration, guided-unguided, acid-baase titration,Achievement test*

I. Introduction

Chemistry is an experimental science which relies primarily on the harmony between theory and practical [1]. The understanding of concepts in practical chemistry will assist in enhancing student's understanding of chemistry [2]. Students have difficulty in making connections between the sub disciplines of chemistry and the link between practical work and theory is often less than obvious because of the approach adopted by teachers in instruction [3].

In chemistry teaching, the importance of harmonizing practical work with theory cannot be over-emphasized. Omolade [4] states that; if the academic achievement of students is to be enhanced, learners must have a deep understanding of the 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.

Chemistry is undoubtedly the central science that forms the basic foundation to many disciplines. In spite of this important position of chemistry among other science and science related disciplines, students' academic performance of senior secondary students in the subject has for many years remained a matter of serious concern for professional bodies, educational administrators and government. Efforts made through research to discover the remote causes of the persistent failure revealed that secondary school chemistry teachers mainly adopt the traditional method in the teaching and learning of chemistry. A number of factors have been posited for the massive decline in students overall performance in chemistry at SSCE and these include but not limited to inadequate instructional methods[5 ,6]; inadequate laboratory facilities[7] and lack of practical skills. Akalonu in Omwirhiren[5] observed that students have many weaknesses in the practical aspect of the chemistry examination and this is not unconnected with the rush hour and manner in which this aspect of the syllabus is taught in some Nigerian secondary schools. The authors hypothesized that if practical chemistry is taught in harmony with the theory of acid-base, performance of students is likely to be enhanced and concepts comprehended.

Meaningful learning occurs when learners comprehend concepts and are able to connect them with previous knowledge [8]. When students learn chemistry meaningfully, their ability to reflect on their own learning and make adjustments accordingly fosters deeper learning. Deeper learning is the key strategy through which students find meaning and understanding from course material and experiences [9] which in turn may result to competence of knowledge transfer to other domains and how to apply the knowledge in answering questions and resolving problems

Laboratory method is an activity-based, student centred teaching method where students learn by carrying out activities in the laboratory[10]).These activities include, touching, seeing, feeling, weighting, measuring, demonstrating, carrying out tests/experiments and any other practical activities in the laboratory. A deeper understanding of the science and technological processes can be achieved through laboratory activities which encourage active participation and serve to develop critical thinking and also provide concrete experiences to substantiate the theoretical aspect that might have been taught. Mkpa [11] maintains that laboratory activities provide exercises/problems based upon real physical situations and also appreciation of the various methods used in experimental science. Such methods include understanding competence in the use of apparatus, training in awareness of the problems involved in precise laboratory work. These methods help learners to construct definitions of concepts, formulate relevant questions and theories relating to any assumptions and arguments used in the experimental process. According to this author, the laboratory teaching method serves the following purposes: Motivating students by stimulating interest, developing understanding of scientific inquiry and expertise, inculcating scientific attitudes into students and encouraging social skill development.

Guided Inquiry teaching method has been described as problem solving, critical thinking, reflective inquiry, deductive thinking and not mere personal assumptions. It is a method of teaching that involves probing, finding out, investigating, analyzing, synthesizing, discovering, evaluating, questioning and thinking [12]. Guided inquiry teaching method allows students/pupils to engage in experimentation similar to that of real scientists. Through these activities of inquiry, teachers can encourage their students to expand their critical thinking skills and use their logic to derive answers to scientific quandaries. Adejo[13] noted that for the students to meaningfully engage in an inquiry, there is need for the 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 resource. Sola and Ojo[14] maintained that, inquiry approach is more suitable for "intuitive and creative children who are full of enthusiasm and active". German [15], 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 offer but if used incompetently as fashion, it is probably more disastrous to learning than exclusive reliance of the former methods".*

A lecture-demonstration method is a gap filled to enhance the effectiveness of lecture and demonstration method. It 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. A skilled educator may wish to both tell and show what steps to take in an educational process. A demonstration is usually accompanied by a thorough explanation, which is essentially a lecture [14].

