EFFECTS OF LABORATORY METHOD ON STUDENTS' ACQUISITION OF SCIENCE PROCESS SKILLS IN SENIOR SECONDARY SCHOOL CHEMISTRY IN DELTA STATE, NIGERIA

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Abstract:

The study was designed to investigate the effects of laboratory method on students' acquisition of science process skills in senior secondary school Chemistry. To guide this study, three hypotheses were raised and tested. The design of the study was a non-randomised pre-test, post-test control group quasi-experimental design. Six secondary schools were selected using a stratified random sampling technique. Three schools were used as the experimental group and the other three as the control group. One hundred and ninety-eight (198) students of six (6) intact classes made up of the sample for the study. The instruments for the study consisted of Chemistry Practical Ability Test (CPAT) and Chemistry Process Skills Rating Scale (CPSRS). The major findings of the study are: the laboratory method enhances students' acquisition of science process skills in both quantitative and qualitative analyses more than the lecture method, the laboratory method contributed about 74% to students' acquisition of science process skills and students acquire more science process skills in quantitative analysis than in qualitative analysis. Based on the findings, some recommendations were made among which are that the laboratory method should be used for teaching practical aspects of Chemistry always; Chemistry practical work should commence from senior secondary school one with separate periods per week instead of keeping students till senior secondary school three before such exposure. The conclusion of the study is that the laboratory method enhances students' acquisition of science process skills in both quantitative and qualitative analyses rather than lectures. The following recommendations were made: the use of laboratory method should be employed in teaching practical aspects of Chemistry

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always, and a separate period per week should be given for laboratory activities with reference to the scheme of work among others.

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1. Introduction

One of the purposes of education in Nigeria is to inculcate the spirit of inquiry and creativity through the exploration of nature, the local environment, experimentation, and discovery in the child (FGN, 2004). In specific terms, education at the secondary school level is expected to raise a generation of people who can think for themselves and provide technical knowledge and vocational skills necessary for agricultural, industrial, commercial, and economic development (FGN, 2004). With unemployment currently plaguing the country, emphasis is shifting towards the acquisition of vocational, technical, and agricultural skills for self-employment and reliance. Science and technology have been identified as important factors of socio-economic development (Ajayalemi, 1991 and Ibraheem, 2004). Therefore, to stem the problem of unemployment and create a robust economy, there is a need to develop and channel our curriculum towards skill acquisition through effective methods of teaching, especially in the sciences. This is because the scientific development of any nation depends on the level of scientific literacy and process skills in secondary school science.

The educational state of any nation remains the major determinant of its development in all ramifications. Ajaja (2009) notes that the values of liberal education such as curiosity, honesty, open-mindedness, objectivity, and pursuit of truth are regular characteristics of the teaching of science. These values, when built into the teaching and learning of science, will create room for the acquisition of necessary skills not only in the sciences but also in technical and vocational subjects. Nwagbo (2002) stated that the industrial and technological development of any nation is dependent on the extent of scientific literacy of her citizens and that secondary school science is one of the key foundations. Corroborating this, Mulenwa (2002) opined that it is now a well-recognised and acceptable fact worldwide that knowledge and skills in science and technology are vital for the development of any society or nation. Therefore, there is an increasing drift from the mere teaching of science to the practising of science for developmental changes.

The process of science affords students the opportunity to acquire a wide range of skills commonly called the Science Process Skills (SPS). These skills include observation, measurement, communication, prediction, classification, inference, formulation of hypothesis, controlling, manipulation of variables, interpretation of data, experimentation, raising of questions, building of mental modelling, and making of operational definitions (Valentino, 2000). Science Process Skills (SPS) deal with skills used by scientists for composing knowledge, raising or solving problems, and making conclusions through inquiry. They enable us to define the problems around us as well as

observe, analyses, hypothesise, experiment, conclude, generalise, and apply the information acquired through necessary skills.

