EFFECT OF SMALL SCALE EXPERIMENT (SSE) ON SECONDARY SCHOOL STUDENTS' ACHIEVEMENT AND RETENTION IN CHEMISTRY IN AWKA EDUCATIONAL ZONE

BY

GIFT-OHAKWE, JUDITH CHIOMA

PG/MED/SD/10/57447

DEPARTMENT OF SCIENCE EDUCATION
FACULTY OF EDUCATION
UNIVERSITY OF NIGERIA, NSUKKA

AUGUST, 2018

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A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF SCIENCE EDUCATION, FACULTY OF EDUCATION UNIVERSITY OF NIGERIA, NSUKKA

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTERS DEGREE IN EDUCATION (M.ED), SCIENCE EDUCATION-CHEMISTRY

SUPERVISOR: PROF. U.M. NZEWI

AUGUST, 2018

CERTIFICATION

Gift- Ohakwe, Judith Chioma a post-graduate student of the Department of Science Education with registration number: PG/M.ED/SD/10/57447 has satisfactorily completed the requirements for award of Masters Degree in Education (M.ED). The work embodied in this project is original and has not been submitted in part or full to any other degree of this or any other University.

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Gift- Ohakwe, Judith Chioma — Prof. U.M. Nzewi

REG NO:PG/M.ED/SD/10/57447 — Supervisor

APPROVAL PAGE

This project has been approved for the Department of Science Education, University of Nigeria, Nsukka.

By

_____	_____
Prof. U.M. Nzewi	External Examiner
Supervisor	
_____	_____
Internal Examiner	Prof. J.C Adigwe
	Head of Department

_____

Prof. D.U. Ngwoke

Dean of Faculty

DEDICATION

This research is dedicated to God, the Father of my Lord Jesus Christ and to my parents Late Mr. & Mrs. G.L. Ofoji who inspired me to cherish Education

ACKNOWLEDGEMENTS

My Immense gratitude goes to God Almighty, the author and finisher of my life, the beginning and the end, the one who opens a door and nobody will be able to close it, for His infinite mercies and protection throughout the course of this programme. My profound gratitude also goes to my supervisor, Prof. U.M. Nzewi for her wonderful and untiring guidance, careful and thorough supervision of this work. In fact, she is a perfect representation of an ideal mother. My thanks go to Dr. Queen Ibenegbu for her persistent encouragement, you are a friend indeed. My Lecturers in Science Education Department University of Nigeria Nsukka, like Profs. D.N. Eze, A. Nwosu, B.G. Nworgu, Z.C. Njoku, L.N. Nworgu, C.R Nwagbo and Dr. F. Ezeudu, may God continue to enlarge your coast for assisting me well academically. Also my thanks go to all the academic and non-academic staff of the department for their support.

My special thanks and appreciation go to my lovely husband Ven. Gift .C. Ohakwe for his care, encouragement and support in every ramification. Finally, I sincerely thank my children, Goodchild, Precious and Munachimso for their understanding in all these years and my friends and course mates, Ven. Ab C. Okorie, Bro. Charles and family, Jane Nwolise, Nonye Obi, Ejike, Tessy, Pat, Ngozi and Chinyere for their prayers and moral support towards the completion of this study. May our good Lord bless you.

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ABSTRACT

This study investigated the effect of Small Scale Experiments (SSE) on Secondary School Students' Achievement and Retention in Chemistry in Awka Educational Zone. The design of the study was quasi- experimental, specifically the Pre-test, Post-test, Non-equivalent Control Group Design. A sample of one hundred and forty nine Senior Secondary School one (SSS1) Chemistry students located in three co-educational schools in Awka Zone of Anambra State were used for the study. To guide the study, four research questions were posed and four hypotheses were formulated and tested at 0.05% probability level. An Instrument known as Chemistry Achievement Test (CAT) was used for data collection. The CAT has a reliability index of 0.81 using Kuder- Richardson 20 (K-R_{20}). Two groups of students were used for this study; they are experimental and control groups. The experimental group was taught using Small Scale Experiment approach while the control group was taught using the conventional demonstration method. The treatment lasted for six weeks. The instrument was reshuffled and re-administered to the students after two weeks to test for retention. The data collected were analyzed using mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05% level of significance. The results of the study revealed that Small Scale Experiment (SSE) approach was superior to conventional demonstration method in facilitating student's achievement and retention in chemistry. There was no significant difference in the mean scores of male and female students in chemistry after the treatment, although male students performed slightly better than their female counterparts. In line with the findings of the study, the Educational Implications of the findings were highlighted and some recommendations were equally proffered which include that science teachers, science educators and textbook writers should adopt SSE when teaching or writing of textbooks to enhance student's achievement and retention.

CHAPTER ONE

INTRODUCTION

Background of the Study

Science is an ordered arrangement of ascertained knowledge, including the method by which such knowledge is extended and the criteria by which its truth is tested. Science plays a significant role in the economic development of a nation. It is also important in National development because knowledge of science has helped human development in the area of health, communication, transportation, industrialization, food production, education, synthesis and research. Chemistry as one of the core science subjects according to International Council of Chemical Association (ICCA) (2000) has been found very useful in all areas of life from food and clothing, housing, communication and transport to other problems in the energy sector, information technologies, industries and waste disposal. This underscores the reasons for emphasizing the promotion of Science as the means for achieving technological development in many countries. Striving for development in science and technology becomes imperative as it serves as a driving wheel for economic empowerment of the countries. Therefore, for a country to be economically viable, it must strengthen its science and technology programmes in content as well as in teaching and learning at secondary schools level (Gero, 2011).

Chemistry is a science based systematic study of the composition, properties and reactivities of matter at atomic and molecular levels. Chemistry is a branch of science that deals with the study of nature of matter and probes into the principles governing the changes in matter (Ababio, 2010). Chemistry is a subject whose practical, intellectual and aesthetic value is becoming more highly priced daily in every industrial sector that contributes to national

development. Study has shown that most developing countries of the world show about 80 percent dependency upon chemistry and its products to achieve and maintain an expected level of development (Okorie, 2010). This can be seen when the place of petrochemicals and allied industries in the world and in Nigerian economies are considered (Umeoduagu, 2000). Research evidences have proved that chemistry contributes to quality of life and nation building; it has helped to produce many technologies (Okorie, 2010).

Chemistry is one of the science subjects taught at secondary schools in Nigeria. Its inclusion in the school curriculum is predicated by the emphasis placed in the teaching of science subjects as instrument per excellence for nation building. Chemistry and indeed chemists are linked to everything on earth as aptly captured in a slogan: What on earth is not chemistry? Chemistry plays a pivotal role at engineering sustainable economic development and growth of any nation (Adesoji, 2006). The importance of chemistry in the development of any nation cannot be underrated, especially in Nigeria where the national income rests on petroleum and Ola, Dayo, Gbenya and Akaoni (2010) accepting that any nation aspiring to be scientifically and technologically developed must have adequate level of chemistry education. Chemistry is a pre-requisite for a number of careers in the tertiary institution and this call for the need in teaching it effectively (Okorie, 2010). Chemistry as a discipline explains the composition of drugs, paints, blood, fertilizers, crude oil and most engineering materials (Ababio, 2010). Chemistry is taught in secondary school in Nigeria and is guided by some objectives.

The objectives of teaching chemistry according to the Nigerian Educational Research and Development (NERDC, 2007) at the senior Secondary level includes enabling students to: develop interest in the subject of chemistry; acquire basic theoretical and practical knowledge and skills; develop interest in Science, Technology and Mathematics (STM), acquire basic STM

sknowledge and skills; develop reasonable level of competence in information computer technology applications that will engender entrepreneurial skills, apply skills to meet societal needs of creating employment and wealth, be positioned to take advantage of the numerous career opportunities offered by chemistry. Also, to be adequately prepared for further studies in chemistry, provide students with basic knowledge in chemical concepts and principles through efficient selection of content and sequencing, facilitate a smooth transition in the use of scientific concepts and techniques acquired in the new Basic Science and Technology curriculum with chemistry, provide a course which is complete for students not proceeding to higher education while at the same time provide a reasonable adequate foundation for a post-secondary school chemistry above, show chemistry and its links with industry, everyday life activities and hazards show chemistry and its inter-relationship with other subjects.

Chemistry is one of the basic sciences which are essentially the pre-requisites for technological breakthrough. Hence the need for effective chemistry instruction in secondary schools is to ensure adequate understanding of chemistry concepts by students through practical exercises. It is typically an experimental science and relies primarily on practical work because it studies the composition, structure and properties of material substances, of the interaction between them and of the effects on them, of the addition or removal of energy in any of its several. Material substances studied in chemistry are made to interact during practical or experimental work to bring out their properties. Practical chemistry is the experimental method of teaching chemistry and it is always conducted with chemicals and equipment. Practical chemistry helps to consolidate conceptual understanding of chemistry as a subject. According to Mbajiorgu and Reid (2004), Laboratory work in Chemistry is used for problem solving and development of concepts. Practical science lessons help students to investigate problems and

internalize scientific methods and the ability to manipulate apparatus. Therefore, Acids, bases and separation of mixtures are aspects of chemistry studies in senior secondary school one (SSI) will be studied in this work. The rationale for the use of this unit is that it has been found to be one of the areas of difficulties for secondary school students and its practical oriented involving the use of chemicals. All these activities accruable from practical in these units could help to boost understanding of chemistry, thereby enhancing students' achievement in the subject.

Achievement is the scholastic standing of a student at a given moment. It has to do with the successful accomplishment of goal(s). The purpose of testing an achievement is to help the teacher and the students evaluate and estimate the degree of success attained in learning a given concept (Adeyemi, 2008). It is also useful in testing the retention of information and skill. It is equally appropriate in determining the efficiency of instruction.

One of the issues at stake in education today is students' achievement measure in relation to teaching and the overall success of learning outcome. The achievement of the objectives of chemistry curriculum at the senior secondary school may not be feasible without the use of appropriate teaching method. Evidence shows that there is poor achievement in chemistry (Njoku, 2009; Okoli, 2006, Tagbo, 2015 and Okoroafor, 2016). These researchers reported that poor teaching methods adopted by chemistry teachers during instruction are one of the main causes of student's failure and poor achievement in chemistry. The researchers noted that efforts by teachers to improve students' learning seem not to yield encouraging result as students have continued to show weakness in the knowledge of chemical concepts and principles, which are the basic ingredients of science. In addition, data of West African Examination Council (WAEC) 2011-2015, showed that students overall achievement in chemistry is very poor.

This poor achievement exists in both teacher-made chemistry examinations and public senior secondary school examinations. WAEC (2011-2015) reported that the percentages of students that passed chemistry at credit level and above in the senior secondary certificate 2011, 2012, 2013, 2014 and 2015 were 50.94%, 44.90%, 45.96%, 44.44% and 43.69% respectively. The 2014, chief examiners' reports unveiled lapses exhibited by students in WAEC examinations most of which stem from inadequate practical experiences. The lapses are as follows: failure to adhere to instructions; poor understanding of the demands of the questions, poor practical exposure and giving theoretical answer to practical questions; inadequate use of terminologies especially in qualitative analysis and muddling up of test and introducing of chemicals reagents not mentioned in the prescribed tests. Also the report showed that students have problem of inability to record observations correctly and give logical inferences to the observations made. With the observed lapses, the objectives of secondary school chemistry may not be achieved and they are pointer to students' inadequate practical experiences before external examination. Students' exhibition of the listed lapse means that they were poorly taught. Most of the lapses stem from lack of exposure to adequate and required practical experiences, which could affect students retention of chemistry concept taught.

Retention is the ability to recall facts and figures in memory. It is an individual's ability to remember and recall information, materials and experiences learned over time. The acquired materials in the mind need to be preserved in form of images for knowledge to develop. When a stimulating situation occurs, retained images are revived or reproduced to make memorization possible (Okeke, 2008). Chemistry concepts therefore, need to be presented to the learners in a way or method that touches their sub consciousness, which can trigger quick recalling of the concept being taught or learnt. Okorie also stated that teachers could improve retention of

concepts and information by explicitly creating memorable events involving visual or auditory images with projects, plays, simulations, experimentation and other forms of active learning, to boost student's retention of the concept. Okeke (2008) further stated that whatever students have retained for about 12 to 24 weeks after instruction, they might retain forever. In addition, the more time that passes after learning, the less information will be remembered. This form of forgetting is often referred to as "time decay" (Woolfolk, 1998). For instance, neural connections, like muscles grow weak without use. Okoye (2012) refers to retention as the process of maintaining the availability of new meanings or some part of them. It may be suggested that the amount of the original meaning that will be retained at any given point in time is a variable quantity. Forgetting represents a decrement in the availability of an acquired meaning, which describes the loss in availability that occurs between the original establishment of the meaning and its later reproduction. Considering the two terms, retention is seen as a positive aspect of memory while forgetting is seen as the negative aspect. Frequent reviews and tests, elaborated feedback and active involvement of students in learning projects have been associated with longer retention. Okoye (2012) further stated that active participation during instruction increases learning and retention. To validate this statement, this study aims to find out how Small Scale Experiment (SSE) could enhance chemistry student retention of knowledge.

Since adequate furnished laboratories remain a dream in many secondary schools, it becomes imperative that alternative ways of meeting the needs of practical work must be embarked upon. One of such ways or solution could be a cost reducing strategy. Cost reducing strategy could be any of the following: Small scale experiment, improvisation, Precautionary measures in application of expendable, possible recycling of chemicals and demonstration. All these are geared towards reducing the amount of money that would have been needed for

materials for conducting practical chemistry. Of all these the study will focus on small scale experiment. The practical aspect of chemistry helps to remove misconceptions, confusion and fear from learners. More often than not, this importance or salient part of teaching chemistry is skipped either, because the practical teaching materials are not available or are insufficient. In theory, practical work is an established part of university-level chemistry courses. However, mainly due to budget constraints, large class size, time constraints and inadequate teacher preparations, practical activities are frequently left out from chemistry classroom instruction in most developing countries. Small-scale chemistry (SSC) experimentation in which one uses miniature chemical equipment can drastically reduce quantities of chemicals used during experimentation, which can help overcome some of the barriers preventing experimental work in the chemistry classroom.

Experiments are the backbone of chemistry teaching and learning. Experimental works both in the classroom and in outdoors are an essential component of effective chemistry instruction, which could enhance student's experience, understanding, skills and enjoyment of science. According to Dike (2009), practical work makes instruction something that learners participate in, rather than what they are subject to do. The researcher further stated that practical work supports aspirations towards further study and acquisition of prerequisite skills for survival. According to Ali (2008), practical activity is the various technical work components systematically carried out with the ultimate intention of creating a product or explaining scientific phenomena. Nzewi (2008) opined that practical activities can be regarded as a strategy that could be adopted to make the task of a teacher (teaching) more real to the students as opposed to abstract or theoretical presentation of facts, principles and concepts of subject matter. Nzewi maintained that practical activities should be encouraged to get the students in hands-on,

mind-on activities using varieties of instructional materials and equipment to drive home the lesson.

Experiments in chemistry demand various chemicals and equipment and some of the laboratory equipment and chemicals are often inadequate in schools. Asiyai (2006) stated that schools in developing countries, of which Nigeria is one, often lack basic facilities, which are indispensable for effective teaching, learning and retention of chemistry concepts. Chemistry laboratories demand huge sum of money to get them well equipped. Neither the money required for equipping the laboratories nor chemicals and equipment are made adequately available to schools. Under the condition of insufficiency of laboratory materials, it is not easy to effectively teach and learn chemistry. Based on the importance of science to the fast growing of a nation, science (chemistry) should be taught in a manner and approach that will enable the students to grasp the huge importance of the subject and enhance students achievement in the subject.