Despite the several research evidence in favour of these instructional methods, there is as yet little or no study in Kaduna state, Nigeria to examine how it will impact on students' achievement in chemistry irrespective of the decrying persistent failure in the subject. The study therefore focuses on how academic achievement in practical chemistry is enhanced using the three instructional methods.

II. Purpose of the study

The purpose of this study is to investigate the effect of laboratory, guided-unguided discovery and lecture-demonstration teaching methods on senior secondary, student's achievement in acid-base titration practical test in selected secondary schools in Giwa Local Government. Specifically, the study sought to:

i. Determine whether teaching students using guided-unguided, laboratory methods could have effect on their achievement.
ii. Determine whether teaching students with lecture-demonstration method could have effect on their achievement.

iii. Determine if combining laboratory, guided-unguided and lecture demonstration methods could affect the retentive ability of the students.

III. Research Questions

Two research questions were posed for the study;

i. Do teaching students using guided-unguided and laboratory methods have effect on their academic achievement?
ii. Does teaching students with lecture demonstration method have effect on their achievement and retention in practical chemistry ?

IV. Null Hypotheses

The following null hypotheses were generated for the study at 0.05 significant levels.

1. There is no significant difference in the performance of students taught acid-base titration using lecture-demonstration method (LDM) and those students taught acid-base titration using inquiry (IQM) guided-unguided discovery method in the experimental group.
2. There is no significant difference in the performance of students taught acid-base titration using laboratory method (LM) and those students taught using inquiry method (IQM) in the control group.
3. There is no significant difference in the performance of students taught acid-base titration using laboratory method (LM) and those students taught acid-base titration using lecture-demonstration method (LDM) in the experimental method.
4. There is no significant difference in the performance of students taught acid-base titration using LDM and IQM students in the control group.

V. Significance of The Study

The findings of this study would be of help to the following

i. Students would benefit greatly in comprehension and their interest in practical chemistry would be aroused using laboratory, lecture-demonstration and guided-unguided discovery methods.
ii. Chemistry teachers will utilize the findings of this study to enhance their competence and professional development in their chemistry laboratory and classrooms in helping students' understanding of chemistry concepts through laboratory, lecture-demonstration and guided inquiry teaching method.
iii. This research work will aid educational planners/administrators to provide the necessary tools and favourable conditions to enhance the practice using laboratory, lecture-demonstration and guided-unguided discovery methods as it relates to specific topics in the senior secondary curriculum..
iv. This work will go a long way in assisting future researchers by carrying out similar studies on other topics in chemistry with diversified group of subjects.

VI. Methodology

6.1 Research Design

The study used pre-test-post-test quasi-experimental design. The study area was Giwa Local Government Area of Kaduna State in Northern Nigeria. The instruments used for the study were: notes on acid-base titration reagents, apparatus and materials for the practical exercise and a twenty-items supply response questions used for the pre-test, post-test tagged Acid-Base Achievement Test (ABAT).

6.2 Population of the Study

The population of this study comprises of all secondary schools in Giwa Local Government Area of Kaduna State. Giwa and its environ is made up of thirteen secondary schools with a population of about nine thousand two hundred and seventy seven (9277) students(data from Giwa Education Authority). The schools are mostly co-educational, only one that is single sex (female only).

6.3 Sample

The sample consist of 123 students from four (4) of the senior secondary schools, SSII and SSIII science students constituted the subject for the study. The schools were randomly assigned to four groups as shown:

Table 1: Research design layout

Schools	**Treatment type**	
Government Secondary School YakaWada (GSS Y/Wada)	LDM	35
Government Secondary School Kaya (GSS Kaya)	CG	15
Government Secondary School Giwa (GSS Giwa)	LM	36
Malam Abdulkarim Islamic Science Secondary School Giwa (MAISS Giwa)	IQM	37
Total		123

LDM: lecture-demonstration method, IQM: inquiry method, LM: laboratory method, CG: control

6.4 Instrument for Data collection

Instrument used was the acid-base achievement test (ABAT) 1 and 2. The test items were twenty-four (24) consisting of twenty objectives and four essay-type questions derived from senior secondary school syllabus The posttest also comprised ten restructured questions on the same topics.