Ifeakor (2006) observed that most Nigerian schools still maintain the use of "chalk and talk" method for teaching rather than an interactive and investigative approach. In affirmation, Inomiesa (2010) emphasised that some teachers do not want to change their methods of teaching and this has led to a very chaotic situation in their classrooms. A close view of the emphasis of researchers cited earlier points to the need for a shift from conventional teaching methods to student-centred methods. Therefore, there should be a shift from conventional teaching methods such as the lecture method to student-centred methods which will enable students to find out for themselves rather than being fed with information by the teacher. Some of these methods include inquiry, guided discovery, questioning, cooperative learning, laboratory, and problem-solving. These methods are currently the trend of educational researches (Abdullahi, 2000; Adedibu & Olayiwola, 2007).

Chemistry is generally referred to as the mother of all sciences because the choice of courses and careers in science and applied science is determined by how well a student performs in Chemistry at Senior Secondary Certificate Examination (SSCE) Oloruntegbe, Orole and Odutunji (2005). Basically, no science-related course or career in Nigerian higher institutions is studied without a credit pass in Chemistry. A look at the Joint Admission and Matriculation Board (JAMB) brochure shows that Chemistry is a core subject to be written for most science-related course. Therefore, Chemistry is a vital core science subject on which all other science subjects depend for necessary development and technological advancement; this is why Chemistry must be given the necessary attention it deserves in our schools.

The Chief Examiner for 2006 and 2007 WASSCE emphasised that there were many problems in both quantitative and qualitative analysis because students lacked experience in practical work, hence theoretical answers were given to practical questions. If qualitative and quantitative analyses in Chemistry practical work must be improved, then, there must be deliberate efforts directed towards laboratory activities that would enhance students' acquisition of science process skills in Chemistry. The improvement of qualitative and quantitative analyses in the subject would require teaching practical work by using laboratory methods since it involves the application of many process skills. Therefore, the importance of the laboratory method in teaching and learning Chemistry cannot be overemphasised.

Students are rarely exposed to practical work because science teachers do not place much value and attention on the process of science through laboratory activities since they feel it takes time away from teaching to cover the prescribed examination-driven curriculum (Alam, Oke & Orimogunge, 2010; Abamba, 2012). This has also encouraged teachers and students to depend on WAEC and NECO instruction manuals instead of preparing students through student-centred methods. Again, mastery of skills has been observed to differ among male and female students due to gender effect. Sometimes, females do better although with weaknesses observed in certain areas. Therefore, it will

be necessary to look into the level of acquisition of these SPS in Senior Secondary School Chemistry. Based on the importance of laboratory activities in skill acquisition and achievement of students in examinations, it becomes imperative for students to be well abreast with laboratory activities to improve SPS and performance. Hence, this work examined the effects of laboratory method on students' level of acquisition of the necessary skills needed in both quantitative and qualitative analyses in Senior Secondary School Chemistry.

2. Literature Review

Orimogunje, Oloruntegbe, and Gazi (2010) showed that the source of students' study has a strong influence on students' study habits which are causally reflected in students' efficiency and performance in practical lessons in volumetric analysis. An analysis by Akinbobola and Afolabi (2010) on Science Process Skills in West African Senior School certificate Examination Physics practical for a period of ten years (1998-2007) showed a high percentage rate of basic (lower order) Science Process Skills of 63% when compared with integrated (higher-order) Science Process Skills of 37%. The results also indicated that the number of basic process skills is significantly higher than integrated process skills at the WAEC Physics practical examination, it can be inferred that Chemistry as a science subject may not be different. As such, SPS in Physics is applicable in Chemistry. Also, Ergul, Simekli, Calis, Ozdilek, Gocmencelebi, and Sanli (2011) showed that the use of inquiry-based science teaching methods significantly enhances students' science process skills and attitudes.

2.1 Qualitative and Quantitative Analyses in Senior Secondary School Chemistry

Chemistry is essentially a practical-oriented science subject that demands proper exhibition of good skills. However, it has been observed from research that students are rarely exposed to practical work and this is giving rise to poor performance in Chemistry in both qualitative and quantitative analyses (Njoku, 2003 and Njelita, 2008). A National Research Council (2005) report revealed that students' standard in relation to laboratory activities is very poor because they do not learn much in that area. Therefore, both analyses are essentially vital in Senior Secondary School Chemistry.