While experimental activities are considered essential in chemistry teaching, it is also associated with a number of burdens including high cost of equipment and chemicals, chemical hazard risk, and environmental pollution (Ameh and Dantani, 2012). Furthermore, practical work requires more time and the presence of qualified and experienced teachers and technical assistants (Daluba, 2013). As a result, it is frequently missed from the real curriculum in schools around the world, especially where resources are scarce. Though no extensive studies have been conducted on the situation of secondary science teaching in Nigeria, the few available studies have demonstrated the lack of hands-on practical activities in schools (Jodi, 2010). Lawal, (2009), for example, reported that, for a number of reasons, secondary school students in Nigeria were not getting science hands-on experiences as specified in the curriculum. Similar findings Muhammad (2014) had been reported in a study conducted to assess the overall quality of

secondary science teaching in North Nigeria, amongst the reasons mentioned are: absence of laboratory room, lack of equipment and chemicals, shortage of time, large workload, absence of laboratory technical assistants, fear of chemical hazards, teachers feeling inadequately prepared, lack of laboratory manuals, lack of basic facilities such as water or electricity, and large class size. Some of these challenges associated with chemistry practical work may be overcome through the use of a Small-Scale/Micro Scale Chemistry Experimentation approach.

Small-Scale Experiment (SSE) is chemistry practical carried out on a reduced scale using small quantities of chemicals and often, but not always, simple equipment with a shift from glassware to plastic materials. Singh, Szafran, and Pike (1999) reckon that at the lower end of the scale, solids and liquids of 25–100 milligrams and 100–200 micro liters respectively may be used without compromising the quality and standard of the chemical applications in education and industry. The terms micro scale and small-scale are often used interchangeably and refer to a similar scale of chemistry (Zakaria, Latip and Tantayanon, 2012). Small-scale experimental techniques are a fairly recent innovation in school chemistry, but most students take readily to them when they are exposed to them. Manipulative skills are important and students need to be capable of careful manipulation to carry this out successfully. The small-scale experiment minimizes apparatus and chemical requirements and takes less time to perform than the experiments on the usual scales. Although the solutions used do present minor hazards, the use of such small quantities reduces risks from those hazards to very low levels (Zakaria, Latip and Tantayanon, 2012). The technique also makes the point that quantitative chemical experimentation does not always have to be performed on the traditional “bucket scale” at school level.

An example of small-scale Experiment (SSE) is reducing the concentrations and volumes of chemicals or grams of solid laboratory materials required for volumetric analysis and yet getting the same result as though the conventional quantities of the materials were used. In volumetric or quantitative analysis (acid base titration), practical lesson is conventionally done with pipette of 20 or 25cm^3 for base and burette of 50cm^3 for acid, but in SSE, to reduce cost, syringes or micro burette and pipette of 5 to 10cm^3 could be used for both acid and base and a drop of an indicator will be used instead of the normal two-drops. The small quantity of chemical used in SSE affords every student the opportunity to practice and get exposed to the properties of expendables used and some skills which are useful in conducting the actual conventional practical lessons. Mafumiko (2006) viewed small-scale experiments as one of the cost-reducing strategy used in teaching chemistry. One advantage of this experiment is that cost is actually reduced but the result of the experiment remains unchanged.

The benefits of implementing Small Scale Experimentation in chemistry teaching have been reported by many researchers (Ciardullo, 2000, Mattson, 2005, Tantayanon, 2010, Orna, 2010 and Poppe, Markic & Eilks, 2011). Some of the mentioned benefits include: saves money and time, increases safety, is easy to use and environment friendly, instills ethics of resource conservation, enhances students' understanding of scientific concepts, maintains students' interest towards the subject, uniquely engage students in hands-on learning experiences, and experiments are perceived by students as easy and fun. Mattson (2005) argues that the SSE approach can help address many of the challenges that teachers face when planning practical work including shortage of equipment and chemicals, lack of laboratory space, lack of laboratory assistants, shortage of time, and lack of confidence by teachers. It can also be argued that the problem has been worsened by the recently observed fast- growing student population in the

sciences not being matched with resources. Most of the teachers have resorted to teaching chemistry practical using demonstration method. Some of the challenges associated with chemistry practical work may be overcome through the use of a small-scale/micro scale chemistry experimentation approach.

Experiments which involve heating, the use of organic solvents or concentrated acids are unsuitable for the approach in which most of the equipment is made of plastic materials (Kelkar and Dhavale, 2000). Nowadays, there are alternatives in which some glass equipment are alternative to practical which comes in form of demonstration of the actual experiment by the instructor to the learners, hence this study seeks to investigate the effect of SSE and demonstration method on students' achievement in chemistry.

Demonstration method is one where the student observes the portrayal of a procedure, technique, or operation involved in carrying out a practical without actually being involved in the practical. The demonstration method shows how to do something or how something works. Demonstration involves showing by reason or proof, explaining or making clear by use of examples of experiments. It is also a means to clearly show students what a concept of phenomena looks like. Demonstration method refers to the type of teaching method in which the teacher is the principal actor while the learners watch with the intention to act later. Here the teacher does whatever the learners are expected to do at the end of the lesson by showing them how to do it and explaining the step-by-step process to them (Ameh, Daniel and Akus, 2007). Mundi (2006) described demonstration as a display or an exhibition usually done by the teacher while the students watch with keen interest.

Demonstration involves showing how something works or the steps involved in the process. Some of the advantages of this method as outlined by Mundi (2006) includes having the

ability to facilitate material economy; attention inducer and a powerful motivator in lesson delivery and can help to motivate students when carried out by skilled teachers and it is good in showing the appropriate ways of doing things. As a teaching technique, a demonstration is a valuable alternative to getting students to 'learn by doing'. Teacher demonstrations can introduce students to specialized equipment and materials and show them how they are used. At the same time, they can draw students' attention to the psychomotor skills needed to undertake delicate tasks such as an experiment or a dissection. Since demonstration method is an alternative to practical, which involves the teacher carrying out the practical activities while the students observe, it could have the potentials of enhancing student's achievement in chemistry because they have seen the processes involved in carrying out the chemistry practical. The above assertion about practical activities showed that it could be a good method of inculcating skills and enhancing students' achievement and the use of SSE and demonstration method could streamline gender differences in students' achievement in chemistry.

Gender is a set of characteristics distinguishing between male and female, particularly in the cases of men and women (Orji, 2012). According to Orji, depending on the context, the discriminating characteristics vary from sex to social role to gender identity. It is a sociological concept that ascribed a certain roles to male and female. An issue of contention in Nigeria education system today is the issue of gender. Gender roles may be hard to change but as they are sociological label, they are subject to change. Although they are internalized very early in life, they vary across, social, political, educational and economic dimensions. Considering the analytic and tasking nature of science, females are socialized early in life to believe that science, technology and mathematics (STM) are meant for males (Longe and Adedeji, 2013).

Educators like Okorie, 2010, Orji, 2012, Longe and Adedeji, 2013 & Ezeudu and Obi (2013) have expressed diverse views about gender and achievement especially in chemistry. While some are of the view that male students do better than female students, others disagree with this view, arguing that achievement is a factor dependent on several factors such as socio – economic background, teaching method among others (Ameh and Dantani, 2012). If education as viewed by Jegede (2010) should be seen as the right of every child everywhere, every girl therefore should be given the opportunity of transforming her life and that of her community. Measures to encourage women to embrace science, technology and mathematics are as many as the opinions of education differ. In Nigeria gender bias is still prevalent; it has persisted even within the science classroom. Lawal (2009) stated that gender issue is an important factor in educational setting and could be a militating factor to high achievement of learners in sciences. When academic achievement of boys and girls in science subjects are compared however, some showed no significant difference (Muhammad, 2014).

Unfortunately, the findings seem to be inconclusive. The influence of gender on students' achievement has been a concern to many educational researchers. Nevertheless, no consistent result has been obtained. For instance, Nbina and Avwiri (2014) reported that gender has no effect on students' achievement in chemistry. Similarly, Oloyede (2010) also asserted that emerging data on differences in gender and students achievement in chemistry indicated that students did not exhibit any gender difference in achievement and retention in chemistry. Eriba and Sesugh (2006) stated that the difference between the mean scores for boys and girls was not statistically significant in chemistry achievement. Okorie (2010) revealed that there is no significant difference in achievement of male and female students in chemistry while Ukozor and Uzomah (2010), found out that gender is a significant factor in achievement in favor of males.

From the above studies, it could be deduced that the influence of gender on students' achievement has attracted attention of educational researchers in the past years. It is also noteworthy that these various researchers have come up with different findings.

Also, in many Nigerian schools, female students are presumed to evade the study of chemistry due to several factors like psychological, motivation and interest (Fatokun, Egya and Uzoechi, 2016). Women Scientists are very few in Nigeria though the National Population Census clearly showed that the population of females' out- numbered that of males. The issue of how male or female students learn and retain chemical concepts is a concern. Therefore, teaching method that would benefit both genders needs to be adopted by the chemistry teachers. Therefore, the present study seeks to find out if the use of SSE will enhance students' achievement in chemistry.

Statement of the Problem

Chemistry is a practical oriented subject that occupies a prominent place in school science curriculum. It is an experimental science that needs a high level of practical work for its understanding, development and application. Its practical activities do not only enhance performance but acquaint students with science process skills which are the intellectual skills needed to practice and understand science and which also aids creativity development among learners. This can only be achieved if appropriate teaching strategies are employed.

Unfortunately, it has been observed that students' performance in practical chemistry in Nigeria has been very poor despite all the efforts made to help them achieve high in the subject. In addition to the poor achievement researchers submitted that students' interest in practical chemistry is equally poor. Efforts to ameliorate these problems have include improvement on the teaching strategies for the teaching of the practical activities. Researchers have reported that, for a number of reasons, secondary school students in the country were not getting science hands-on

experiences in chemistry. Some of the reasons for these include absence of laboratory room, lack of equipment and chemicals, shortage of time, large workload, absence of laboratory technical assistants, fear of chemical hazards, teachers feeling inadequately prepared, lack of laboratory manuals, lack of basic facilities such as water or electricity, and large class size. It can also be argued that the problem has been worsened by the recently observed fast- growing student population in the sciences not being matched with resources. Most of the teachers have resorted to teaching chemistry practical using demonstration method. It is envisaged that some of the challenges associated with chemistry practical work may be overcome through the use of small-scale/micro scale chemistry experimentation approach or demonstration method. Hence, the problem of this study posed as a question is, what is the effect of small scale experiment on students' achievement and retention in chemistry?

Purpose of the Study

The purpose of this study is to investigate the effect of SSE on senior secondary school student's achievement and retention in chemistry in Awka Education Zone. Specifically, the objectives of the study are to determine the;

1. effect of SSE method on students' mean achievement scores in chemistry
2. effect of SSE on students' mean retention scores in chemistry
3. influence of gender on students' mean achievement scores in Chemistry when taught with SSE
4. influence of gender on students' mean retention scores in Chemistry when taught with SSE

Significance of the Study

This study has both theoretical and practical significance. The theoretical significance of this study is anchored on J. S. Bruner's Cognitive theory of 1966. Bruner's major concern has been to determine how people actively select, retain and transform information, which is the main essence of learning. The theory centers on learning through discovery, hence Bruner maintains that the learner should obtain knowledge through the use of materials and the learner's mental processes. Bruner (1966) states that a theory of instruction should address four major aspects: (1) predisposition towards learning, (2) the ways in which a body of knowledge can be structured so that it can be most readily grasped by the learner, (3) the most effective sequences in which to present material and (4) the nature and pacing of rewards and punishments. Good methods for structuring knowledge should result in simplifying, generating new propositions, and increasing the manipulation of information. Furthermore, Bruner's ideas about learning can be related to the need for practical application of knowledge since the present study requires carrying out practical work in chemistry using Small Scale Experiment. Hence the findings of this study help to validate the Bruner's theory of cognitive development.

Practically, the findings of this study will be beneficial to the following: teachers, parents, students, curriculum planners, policy makers and researchers .The findings of this study will help chemistry teachers to address the problem not carrying out adequate practical activities in chemistry due to shortage of resources, when the teachers apply this approach in teaching, it will make their chemistry lesson more effective and make the students to actively participate in the class. This study will also provide teachers with alternative method of teaching chemistry for easy understanding resulting to improvement in achievement of students. The findings of this

study will contribute to ensuring effective chemistry teaching through application of Small Scale Experiment. As SSE allows the use of small quantity of chemicals, practical lessons can go on when chemicals are in short supply. The study will serve to open new ways of responding to the challenges of teaching and learning chemistry since the strategy will incorporate principles of learning and effective teaching. If the chemistry teachers adopt the use of SSE, the scheme of work will be covered on time and the excess work load usually experienced as external examination draws near will be reduced. In addition, teachers' effectiveness will be enhanced with the use of SSE.

The finding of this study will stimulate critical thinking amongst chemistry students. This critical thinking is what leads to problem solving thereby achieving transformation in education. Thus, chemistry students will develop positive attitude towards chemistry; and this will enhance higher achievement of students in the subject. The result of this study will also reveal the activity-oriented nature of the constructivist instructional approach, which takes every group of students along during the course of instruction, thereby helping every student to operate at a steady rate, and this in turn enhances students' academic achievement in chemistry. Because of the motivation felt by students, they may decide to choose chemistry related careers like: Medicine, Pharmacy, Industrial chemistry, nursing and so on at the tertiary level of their education.

The findings of this study will help parents to change their stereotyped behavior and stop exhibiting gender bias in families thereby encouraging gender equity in offering chemistry as a school subject. This is because when both male and female students find chemistry lessons to be engaging and fun, at the same time they will be engaging in scientific activities at home which will help to inform the parents more on the need to mainstream gender gaps at home.

Curriculum planners would utilize the information from the findings of the study in their future curriculum planning. The findings of this study may help curriculum planners to adopt SSE approaches in their future curriculum plans particularly in chemistry as an alternative to not carrying out practical activities due to lack of adequate supply of resources.

The findings of this research work will assist policy makers in developing course of study for pre-service chemistry teachers seeing that SSE is applicable when Laboratory materials are inadequate.

To other researchers, the finding of this study will help them to find basis for further studies on the best approach to teach science subjects especially chemistry. The work will serve as a stepping-stone for them to investigate on the effects of the same approach on other levels of education or other subjects.

Scope of the study

The study is on the effect of Small Scale Experiment on students' achievement and retention in chemistry. The study was carried out using SS I students in selected secondary schools in Awka Educational Zone of Anambra State. The choice of SS1 class for the study is because the topics listed below are usually taught at SS1 level in line with the provisions of the curriculum. Secondly, SS1 is a foundation class for chemistry and if the method is found effective can be used in their subsequent classes, so as to improve the students' achievement in chemistry in the final examination. The content scope of the study is delimited to Acids, bases and separation of mixtures. The rationale for the use of this unit is that it has been found to be one of the areas of difficulties for secondary school students and its practical oriented involving the use of chemicals.

Research Questions

The following research questions were posed to guide this study.

1. What are the mean achievement scores of students taught chemistry using SSE and those taught using demonstration method?
2. What are the mean retention scores of students taught chemistry using SSE and those taught using demonstration method?
3. What is the influence of gender on students' mean achievement score in chemistry when taught with SSE?
4. What is the influence of gender on students' mean retention score in chemistry when taught with SSE?

Hypotheses

The following null hypotheses were formulated to guide the study and were tested at 0.05 level of significance.

HO_1: There is no significant difference in the mean achievements scores of students taught chemistry using SSE and those taught using DM.

HO_2: There is no significant difference in the mean achievement score of male and female students in chemistry when taught with SSE

HO_3: There is no significant difference in the mean retention scores of students taught chemistry using SSE and those taught using DM.