The research involved two main stages, which were the administration of pre-test and post-test that contained the same questions arranged in different order. The study would be conducted for a period of three weeks during which the topic acid-base titration was covered and was carried out in two areas of which GSS Y/Wada, GSS Giwa and MAISS were gathered in MAISS School and GSS Kaya. The pre-test was administered in the first day of the research exercise to the 80 and 43 students in each of the area before the experimental groups were subjected to treatments. All the practical sessions were held in the school laboratory with the materials provided by the school.

After the administration of the pre-test, students in all groups of two areas were given the topic, acid-base titration by the researcher and were introduced about the equipment, procedure, definition of terms and how to set up retort stand for practical. The groups were divided into subgroups and were exposed to inquiry (guided- unguided) discovery and laboratory methods during the first week of the research exercise. Students were given ten (10) days to read about the topic and make the list of materials and apparatus required for the experiment. The researcher taught the theory and the students' carried out the practical exercise with the assistance and guidance of the researcher. Two practical exercises were carried out in a week. Questions were entertained during the practical sessions from the students. The students were also taught with lecture-demonstration method. The students were not given a topic ahead of the class and were not divided into subgroups. The researcher taught and demonstrated the practical aspect while the students watched and a few students were allowed to demonstrate a repeat of the experiment.

The students of control group were taught both the theory and practical using traditional methods of teaching. The teaching process lasted for five weeks and a post-test was administered to all the students.

6.5 Validation of the Research instrument

Before administering the test items, the questions were subjected to content and face validity by other experts in chemistry so as to ascertain their appropriateness. As to face validity, the test items which were derived from standardized test were administered to twenty non participating students but of the same cultural background offering chemistry as a subject. This was done to determine the difficulty level of the question. This led to the modification and rejection of some items. The reliability coefficient was computed using Pearson-product moment correlation method and the value was r= 083. This indicate that the test was reliable and as such would test what it was out to test.

6.6 Method of Data Analysis

The data collected were analyzed using the mean, standard deviation and the t-test analysis to test the significance difference among the three methods of teaching and one-way analysis of variance (ANOVA) to compare the means of the scores of the students in the two groups on acid-base achievement test (ABAT 1) called pre-test were compared. This was also done for ABAT 2, which is the post-test. The analysis of the results were carried out at P< 0.05 level of significance.

VII. Results

Table 2: t-test analysis of performance of students in LM and LDM groups.

Group	N	$\bar{x}$	S.D	Df	tc
LM	36	82.88	11.89		
LDM	35	73.03	13.43	69	16.24

p>0.05, Ft = 3.92

H_o 1- Hypothesis One

There is no significant difference between the performances of students taught acid-base titration practical using LM and those taught with LDM.

The scores obtained in the post-test were subjected to t-test analysis and the result is presented in table 3. From table 2, tc = 16.24 while $t_t = 1.67$ at $p<0.05$, df = 69 that is tc = 16.24 > t_t = 1.67 which implies that subjecting the students at certain relevant experiences enhance better performance.

Table 3: t-test analysis of performance of students in LM and IQM groups

Group	N	$\bar{x}$	S.D	Df	tc
LM	36	82.88	11.89		
IQM	37	82.11	7.655	71	11.84

p>0.05, Ft = 3.92

H_o 2- Hypothesis Two

There is no significant difference in the performance of students taught with LM and those taught with IQM.

To test this hypothesis, it was also subjected to t-test analysis (table 3). From the table tc= 11.84 while t_t = 1.67 at p > 0.05, df = 71 i.e tc > t_t which implies that a significant difference exists which is in favour of LM.

