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# *Effect of Laboratory Techniques on Nigerian Secondary School Chemistry Students' Academic Achievement and Interest*

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## Abstract
*This study investigated the effects of laboratory techniques on academic achievement and interest of secondary school chemistry students and examined the influence of gender on students taught with Laboratory techniques and Lecture method. A quasi experimental/control design was adopted. Three research questions were raised and three hypotheses were formulated and tested at 0.05 level of significance. A sample of 100 Senior Secondary Two (SSII) students from two schools in Kaduna metropolis was drawn from a population of 1,655 students and 24 schools using purposive sampling technique; one of the schools was assigned experimental group while the other was control group. The instruments used for data collection were Chemistry Achievement Test (CAT) and Chemistry Students' Interest Scale (CSIS). CAT and CSIS were administered to students as pretest and posttest. The results were analyzed using Mean and Standard Deviation. t-test statistic was used to test the hypotheses. The result indicated that students taught with laboratory techniques achieved significantly better than their counterparts taught using Lecture method; and there was no significant difference in the posttest achievement scores of male and female students taught with laboratory techniques. It was recommended that laboratory techniques should be encouraged for teaching chemistry practical in secondary schools.*
**Keywords:** Laboratory, Techniques, Chemistry, Achievement, Gender, Interest

## Introduction
From the perspective of promoting standard of education, the instructional technique employed plays important role in learning important ideas and skills if standard education is to become reality in the nation's classroom. Techniques are the tools used by teacher to carry out the strategy (Van-der Horst & McDonald, 2003) and focus on the techniques, subject matter and teaching media used to reach the set objectives. According to Hermann (2005), the effectiveness of teaching any subject should be measured in terms of the expertise of what to teach, how to teach it and when to educate it. The "how" of instructing constitutes what is called teaching (Hermann, 2005). No

wonder National Commission for Colleges of Education (NCCE) (2002) noted that the efficient teacher has various techniques at his disposal and needs to select and use appropriate techniques of teaching a particular concept, especially when instructing and knowledge is desired.

Teaching is a procedure which generally takes place in a classroom. It is a formal technique in which the teacher interacts with the students in order to supply what he wishes the novices to learn in accordance to their studying wishes. It is a systematic way to gain some pre-determined goals. Teaching is to motivate and to fill the minds of the learner with knowledge leading them to the desired behaviour. It is an act of imparting understanding of ideas and primary existence skills. To achieve this, teacher needs to improve on the techniques in the teaching and learning process, especially in teaching science subjects. Science is a procedure that is geared in the direction of trouble fixing in order to find solutions to human problems. Nwagbo (2006) defines science as mental activity carried out by humans, and designed to discover data about the world in which he lives as well as to find out the ways in which the data can be organized to benefit human race.

Looking at the various definitions of science, it can be viewed as not simply mere acquisition of facts, but as an alternative to the active involvement of students via activity-based strategies such as discussion method, fieldtrip, discovery, co-operative and guided inquiry strategies. These teaching techniques make the instructing and mastering of science extra meaningful in such a way that these students would be capable of unfolding standards by themselves as a skill of accomplishing one of the goals of the National Policy on Education (FME, 2004). Students' passion for science therefore be aroused at the secondary school level in order to put together for them subsequent research in science guides at the tertiary level to realise these goals. Man is dependent on science for everyday activities that affect daily lives. Therefore, sound knowledge of chemistry as one of the science subjects is important for the management of natural resources and towards achieving self-reliance in the life of an individual (Dutta, 2006; Achufusi, Umeh & Okoye, 2009).

Chemistry as a science subject occupies a central position in the scientific and technological advancement of any nation (Bugaje, 2013). It covers a large and special position among other science subjects because of the several applications to which its standards are being used to enhance man's environments. The teaching of chemistry needs to therefore, mirror the processes and techniques of contemporary science. The role and importance of chemistry are clearly seen and known in the scientific and technological development in Nigeria. Within the context of science education, chemistry has been identified as a major subject and its applications in scientific and technological development of any nation has been widely reported (Adesoji, 2009). It

was as a result of the recognition given to chemistry in the development of the individual and the nation that chemistry was made a core-subject in secondary and tertiary education among other natural sciences and science related courses in Nigerian Education system, such as medicine, biochemistry, pharmacy, agricultural science, laboratory technology, geology etc; because of its recognition in the development of individual and nation (Edomwonyi & Avaa, 2011; Bugaje, 2013).