HO_4: There is no significant difference in the mean retention score of male and female students in chemistry when taught with SSE.

CHAPTER TWO

REVIEW OF LITERATURE

This chapter will be concerned with the review of literature. The related literatures will be reviewed under the following sub-headings:

Conceptual Framework

Conceptual Schema

- Chemistry
- Achievement and Retention in Practical Chemistry
- Small Scale Experiment
- Demonstration

Theoretical Framework

Jerome Bruner's Cognitive Theory

Vygostsky' Social Learning Theory

Related Empirical Studies

- Studies on Small Scale Experiment
- Studies on Demonstration
- Studies on Gender
- Studies on students' Achievement and Retention in Chemistry

Summary of Literature Review

Conceptual Framework

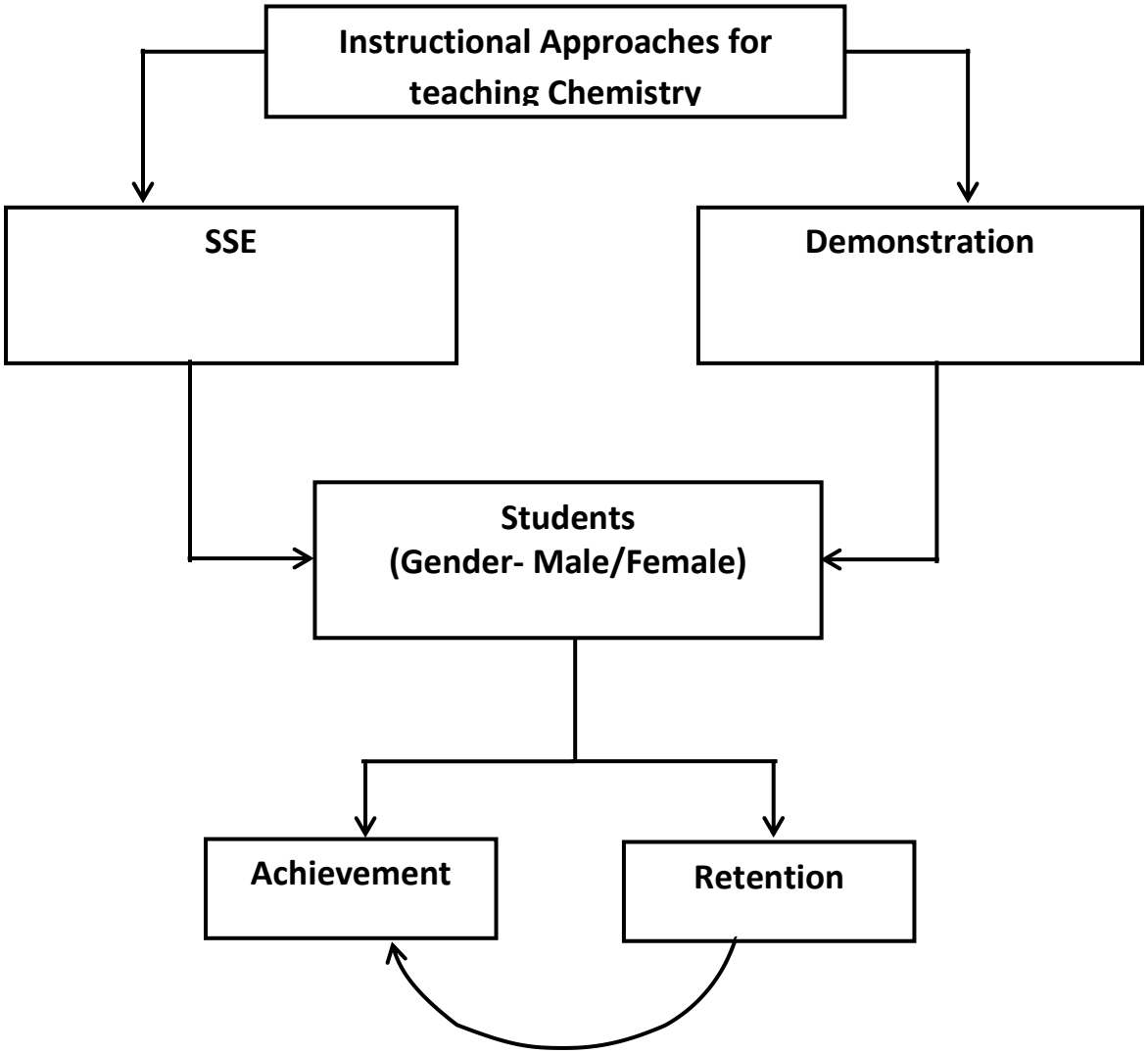

Fig.1 Conceptual Schema

This represents the relationships between the variable in the study. From the schema, is seen that when chemistry students are exposed to chemistry practical using SSE or Demonstration approach to teaching, either of the approaches could help to enhance students' achievement and retention in chemistry irrespective of their gender.

CHEMISTRY

Chemistry is a branch of science that deals with the study of matter especially, the composition, properties and uses of matter. Chemistry involves the making of various substances, finding out their properties and how they react with one another, determining patterns in their knowledge and attempting to comprehend properties and phenomena with regards to atoms and molecules and their electronic structures and using their knowledge and understanding to make predictions Ababio (2010). Okeke and Ezekannagba (2000) defined chemistry as a branch of science that deals with compositions and changes of matter. Chemistry has continued to play an increasingly important role in the lives of all humanity. It has helped to produce many technologies from lifesaving pharmaceuticals to computers and other information technologies.

Chemistry is a practical oriented subject that occupies a prominent place in school science curriculum. It is an experimental science that needs a high level of practical work for its understanding, development and application (Ugwu 2007). Its practical activities do not only enhance performance but acquaint students with science process skills which are the intellectual skills needed to practice and understand science and which also aids creativity development among learners. This can only be achieved if appropriate teaching strategies with corresponding assessment technique and instruments are employed.

The role of chemistry in our daily and national life as well as in the industry is undaunted. Many of our day-today activities revolve around chemistry. Chemistry is everywhere; chemistry is life; chemistry is the oracle and crown prince of modern science (Oloyede, 2010; Opara and Waswa, 2013). Despite the key role of chemistry as the central science that forms the basic foundation to many disciplines and in improving the quality of life, the performance of Nigeria

secondary students in the subject has for many years remained a matter of a serious concern (Jegede, 2010; Oloyede, 2010). Chemistry is one of the core science subjects taught in Nigerian secondary schools. It is concerned primarily with the study of the composition, structure properties, reactions and uses of substances and how they interact to yield various products that influence human and their environment. Chemistry education has been identified to be one of the major bedrocks for the transformation of our national economy and hence will be accorded adequate attention (Lawrence and Abraham, 2011). Scientists and Science educationists envisage that Chemistry and its impact on our lives will continue to grow and even at a faster rate in the 21st century. The Senior Secondary School (SSS) Chemistry curriculum is one of the several curriculums designed, to ensure that the aims and objectives at the Federal Government as set out in the National Policy of Education (NPE) (2013) are realized.

Consequently, a number of secondary school chemistry curricula have emerged since the turn of the 21st Century, because of reforms that gave rise to them. The main aim of the 21st Century Secondary Schools Chemistry curricula as expressed on all that curricula is to provide Chemistry-related learning experiences in order for students to develop scientific literacy. Scientific literacy is the skills, attitudes and habits of mind needed to live and participate actively in our rapidly changing science-based world. It is also the aim of the curricula to prepare students for further studies or careers in fields related to Chemistry and to become lifeline learners in science and technology (Okorie, 2011).

A critical examination of the various secondary Chemistry curricula that have emerged for the study of the subject in the 21st Century, showed a common rationale for the reforms that gave rise to these new curricula for example in Nigeria. The Nigerian Educational Research and Development Council (NERDC) Senior Secondary School Curriculum (Chemistry) (NERDC,

2007), states that following Nigeria's endorsement of international protocols for Education for All (EFA) and Millennium Development Goals (MDG), and subject subsequent adoption of a National Economic Empowerment and Development Strategies (NEEDS), it became imperative to update existing Chemistry curriculum to cater for contemporary needs of the nation as a country aspiring to be among the first 20 (twenty) economies in the world by the year 2020.

The defined objectives of the Senior Secondary School (SSS) Chemistry Curriculum Federal Ministry of Education (2007) include to:

- develop interest in chemistry
- acquire basic theoretical and practical knowledge and skills;
- develop reasonable level of competence in ICT application that will engender entrepreneurial skills;
- develop interest in Science (chemistry) Technology and Mathematics(STM)
- facilitate a transition in the use of scientific concepts and techniques in integrated science course
- provide a course which is complete for students not proceeding to higher education while it is at the same time a reasonably adequate foundation for a post-secondary chemistry course
- provide students with basic knowledge of chemical concepts and principles through efficient selection
- provide stimulus for adequate and effective experimental work as an essential component of the course;
- show chemistry and its links with industry, everyday life activities and hazards

- show chemistry and its inter-relationship with other subjects

The inclination of this policy in favour of practical and activity oriented experience was underscored by the recommendation that the problem solving teaching method should be adapted in teaching chemistry with the students learning by doing Emphasis was placed on adequate facilities and the need to draw the attention of the students to examples and experiences in our local environment.

Hence, the intention of chemistry curriculum in Nigeria is that chemistry be presented as experimental experiences for the secondary school students. Nevertheless, research evidence has consistently established that lecture method was mostly used for teaching chemistry; instead of problem-solving teaching strategies. Thus, lecture method encourages rote learning and rote memorization of concepts (Adesoji, 2008 and Ezeano, 2008). In addition, in some schools, practical are delayed in the last month before West African Senior School Certificate examination. It is clear that from the forgoing, what is obtained in the classroom is instructional process are teacher dominated textbook bound and examination-oriented. For example in Hong Kong, the Curriculum Development Council (CDC) and Hong Kong Examinations and Assessment Authority (HKEAA) prepared the chemistry Curriculum and Assessment Guide (Secondary 4-6) which was recommended for use in schools by the Education and manpower Bureau. The document stated the rationale for the new secondary school Chemistry curriculum is as follows: that the study of Chemistry should be exciting, relevant; and suggested that the learning of chemistry be situated in real life contexts.

The adoption of a range of such contexts together with a range of learning and teaching strategies are intended to appeal to students of all abilities and aspiration and to stimulate interest and motivation for learning. Students are expected to be able to apply their knowledge of

chemistry, to appreciate the relationship between chemistry and other disciplines, to be aware of the science-technology–society-environment (STSE) connections within contemporary issues and to become responsible citizen. (Hong kong Special Administrative Region Government (HKSARG, 2007:3). In United Kingdom Chemistry teaching is much more experimentally based, heuristic and student-centered. Okorie (2011: 27) stated that Secondary Schools Chemistry Curriculum reform in the 21st Century for Nigerian Education should consider the following:

- Method of presentation and delivery of individual concepts in chemistry must change in our classrooms and laboratory: the old way of teaching must give way to new methods in which new technologies and new devices are employed to assist students in learning. The use of computer based classroom projection tools, the Internet, and computer software, which implies a move into an effective means of teaching.
- Our educational system should embark on massive training and retraining of teachers of chemistry at all levels. Our teachers must be proficient in the use of modern techniques in teaching and research.
- The Chemistry education at the Secondary school system in Nigeria should place premium and emphasis in information communications technology (ICT), acquisition of relevant knowledge and skills and more importantly the application of these in making life more meaningful.
- Chemistry textbooks for use in the 21st century in the Nigerian Secondary educational system should reflect the dynamic changing curricula will offer new ideas about how chemistry teachers should teach individual chemical concepts and these new ideas must be accepted as done in the rest of the world

- The senior secondary schools chemistry laboratories should be equipped with the right equipment and stocked with the required chemicals, to meet international standard.
- The senior secondary school chemistry courses should be more activity-oriented experimental and problem solving approach should be approved in teaching of chemical concepts. Laboratory activities reinforce learning of chemical concepts and promotes skills development in scientific investigation and communication, thereby leading to high achievement and attitude of students towards chemistry (Okorie, 2011)

Students' Achievement and Retention in Practical Chemistry

Chemistry is one of the important science subjects taught in our secondary and tertiary institutions. The subject, chemistry is taught both theoretically and practically. The practical aspect of chemistry helps to remove misconceptions, confusion and fear from learners. More often than not, this importance or salient part of teaching chemistry is skipped either, because the practical teaching materials are not available or are insufficient (Oloyede, 2010). It is a known fact that lack of practical experience always contribute to students' poor achievement in chemistry. Chemistry practical involves the manipulation of chemicals and equipment (laboratory materials), helps 'students to internalize science process skills and enhances their achievement of chemistry knowledge/concepts (Nbina and Avwiri, 2014). Chemistry teaching cannot be done effectively if practical chemistry lessons are not involved. This is because the practical chemistry lessons expose the learners to the realities of concepts they learnt theoretically. The students on their own practice with laboratory materials and then clear some misconceptions and confusions, which they might have acquired during theory lessons. Practical chemistry lessons help to make the teaching and learning of chemistry effective and consequently enhance achievement and transfer of learning to other related tasks. Practical

chemistry lesson involves sense organs of touch, smell, sight and others and so make deep impressions on the learners.

Unfortunately, it has been observed that students' performance in practical chemistry in Nigeria has been very poor despite all the efforts to help them achieve high in the subject (Udochukwu, 2008; Oloyede, 2010; Oludipe and Awokoya, 2010 and Nbina andAvwiri, 2014). Efforts to ameliorate these problems have been on improvement on the teaching strategies and resources for the teaching of the practical activities. It becomes worthwhile to explore the effects of practical activity instructional method on students' achievement in practical chemistry. Academic achievement can be enhanced by formation of clear concept and use of the principle of learning by doing (practical). Formation of clear concept entails the application of more than one sense organ in a learning activity. This is directly applicable to practical chemicals lessons where sense organs (of touch, sight, smell and or hearing) are utilized in learning. Active participation of students in practical lesson as in small-scale experiments could help to improve students' academic achievement and willingness to learn. The knowledge of principles and laws learnt theoretically are concretized by practical chemistry lessons. The application of SSE, Small-scale experiment in practical chemistry could promote the learning of chemistry in general and practical chemistry in particular since it allows students to get exposed to chemistry practical as against not carrying out practical due to lack of adequate provision of instructional materials.

Small Scale Experiment in Chemistry Teaching

Experimental work is an established part of chemistry as a subject. However, mainly due to budget constraints, large class size, time constraints and inadequate teacher preparations, practical activities are frequently left out from chemistry classroom instruction in most schools.

Many secondary schools in Nigeria have some limitations in the implementation of chemistry experiments in classrooms. For example, many experiments involve high cost, inadequate equipment, toxic chemicals, and the production of chemical waste, and is time consuming (Daluba, 2013). As a result, many students graduate from secondary school with inadequate experimental experience and capability to do science. They also possess insufficient science process skills especially integrated skills. When these students enter a university, they lack confidence to carry out work in a chemistry laboratory. For this reason, small scale chemistry experiments have been developed and introduced to minimise the stated problems. This type of experiments has many advantages as identified by researchers (Abdullah, Mohamed and Ismail, 2009, Daluba, 2013 and Abdullah, Mohamed & Ismail, 2013).

Small scale experiments were introduced in chemistry laboratories to minimize the high cost and amounts of chemicals, laboratory glassware and equipment requirements, high expense for waste disposal, and time-consuming activities. These experiments were sometimes called micro-scale or mini-scale experiments (Martin and Gilbert, 2011). Although the scale of chemicals used in these experiments was minimized, the concepts of the experiments as well as necessary laboratory techniques and skills were still maintained (Martin and Gilbert, 2011). The conversion of regular to small scale experiments led to some educational benefits, such as introducing students to specific techniques that might be dangerous to be performed on a macro-scale, and reduce time for performing experiments. They are advocated in secondary school chemistry since they provide students with opportunities to perform experiments and practice techniques and skills no matter what stated constrains still exist. Therefore, small scale experiments have been gaining in popularity in many developed countries.