Table 4: t-test analysis of performance of students in LDM and IQM groups

Group	N	$\bar{x}$	S.D	Df	tc
LDM	35	73.03	13.43		
LQM	37	82.11	7.655	70	13.59

p>0.05, Ft = 3.92

H_o 3- Hypothesis Three

There is no significant difference in the performance of students taught with LDM and those taught with IQM. This hypothesis was tested using t-test analysis (table 4). From this table (5) tc = 13.59 while t_t = 1.67 at p <0.05, df = 70 that is tc> t_t

Table 5: Analysis of the Variance of the Differences in the Scores of the Post-test of students in LM, IQM and LDM groups and control groups

Sources of variation	Sum of square	Df	Variance estimate	Fc	Ft
Between sample	77034	3	25678.00		
Within sample	19629	144	136.3125	188.38	3.92

p>0.05, Ft = 3.92

H_o 4- Hypothesis Four

There is no significant difference in the performance of students in the three experimental groups that is LDM, IQM, LM and those in the control group. To test this hypothesis, analysis of variance (ANOVA) test was carried out on acid-base achievement test result. The result is presented in table 5. Results from table 6 shows that Fc = 188.38 while Ft = 3.92 at p < 0.05, df = 3.144 that is Fc > Ft which shows that there is a significant difference in the performance of students in the groups.

VIII. Discussion

The results of this study have provided another empirical evidence in support of the efficacy of activity based instructional methods in the teaching of chemistry. On the effect of LM and LDM in table 2, the achievement of students in acid-base titration practical test for post-test was observed that t-calculated (16.24) was greater than t-critical (1.67) at 69 degree of freedom and 0.05 significance level and the mean score (82.88 and 73.03). Hence, the null hypothesis was rejected implying that there is a significant difference in LM and LDM on student's achievement in acid-base titration practical test in chemistry. Previous studies has also observed higher achievement in chemistry as the laboratory produces in students concrete experiences with objects and concepts and in providing students with opportunities to engage in the process of investigation and inquiry [13,16,17]. In fact Ogbeba[18] emphasized that laboratory activities when performed individually or in small groups is beneficial than large-group demonstrations, science museum visits or diffused field trips, discussions and audio-visual aided study (e.g. viewing filmed experiments). Abdullahi[19] also stressed that laboratory was an integral part of science teaching. He pointed out that studies on methodology of science teaching had shown that students learned more when they are given opportunity to learn through "doing" than when they are allowed to observe.

On the effect of LM and IQM indicated in table 3, on the achievement of students in acid-base titration practical test for post-test t-calculated (11.84) was also greater than t-critical (1.67) at 71 degree of freedom and 0.05 level of significance. The null hypothesis was rejected and the result of mean score of LM and IQM (82.88 and 82.11) also show that LM is more effective than IQM. In the inquiry model, the science teacher will create a situation in the classroom in which students are asked to formulate their own ideas, state their opinion on an important issue or to find things out for themselves. One proposed list of inquiry process in science education include: observing, measuring, predicting, inferring, using numbers, using space-time relationship, defining operationally, formulating hypothesis, interpreting data, controlling variables, experimenting and communicating. In teaching in school situation, very little time is spent by students doing inquiry activities and the predominant method of teaching in science is recitation not inquiry.

Akinsete[20] reported that when inquiry models of teaching were implemented, they were very effective in enhancing student's performance, attitudes and skills development. They reported that student achievement scores, attitudes and process and analytic skills were either raised or greatly enhanced by participating in inquiry programs while the inclusion of inquiry models of teaching in secondary science classroom is desirable, the reluctance on the part of the science teachers to implement inquiry in the classroom are due to their lack of skills and strategies, lack of equipment and material especially in rural schools and the claim that inquiry method was only effective with bright students and it caused too many problems with lower ability student. The effectiveness of the inquiry method in this study was due to well-equipped laboratories in the schools and with available materials, sufficient books in the library, active teachers who make students to respond because they are being exposed to this model of teaching and learning earlier and although, the teacher have the necessary skills, they have been practicing the method with the students all along. It was also found that the level of response is very high with almost all students while very few of them were not concentrating. In spite of these achievements, the evidence is that inquiry models of teaching are viable approaches to teaching and should be part of the science teacher's repertoire as a fundamental part of science teaching.