The importance of chemistry and the acceptability of National Policy on Education (FME, 2004) statement are responsible for the prime position accorded science and in particular chemistry worldwide. However, in spite of the various innovations introduced into the educational system, the importance of chemistry to mankind, and the efforts of government and researchers regarding its teaching and learning, students still exhibit low interest in the subject. This leads to poor performance in Secondary School Certificate Examination (SSCE) in chemistry in Nigerian secondary schools (Jegede, 2003). The promotion of students' interest and success in science, as a result of their encouraging performances, remains unattained and as a result serves as a limiting factor to gain access into the fields of science (Osokoya, 2007).

There are two teaching strategies identified by McCown, Driscoll and Roop (1996); they are teacher-centred instruction and student-centred instruction. Teacher-centred instruction focuses on the teacher presenting key concepts of the subject matter in the form of a lecture. If learners need elaboration or need to ask questions, they ask the teacher directly. While Student-centred instruction focuses on the teacher organizing the learners into groups and then providing them with recourse materials. This strategy spreads the responsibility for learning between the teachers and the learners (McCown et. al, 1996). A learner-centered approach is also consistent with a constructive view of learning (McCown et. al, 1996), with learning best done in real life environments where learning concepts and ideas should be learned in diverse ways. There are however varieties of techniques that can be associated with each of the strategies; this study specifically focus on the lecture method (teacher-centred) and laboratory learning technique (student-centred).

Lecture method is described as presenting information to a group of student for the purpose of instruction. This method assumes that all the learners need the same information presented in the same way, at the same place and at the same time. The method is appropriate when presenting key information to learners who have the attention span, self discipline and motivation to benefit from the method (Westwood, 2008). Lecture method, traditionally referred to as didactic method is defined as a technique in which one person, usually the teacher, provides a spoken discourse on a particular situation (Atadoga & Onaolapo, 2008). Lecture is used for elaborating, simplifying, clarifying and discussing new topics or bringing learners up to date on the

most recent information or views on problems and troubles associated to the learners, and this method is quick, concise and integrated (Westwood, 2008). Effectiveness of lecture method depends on the kind of student, instances of the class, the subject, educational purposes and teacher's very own characteristics and skills. According to Adesoji (2009), many lecturers have regular lecture approach as an appropriate way of imparting knowledge because instructional gadget places so much emphasis on external examinations. However, the lecture method provides little opportunity for learners to interact with each other, the teacher or with the materials, and therefore discourages the social construct of knowledge and skills. Learners also tend to be passive and lack confidence to ask questions when in large group despite the fact that they differ in prior knowledge, experience and motivation (Westwood, 2008). It is a detriment to student learning, when it is considered that one of the targets of science education is to increase student's interest in science and technology as today's society relies generally on development in science and technology.

Ironically, lecturing and questioning are the most common teaching methods in most of the traditional chemistry classrooms in Nigerian secondary schools (Afolabi, 2004). Students are exposed mainly to subject matters and they generally cannot understand why they learn those subjects, when they are not interested in them, or when they know that this knowledge will never be of any use to them throughout their life. The teaching and learning of chemistry concepts must therefore be executed through teaching strategies that are activity-oriented and student-centred such as discussion method, demonstration method, guided inquiry approach, fieldtrip as well as laboratory technique (Okebukola, 2004).

Laboratory learning is an instructional technique that focuses the learners' attention on the content, and learners actively process content and this in turn allows for the construction of knowledge. Laboratory experiences have been reported to promote science education goals including the enhancement of students' understanding of concepts in science and its applications; scientific practical skills and problem solving abilities; scientific attitude; understanding of how science and scientists work; interest and motivation. Science educators believed that the laboratory is an important means of instruction in science. Laboratory instructional technique was considered essential because it provided training in observation, supplied detailed information, and aroused students' interest. Interest in this context could be defined as an activity one enjoys and devotes time in doing (Okeke, 2011). Interest could also be seen as a feeling student has in the cause of wanting to know or learn more about something.