Small-scale experimentation (SSE) in which one uses miniature chemical/equipment can drastically reduce quantities of chemicals used during experimentation, which can help overcome some of the barriers preventing practical work in the chemistry classroom. It is an environmentally safe pollution prevention method of performing chemical processes using small quantities of chemicals without compromising the quality and standard of chemical applications in education and industry. Thus, where students formerly worked with 10-50 g of starting material and 50-500 g of solvent, they may now work with 10-150 mg of reactant and 1-10 g of solvent. By Industrial standards all school chemistry is small scale; 50ml here, 1g there, small scale experiment entails miniaturizing the quantity of chemicals required for a particular experiment. For example it means reducing the concentration and volumes of chemicals or grams of solid laboratory materials required for volumetric analysis and yet getting the same result as though the conventional quantities of the materials were used.

Working at this scale has many advantages; it reduces time, cost and waste involved and encourages students to think about environmental protection. According to Acharry and Suwannathada, 2010), small scale experiment is a contrivance whereby the adaptive and committed teacher miniaturizes the size, mass and volumes of experimental quantities without necessarily affecting the experiment procedures and results and without jeopardizing the overall learning outcomes. Small- scale experiment is an effective way of reducing cost incurred in practical chemistry. It is a means of teaching practical in times of stress such as; when materials and equipment are expensive, when the constraining budgetary allocation at times had not permitted conventional experiment, when the provision of facilities had not kept pace with the astronomical rise in students' population and small- scale experiment can be accentuated as

shown below (Abdullah, Mohamed and Ismail, 2009: 64). Below is a tabular representation of small scale experiment as against the conventional experiment.

Topic	**Conventional or Macro approach**	**Small scale experiment**
Acid- base Titration	0.5m of hydrochloric acid and 0.5m of sodium hydroxide solutions were prepared. Also conventional apparatus burette 50cm^3 and pipette 20 or 25m^3 were used in the titration	0.5m of hydrochloric acid and 0.5m of sodium hydroxide solution were prepared. Improvised burette and pipette of 10cm^3
Identification of common ions: cations and anions	The mass of the sample used was between 0.5g and 1.0g per student or between 15cm^3 and 30cm^3 of the sample solution per student	Syringes use in the titration 0.01g to 0.05g of the sample was given to each students or 1cm^3 to 3cm^3 of the sample solution. The apparatus used were miniature models of those employed.
Preparation, physical and reactions of H_2S	Use of kipp's apparatus. Only a maximum of one model was available in 53% of the sample schools 43% of the schools had no apparatus; price of Kipp's apparatus was about #1, 700,000	Discuss plastic wash bottles fitted with a cork through which a discussed coco cola straw was passed. This model was available to every student for it is cheap.
Preparation Physical and reactions of ethanol	Use of quick-fit apparatus. Only a maximum of one quick fit apparatus in 20% of all the 30 schools had the apparatus. One cost about N2, 500.00	A distribution model considerately scaled down in size and within the reach of many students to pay N30.00 to a local welder.

Fig. I: Tabular representation of small scale experiment as against the conventional experiment according to (Abdullah, Mohamed and Ismail, 2009:64).

The small-scale experiment example given above entails reduction in mass, volume, concentration and use of cheaper, improvised apparatus. The reductions save money and still help in teaching and learning of concepts under study. The quantity of materials used by a

student for experiment is scaled down and the result is that the quantity of materials used by students for a macro experiment is equivalent to the quantity used by at least ten students, for small scale experiment. In this, any volumetric analysis involving neutralization titration, effort should be made to reach the desired goal of what is intended with cost effectiveness, by scaling down the molarities (concentration in moles per dm3) of the reactants and so preserved or saved a reasonable quantity of the samples. This means that if 10 students use IM NaOH in a reaction, a total of 400g of the sample will be used. If the concentration is scaled down to 0.IM then a total of 0.40g x 10 (4g) will be used for the 10 students, meaning that 396g of NaOH is saved for future practical.

Small-Scale experiment as an aspect of CRTs (Cost Reducing Teaching strategy) saves a lot of chemical and money. So it is expedient in Nigerian secondary schools where materials for teaching and learning sciences, especially, chemistry are rarely sufficient. In view of this fact, one of the options left is for chemistry teachers to apply sufficient ingenuity that will enable them fashion replicas of the conventional materials which could still amount to saving costs. This study will employ this approach to compare its effectiveness as against the demonstration method which teachers use as an alternative to practical especially when there is inadequate provision of materials and chemicals needed for standard or conventional experiments.

Demonstration Method

Demonstration involves showing by reason or proof, explaining or making clear by use of examples or experiments. It concerns carrying out activities to educate science concepts. The activities can be carried out by the teacher alone, teacher with the students; student who is knowledgeable in the activity and a resource person while others observe. The materials and chemicals which would have been used by the observers are saved and could be used next time for practical lesson. Demonstration method is one where the student observes the portrayal of a procedure, technique, or operation involved in carrying out a practical without actually being involved in the practical. The demonstration method shows how to do something or how something works. Demonstration involves showing by reason or proof, explaining or making clear by use of examples of experiments. It is also a means to clearly show students what a concept of phenomena looks like. In teaching through demonstration, students are set up to potentially conceptualize class material more effectively. Demonstrations often occur when students have a hard time connecting theories to actual practice or in the absence of materials for practical activities to show students what a concept looks like. It is an alternative means of practical. In using demonstration, teachers not only demonstrate specific learning concepts within the classroom, they can also participate in demonstration to help improve their own teaching strategies, which may or may not be demonstrative in nature (). Demonstration, or clearly showing (a gamut that ranges from mere pointing to more sophisticated strategies such as chemical reactions), can possibly be used in portraying ideas such as defining words. At first, simple observation and communication through pointing to an object, area, or place like the sun, moon or any other object.

Demonstration method refers to the type of teaching method in which the teacher is the principal actor while the learners watch with the intention to act later. Here the teacher does whatever the learners are expected to do at the end of the lesson by showing them how to do it and explaining the step-by-step process to them (Ameh, Daniel and Akus, 2007). Mundi (2006) described demonstration as a display or an exhibition usually done by the teacher while the students watch with keen interest. It involves showing how something works or the steps involved in the process. Some of the advantages of this method as outlined by Mundi (2006) as having the ability to facilitate material economy; attention inducer and a powerful motivator in lesson delivery and can help to motivate students when carried out by skilled teachers and it is good in showing the appropriate ways of doing things. As a teaching technique, a demonstration is a valuable alternative to getting students to 'learn by doing'. Teacher demonstrations can introduce students to specialized equipment and materials and show them how they are used. At the same time, they can draw students' attention to the psychomotor skills needed to undertake delicate tasks such as an experiment or a dissection. More importantly perhaps, teacher demonstrations can provide students with opportunities to develop key scientific skills. Students can be encouraged to make predictions and announce or record their observations as they watch. Demonstrations are often accompanied by explanations. As with all explanations, asking your students questions, at the start and as you progress, can help you to assess their prior knowledge and evolving understanding, enabling you to reinforce and clarify points as necessary. Similarly, whether they are made individually or collectively, their scientific conclusions can help you identify appropriate ways of reinforcing or extending their learning.

Demonstration method of teaching is a traditional classroom method used to achieve psychomotor and cognitive objectives. In using demonstration, the objectives of the lesson are

stated. The teacher may be called demonstrator, who demonstrates the activity before the student. Students try to initiate the demonstrated activity. In using demonstration, if there is any query the teacher tries to satisfy them by further demonstration and illustrations. The second step, also known as integration, the teacher integrates all the activities and then these activates are rehearsed revised and evaluated. This teaching strategy is based on the following principles; Learning by doing maxim is followed; Skills can be developed by limitation and the perception helps in imitation. The demerit is that it does not provide all the students with hands- on activities to learn practical skills and gain experiences which may improve their achievement in chemistry. As an alternative to the use of demonstration in chemistry practical, this study seeks to find out if the use of small scale Experiment which involves carrying out chemistry practical in reduced scale using small quantities of chemicals and often, but not always, simple equipment with a shift from glassware to plastic materials. This is to investigate which of these approaches will be more efficacious in enhancing students' achievement and retention in chemistry.

Theoretical Framework

Jerome Bruner Cognitive Learning Theory

Jerome Bruner propounded discovery learning theory in (1961). Jerome Bruner theory emphasizes the importance of the discovery learning method. Bruner is credited with originating discovery learning. Bruner argues that practice in discovering for oneself teaches one to acquire information in a way that makes the information more readily viable in problem solving. One is able to do this either because his cognitive structure is largely turned to absorb new information in which case there is familiarity and the new set is simply assimilated or if the new learning is incompatible to the existing structure of knowledge, a restructuring to accommodate the new learning must take place. Bruner contends that there are two forms of discovery learning,

namely assimilation and accommodation. Bruner emphasized that teachers will deliberately build potential incongruities into learning materials, which will cause disequilibrium in the learner. As the learner tries to resolve such disequilibrium, Bruner eventually makes some discovery through the process of cognitive restructuring by either assimilating the learning material or accommodating it into his existing knowledge.

The implication of Bruner's learning theory to chemistry teaching is that Brunner specified the need for discovery learning. Teacher should in the process of instruction deliberately create problems. Bruner's theory is based on a hierarchy of intellectual skills organized to complexity that can be used to identify prerequisites necessary to facilitate learning at each level. Chemistry instruction can be made more efficient by providing a careful sequencing of material to allow learners to build upon what they already know and go beyond the information they have been given to discover the key principles by themselves.

Bruner's theory is in line with constructivist approach of science teaching because Bruner's theory deliberated here on discovery learning activity, intuition and problem solving. Constructivist approach says that all knowledge is constructed from a base of prior knowledge. The children are not blank slate and knowledge cannot be imparted without the child making sense of it according to his or her current conceptions. This theory is related to the present study because in the use of small scale experiment, students are engaged in to discovering fact by using a reduced quantity and volume of chemical. The idea in the study is to ensure that the students are given the opportunity to discover fact by themselves and students learn best when they are allowed to construct a personal understanding based on experiencing things and reflecting on those experiences.

Vygotsky's constructivist Social Learning Theory:

Lee Vygotsky propounded social constructivist theory in (1978). Social or Vygotskian learning theory reasons that social interaction plays a fundamental role in the development of cognition. Individual development derives from social interactions within which cultural meanings are shared by the group and eventually internalized by the individuals. Individuals construct knowledge in transaction with the environment, and in the process, both the individual and the environment are changed. The subject of study is dialectical relationship between the individual, social and cultural milieu.

Schools are the socio-cultural settings where teaching and learning take place and where cultural tools such as reading, writing, mathematics, chemistry, and certain modes of discourse are utilized. This approach assumes that theory and practice do not develop in a vacuum. They are shaped by dominant cultural assumptions. Formal knowledge, the subject instruction and the manner of its presentation are influenced by historical and cultural environment that generated them. Instruction can be made more efficient when learners engage in activities and receive guidance mediated by appropriate tools.

The constructivist theory of learning has important implication on the teaching-learning process in the classroom. It is common that science education focus on the scientific learning of the learner's knowledge as a holistic individual. Using the constructivist theory of learning encourages the students to reflect their own knowledge which is important in the learning process.

Constructivist theory admit that effective learning occurs when the learner is actively involved during teaching and learning process and therefore advocate for hand-on and mind-on pedagogy. Constructivists saw the learner as a king who is creative, innovative, originality and

self-directed, not a servant who takes orders without question. But the teacher is the servant, mentor, facilitator, mid-wife and a helper who stands to guide the students during teaching and learning process. According to the social constructivism approach, instructors have to adapt to the role of facilitators and not teachers. A teacher tells, a facilitator asks; a teacher lectures from the front, a facilitator supports from the back; a teacher gives answers according to a set curriculum, a facilitator provides guidelines and creates the environment for the learner to arrive at his or her own conclusions; a teacher mostly gives a monologue, a facilitator is in continuous dialogue with the learners. The important features of constructivist pedagogy are: identifying and building on knowledge schemes that learners bring to lessons; developing and restructuring those knowledge schemes through experiences with phenomena, and through exploratory talk and teacher intervention; enabling students to construct knowledge for themselves and use appropriately conventional science schemes; encouraging students to take responsibility for their own learning; helps students to develop an understanding of the nature and status of scientific knowledge itself, the claims it makes and the way these are validated which may change over time. In summarizing, social constructivism theory, remains an underlining theory behind the use of small scale experiment because the students work in a social context and interact with their classmate during knowledge construction as against the teacher demonstration which makes the students passive listeners in the classroom.

Review of Empirical Studies

Studies on Small Scale Experiment

Tesfamariam, Lykknes and Kvittingen (2015) carried out a study titles “small but doing great”: an investigation of small-scale chemistry experimentation for effective undergraduate practical

work. This study evaluated the effectiveness of using miniature chemical equipment at the undergraduate level in increasing students' understanding of chemistry concepts as well as in improving their attitude towards chemistry practical work. Two comparable groups of first-year students who enrolled for a Practical General Chemistry course participated. A quasi-experimental design was employed in which the experimental group ($N = 49$) used the SSC approach while the control group ($N = 52$) followed the traditional approach for over 8 weeks. Data were gathered using chemistry tests, attitude and perception questionnaires and interviews. Findings showed that the SSC approach was as effective as the traditional laboratory approach in improving students' attitude towards practical work, but more effective in enhancing students' understanding of chemistry concepts. More interestingly, SSC was positively accepted by both students and instructors as an effective strategy for teaching first-year undergraduate chemistry practical. Some shortcomings of the approach were also identified. This study is related to the present study because it involves the use of cost reducing chemicals which is what SSE is all about but the two studies are different in terms of the type of cost reducing experiment, level of students used for the two studies are and location where the two studies where carried were out.

Supasorn, Kamsai and Promarak (2013) carried out a study on enhancement of learning achievement of organic chemistry using inquiry-based semi-small scale experiments (SSSEs).The study aimed to investigate students' learning achievement and retention of organic chemistry by using seven inquiry-based Semi-Small Scale Experiments (SSSEs) of 21 hours duration. These experiments included: 1) functional groups, 2) hydrocarbon compounds, 3) alcohols and ethers, 4) aldehydes and ketones, 5) carboxylic acids, 6) esters, and 7) amines and amides. Fifty-one Grade 12 students at Khukhan School in Srisaket province of Thailand during the first academic semester of 2012 were purposively selected as participants. The study was

carried out using a quasi-experimental design. The data collected, included students' learning achievement test scores of organic chemistry, learning retention scores 14 days after the implementation, and a survey of student satisfaction in learning inquiry-based SSSEs, were analyzed. The paired-samples t-test analysis indicated that the students obtained an average post-test score of learning achievement (mean 29.53, SD 2.98) statistically higher than that of the average pre-test score (mean 13.76, SD 1.98) at 0.05 level of significance. It also showed that the students' average learning retention score (mean 28.82, SD 3.05) was not different from their post-test score of achievement at 0.05 level of significance. In addition, their satisfaction in learning inquiry-based SSSEs was at a 'high' level (mean 4.14, SD 0.33). It can be implied that the inquiry-based SSSEs were effective in the promotion of students' learning as the students obtained high scores in the learning achievement and retention tests and were highly satisfied with the SSSEs. This study is related to the present study in terms of design of the study, and the use of small scale experiment which the present study seeks to compare with demonstration method. This study is related to the present study because it involves the use of cost reducing chemicals which is what SSE is all about but the two studies are different in terms of the type of cost reducing experiment, level of students used for the two studies are and location where the two studies where carried were out.