On the effect of LDM and IQM in table 4 on achievement of students in acid-base titration practical test, mean scores (82.11 and 73.03) t-calculated (13.59) was greater than t-critical (1.67) at 70 degree of freedom and 0.05 significance level. Thus, the null hypothesis was rejected implying that there is a significant difference in acid-base titration practical in student's achievement test. Furthermore, IQM and LDM also yielded a significant difference when compared with the control group. The lecture method is the most widely used form of presentation and may be combined with other teaching method to give added meaning and direction. For example, a demonstration is usually accompanied by a thorough explanation, which is essentially a lecture. The students in this study are conversant with LDM as their teachers often use it because of its adaptability to many different settings including either small or large groups, which obtained in our school system here and to practical demonstration which the teacher are used to due to insufficient materials in our laboratories. A major criticism of this method is its being teacher-centered allowing little or no participation from the students and without feedback.

In table 5, F-test statistic was used to analyze the data to test null hypothesis which stated that there was no significant difference among the teaching methodologies used for this study (LM, LDM, IQM and CG) in the achievement of students in acid-base titration practical test. Table 5 gives the summary of the computation at 0.05 significance level and the degree of freedom = 3, 144, the F-calculated was 188.38 and F-critical value was 3.92. Hence, F-critical was not significant, the hypothesis was rejected. Therefore, there was a significant difference in the achievement of students in acid-base titration practical test for post-test in chemistry.

IX. Conclusion

Results from the study showed that meaningful strategy which encompasses inquiry approaches can lead to higher achievement in science. The laboratory method in this research work produce significantly better performance in the acid-base achievement test than IQM and LDM, thus LM is an effective method of instruction for students in the secondary schools.

The findings of this study has also revealed that LDM, IQM and LM can be used for teaching and learning processes depending on the topic but LM is most effective because it affords the students the opportunity to study on their own. The potential of deeper learning beyond the traditional rote learning was observed in these activity-based methods. Furthermore, it facilitates the transfer of ownership of learning to the students while the teacher functions as a facilitator. The teacher builds from students' prior knowledge and encourages them to construct their own views of the chemistry concepts.

This study concludes that the use of laboratory method of teaching and other activity-based techniques should be embraced by all science teachers and other related areas. In our study we found this to be a fundamental predictor of high achievement in the learning of practical chemistry.

X. Recommendation

In view of the results of these findings and conclusion reached in this study, the following recommendations are hereby offered:

1. As the students in the laboratory method group were found to achieve higher, the method should be encouraged to be used by chemistry teachers in teaching the subject.
2. State ministries of education should ensure that each and every secondary school has at least one well-equipped chemistry laboratory before giving it approval. This is because laboratory work has been found to be essential to the development of practical skills acquisition by the students and enhances their academic achievement.

3. All relevant stakeholders in the education industry should seek for ways of motivating their chemistry teachers through provision of needed facilities so as to encourage them to carryout laboratory work with the students as often as possible.
4. Workshops and seminars should be organized for in-service and practicing chemistry teachers to keep them abreast of the laboratory work. This will enable them to plan and organize adequately for the practical.
5. Supervisors and school heads should strictly monitor the frequent use of the laboratory by both teachers and students of chemistry and other co-operant subjects.
6. More activity-based topics in chemistry (such as chemical energetics, qualitative analysis, water and solution among others) should be tested using these three instructional methods in the teaching and learning of chemistry so as to compare findings.

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