2.1.1 Quantitative Analysis

According to Webster's New World College Dictionary (5th edition), quantitative analysis involves the analysis of an unknown chemical solution by determining the amount of reagent of known concentration necessary to effect a reaction in a known volume of the solution. It is also referred to as 'volumetric analysis' which is commonly called "titration". Following the work of Jean Baptist Andre Dumas, Volumetric Analysis became a widely used procedure in Chemistry and industrial laboratories (Stillwater, 1999). Therefore, titration is as an addition of the titrant to a known quantity of analysis.

Volumetric Analysis is the reaction of an acid with a base. This is why it is also called "acid-base reaction". For the purpose of this study, the focus will be on 'titration'. It is a major aspect of Chemistry practical in Senior Secondary School Chemistry examination; it involves a process of creating a balanced chemical equation and the use of a volumetric apparatus to measure volumes of solutions in weight per volumes since the titration process requires the use of a volumetric apparatus. It is also called volumetric titration. Therefore, Volumetric Analysis at the Senior Secondary School is simply getting the amount of concentration of an unknown chemical solution by using a known concentration of another chemical solution that can effect a reaction by gradually adding together both chemical solutions until the reaction is completed. At completion, an endpoint is observed with the help of an indicator that shows colour change when the reaction is complete. Therefore, mathematical skills are needed to resolve the concentration in terms of mass and moles by using chemical formulae.

Below are the common chemical formulae suitable for solving problems on titration.

$$\frac{C_A V_A}{C_B V_B} = \frac{n_A}{n_B} \tag{1}$$

Where:
C_A = Concentration of acid in mole per $1.0dm^3$
C_B = Concentration of base in mole per $1.0dm^3$
V_A = Volume of acid in cm^3
V_B = Volume of base in cm^3
n_A = Number of mole of acid from the chemical equation
n_B = Number of mole of base from the chemical equation

$$C_A = \frac{P_A}{MM_A}, \ C_B = \frac{P_B}{MM_B} \tag{2}$$

Where:
P_A = Concentration of acid in gram per $1.0dm^3$
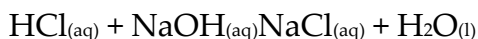P_B = Concentration of base in gram per $1.0dm^3$
MM_A = Molar Mass of acid
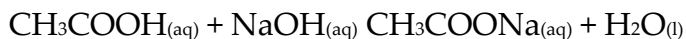MM_B = Molar mass of base

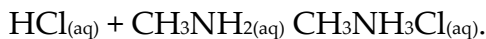Since volumetric titration is a kind of acid-base reaction:
Example:

a) Strong acid + Strong base

$HCl_{(aq)} + NaOH_{(aq)} NaCl_{(aq)} + H_2O_{(l)}$

b) Weak acid + Strong base

$$CH_3COOH_{(aq)} + NaOH_{(aq)} \ CH_3COONa_{(aq)} + H_2O_{(l)}$$

c) Strong acid + weak base

$$HCl_{(aq)} + CH_3NH_{2(aq)} \ CH_3NH_3Cl_{(aq)}.$$
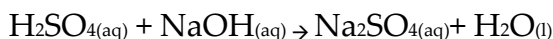
From the reactions above, acid-base reaction type is a major framework of senior secondary school Chemistry syllabus. That is why candidates are tested on their understanding of the principles and procedures of practical work in Chemistry Paper 1 of Senior School Certificate Examination (SSCE). Paper 1 of Chemistry practical at SSCE comprises three major experimental questions of which titration or acid-base reaction is question number 1

Acid-base reaction is a neutralisation reaction since it involves the reaction of Hydrogen ion (H^+) and Hydroxide ion (OH^-). The reaction can be represented in a chemical equation.