Kayaoglu, Akbss, Ozturk (2011) investigated a titled "small scale experimental study: using animations to learn vocabulary"**.** This study investigated whether a difference exists between learning vocabulary via animation and via traditional paper-based method. This small scale study was conducted at Karadeniz Technical University in academic year 2009-2010. Two pre-intermediate classes were randomly selected as the experimental group (n=17), and control group (n=22) as each class accommodated that number. Results obtained from the data gathered

with a pre-test and a post-test applied to each group was analyzed using t-test in SPSS 16.00 version. The findings show that although there is no statistically significant difference between post-tests of each group, there was an increase in the post-test scores of animation group as compared to the pre-test scores. This increase implies that using multimedia such as animations contribute to students' achievement in vocabulary learning. Besides, the teachers' observations and students' opinions indicate that there were relatively positive attitudes towards using such kind of animations in vocabulary learning. They were useful since they address more senses than using paper-based texts; however, they can be distractive if teachers do not pay attention to the proficiency level of students and the content presented. The study supports the idea that multimedia applications can be integrated into language classes not as an alternative way but as an additional way to contribute positively to the atmosphere of class and motivation of students. This study is related to the present study because it involves the use of cost reducing chemicals which is what SSE is all about but the two studies are different in terms of the type of cost reducing experiment, level of students used for the two studies are and location where the two studies where carried were out.

Lykknes and Kvittingen (2014) carried out a small-scale chemistry for a hands-on approach to chemistry practical work in secondary schools: experiences from Ethiopia. The purpose of this study was to investigate the possibility of using a small-scale chemistry (SSC) approach as a means of performing chemistry practical activities in Ethiopian secondary schools. A total of eight experiments from two topics, electrolysis and rate of reaction, in the Ethiopian grade 11 chemistry syllabuses were modified into SSC for use with the MyLab Chemistry Kits (Northwest University, South Africa). The evaluation involved classroom testing of the SSC materials to investigate the effect of the approach compared to the regular teaching approach.

Two comparable groups of Grade 11 science stream students (188 experimental; 195 control) and their chemistry teachers participated in the study. Triangulation procedures involving classroom observation of the use of the SSC approach in classrooms, student achievement tests (pre and post-test), questionnaires, and interviews were employed for data collection. Results showed that the SSC approach can increase students understanding of chemistry concepts. Furthermore, despite the presence of some challenges in operating the small-scale equipment, collecting quantitative data, and maintaining class discipline, the SSC approach was viewed by both teachers and students as cost and time saving, safer, easy to use and enjoyable. This study is related to the present study because it involves the use of cost reducing chemicals which is what SSE is all about but the two studies are different in terms of the type of cost reducing experiment, level of students used for the two studies are and location where the two studies where carried were out.

Elahe and Fateme (2015) carried out a research titled "Micro-scale laboratory: creating effective learning environments toward student teachers in primary education". The study employed a descriptive survey design. To assess the student teachers experiences and opinions about the micro-scale chemistry education based science lessons, student teachers were invited to respond to a questionnaire at the end of the spring semester. The questionnaire consisted of 6 queries. The questionnaire indicates student teachers' views in relation to learning chemistry, active participation, enjoyment of chemistry, and laboratory learning skills with the micro-scale method. The questions focused on what student teachers liked and/or disliked about the micro-scale method, and whether they understood any difference between micro-scale chemistry educations based lessons and the traditional chemistry lesson. A total of 27 primary student teachers, aged between 21-23 years in Teacher Training university in Rasht participated in the

study. Selection of the students was based on those who had shown interest to participate in the study established during the research. Participating student teachers were those who had passed the science education classes. The assessment of students' perception of the effectiveness of the micro scale kit and the results are shown as follow: After working with the micro-scale kit, using traditional equipment for laboratory exercises: interviews with some student teachers revealed that the students saw the purpose of the micro-scale laboratories clearly and considered them valuable. This method revealed very clearly that all aspects of the micro-scale laboratory experience must be seen as a whole. The benefits of micro-scale in the context of developing countries are exemplified by a small number of studies. Among the findings from literature, increase of student laboratory skills, more focus on understanding of the concepts, more opportunity for discussion and reflections, easy and fun experiments for students are seen. This study is related to the present study because it involves the use of cost reducing chemicals which is what SSE is all about but the two studies are different in terms of the type of cost reducing experiment, level of students used for the two studies are and location where the two studies where carried were out.

Winkelmann and Erb (2013) carried out a study on small-group practical work vs. teacher demonstration in geometrical optics. This study aims to increase the understanding of this highly relevant topic. We are going to vary the grade of pupils' activity while they are doing practical work in physics lessons. Two research questions guided the study. The design of the study is quasi experimental. The study compared three treatments. In treatment (1) the students learn a new physical content by observing demonstrations. The crucial point is that in case of demonstration the majority of students watch one person performing the task. That means that it also may happen that a student can be the demonstrator. Another treatment (2) is taught in the

organization form of practical work in small groups. Due to the fact that a demonstration is instructed closely, for reasons of comparability the practical work should be as well. About 428 pupils took part in the study, distributed into twenty-two classes of grade seven, instructed by nine teachers. The variances between the treatments were measured using ANCOVA with a view on the contrasts between the several groups. As a result, not the treatment but one main covariate significantly predicts the dependent variable: the learning effort is influenced by the teacher, but with a small effect size, F (1, 425) = 11, 18; p = .001; r = .16. This study is relate to the present study in terms of the use of demonstration method but differ because the present study seek to compare the achievement and retention of students taught chemistry practical using SSE and demonstration in Awka education zone.

Ezeano (2008) carried out a study on small scale experiment and students' practical chemistry achievement in senior secondary schools. The study considered small scale experiment (SSE) and students achievement in practical chemistry. Two hypotheses guided the research. The design of the study is quasi-experimental design. The experimental group was taught with SSE while the control group was taught with demonstration method (DM). The sample for the study was 100 chemistry students. The instrument for the study was chemistry achievement test (CAT). The sampled students were exposed to the chemistry achievement test before the treatment. After the treatment, the CAT was reshuffled and administered to the students again to detect the effect of SSE on the students' achievement in chemistry. The analysis was done with ANOVA and it revealed that students who were taught with SSE achieved better than those who were taught with demonstration. This study is related to the present study in terms of the use of demonstration and SSE approach but differ because the present study seek to compare the

achievement and retention of students taught chemistry practical using SSE and demonstration in Awka education zone.

Studies on Demonstration

Alagye and Utor (2011) carried out a research on the effect of demonstration strategy in teaching entrepreneurship education among business education students in colleges of education in Jalingo, Taraba State. The purpose of the study was to determine the effect of demonstration strategy in teaching entrepreneurship education among business education students. The study adopted a quasi-experimental design and the population was 150 students of business education (NCE II). The data was analyzed using mean with standard deviation. The study revealed that students taught with demonstration strategy performed better than those taught with lecture method while the post test scores of entrepreneurship strategy was 47.35% with mean gain of score of 32.79 while lecture strategy was 40.76% and mean gain of 26.44. The study is related to the present study because the present study is also interested in the instructional strategy that can enhance entrepreneurship acquisition of chemistry students and also it is related in design and improving skills. The reviewed study was on demonstration strategy as a method of teaching, also the study was on business education while the present study is on practical activities instructional approach in chemistry teaching for acquisition of entrepreneurial skills and students' achievement.

Omwirhiren (2015) carried out a study on enhancing academic achievement and retention in senior secondary school chemistry through discussion and lecture methods: a case study of some selected secondary schools in Gboko, Benue State. The study determined how academic achievement and retention in chemistry is enhanced using the two instructional methods among SSII students and ascertained the differential performance of male and female students in

chemistry with a view of improving student performance in chemistry. The study adopted a non-equivalent pretest, posttest control quasi-experimental design. A total of one hundred and eighteen senior secondary school II students in intact classes were chosen from three schools in Gboko Local Government Area of Benue State using purposive random sampling. The ages of the students ranged between 16-17 years. Data were collected using a 30- item multiple choice Chemistry Achievement Test (CAT), in organic chemistry. Students were assigned to a treatment and a control group. Three hypotheses were generated and tested which were tested at 0.05 level of significance. The data obtained were analyzed using descriptive statistics, t-test, spearman's correlation coefficient and analysis of variance (ANOVA). There was significant difference in students' performance when discussion and lecture strategies were used to teach chemistry (Fcal = 4.65 >Fcrit = 3.85 at $P < 0.05$). There was significant difference in the retention ability of students exposed to discussion and lecture method (rcal = 0.9786 > 0.2353 at $P < 0.05$). There was significant difference in the performance of male and female students in the two groups (tcal = 3.621 >tcrit = 2.000 at $P < 0.05$). The overall results showed that discussion instructional strategy significantly improved students' performance in chemistry better than the lecture instructional strategy. The study concluded that discussion enhanced better achievement and productivity than the lecture method. This study is related to the resent study because it used demonstration as an independent variable of the study.

Studies on Gender

Chinwe and Onyebuchi (2001) carried out a study on influence of gender, school location and the use of play simulation in the achievement in chemistry. Eight intact classes of SS1 students were used, each class from each of the eight sampled schools. Four schools were randomly selected from each of the groups of boys and girls schools from four L.G.A. The

school types were further grouped into rural and urban areas with two from each school type. A sample of 177 students participated in the study 99 males and 78 females with 92 of them from urban schools and 85 from rural schools). The study employed quasi-experimental design. Each intact class received chemistry lesson on organic chemistry after pre-test, each also participated in a post-test. A teacher made test was used as the instrument. The data was analyzed using ANCOVA statistical test to test the two hypotheses and means were used to answer the research questions. The result showed that male students achieved significantly better than female students and also students from urban schools achieved significant better than students from rural schools in organic chemistry. The study is related to the present study as both examine the effect of gender and achievement in chemistry. The study used play simulation method, while the present study is on effects of SSE and demonstration on student's achievement in chemistry.

Ezeudu and Obi (2013) investigated the effect of gender and location on students' achievement in chemistry in Nsukka Local Government Area of Enugu State, Nigeria. It was guided by three research questions and three hypotheses. The sample of the study was made up of 827 students comprising 473 males and 354 females. Eight secondary schools were sampled using simple random sampling techniques. A proforma was the instrument which enable the researchers to copy results from the school past records in the respective schools through the help of the school principals was used to collect data for the study. Means and standard deviations were used to answer the research questions and t-test statistics were used to analyze the hypotheses. The findings showed that male students achieved significantly better than the female students in both urban and rural schools. Also there was no significant difference in the academic achievement of student in urban and rural schools. It was recommended among others that adequate incentives from federal Government, parents and stake holders of education should

be provided to female students to encourage them to achieve better. This study is related to the resent study in terms of gender and students' learning outcome in chemistry but differs in terms of purpose and area of the study.

Duyilemi and Olusa (2009) carried out a study on influence of gender and constructive strategy in students learning of biology at senior secondary schools in Ondo State. The purpose of the study was to find out the influence of gender and constructivist strategy in students' learning of biology at senior secondary schools in Ondo State. The population of the study comprised all senior secondary class I students in Akoko and Owo Local Government Areas of Ondo State with a total of 281 secondary school in both L.G.A of Ondo State. The sample consisted of two single sex schools (all girls) and two co-educational school. The study employed a pre-test, post-test control group, non-randomized quasi experimental design. Two schools were exposed to the experimental study while two served as the control and one intact class in each of the selected schools was used in the study. The data was analyzed using mean scores, ANOVA and multiple classifications analysis. The findings shows that girls in the experimental group taught with constructivist strategy performed higher in biology after treatment. The post-test mean score of girls in the experimental group is 15.3 as against the mean score of 10.6 for the girls in the control group taught with conventional method. Also, the mean scores of students in biology in the experimental group are more or less the same 15.45 for student in single sex school. This shows that irrespective of the type of school, the treatment benefited the female students equally. The study is related to the present study because both studies are interested on the effect of gender on science achievement and the instructional strategy that is suitable for effective teaching and learning. The study is not on the effect of SSE instructional strategy on students' achievement in chemistry, thus there is need for the present.

Longjohn (2009) conducted a study on effect of Game method of teaching on students' academic achievement in chemistry. Specifically, the study aimed at investigating (i) the effect of Game method of teaching on academic achievements (ii) the effect of game method of teaching on academic achievement of boys and girls (iii) the interaction effect of gender and the game method of teaching on academic achievement of students in chemistry. The study employed the pre-test, post-test, quasi-experimental design. The sample consists of 140 students from Rivers state comprising of 72 boys and 68 girls. The results showed that the group taught with Game method performed significantly better than the group taught with the lecture method. Girls performed significantly better than the boys however, there was no significant interaction effect of gender and teaching method on students' academic achievement. The study is related to the present study as both examine the effect of teaching method on gender in chemistry, but the two studies differs in terms of the type of teaching method to be used.

Ezeugwu (2010) conducted a study on student's enrolment and dropout rates by gender in secondary schools in Nsukka L.G.A Enugu State: Implications for Science Education. The purpose of the study was to determine the rate of students' enrolment and dropout by gender in secondary schools in Nsukka L.G.A. A random sample of 15 secondary schools, 15 principals, 30 school drop outs and 60 teachers in Nsukka L.G.A were used. The instrument for data collection was questionnaire and the data was analyzed using percentages, frequencies and t-test statistics. The design used is the descriptive research design. Results obtained in the study showed that students enrolment in each of the periods under review is 8960, (3772 males and 5188 females) in 2004-2005; in 2005-2006, the total was 8456 made up of 3587 males and 4869 females, while in 2006-2007, the figure was 6717 (3053 males and 3664 females). These figures show that in 2004-2005, a total of 504 students (498 males and 6 females) dropped out; in 2005-

2006, a total 1739 (1694 males and 6 females) dropped out; while in 2006-2007, a total of 2243 (2192 males and 51 females) dropped out. Results obtained shows that male students' drop out significantly more than females and that unemployment after secondary education is one of the major causes of students drop out of schools. This study is related to the present study as both examine the effect of gender in science education. Though the reviewed study was on student's enrolment and dropout rates by gender, the present study is on effect of teaching method (SSE) on students' achievement in chemistry.

Ndirika (2013) investigated on the gender disparities in science enrolment and achievement, in Abia State, toward achieving the millennium development goals. The purpose of the study was to investigate enrolment of male and female students in physics and chemistry and the academic performance of male and female students offering physics and chemistry. The study utilized ex-post factor design, the population is made up of all S.S.2 students offering physics and chemistry in three secondary schools in Abia State were used for the study. Science enrollment records of the male and female students in physics and chemistry as well as their achievement scores were collected. The data was analyzed using t-test. Results of the findings shows that 78 (64.24%) of S.S.2 male students enrolled for physics while 38 (36.92) females enrolled for chemistry. Results indicate that more males than female enrolled for both physics and chemistry. It was also observed that there was a significant difference in academic achievement of male and female students in favour of females in physics and chemistry.

This indicates that if females are given adequate encouragement especially from S.S.1 most of them who are science inclined will be confident to choose science subjects. Both studies are related because they want to find out the effect of gender on science achievement. Though the reviewed study was on gender disparities in science enrolment and achievement, the study

failed to show the effect of teaching method on gender and achievement. Thus there is need for the present study.