In a laboratory, students work individually or in small groups on a problem or hypothesis. They use the processes and materials of science to construct their own explanation of scientific phenomena. The advantage is that learners find this technique

motivating through active participation, while working hands-on with materials gives them the opportunity to see experiment being performed (Okeke, 2011). However, this method requires a resource rich environment and learners need to have numeracy and inquiry skills. Laboratory activities are integral and essential part of chemistry teaching and it is needed as a means of obtaining and learning scientific information. It stimulates students' interests as they are made to personally engage in useful scientific activities and experimentations (Okeke, 2011). Students are able to observe and manipulate materials to demonstrate certain aspects of the subject matter which has been learnt in class through lectures or discussions from their teachers. This provides students with opportunities to engage in processes of investigation and inquiry which is believed to enhance quality education. Laboratory activities have long had a distinctive and central role in the science curriculum and science educators have suggested that many benefits accrue from engaging students in science laboratory activities (Hofstein & Lunetta, 2004; Lunetta, Hofstein & Clough, 2007). The distinction between laboratory and traditional classroom learning is that activities are student-centered, with students actively engaged in hands-on, minds-on activities using laboratory techniques (Lazarowitz & Tamir, 1994).

In terms of academic achievement, Adeniran (2006) in Yara (2010) stated that laboratory instructional strategy gives a new approach to science teaching and learning because it provides a non-threatening, realistic and concrete approach to learning of science as opposed to the difficulty encountered in learning the formal, abstract treatment of the typical textbook. Yara (2010) discovered that students taught with Science Laboratory Instructional Strategy performed significantly better than use of traditional lecture and textbook method. The most effective vehicle by which the process of inquiry can be learned appears to be a laboratory technique where the student experiences, firsthand, the inquiry process. Laboratory technique has also been demonstrated to be effective means for comprehension, understanding and application of scientific knowledge. Laboratory experiences provide opportunities for teachers to model best practices in the study of scientific concepts, including application of scientific methodologies, respect for life and the environment, inclusion of learners of all abilities, and consistent adherence to safety standards. Some laboratory activities have been designed and conducted to engage students individually, while others have sought to engage students in small groups and in large-group demonstration settings. Teacher guidance and instructions have ranged from highly structured and teacher-centered to open inquiry (Hofstein & Mamlok-Naaman, 2007).

In this paper, two strategies were adopted as they relate to laboratory method of teaching science particularly in secondary schools. The first one is Laboratory Demonstrations; it begins by demonstrating key techniques or equipment operation or describing the location and handling of special materials. The students are gathered

close to focus them on what the teacher is doing and to ensure that everyone can see and hear. Again, they are focused on the key terms and functions that are in the procedures, and use the demonstration to generate excitement about the laboratory. Allen, O'Connell, Percha, Erickson, Nord, Harper, Bialek and Nam (2009) suggested that the teacher should not attempt to demonstrate equipment he has not practiced using; it is good to be familiar with the equipment operation prior to the demonstration. The second point is Laboratory Instruction; the teacher maintains an active role and consistent pace of interaction throughout the laboratory period so that students learn what to expect from him as an instructor. The teacher gains everyone's attention and provides instruction or feedback for everyone. During the class, he moves around the room to make himself accessible to students, focusing equal time on groups that ask and those that do not ask for help.

Research in chemistry education has continued to seek better approaches for teaching practical chemistry in order to bring about meaningful learning and to identify factors responsible for persistent problems of low interest and achievement in chemistry among students. Oloyede, (2010) and Okeke (2011) conducted researches in practical chemistry involving students' achievement and interest. Okeke (2011) found out that students scored highest mark in theory of practical chemistry examination. This suggests that students were not exposed to practical knowledge to provide meaningful links for students to participate and acquire meaningful knowledge and skills in the laboratory. In relation to academic achievement based on gender when exposed to laboratory technique approach, Nwosu (2001) reported that exposure to science process skill based learning involving activities for both boys and girls yield more effective learning irrespective of gender. Ogunboyede (2003) in line with Nwosu (2001) said that boys are not higher than girls in terms of academic achievement, in his study of sex difference and students' achievement at the primary school level. Usman (2000) and James (2000) also pointed out that male students are academically superior to their female counterparts in science. Njoku (2007) also mentioned that male students were more successful than female students in science, Technical and Mathematical subjects. Okebukola (2002), Tsui and Treagust (2002), reveal that those teaching strategies that are activity-based such as problem solving, discipline trip, undertaking method, guided inquiry strategy and laboratory technique amongst others which involved the learner taking active role in the teaching/learning process, results in better learning and perception of science concepts on the part of the learner. In the findings of Olorukooba (2001), it was reported that teaching techniques can also have an impact on the interest of students positively or negatively; and that students taught the usage of cooperative learning strategy in science have positive attitude to the educational benefits derived from group work.