$$H_2SO_{4(aq)} + NaOH_{(aq)} \rightarrow Na_2SO_{4(aq)} + H_2O_{(l)}$$

That is:

$$H^+ + OH^- \dashrightarrow H_2O \quad H_3O^+ + OH^- \dashrightarrow 2H_2O$$

2.1.2 Qualitative Analysis

In qualitative analysis procedure, the chemical properties of an unknown substance are determined by systematically reacting the unknown with a number of different reagents by predetermining what the particular reaction will produce if a specific ion is present. These ions (actually in the solution) can be identified. For example, if a reaction is known to produce a precipitate (say ion A is present and a precipitate is formed when the reaction is run), then ion A may be present in the solution and there may be other ions that will also precipitate with the presence of a particular reagent. If no precipitate is formed when the reaction is run, then ion A is clearly not present in the unknown solution and a different reaction will have to be run to determine what ions are present. There are two general situations in which qualitative analysis is used. They are the identification of simple salts and the identification of multiple ions in a solution.

In identification of simple salts, requires noting the appearance of the salt sample. This includes the state of the salt, its colour, and its texture. Another thing to note is the heating effect. Heating a salt sample can cause a number of changes which could help to identify the possible content of the salt with the help of the gas evolved. The flame test is also a characteristic property to note during the identification of simple salts. The visible colours emitted vary with the type of ions present in the salt. For example, sodium ion

produces bright yellow, potassium ion produces pale violet, calcium ion is brick red, lead ion is pale bluish, copper ion is greenish blue, and so on.

Simple salts are also identified by making solutions of them. The solubility of salts varies with salt type and temperature. Most crystalline salts like sulphates, nitrates, and chlorides are soluble in water while amorphous like carbonates, sulphites, and phosphates are usually insoluble in water. For the purpose of confirming ions to be identified, it is expected to react either the salt sample or its solution with certain reagents like diluted HNO_3, aqueous NH_3, diluted $NaOH$, $AgNO_3$, freshly prepared $FeSO_4$, $BaCl_2$ lime water, and so on.

2.2 Relevance of Quantitative and Qualitative Analyses

In Chemistry, both quantitative and qualitative relationship between two reacting solutions is important. However, it is not practically efficient. Observation proves that it is difficult and, in many cases, a waste of effort and materials to separate and measure the mass of products of a reaction while they are in solution but volumetric analysis looks a better and faster technique especially if the substances involved are acids and bases since they can be titrated, one after the other, for better quantitative results (Alam, Oke and Orimogunje, 2010).

Therefore, the knowledge of quantitative and qualitative analyses in Chemistry at the secondary school level is inevitable just as it is a functional issue for all science students in higher schools such as colleges and universities. A review of the above shows that quantitative and qualitative analyses are areas of Chemistry, which are necessary and relevant in virtually all fields of science analysis. As long as life and health are vital, the role of quantitative and qualitative analyses in science and technology cannot be ignored.

Practical Chemistry constitutes Paper 1 of the two Papers students are examined in to get their final score in Chemistry. Practical Chemistry is vital since the questions asked require students to demonstrate Science Process Skills in both quantitative (titration) and qualitative analyses. The WAEC reports of 2002 – 2007 point out that one factor associated with failure in Chemistry is students' inability to carry out practical exercises effectively due to lack of necessary scientific skills in practical work. It has become imperative to examine if students' acquisition of Science Process Skills could be improved in both quantitative and qualitative analyses using the laboratory method of teaching, hence, the problem this study intends to solve is: will the use of the laboratory method enhances students' acquisition of Science Process Skills in Senior Secondary School Chemistry? In accordance with the problem of the study, the following null hypotheses were put forward and tested at a 0.05 level of significance:

Ho₁: There is no significant difference in students' acquisition of Science Process Skills in quantitative analysis between those taught with the laboratory method and those taught with the lecture method.

Ho₂: There is no significant difference in students' acquisition of Science Process Skills in qualitative analysis between those taught with the laboratory method and those taught with the lecture method.

Ho₃: There is no significant difference in students' acquisition of Science Process Skills between quantitative analysis and qualitative analysis of students taught with laboratory method.