Studies on students' Achievement and Retention in Chemistry

Fatokun, Egya and Uzoechi (2016) investigated the effect of games teaching approach on chemistry students' achievement and retention in periodicity. The research designed employed was pretest -posttest control quasi experimental design. Multi-stage random sampling technique was used to select 96 students who participated in the study. Periodicity Achievement Test (PAT), used as Pre-Test (PREPAT), Post-Test (POSTPAT), and Post-Post-Test (PPPAT) was developed by the researcher and validated by experts. The reliability coefficient of the instrument obtained using spearman-brown prophecy formula which yielded 0.77. Five hypotheses were formulated and tested at 0.5 level of significance. The pretest was administered to subjects in both groups to measure their knowledge in periodicity. The control group was taught periodicity for four weeks using only the conventional method while the experimental group was also taught periodicity for four weeks with games method. POSTPAT was administered to all the subjects at the end of the fourth week. Two weeks after the administration of POSTPAT, the PPPAT was administered to both groups. The results show that the students taught periodicity using game method achieve and retain better than those taught with conventional method. It was also discovered that gender has no influence on the achievement and retention of those exposed to treatment. This study is related to the present study in terms of students' achievement and retention in chemistry which are variables under study in the present study but the two study defer in terms of the purpose of the study and the areas where the two studies were carried out.

Omwirhiren (2015) carried on enhancing academic achievement and retention in senior secondary school chemistry through discussion and lecture methods in Gboko, Benue State,

Nigeria. The study was initiated to determine how academic achievement and retention in chemistry is enhanced using the two instructional methods among SSII students and ascertained the differential performance of male and female students in chemistry with a view of improving student performance in chemistry. The study adopted a non-equivalent pretest, posttest control quasi-experimental design. A total of one hundred and eighteen senior secondary school II students in intact classes were chosen from three schools in Gboko Local Government Area of Benue State using purposive random sampling. The ages of the students ranged between 16-17 years. Data were collected using a 30- item multiple choice Chemistry Achievement Test (CAT), in organic chemistry. Students were assigned to a treatment and a control group. Three hypotheses were generated and tested which were tested at 0.05 level of significance. The data obtained were analyzed using descriptive statistics, t-test, spearman's correlation coefficient and analysis of variance (ANOVA). There was significant difference in students' performance when discussion and lecture strategies were used to teach chemistry ($F_{cal} = 4.65 > F_{crit} = 3.85$ at $P < 0.05$). There was significant difference in the retention ability of students exposed to discussion and lecture method ($r_{cal} = 0.9786 > 0.2353$ at $P < 0.05$). There was significant difference in the performance of male and female students in the two groups ($t_{cal} = 3.621 > t_{crit} = 2.000$ at $P < 0.05$). The overall results showed that discussion instructional strategy significantly improved students' performance in chemistry better than the lecture instructional strategy. The study concluded that discussion enhanced better achievement and productivity than the lecture method. It was recommended that discussion method should be used to teach organic chemistry in Nigerian Senior Secondary Schools. This study is related to the present study in terms of students' achievement and retention in chemistry, but differs in terms of the methods used in

teaching because this present study will compare the effect of Small scale experiment on students' achievement and retention in chemistry.

Faokun and Eniayeju (2014) carried out a study to enhancing students' achievement, interest and retention in chemistry through an integrated teaching/learning approach. This study was concerned determining the effects of Concept Mapping-Guided Discovery Integrated Teaching Approach on the Learning Style and Achievement of chemistry students. The sample comprised 162 Senior Secondary School (SS 2) students drawn from two Science Schools in Nasarawa State, Nigeria which had equivalent mean scores of 9.68 and 9.49 in their pre-test. Five instruments were developed and validated while the sixth was purely adopted by the investigator for the study, Four null hypotheses were tested at $\alpha = 0.05$ level of significance. Chi Square analysis showed that there was a significant shift in students' learning style from Accommodating and Diverging to Converging and Assimilating when exposed to Concept Mapping- Guided Discovery Approach. Also t-test and ANOVA indicated that those who in experimental group achieved and retained content learnt better. Results of the Scheffe's test for multiple comparisons showed that boys in the Experimental Group performed better than girls. It is therefore concluded that the Concept Mapping- Guided Discovery Integrated Approach be used in secondary schools to successfully teach electrochemistry. It is strongly recommended that chemistry teachers should be encouraged to adopt this method for teaching difficult concepts. This study is related to the present study in terms of students' achievement and retention in chemistry which are variables under study in the present study but the two study defer in terms of the purpose of the study and the areas where the two studies were carried out.

Udogu and Njelita (2010) investigated the effect of constructivist - based instructional model on students' conceptual change and retention on some difficult concepts in Chemistry. A

quasi-experimental, non-equivalent group control design involving two intact classes were used to determine the effect of constructivist-based instructional model-Generative Learning Model (GLM) on students' conceptual change and knowledge retention in chemistry. Effect of GLM on gender is also monitored. Performance of students taught with the above instructional model was compared with those taught with Expository Method (EPM). The sample for the study consisted of 170 SSII Chemistry students from four secondary schools purposeful selected from all the secondary schools in Idemili South Local Government Area of Anambra State. Students from two schools – (one male and the other female) were randomly assigned to experimental group while the other two schools one male and the other female was assigned as control group. A Teacher Made Achievement Test in Chemistry Tests (TMATC) was used. Three sets of these tests were developed 1, II and III. Pre-test was administrated to both groups to determine their entry level. At the end of the treatment Post-test was administered to both groups to determine their achievement after treatment. The third test was administered after an interval of four weeks to measure students' knowledge retention. ANCOVA statistical tool was used to analyze the data collected using pre-test as a co-variant. From the findings, it was very clear that experimental group performed better than the control group. This study is related to the present study in terms of students' achievement and retention in chemistry which are variables under study in the present study but the two study defer in terms of the purpose of the study and the areas where the two studies were carried out.

Obomanu and Nbina (2010) carried out a study on effects of problem solving instructional strategies on students' achievement and retention in chemistry with respect to location in rivers state. The main purpose of this study is to determine how problem solving instructional strategies would affect students' achievement and retention in Chemistry with

particular reference to River State. A pre-test, post-test, non-equivalent control group design was adopted. Two research questions and two hypotheses were respectively answered and tested. Purposive and stratified random sampling was used to select 428 SS II students from two rural and two urban local government areas of Rivers State. These students were randomly assigned to the two treatment groups. Problem Solving with Model and Feedback (Correctives) (PF); Problem Solving with Model Only (PM); and The Control Problem Solving by the Conventional Method (PC). The model used is a Generic Problem Solving Inquiry Model developed by Hungerford (1975). A researcher developed and moderated instrument, Chemistry Achievement Test (CAT) and lesson plans were used for the study. Data collected were analyzed using Mean, Standard Deviation (SD) and some gains of achievement and retention and that the hierarchical order of achievement is PF, PM and PC. No significant differences were observed in the post-test mean scores of urban and rural subjects in the achievement is PF, PM and PC. No significant differences were observed in the post-test mean scores of urban and rural subjects in the achievement and retention tests administered in the course of the study. Based on the findings, it is recommended that both rural and urban Chemistry teachers use problem solving instructional strategies, particularly that in which use of a model is supplemented with feedback-correctives in teaching. This study is related to the present study in terms of students achievement in chemistry, while this present study will compare the effect of Small scale experiment on students' achievement in chemistry.

Ugwu (2004), investigated on the effect of practical activities on achievement in chemistry among senior secondary school students in Enugu State. The study was specifically designed to determine the interactive effect of practical activities on theoretical understanding of chemistry students. Determine the difference in achievement between students exposed to

practical activities and those exposed to lecture method. The study was quasi – experimental design. 300 Senior Secondary School II Chemistry Students in Enugu State was used this was selected using purposive sampling. The instrument for data collection was an achievement test. The finding revealed that students taught using guided discovery method performed better than those taught using lecture method. Also there is a significant difference in the mean achievement of male and female students taught practical chemistry using guided discovery method. The study is related to the present study as both worked on students achievement in chemistry. The two studies differ in terms of location and purpose of the study because the present study seeks to investigate the effect of SSE achievement in chemistry.

Summary of Literature Review

Chemistry is a branch of science that deals with the study of matter especially, the composition, properties and uses of matter. Chemistry involves the making of various substances, finding out their properties and how they react with one another, determining patterns in their knowledge and attempting to comprehend properties and phenomena with regards to atoms and molecules and their electronic structures and using their knowledge and understanding to make predictions. Chemistry practical also was seen to involve the manipulation of chemicals and equipment (laboratory materials), helps 'students to internalize science process skills and enhances their achievement of chemistry knowledge/concepts.

Small- scale experiment was seen as an effective way of reducing cost incurred in practical chemistry. It is a means of teaching practical in times of stress such as; when materials and equipment are expensive, when the constraining budgetary allocation at times had not permitted conventional experiment, when the provision of facilities had not kept pace with the astronomical rise in students' population. In small scale experiment, quantity of materials used

by a student for experiment is scaled down and the result is that the quantity of materials used by students for a macro experiment is equivalent to the quantity used by at least ten students, for small scale experiment. Demonstration method on its own refers to the type of teaching method in which the teacher is the principal actor while the learners watch with the intention to act later. Here the teacher does whatever the learners are expected to do at the end of the lesson by showing them how to do it and explaining the step-by-step process to them.

Under the theoretical framework, Brunner's discovery leaning theory and Vygotsky's social learning theory was reviewed and anchored to the present study. In the review of empirical studies, studies on small scale experiment, students' achievement and retention in chemistry and gender were reviewed. From the studies reviewed, it was discovered that some researchers have investigated the use of Small Scale experiment on students achievement in chemistry and other science subjects, but the review showed that of such knowledge carried out using SSI chemistry students in Nsukka Education Zone of Enugu State. Hence the need for the presents study

CHAPTER THREE

RESEARCH METHOD

This chapter describes the general method the researcher adopted in carrying out the study under the following sub-headings; design of the study, area of the study, population of the study, sample and sampling technique, instrument for data collection, validation of the instrument, reliability of the instrument, experimental procedures, control of extraneous variables and method of data analysis.

Design of the Study

The design of this study is quasi-experimental. Specifically, the non-equivalent control group design. According to (Nworgu, 2015), non-equivalent control group quasi experimental design is a design that does not allow for the assignment of subjects to experimental and control groups through randomization process. This study adopted this design because there was no randomization of research subjects, rather intact classes were used. The design is represented schematically as follows:

Schematically representation of non-equivalent control group Design

Group	Pretest		Post Test	Retention
Experimental (E)	O_1	X	O_2	O_3
Control (C)	O_1	---- X	O_2	O_3

Where

E = Experimental group (SSE)
C = Control group (DEMO)
O_1 = Pre–test
O_2 = Post–test
O_3 = Retention
X = Treatment group
--- = unequal group

Area of the Study

The area of the study is Awka Education Zone of Anambra State, which comprised Njikoka L.G.A, Dunukofia L.G.A, Awka south L.G.A, Awka north L.G.A and Anaocha L.G.A. There are 61 governments owned senior secondary schools in Awka Education zone, i.e. 11 in Njikoka L.G.A; 8 in Dunukofia, 18 in Awka south, 8 in Awka north and16 in Anaocha L.G.A. Also, out of the 61 schools, there are 11 urban secondary schools and 50 rural schools. The choice of the zone is borne out of the fact that researches have shown that students in the zone have a lot of problems in carrying out practical in chemistry probably due to lack or inadequate provision of laboratory facilities and chemicals for experiment and this may have contributed to poor academic achievement of students in chemistry. Hence, the researcher wants to investigate whether Small Scale Experiment will enhance students' achievement and retention in chemistry.

Population of the Study

All the 3131 senior secondary one (SSI) Chemistry students in all the government owned coeducational secondary schools in Awka Education Zone formed the population of the study. The total population of SSI students in all the government owned co-educational secondary schools in Awka Education Zone. The breakdown includes: Njikoka L.G.A.(280 students-106 males and 184 females); Dunukofia L.G.A. (380 students- 148 males and 232 females); Awka south L.G.A (1420 Students-678 males and 742 females), Awka north L.G.A(520 students-248 males and 272 females, Anaocha L.G.A(531 students-267 males and 264 females).(Post Primary School Services Commission HQ. Awka (PPSSC) 2017/18 Academic Record.

Sample and Sampling Technique

One hundred and forty nine SSI chemistry students (149) formed the sample for this study. The chemistry students were drawn from the population of the study using simple random

and purposive sampling techniques. Simple random sampling technique was used to select one local government area out of the five local government areas that made up Awka Educational Zone, from that Awka south Local Government Area was selected. Further, purposive sampling technique was used to sample three co-educational senior secondary school from Awka south L.G.A. The choice of these schools is because the researcher proposed to use schools that have a well-structured and organized laboratory because the study involves experimentation, and also schools that have experienced chemistry teachers. The reason for choice of coeducational school is because gender is a moderating variable of the study. In each school, two intact classes were used for the study.

Instrument for Data Collection

The instrument for data collection in this study was Chemistry Achievement Test (CAT). The CAT consists of 40 multiple response test items with four option format (A, B, C and D). CAT was developed based on the contents taught in the lessons. Some items in CAT were developed by the researcher while some were drawn from past WAEC question papers. To determine the number of items to be generated from a particular unit, the researcher made use of table of specification. Each correct answer in the test carries I mark.

Validation of Instruments

The instrument was validated by three experts, two from Measurement and Evaluation and one from chemistry unit all in department of Science Education, University of Nigeria, Nsukka. These experts were requested to examine the instrument in terms of: appropriateness and adequacy of the items in measuring what they are intended to measure, suitability of the language used in the instrument in terms of clarity and comprehension. Content validation was

also established for the CAT using test blue print (Table of Specification). The suggestions of the experts were used by the researcher to modify the items in the instruments.

Reliability of the Instrument

The instruments CAT was trial tested by administering the instrument to 40 S.S. I chemistry students from a secondary school in Awka south LGA which was not part of the schools used for the actual experiment but have similar characteristics with the sampled schools. The data collected from the responses of students were used to calculate the reliability of the instrument using Kuder Richardson 20 (K-R-20) and it yielded an internal consistency index of 0.81.

Training Programme of Teachers (research assistants)

In order to control error which may arise as a result of teacher difference the researcher organized a one week pre-experimental training programme for the regular chemistry teachers of the classes selected from the sampled schools used for the study. There was training for the teachers on how to use the lesson plans developed by the researcher to teach the selected topics through SSE and demonstration method. The chemistry teachers who served as research assistants in the study were instructed on how to carry out the experiment using Small Scale Experiments. The teachers for the SSE which involve the use of small quantity of chemical of low concentration to conduct practical lessons were instructed on how to use reduced volume and moles of chemicals and materials to carry out chemistry practical while the teacher for the demonstration group was instructed on how to carry out practical through demonstration. In SSE, every student is provided with hands- on- activities in order to learn practical skills and gain experience that can enhance students' achievement in chemistry. The assistants were instructed on their role and that of the students in the learning process during the practical sessions.

Experimental Procedure

Two instructional approaches were employed for this study; the SSE group and demonstration group. The experimental group was taught using Small Scale Experiment while the control group was taught chemistry practical using demonstration method. The regular chemistry class teachers were used for the study in both experimental and control groups. Instructions were given to the chemistry teachers who taught the experimental group using Small Scale Experiment approach and the chemistry teachers who taught the control group using the conventional demonstration method. Since intact classes were used, two classes each were randomly assigned to both experimental and control groups.

Pre-test was administered to both the experimental and control groups after which the treatment began. The treatment lasted for 4 weeks. The treatment involved exposing the students to practical activities using Small Scale Experiments so as to foster students' hands on activity. The control group was taught the same chemistry concepts using demonstration method. Lesson plans for both treatment and control groups are the same in terms of contents, instructional objectives, length of time for teaching and mode of evaluation except for practical activities in the treatment group. Moreover, all the students in the experimental group were involved in the experiment since it is being carried out under a school setting.