**Statement of the problem**

Issues concerning students' underachievement in chemistry and how to solve the problem have been the concern of science educators hence several methods like the use of concept mapping, cooperative learning, problem solving techniques and games have been tried out by researchers to improve the teaching/learning and possible improvement in students' learning outcomes. In the same vein, this researcher is set out to investigate the effect of laboratory technique on students' academic achievement and interest in chemistry.

**Research questions**

The following research questions were formulated to guide this study:

1) Does the laboratory learning technique have gender related effect on academic achievement of chemistry students?
2) What is the difference in the mean achievement scores of chemistry students in laboratory learning technique and Lecture method?
3) What is the effect of laboratory learning technique on the interest of students in chemistry?

**Hypotheses**

The following null hypotheses were tested at 0.05 level of significance:

**Ho1:** There is no significant difference in the mean achievement scores of male and female chemistry students exposed to laboratory learning technique.

**Ho2:** There is no significant difference in the mean achievement scores of chemistry students exposed to laboratory learning technique and those exposed to lecture methods.

**Ho3:** There is no significant difference in the mean interest scores of chemistry students exposed to Laboratory learning technique.

**Methodology**

The study adopted Quasi-experimental/control design, which used pre-test and post-test for the two groups of students before and after the experiment. The area of the study is Sabon Tasha Education Zone of Kaduna State. The population of this study consists of all Senior Secondary School Two (SSII) chemistry students of public senior secondary schools located in Kaduna Metropolis. These schools were used for the study because they represent the types of schools found in Kaduna State being public schools, day and co-educational. A total of twenty-four (24) Senior Secondary Schools were selected within the Zone with a total population of one thousand six hundred and fifty-five (1,655) SSII science students consisting of 881 males and 774 females. Students offering chemistry in SSII in the zone were considered appropriate for the study because of their experience in chemistry and stability in secondary education

than SSI students who have not yet gained much academic experience and SSIII students who are busy preparing for Secondary School Certificate Examination.

The sample for the study comprised 100 SSII students offering chemistry (70 males and 30 females) randomly drawn out from a group of 142 SSII science students in two co-educational schools (82 and 60) in the Zone. The 100 students were selected because not all the 142 science students offer chemistry. School that has equipment for practical class was selected as experimental group while another school as control group. Since all the schools in the population are located in different areas, it is believed that no interaction occurred between the groups during the time of the treatment, which could affect the result of the study.

The instruments for the research were Chemistry Achievement Test (CAT) and Chemistry Students' Interest Scale (CSIS). The pre-test and post-test were conducted using CAT. The CAT consisted of 40 multiple choice items covering Titration, a content in the chemistry syllabus. The items were derived from the West African Examination Council (WAEC) past objective questions of the years 2010 to 2018 which was believed to have been standardised. For the post-test, pre-test was reshuffled without altering options.

The CSIS questionnaire consisted of 21 items based on the Likert's four-point scale - Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The questionnaire was distributed to the experimental group before and after treatment in order to identify a change, if any, in the interest of the students in chemistry and their responses collected. Students in the experimental group were taught chemistry concept by the researcher in order to ensure efficient chemistry practical class and to ensure that the teaching method was in accordance with the direction of the laboratory procedures and safety. The control group was also taught same concepts by the class teacher using lecture method. After the treatment had been completed, the students were post-tested and data were collected, collated and analysed using Mean, Standard Deviation and t-test.

**Presentation of results**

**Research Question One:** Does the laboratory learning technique have gender related effect on academic achievement of chemistry students?

To decide the degree to which the laboratory learning technique has gender related effect on academic achievement of chemistry students, a descriptive statistics was used with reference to the mean difference between the male and female students in the experimental group of the study.

**Table 1:** Results of t-test Analysis of the Posttest Mean Achievement Scores of the Male and Female in Experimental Group

| Groups | N | $\bar{x}$ | SD | df | t-value | p-value |
|---|---|---|---|---|---|---|
| Male | 31 | 38.08 | 3.60 | 48 | 1.76** | 0.650 |
| Female | 19 | 34.28 | 2.58 | | | |

******Not Significant at p > 0.05

Table 1 shows the mean achievement scores of male and female students. The table shows that male students have mean and standard deviation of 38.08 and 3.60 respectively while the female students have mean and standard deviation of 34.28 and 2.58 respectively. Also there is a mean difference of 3.45 which is in favour of the male students. This indicates that the male students perform higher than the female students. However, the researcher ought not to conclude whether or not the mean difference was significant until hypothesis one was tested.