3. Material and Methods

This study employed a non-randomized pre-test, post-test control group quasi-experimental design. The population of the study consisted twenty-five thousand, eight hundred and eighty-six (25,886) students of Senior Secondary School Two (SS2) across one hundred and forty-nine (149) public schools spread across the eight (8) Local Government Areas of Delta Central Senatorial District. Six (6) Chemistry teachers and one hundred and ninety-eight (198) senior secondary school (SS2) Chemistry students of the 2012/2013 academic session from six (6) selected secondary schools having Chemistry laboratories in Delta Central Senatorial District were sampled using stratified random sampling to avoid the problem of inadequate Chemistry laboratory facilities. The one hundred and ninety-eight (198) Senior Secondary School Two (SS2) Chemistry students were from intact classes of the sampled schools comprising both males and females.

Three instruments will be used in the study:
1) Chemistry Practical Ability Test (CPAT),
2) Chemistry Process Skills Rating Scale (CPSRS),
3) Instruction Manual for Quantitative and Qualitative Analyses (IMQQA).

The Practical Ability Test items were drawn from West African Senior School Certificate Examination (WASSCE) Chemistry question paper 3. It is an alternative to practical paper which is capable of helping to ascertain the level of understanding and acquisition of Chemistry Process Skills in Quantitative and Qualitative Analyses.

Chemistry Process Skills Rating Scale (CPSRS) is a rating scale designed to assess the level of acquisition of Chemistry Process Skills in CPAT. It is made up of grading points to rate each of the Chemistry Process Skills in Quantitative and Qualitative Analyses.

The instructional manual for Quantitative and Qualitative Analyses (IMQQA) is the teachers' instructional manual to teach using the laboratory method after administering the pre-test instrument.

The CPAT was adopted from 2003-2012 November WASSCE Chemistry paper 3. The instrument was not validated since it was already standardized. The CPSRS was constructed and developed with respect to the specified curriculum contents on volumetric analysis and was validated by two science education lecturers and a lecturer in measurement and evaluation to ensure its face and content validity. After necessary corrections and modifications, the instruments were administered accordingly.

The CPAT was administered to the sampled students in SS2. Responses to the designed questions in the CPAT were collected and rated using CPSRS. Each process skill was rated using two (2) for those who answered the question correctly, one (1) for those who got half of the answer while zero (0) for those who failed to answer the question correctly. CPAT and CPSRS were trial tested in a school that is not part of the study. The reliability was estimated using Pearson Product Moment Correlation Coefficient. The reliability coefficient of 0.707 was obtained.

3.1 Treatment Procedure

The Chemistry Practical Ability Test (CPAT) was administered to the SS2 Chemistry students from the sampled schools. Three schools were used as the experimental group while the other three schools as the control group. The trained Chemistry teachers were used to both teach using the laboratory method and administer the CPAT, and the responses were retrieved the same day for marking and rating using CPSRS by the researcher. Members of the experimental group of the study were treated at another time using the laboratory method of instruction (Instructional Manual for Quantitative and Qualitative Analyses (IMQQA)) while the conventional method remained unchanged for the control group. Thereafter, the CPAT was administered to the students in both groups accordingly by the same trained teachers. Responses from each student were collected that same day for scoring and rating by the researcher using the CPSRS.

Mean and standard deviation, t-test analysis, and ANCOVA were used to analyse the data collected.

4. Results and Discussion

The data obtained is analysed and presented below:

4.1 Hypothesis 1

Hypothesis 1 examined whether there is a significant difference in students' acquisition of science process skills in quantitative analysis between those taught with laboratory method and those taught with lecture method. The result is presented in the table below.

Table 1: Mean and Standard deviation of students' level of acquisition of SPS
in quantitative analysis between those taught using Laboratory and Lecture methods

Method of Instruction	Mean	Std. Deviation	N
Lecture	10.5766	6.32391	111
Laboratory	18.7816	7.58276	87
Total	14.1818	8.00617	198

From Table 1, the result shows that the mean value and standard deviation for the laboratory method, 18.7516 and 7.58276 are higher than those of the lecture method 10.58 and 6.32. This implies that there is a difference in the acquisition of science process skills

in quantitative analysis between those taught with laboratory method and those taught with lecture method.

When subjected to inferential statistics using ANCOVA, the result is presented in Table 2.