After the treatment, posttest (after reshuffling of the items in the achievement test) was administered to both experimental and control groups using CAT. The scripts from both pre-test and post-test of the two groups was marked and scored using the marking guide provided by the researcher. The data collected from the pre-test and post-test were analyzed using mean and standard deviation for the research questions and Analysis of Covariance (ANCOVA) for testing the hypotheses at 0.05 level of significance.

Control of Extraneous Variables

The researcher adopted the following procedure in order to control some of the identified variables that may have effect on the dependent variables if left uncontrolled.

Teacher variables: In order to minimize the errors that might arise as a result of teacher difference on the student's achievement, the researcher organized a week pre-experimental training programme for the research assistants used for the study using the lesson plan prepared by the researcher. Two of the teachers were in charge of the control group and the other two for experimental group. The researcher supervised the research assistants by allowing them to demonstrate what they have been taught during the training before they commence the actual teaching. This was done in order to ensure uniformity so as to control teacher's variables. The individual problems of the research assistants which might introduce error were detected and resolved. The research assistants used the lesson notes prepared by the researcher on the topics that made up the unit. The lesson notes and procedures for delivering the lessons were discussed extensively during the training. This study was regularly monitored by the researcher to ensure that the teachers did not deviate from the expected procedure of instruction.

Experimental Bias: The actual instructions for the groups were carried out by the regular chemistry teachers in the three schools that were used for the study. The researcher was not directly involved in the administration of the research conditions. This is to avoid bias on the part of the subjects.

Instructional situation variable: The researcher issued out an instructional guide to the research assistants in all the groups in order to ensure that the instructional situation is the same for all the schools selected for the study. Teaching and testing was conducted in all the chemistry classes of S.S1 in the various schools selected for the study and not just in the intact classes drawn. This

was done to avoid Hawthorne effect (a situation in which research subjects behavior is affected not by the treatment but by their knowledge of participation in study) and Novelty effect (increased interest, motivation or participation on the part of the subject simply because they are doing some-thing different). Pretest and posttest was administered to all the classes by the research assistants but data for the study was restricted to the intact classes drawn for the study.

Irregular participation and experimental mortality: To reduce this variable, the research assistants compelled the students to be punctual. To ensure this, there was roll call of the subjects before and after each lesson. Finally, a student who did not complete all the sessions was dropped.

Subject interaction: the researcher ensured that the experimental and control group were selected from different schools because of the awareness of the possible interaction between the experimental and control groups. This was done to reduce the errors that might arise from interaction and exchange of ideas among research subjects from the two groups.

Inter group variable:

Inter group interaction were eliminated by subjecting all the SS1 chemistry students in a particular sample school to the same treatment, either as experimental or control groups. The researcher eliminated the error of non-equivalence arising from non-randomization of the students by using the analysis of covariance (ANCOVA) for data analysis.

Method of Data Analysis

The scores obtained from the research questions were analyzed using mean and standard deviation while the hypotheses were tested using Analysis of Covariance (ANCOVA).

CHAPTER FOUR

ANALYSIS OF DATA AND RESULTS

This chapter presented the results of data analysis carried out for the study based on four research questions and four hypotheses that guided the study. The results were presented according to research questions and hypotheses that guided the study.

Research Question 1

What is the effect of Small Scale Experiment on mean achievement scores of students in chemistry?

Table 1: Mean ($\bar{x}$) and Standard Deviation (SD) of student's achievement scores in Chemistry

Group	N	Pretest		Posttest		Gain score
		$\bar{x}$	SD	$\bar{x}$	SD	
Experimental group (Small Scale Experiment)	71	14.80	4.34	29.24	2.89	14.44
Control group (Demonstration)	78	15.49	4.21	23.67	3.56	8.18

The data on students' achievement in table I revealed that students taught chemistry using Small Scale Experiment had mean achievement score of 14.80 in pretest and 29.24 in posttest while the mean achievement score of students taught chemistry using the conventional Demonstration was 15.49 in pretest and 23.67 in posttest. Students taught chemistry using Small Scale Experiment had gain score of 14.44, while their counterparts taught chemistry using conventional Demonstration had gain score of 8.18. Therefore, students taught chemistry using Small Scale Experiment performed better than their counterparts taught using conventional Demonstration method.

Research Question 2

What is the effect of Small Scale Experiment on mean retention scores of students in chemistry?

Table 2: Mean ($\bar{x}$) and Standard Deviation (SD) of Students' Retention in Chemistry

Method	N	Pre-test		Post-test		Gain score
		$\bar{x}$	SD	$\bar{x}$	SD	
Experimental group (Small Scale Experiment)	71	8.23	2.63	25.08	6.76	16.85
Conventional group (Demonstration)	78	7.56	2.36	18.78	7.74	11.22

The data on Retention in table 2 revealed that students taught chemistry using Small Scale Experiment had mean pre-test score of 8.23 and post-test score of 25.08 while the students taught using the conventional demonstration had pre-test score of 7.56 and post test score of 18.78. Students taught chemistry using Small Scale Experiment had gain score of 16.85 and their counterparts taught using conventional method had gain score of 11.22. Therefore, students taught chemistry using Small Scale Experiment had higher retention score than their counterparts taught using the conventional demonstration method.

Research Question 3

What is the influence of gender on mean achievement scores of students taught chemistry with SSE

Table 3: Mean ($\bar{x}$) and Standard Deviation (SD) of male and female students' achievement in chemistry

Gender	N	Pretest		Posttest		Gain Score
		$\bar{x}$	SD	$\bar{x}$	SD	
MALE	70	15.34	4.13	28.10	3.14	12.76
FEMALE	79	15.62	4.30	24.76	4.55	9.14

Data in Table 3 revealed mean achievement score of 15.34 in pretest and 28.10 in post test for male students, while the female students had mean achievement score of 15.62 in pretest and 24.76 in post test. Male students had gain score of 12.76 while their female counterparts had gain score of 9.14. Male students therefore, had high achievement score than their female counterparts in chemistry.

Research Question 4

What is the influence of gender on mean Retention scores of students taught chemistry with SSE

Table 4: Mean ($\bar{x}$) and Standard Deviation (SD) of male and female students' retention in chemistry

Gender	N	Pre-test		Post-test		Gain Score
		$\bar{x}$	SD	$\bar{x}$	SD	
MALE	70	7.81	2.52	24.13	7.53	16.32
FEMALE	79	7.94	2.51	19.71	7.71	11.77

Data in Table 4 revealed mean Retention score of 7.81 in pre-test and 24.13 in posttest for male chemistry student, while the female chemistry students had mean Retention score of 7.94 in pre test and 19.71 in post test. Male students had gain score of 16.32 while their female counterparts had gain score of 11.77. Therefore, male student had a higher positive Retention towards chemistry than their female counterparts when Small Scale Experiment was applied in teaching chemistry.

***Ho_1*: There is no significant difference in the mean achievement scores of students taught chemistry with Small Scale Experiment and those taught with Demonstration method.**

Table 5: Analysis of Covariance of students' mean achievement score in chemistry

SOURCES OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIG	DCS
Corrected model	1743.748[a]	8	217.968	31.749	.000	Sig
Intercept	5127.154	1	5127.154	746.824	.000	Sig
Pre-test	174.430	1	175.430	25.553	.000	Sig
Method (treatment)	631.404	1	631.404	91.971	.000	Sig
Gender	102.082	1	102.082	14.869	.000	Sig
Method x Gender	35.262	1	35.262	5.136	.025	Not Sig
Error	961.138	140	6.865			
Total	105993.000	149				
Corrected total	2704.886	148				

R Squared = .645 (Adjusted R Squared = .624)

Data in table 5 showed that there is significant effect of method on students' achievement in chemistry f(1,149) =15.951, p<.000. The null hypothesis therefore was rejected because the significance is less than 0.05 indicating that there was significant difference in the mean achievement score of students taught chemistry using Small Scale Experiment and those taught using conventional Demonstration.

***HO_3*: There is no significant difference in the mean achievement scores of male and female students taught chemistry using Small Scale Experiment.**

Data in table 5 revealed no significant influence of gender on students achievement in chemistry f (1,149) = 2.694, p>.103. The null hypothesis was not rejected, because the significance is above 0.05 indicating that there was no significant difference in the mean achievement scores of male and female students taught chemistry using Small Scale Experiment.

***HO_2*: There is no significant difference in the mean retention scores of students taught chemistry using Small Scale Experiment and those taught with Demonstration method.**

Table 6: Analysis of covariance of students' mean retention score in chemistry

SOURCES OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIG	DCS
Corrected model	3521.287[a]	8	440.161	10.702	.000	Sig
Intercept	3219.841	1	3219.841	78.289	.000	Sig
Pre-test	482.005	1	482.005	11.720	.001	Sig
Method (treatment)	1021.753	1	1021.753	24.844	.000	Sig
Gender	91.980	1	91.980	2.236	.137	Not Sig
Method x Gender	148.884	1	148.884	3.260	.059	Not Sig
Error	5757.840	140	41.127			
Total	79994.000	149				
Corrected total	9279.128	148				

R Squared = .379 (Adjusted R Squared = .344)

Data in table 6 showed that there is significant effect of Small Scale Experiment on students' Retention in chemistry f (1, 149) = .241, p<.625. The null hypothesis therefore was not rejected because the significance is above 0.05, indicating that there was significance difference in the mean Retention score of students using Small Scale Experiment.

***HO_4*: There is no significant difference in the mean retention scores of males and females students taught chemistry using Small Scale Experiment.**

Table 6 revealed that there is no significant influence of gender on students mean retention scores in chemistry f(1,149) =p> 640 .425. The null hypotheses was not rejected because the significance is above 0.05, indicating that there is no significant difference in the mean retention scores of students taught chemistry using Small Scale Experiment.

Summary of major findings

- Students taught chemistry using Small Scale Experiment performed better than their counterparts taught using conventional demonstration method. The hypothesis showed that there is significant difference in the mean achievement score of students taught chemistry using Small Scale Experiment and those taught using the conventional Demonstration
- Students taught chemistry using Small Scale Experiment had higher mean Retention score than their counterparts taught using conventional method. The hypothesis showed that there is significant difference in the mean Retention score of students taught chemistry using Small Scale Experiment and those taught using the conventional Demonstration
- Male students had higher mean achievement score than their female counterparts in chemistry when taught with SSE. The test of hypothesis showed that gender is a significant factor in the mean achievement score of students in chemistry
- Male student taught chemistry using Small Scale Experiment had higher mean retention score than their female counterparts when taught with SSE. The test of hypothesis showed that gender is not a significant factor in the mean retention score of students in chemistry

CHAPTER FIVE

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the discussion of the results, conclusion reached from the findings, educational implications of the findings, recommendations, limitations of the study, suggestion for further studies and the summary of the study.

Discussion of the Findings of the Study

Discussion of the findings of the study is presented under the following subheadings:

- Effect of Small Scale Experiment on students' achievement and retention in chemistry
- Influence of gender on students' achievement and retention in chemistry

Effect of Small Scale Experiment on students' achievement and retention

The Small Scale Experiment mode of instruction was superior to the conventional demonstration method in facilitating student's achievement in chemistry. The test of hypothesis showed that instructional treatment (method) is a significant factor in the mean achievement scores of students in chemistry. The differences in performances might have been because the students were required to construct knowledge by themselves, thereby imbibing the scientific processes involved in learning chemistry, which enabled them to perform better than their counterparts taught chemistry using conventional method. When the students generate their own question, analyze and discuss their findings and finally organize their thoughts, they seemed to understand their own information better than the ones the teachers introduced to them. The Small Scale Experiment instructional approach was more effective because the instructions were characterized by active student's involvement, thereby capturing the interest of the students and maximizing comprehension of the subject matter.

Irrespective of the fact that small scale experiment involves the use of reduced concentrations and volumes of chemicals or grams of solid laboratory materials required for volumetric analysis, yet the students got the same result as though the conventional quantities of the materials were used. In volumetric or quantitative analysis (acid base titration), practical lesson is conventionally done with pipette of 20 or 25cm^3 for base and burette of 50cm^3 for acid, but in SSE, to reduce cost, syringes or micro burette and pipette of 5 to 10cm^3 could be used for both acid and base and a drop of an indicator will be used instead of the normal two-drops. The small quantity of chemical used in SSE affords every student the opportunity to practice and get exposed to the properties of expendables used and some skills which are useful in conducting the actual conventional practical lessons. This may have given the students opportunity to get involved in carrying out practical unlike the conventional classroom where the teacher demonstrates the experiment for the student to see.

Also the finding from the study showed that students taught chemistry using Small Scale Experiment had high mean retention score in chemistry than their counterparts that were taught with conventional method. The result of the hypothesis showed that method is a significant factor in the mean retention score of students in chemistry. Small Scale Experiment promotes a student-based philosophy in which the instructor takes on the non- traditional role of mentor or coach, leaving the students to discover solutions for themselves, by constructing their own knowledge. Small Scale Experiment is a learner- centered approach, which creates an enabling environment where learners can make discover information by themselves, thereby acquiring positive retention towards the subject.

The finding could be as a result of the fact that the use of small scale experiment increases safety, is easy to use and environment friendly. It could also be as a result of the fact that it

instills ethics of resource conservation, enhances students' understanding of scientific concepts, maintains students' interest towards the subject and it uniquely engages students in hands-on learning experiences, and experiments are perceived by students as easy and fun. Mattson (2005) argues that the SSE approach can help address many of the challenges that teachers face when planning practical work including shortage of equipment and chemicals, lack of laboratory space, lack of laboratory assistants, shortage of time, and lack of confidence by teachers.

This approach emphasizes an active involvement of students in carrying out practical which eventually led to high retention of chemistry concept. Student's participation in practical shifts the role of the instructors from givers of information to facilitators of student's learning, thereby promoting student's retention of learning. The finding of this study is in agreement with that of Tesfamariam, Lykknes and Kvittingen (2015) who investigated small-scale chemistry experimentation and found out that it increased students' achievement in practical chemistry. The result is also in line with the finding of Ezeano (2008),Supasorn, Kamsai and Promarak (2013),Kayaoglu, Dag and Ozturk (2011), Kayaoglu, akbss, ozturk (2011), Lykknes and Kvittingen (2014), whom in their respective studies found out that students taught chemistry using reduced or small scale experiment approach had higher mean achievement score in chemistry than their counterparts taught using the conventional demonstration method.

Also, the finding on students retention in chemistry is in line with the findings of Omwirhiren (2015), Faokun and Eniayeju (2014), Obomanu and Nbina (2010), Udogu & Njelita (2010) and Ugwu (2004) who found out that leaner centered instructional approaches enhances students retention in chemistry,

Influence of gender on students' achievement and retention in Chemistry

Result of the study on the influence of gender on the mean achievement scores of the students in chemistry showed that male students taught chemistry using Small Scale Experimental approach performed better than their female counterparts. The test of hypothesis showed that gender is a significant factor in the mean achievement scores of students in chemistry. This could be because of the different socialization processes of male and female persons in which the males are expected to explore their environment while the female ones are to conform or maintain their existing environment. The male students are allowed to play with toys and other forms of machines in the environment, which enables them to imbibe the culture of exploration, which the females are not always exposed to. Notwithstanding; male students significantly perform better than female students in chemistry. The finding supports the finding of Ezeudu and Obi (2013), Ndirika (2013), Ezeugwu (2010), Duyilemi and Olusa (2009), Longjohn (2009), who found that that male students perform better that their female counterparts in sciences.