**Ho1:** There is no significant difference in the mean achievement scores of male and female chemistry students exposed to laboratory learning technique.

The hypothesis was generated to find out the difference between male and female chemistry students exposed to laboratory learning technique. Scores of students obtained from specific gender were subjected to t-test analysis and the result obtained is presented in Table 1. The result showed that the p-value is 0.650 which is greater than the level of significance at $\alpha$ = 0.05 with df = 48. This means that there is no significant difference between the post-test scores of male and female chemistry students when exposed to Laboratory learning technique. This implies that the achievement level of male students exposed to Laboratory learning technique is the same with their female counterparts. Therefore, the null hypothesis one, which states that there is no significant difference in the mean achievement scores of male and female chemistry students exposed to Laboratory learning technique, is retained and accepted.

**Research Question Two:** What is the difference in the mean achievement scores of chemistry students in Laboratory learning technique and Lecture method?

To confirm the outcome of Laboratory Learning Technique on the academic achievement of chemistry students, a descriptive statistical test was used which focused on mean, standard deviation and the mean difference between the experimental and control group as regard to the question stated.

**Table 2:** Results of t-test Analysis of the Posttest Mean Achievement Scores of the Experimental and Control Groups

| **Groups** | **N** | $\bar{x}$ | **SD** | **df** | **t-value** | **p-value** |
|---|---|---|---|---|---|---|
| Experimental Group | 50 | 37.77 | 2.83 | 98 | 25.05* | 0.000 |
| Control Group | 50 | 28.03 | 2.45 | | | |

*Significant at $p<0.05$

Table 2 shows that the mean achievement score and standard deviation of students in the experimental group are 37.77 and 2.83 while the mean achievement score and standard deviation of the control group are 28.03 and 2.45 respectively. There is also a mean difference of 4.45 which is in favour of the experimental group. This indicates that the students in the experimental group performed higher than their counterpart in the control group. To establish whether or not the observed difference in achievement between the two groups was significant, hypothesis two was tested.

**Ho2:** There is no significant difference in the mean academic achievement score of chemistry students exposed to laboratory technique method and those exposed to lecture method.

Scores of students acquired in the different schools had been subjected to t-test analysis and the result obtained is presented in Table 2. The result showed that the t-value is 25.05 as p-value is 0.00 which is less than 0.05 level of significance with df = 98. This indicates that there is significant difference between the post-test scores of the experimental and the control groups in favour of the experimental group. Thus the hypothesis was therefore rejected. This implies that significant difference existed in the mean achievement scores of students taught with laboratory technique approach and those taught the same concepts of chemistry using lecture method in favour of the group taught using laboratory technique approach.

**Research Question Three:** What is the effect of laboratory learning technique on the interest of students in chemistry?

To answer the research question, a descriptive statistic of mean rank was used to find out the interest of students in chemistry as occurred with the experimental group.

**Table 3:** Descriptive Statistics results of interest of the Experimental Group exposed to treatment

| **Groups** | **N** | $\bar{x}$ | **Sum of Rank** | **Mann-Whitney U** | **Z-value** | **p-value** |
|---|---|---|---|---|---|---|
| Interest before Treatment | 50 | 25.58 | 1099.94 | | | |
| | | | | 1099.94 | -9.298* | 0.00 |
| Interest after Treatment | 50 | 75.58 | 32.4878 | | | |

*Significant at $p < 0.05$

Table 3 shows that there is an interest change in the experimental group exposed to treatment. It shows that the mean rank score of interest before treatment is 25.58 and the mean rank score after treatment is 75.58. Also, there is a mean difference of 50.00 which is in favour of interest after treatment. This indicates that there is high influence observed on the interest after treatment. However, the researcher could not conclude whether or not the mean difference was significant until the hypothesis three was tested.

**Ho3:** There is no significant difference in the interest change of chemistry students after exposure to Laboratory learning technique.

The pretest and posttest data collected through the CSIS have been subjected to Mann-Whitney test to determine if there is any significant difference between the interests of chemistry students after exposure to laboratory learning technique. Summary of the analysis is presented in Table 3.