Table 2: Summary of ANCOVA for significant difference on students' level of acquisition of SPS in quantitative analysis between those taught using Laboratory and Lecture methods

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	9392.314[a]	2	4696.157	283.064	.000
Intercept	5621.638	1	5621.638	338.848	.000
PreQTV	6108.809	1	6108.809	368.212	.000
Group	4851.381	1	4851.381	**292.420**	.000
Error	3235.140	195	16.590		
Total	52450.000	198			
Corrected Total	12627.455	197			
a. R Squared = .744 (Adjusted R Squared = .741)					

From Table 2, the result shows $F_{(1,195)} =292.42$, P=0.000 which is significant. Therefore, HO_1 is rejected. This implies that there is a significant difference in the acquisition of science process skills between students taught with laboratory method and those taught with lecture method in quantitative analysis. From the adjusted R square value, the laboratory method contributed to 74% of the acquired SPS skills.

4.2 Hypothesis 2

Hypothesis 2 examined whether there is no significant difference in students' acquisition of science process skills in qualitative analysis between those taught with the laboratory method and those taught with the lecture method.

The data on Hypothesis 2 are presented in Table 3.

Table 3. Mean and Standard Deviation on Students' acquisition of SPS in Quantitative Analysis between those taught with Laboratory and Lecture Methods

Method of Instruction	Mean	Std. Deviation	N
Lecture	4.2523	2.80087	111
Experimental	14.6667	6.76803	87
Total	8.8283	7.15746	198

From Table 3, the result shows that the mean value and standard deviation for the lecture method, 4.25 and 2.80, are far lower than those of the laboratory method, 14.67 and 6.77. This implies that a difference exists in the acquisition of science process skills in qualitative analysis between those taught with the lecture method and those taught with the laboratory method. When subjected to inferential statistics using ANCOVA, the result of the ANCOVA carried out on HO_2 is presented in Table 4.

Table 4. Summary of ANCOVA for Significant difference on Students' acquisition of SPS
in Quantitative Analysis between those taught with Laboratory and Lecture Methods

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	5642.373[a]	2	2821.187	123.631	.000
Intercept	7845.650	1	7845.650	343.814	.000
PreQLV	352.482	1	352.482	15.447	.000
Group	5280.367	1	5280.367	231.398	.000
Error	4449.789	195	22.819		
Total	25524.000	198			
Corrected Total	10092.162	197			
a. R Squared = .559 (Adjusted R Squared = .555)					

From Table 4, the result shows that the F (1,195) = 231.398, P=0.000 is significant. Therefore, the null hypothesis two is rejected. This implies that there is a significant difference in students' acquisition of science process skills in qualitative analysis between those taught with laboratory method and those taught with lecture method.

4.3 Hypothesis 3

Hypothesis 3 examined whether there is no significant difference in students' acquisition of science process skills between quantitative analysis and qualitative analysis when taught using the laboratory method. The data on Hypothesis 3 are presented in Table 5.

Table 5: Mean and Standard Deviation on Students acquisition of SPS
between Quantitative and qualitative Analysis taught with Laboratory Methods

Source of Variation	N	Mean	Std. Deviation	Std. Error Mean
Quantitative	87	18.7816	7.58276	.81296
Qualitative	87	14.6667	6.76803	.72561

From Table 5, QTV stands for post-test on quantitative analysis while QLV stands for post-test on qualitative analysis. The result reveals that the mean value and the standard deviation for quantitative analysis, 18.78 and 7.58, are higher than those of qualitative analysis, 14.67 and 6.77. This implies that there is a difference in the acquisition of science process skills between quantitative analysis and qualitative analysis using laboratory method.

When subjected to inferential statistics using a t-test on HO3, is presented in Table 6.

Table 6: T-test between Quantitative and Qualitative Analysis taught with Laboratory Methods

Method	N	Df	t-cal.	t-crit.	Decision
Quantitative Analysis	87	172	3.78	1.96	Rejected
Qualitative Analysis	87				

From Table 6, the result of the t-test shows that the t-calculated value of 3.78 is higher than the t-critical value of 1.960. Based on this result, null hypothesis three is rejected. It

implies that there is a significant difference in students' acquisition of science process skills between quantitative analysis and qualitative analysis.