The result introduced in Table 3 revealed that at 0.05 level of significance, p-value of 0.000 with df = 48 was obtained. The p-value obtained is less than the level of significance hence, the null hypothesis of no significant difference in the interest of chemistry students after exposure to laboratory technique method is rejected; meaning that there is significant difference in the interest of chemistry students after exposure to laboratory technique strategy. Students' interest improved positively towards chemistry after treatment as noted from the Mann-Whitney U of 1099.94 and a negative Z-Value of -9.298.

**Discussion of the findings**

Using both pre-test and post-test results, it was shown statistically that while there was no difference between the group prior to intervention, the experimental group performed significantly better than the control group after treatment. This is consistent

with the claims that laboratory technique provided training in observation, supplied detailed information, and aroused student's interest (Okeke, 2011). The results in this article suggest that laboratory learning is a better technique than lecture method in chemistry even though laboratory learning takes a longer period than lecture method. Another important aspect is that laboratory learning ensures students' participation in the teaching learning process. Laboratory learning helps to cater for science students of different abilities and interest (Okebukola, 2004). The effect on gender difference is in line with the findings of Njoku (2007) in which male students were more successful than their female counterparts. With respect to students' interest in the subject using laboratory instruction, the result suggested that students had interest in chemistry after using laboratory instruction following the sequence that students can see the apparatus and the procedures to investigate some theories on their own.

Table 1 shows that laboratory technique enhances the academic achievement of male and female students at senior secondary school level. It implies that the achievement level of male students exposed to laboratory technique strategy is the same with their female counterparts. This finding is in agreement with that of Nwosu (2001) who reported that exposure to science process skill based learning involving activities for both boys and girls yield more effective learning irrespective of gender. Ogunboyede (2003) in line with Nwosu (2001) said that boys are not higher than girls in terms of academic achievement in his study of sex difference and students' achievement at the primary school level. The finding is however in disagreement with that of Usman (2000) and James (2000) who pointed out that male students are academically superior to their female counterparts in science. Also, Njoku (2007) mentioned that male students were more successful than female students in science, Technical and Mathematical subjects.

Table 2 result of testing hypothesis two shows that there is significant difference in the mean academic achievement scores of chemistry students exposed to Laboratory technique and those taught with Lecture method. This is probably due to use of an activity-oriented method on the experimental group. It indicates that laboratory technique has a significant effect because when used on the experimental group, it improved their achievement better than the control group. In agreement to this, research findings of science educators like, Okebukola (2002), Tsui and Treagust (2002), revealed that those teaching strategies that are activity-based such as problem solving, discipline trip, undertaking method, guided inquiry strategy and laboratory technique amongst others which involved the learner taking active role in the teaching/learning process, result in better learning and perception of science concepts on the part of the learner.

Table 3 is based on students' interest in chemistry; the result shows that laboratory technique positively enhances interest of students in chemistry. This is due to the fact that students' active participation and teaching materials which was actually helpful to them as they saw practical lessons and facilitated their perception as well as encouraged their conceptual restructuring and interest in laboratory technique. Findings of this hypothesis is in agreement with the findings of Olorukooba (2001) which published that teaching techniques can also have an impact on the interest of students positively or negatively; he said that students taught the usage of cooperative learning strategy in science has positive attitude to the educational benefits derived from group work. This study also agreed with Okeke, (2011) who found out that, students scored highest mark in theory of practical chemistry examination, which means that if students are exposed to practical session through laboratory activities they will do better.

**Conclusion**

Laboratory learning technique was found in the study to be more helpful to teaching secondary school chemistry than the Lecture method, hence, it would be recommended for the teaching and learning of chemistry to any group of secondary school students irrespective of gender. There is a distinction in the interest of chemistry students after exposure to laboratory learning technique. This is because a significant difference was noticed in the interest of the experimental group after treatment using laboratory learning technique.

**Recommendations**

Based on the results of this study, and in view of the fact that, the teaching and learning of chemistry in secondary school system has been problematic over the years the following recommendations are made:

1) Teachers should be encouraged to undertake innovative and student-centered strategies that foster meaningful learning in science and do away with the age-long teacher-centered method that are in use now.

2) Teacher training institutions such as College of Education and Faculties of Education in Universities should review the science training curriculum to inculcate in the pre-service teachers the pedagogical expertise that will permit lively students' participation in the teaching of chemistry. These are activities in which students concentrate, experience enjoyment and are furnished with instant intrinsic satisfaction of activity for the future.

3) Government should also supply adequate equipment and materials to schools when required. Qualified chemistry teachers should be posted to schools to teach chemistry.

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