5. Discussion

The study examined the effects of laboratory method on students' acquisition of science process skills in senior secondary school Chemistry. Results showed that both groups acquired the necessary skills required in quantitative analysis, though the group exposed to the laboratory method acquired more skills than those exposed to the lecture method. It showed that a difference exists in the level of students' acquisition of science process skills with respect to the method of teaching applied. Results further showed that the difference is statistically significant when subjected to inferential (ANCOVA) statistics in favour of the laboratory method. This means that students exposed to laboratory method acquire more science process skills embedded in quantitative analysis than those exposed to lecture method. This finding is in consonance with Ergul, Simekli, Calis, Ozdilek, Gocmencelebi, and Sanli (2011) who examined the effects of inquiry-based science teaching on elementary school students' science process skills and science attitude in Turkey. They found that the use of inquiry-based methods significantly enhanced students' science process skills. The work of Meltem and Oguz (2010) also agrees with this research finding. The work revealed that the level of achievement and acquisition of science process skills by students is enhanced by the science process skills–based learning approach when compared with the traditional learning method. The work of Krieger (1997) which examined the effects of a microcomputer-based Chemistry laboratory on the acquisition of science process skills using analysis of covariance showed that the microscopic mode-based Chemistry laboratory approach increased the level of acquisition of science process skills in certain areas.

Also, this study tried to find out whether there is a difference in the level of students' acquisition of science process skills in qualitative analysis between the group taught using the laboratory method and that taught using the lecture method. Results showed that both groups acquired the needed skills, though, the group exposed to the laboratory method significantly acquired more skills than those exposed to the lecture method. It showed that a difference exists in the level of students' acquisition of science process skills between the group exposed to the laboratory method and that exposed to the lecture method. The result further showed that the difference is statistically significant when subjected to inferential statistics (ANCOVA), in favour of the laboratory method. It means that students exposed to laboratory method acquire more science process skills in qualitative analysis than those exposed to lecture method. This finding is in consonance with the findings of Ergul *et al.* (2011), Meltem and Oguz (2010), who found that there is a significant increase in science process skills of students with other methods of teaching when compared with traditional methods like lecturing method.

The study further examined whether any difference exists in students' acquisition of science process skills between quantitative analysis and qualitative analysis. Results

showed that students acquired the needed skills in both analyses but a difference exists in the level of students' acquisition of science process skills with respect to the type of analysis engaged. The result also showed that the difference is statistically significant when subjected to t-test in favour of quantitative analysis. This means that the students acquired more skills in quantitative analysis than in qualitative analysis. This is in consonance with the work of Omojuwa (2010) who found that large proportions of students find difficulties in the acquisition of skills like formulation of hypothesis, interpretation of data, and making of predictions and inferences while other areas like measuring, classification, manipulation of variables and raising of questions were not found difficult. The process skills found difficult were certain skills relating to qualitative analysis. It can be implied that the difficulties experienced in these skills create multiplier effects on the difference between quantitative analysis and qualitative analysis.

6. Recommendations

Based on the findings of the study, the following recommendations were made:

1) The use of laboratory method should be employed in teaching practical aspects of Chemistry always.
2) A separate period per week should be given for laboratory activities with reference to the scheme of work.
3) The need for in-service training for Chemistry teachers is also recommended to educate them on activity-centred methods like laboratory and discovery methods.
4) Chemistry teachers should involve students more in laboratory and practical activities while teaching.

7. Conclusion

The study highlighted the effects of the laboratory method on students' acquisition of science process skills based on quantitative and qualitative analyses. Findings indicated that the laboratory method enhances students' acquisition of science process skills in both qualitative and quantitative analyses than the lecture method. Also, the laboratory method accounted for 74% of the acquired SPS skills and lastly, it was found that students acquire more skills in quantitative analysis than in qualitative analysis.

Therefore, it can be concluded that the use of laboratory method enhances the acquisition of science process skills in Chemistry in senior secondary school since the laboratory method is known to be child and activity-centred.

Conflict of Interest Statement
The authors declare no conflict of interest

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