Conclusion

From the results obtained in the study on the effects of Small Scale Experiment approach on student achievement in chemistry, it was found out that students taught chemistry using Small Scale Experiment performed better than their counterparts, taught chemistry using the conventional demonstration method. Furthermore, students taught chemistry using Small Scale Experiment had higher mean retention score in chemistry than their counterparts taught chemistry using the conventional demonstration method. However, gender did not significantly influence students' achievement in chemistry, even though the posttest mean scores of male

students was slightly higher than that of their female counterparts. In terms of retention to chemistry, gender did not significantly influence students' retention to chemistry. Male students taught chemistry using Small Scale Experiment approach method had higher mean retention score in chemistry than their female counterparts.

Educational Implications of the Findings

The findings of this study have implications for education particularly in teaching chemistry in secondary schools. The implications of this study border on development of more virile instructional approach for teaching chemistry. The study revealed that Small Scale Experiment approach was superior to conventional demonstration method. These results imply that the current instructional approach used in teaching might have been partly responsible for student's poor performance and poor retention in chemistry.

The findings of this study equally has implication for science teachers. They should endeavour to use innovative student-centered instructional approaches like the Small Scale Experiment approach other than traditional teaching methods since the latter is not students centered and cannot enhance student's achievement. In addition, science teachers should ensure that students' cognition is activated during teaching and learning, this will make them to focus on the learning task. Furthermore, the finding of the study showed that male and female students perform differently during science chemistry instruction. Hence, science teachers should consider the gender of their students when teaching.

Authors and publishers of Chemistry books are not left out. They should incorporate Small Scale Experiment approach -based approach as an alternative to demonstration method in the absence of the conventional chemicals and apparatus for proper chemistry practical in

schools while writing there science books because it will make the students to experience cognitive conflict, which in turn help them to experience conceptual shift that will eventually enhance their achievement in chemistry. The authors and publisher of science books should ensure that they incorporate Small Scale Experiment approach s and inquiry-inducing practical in their books for this will trigger and sustain students' achievement.

The findings of this study implied that curriculum planners should include Small Scale Experiment instructions in future curriculum designing and redesigning in place of Alternative to practical.

Recommendations

Based on the findings of this study, and their implications, the following recommendations are made.

a. In view of the fact that the Small Scale Experiment approach was more effective in teaching chemistry and enhancing students' achievement and retention in chemistry, the Ministries of Education should ensure that textbook authors incorporate Small Scale Experiment approach in the instructional methods for secondary schools.
b. Chemistry teachers should be trained on how best to involve students during instructions so as to facilitate students' achievement and retention in the lesson. This could be achieved through seminars and workshops for teachers in secondary schools.
c. Teachers should make teaching and learning of science gender friendly.
d. Teachers should desist from imposing their ideas of instruction on the students especially during lesson planning, implementation and evaluation. The teacher should engage the

students in constructing their own ideas and information by seeking for alternatives where facilities are limited.

e. The curriculum planners should ensure that they incorporate Small Scale Experiment approach in chemistry curriculum, as it will help to promote students' achievement and retention in chemistry

Limitations of the Study

The generalizations made with respect to this study are however subject to the following limitations:

1. Since different teachers were used for different groups, it could be assumed that they might not have been of equal attributes in terms of method, cognitive, personality and affective functioning. This might have introduced error in the study.
2. There was also the problem of absenteeism among the students. The fact that some students skipped classes may have influenced their performance.

Suggestions for Further Study

Based on the findings and limitations of this research, the following topics are suggested for further research.

- The study should be replicated in other science discipline like basic science, biology, physics and mathematics.
- The study should also be replicated with other practical based topics in chemistry
- Another study should be conducted to find out the effect of Small Scale Experiment approach and other types of cost reducing instructional approaches on students' achievement in

chemistry to determine which one is more effective in enhancing student's achievement and retention in chemistry.

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APPENDIX A

CHEMISTRY ACHIEVEMENT TEST (CAT).

Instruction

Below are questions on separation of Mixtures, Acids and Bases.

Fill the data and answer the questions that follow.

Part A: Personal Data

Name of School----------

Class----------

Gender

Male ☐ Female ☐

PART B

Answer all the questions in this section. Each question is followed by four options lettered A-D. Choose the correct option for each question and circle it as shown in the example below.

Example: The three states of matter include the following except:

A. Solid
B. Liquid
C. Gas
D. Petrol

Answer is (D)

Now answer the following questions.

1. In a mixture of petrol and water, two distinct layers are formed because
   A. Water is less dense than petrol.
   B. Petrol and water were not mixed thoroughly
   C. Water and petrol are immiscible.
   D. Of the presence of hydrogen bond.
2. The principle of paper chromatography is based mainly on different rates of movement of substances over
   A. Wet surface
   B. A smooth surface
   C. A hard surface
   D. An adsorbent surface.
3. An extract from hibiscus flower can be separated by
   A. Fractional distillation
   B. Chromatography
   C. Evaporation
   D. Filtration.
4. In paper chromatography the strip of paper must not touch the liquid in the container so as not to _____

A. Make the paper become wet.
B. Protect the paper.
C. Dissolve the mixture
D. Provide support for the container.

5. During filtration, the solid particles collected on the filter paper are called_____
   A. Filtrate
   B. Residue
   C. Distillate
   D. Crystals
6. A mixture of sulphur and iron filings can be separated by
   A. Decantation
   B. Distillation
   C. Evaporation
   D. Magnetisation
7. A mixture of oil and water can be separated by_____
   A. Sublimation
   B. Evaporation
   C. Using separating funnel
   D. Distillation
8. The following are examples of mixtures except
   A. Air
   B. Blood
   C. Urine
   D. Water
9. Sieving is one of the separation techniques in
   A. Mining industry
   B. Salt industry
   C. Petroleum industry
   D. Sugar industry
10. A mixture of iron dust and zinc dust can be separated by
    A. Sieving
    B. Sublimation
    C. Magnetic separation
    D. Filtration
11. The reaction between an acid and a base is known as_____
    A. Crystallization
    B. Neutralization
    C. Combination
    D. Chromatography.
12. An acid is defined as:
    A. a substance that gives hydroxide ion when dissolved in water
    B. a substance that produces salt and water when dissolved in water.
    C. a substance which produces hydrogen ion (H^+) as the only positive ion when dissolved in water.
    D. as substance that produces ions when dissolved in water.
13. Which of the following statements is incorrect about an alkali?

A. An alkalis neutralizes an acid and produces salt and water only
B. alkali have bitter taste
C. Alkali turn blue litmus paper red.
D. Alkali turn red litmus paper blue.

14. Bases cannot be used for one of the followings:
A. Electrolyte in lead accumulators
B. Making soap
C. Neutralizing acidic soil
D. Making shaving cream

15 The instrument used to measure the acidity of a solution is called
A. pH metre
B. Indicator
C. Litmus paper
D. Metre rule.

16. A neutral solution has pH value of_____
A. 2
B. 7
C. 14
D. 8

17. All of these are properties of acids except
A. Acids generally have sour taste.
B. Acids neutralize bases to form salt and water only.
C. Strong acids are corrosive
D. Acids have bitter taste.

18. What effect will a solution of pH12 have on litmus paper?
A. Neutral
B. Acidic
C. Alkaline
D. No effect

19. The following substances can conduct electricity, except
A. Sodium hydroxide solution
B. Tetraoxosulphate(vi) acid solution
C. sodium chloride solution
D. solid potassiumtrioxonitrate(v)

20. One of the followings is not an example of an acid.
A. CH_3COOH
B. NaOH
C. H_2SO_4
D. HCl

21. Substances that taste bitter and turn red litmus paper blue are called
A. Bases
B. Acids
C. Salts
D. Indicators.

22. Which one of the four solutions, W, X, Y, Z with pH 4, 6,8,10 respectively is most acidic?
    A. Y.
    B. X.
    C. W.
    D. Z.

23. An example of a substance that undergo sublimation is_____
    A. Iodine crystal
    B. Sodium chloride crystal
    C. Copper (II) tetraoxosulphate (iv) crystals
    D. Silver Chloride crystals.

24. Acids that occur naturally in plants and animals are generally called
    A. Propanoic acids
    B. Mineral acids
    C. Organic acids
    D. Acetic acids.

25. All the following are examples of soluble bases except
    A. Potassium hydroxide
    B. Sodium Hydroxide
    C. Calcium Hydroxide
    D. magnesium hydroxide

26. A mixture is defined as _____
    A. a substance that contains two or more elements or compounds physically combined and can be separated by physical process.
    B. a substance that contains two or more elements and can be separated by chemical means.
    C. a substance neutrally bonded together.
    D. a substance that occurs naturally.

27. Which of the following is not a separating technique?
    A. Chromatography
    B. Filtration
    C. Radiation
    D. decantation

28. The different colours of the green chlorophyll in leaves can be separated by
    A. Decantation
    B. paper chromatography
    C. distillation
    D. crystallization

29. A mixture of mud and water can be separated by
    A. Decantation
    B. chromatography
    C. hand picking
    D. Magnetic separation
    E.

30. _____ method is used in salt making industries

A. Decantation
B. Evaporation
C. Chromatography
D. Separating funnel

31. Solutions in which the ph is less than 7 are_____

A. Acidic

B. Alkaline

C. Neutral

D. None of the above

32. _____ has ph value above 7

A. Acid

B. Base

C. Salt

D. None of the above

33. All the following are examples of base except _____

A. Potassium hydroxide

B. Sodium hydroxide

C. Calcium hydroxide

D. Zinc chloride

34. When sulphur (iv) oxide (SO_2) is bubbled into water

A. Sulphur trioxide is formed

B. Hydrogen sulphide is formed

C. Tetraoxosulphate (vi) acid is formed

D. Trioxosulphate (iv) acid is formed

35. One of the following is not an example of common acid base indicator

A. Methyl orange

B. Phenolphthalein

C. Litmus paper

D. Ethyl lead

36. A heterogeneous mixture can be defined as any mixture

A. Formed by mixture of solid and liquid

B. Of a solute and solvent

C. Whose composition is not uniform

D. Whose composition is uniform

37. The following acids are monobasic except. _____

A. Hydrochloric acid

B. Hydrofluoric acid

C. Trioxosulphate (iv) acid

D. Ethanoic acid

38. The basicity of an acid is defined as the _____

A. Number of replaceable hydrogen ion in one molecule of acid

B. Number of replaceable hydroxide ion in one molecule of a base

C. Number of replaceable hydroxonium ion in one molecule of a base

D. Number of non metallic ion in one molecule of a base

39. A soluble base is known as _____

A. An acid anhydride

B. A basic acid

C. An alkali

D. A basic salt

40. Which of the following statement is not true about acids?

A. Acid reacts with some metals to liberate hydrogen gas

B. Acid reacts with ammonium salt to generate ammonia gas

C. Acid reacts with trioxocarbonate (iv) to liberate carbon (iv) oxide

D. Acid reacts with bases and alkali to form salt and water only

MARKING SCHEME FOR CAT

1.	C
2.	D
3.	B
4.	C
5.	B
6.	D
7.	C
8.	D
9.	A
10.	C
11.	B
12.	C
13.	C
14.	A
15.	A
16.	B
17.	D
18.	C
19.	D
20.	B
21.	A
22.	C
23.	A
24.	C
25.	D
26.	A
27.	C
28.	B
29.	A
30.	B
31.	A
32.	C
33.	D
34.	A
35.	D
36.	C
37.	C
38.	A
39.	C
40.	B

APPENDIX B

TABLE OF SPECIFICATIONS FOR A FORTY ITEM TEST ON CAT (CHEMISTRY ACHIEVEMENT TEST)

Cognitive Level CONTENT.	Knowledge 40%	Comprehension 25%	Application 15%	Analysis 20%	Synthesis	Evaluation	TOTAL
Acids (32.5%)	12,15, 24,31,	17,20, 35, 37,	22.	11, 34, 38, 40	_	_	13
Bases (25%)	18,32,39	16, 21,25, 33	14	13, 19	_	_	10
Separation of mixture. 42.5 %	1, 2, 5, 6, 7, 10, 23, 30, 36	4, 8	3, 9, 28, 29	26, 27	_	_	17
Total. 100%	**16**	**10**	**6**	**8**	**_**	**_**	**40**

APPENDIX C

LESSON NOTE ON SMALL SCALE EXPERIMENT
Lesson for Week 1
Subject: Chemistry

Class: SS1

Topic: Acids

Duration: Double Period (80 mins)

Instructional objectives: At the end of the lesson,

The students should be able to:

i. define an acid
ii. give examples of acid
iii. identify an acid using the physical properties
iv. classify acids into organic and inorganic acids giving examples
v. state the uses of acids
vi. explain that solutions with pH less than 7 are acids and solutions with pH more than 7 are bases
vii. clarify that a solution with pH 7 is neither an acid nor a base but a neutral solution

Instructional Materials

Unripe oranges or guava, reduced number of litmus paper, vinegar, Acid solutions, water, a pH metre.

Previous knowledge: The students have tasted unripe oranges before:

Activity 1:

The teacher mentally engages the students by asking the following thought- provoking questions:

(i) How does an unripe orange taste?
(ii) What is the colour of blue litmus paper when dipped in acid solution and water respectively

(iii) What is the colour of the blue litmus paper in vinegar and water squeezed out from unripe oranges?

(iv) Does the unripe orange also contain acid?

(v) What will happen when you mistakenly touch your skin with oil from fresh cashew nut?

These questions will review the student's previous knowledge and also create interest and curiosity in them. The student will be given time to think about the problems.

ACTIVITY 2: The students will work in group of five. The students will be provided with the following materials to enable then carry out the experiment; litmus paper (blue and red), vinegar, water, dilute hydrochloric acid. The students will test the different solutions using small quantity of litmus papers and record their observations. The students will also be provided with the pH metre and they will use the indicator papers to check the degree of acidity of the different solutions. The students will discuss their observations with other students and ask questions where necessary. This activity phase will help the students to solve the identified problems.

ACTIVITY 3: In this stage, the teacher will call the students group by group to explain what they have done and observed. The students will use their own language to explain what they have learnt. The teacher will listen to the different group's explanations. The teacher will now explain that an acid is a substance which produces hydrogen ions when dissolved in water. Acid has the following physical characteristics:

- an acid solution turns blue litmus paper to red and has no effect on red litmus paper
- acid tastes sour
- concentrated acids are corrosive.

There are two classes of acids: organic acids occur naturally in plants and animals, examples are, fatty acid from fats and oil, lactic acid from milk, amino acid from protein, ascorbic acid from citrus fruits, etc. The acids prepared in the laboratory using mineral elements are called mineral or inorganic acids examples are: hydrochloric acid, trioxonitrate { v} acid, tetraoxosulphate {vi} acid.The teacher will explain that the PH is a measure of the acidity or alkalinity of solutions and substances' PH metres' range from 0-14 solutions in which the pH is less than 7 are acidic. Solutions in which the PH is greater than 7 are alkaline. A neutral solution has a pH value of 7. A neutral solution is one in which the concentrations of hydrogen ions and hydroxyl ions are equal.

The smaller the pH value the stronger the acid and the larger the pH value the stronger the alkali. The teacher will also explain the uses of acids.

Activity 4: here the students will expand and solidify their understanding of acid and generalize it to other new situations. The students will dilute the different solutions given to them and use the pH metre provided to determine the degree of acidity of the different solutions by matching the colour change with the indicators.

A**ctivity 5:** The teacher will evaluate the student's knowledge and/ or skills application of the new concepts and change in thinking by asking them the following questions:

What is an acid?

I. What are the classes of acids?

II. Mention 3 physical properties of acids?

III. Give 3 examples of organic acids and their uses

IV. Mention 3 inorganic acids and their uses

V. What is the name of the instrument used to measure the acidity/alkalinity of a solution.

Remarks

Correct answers to the above questions show that the students have mastered the concept of acids.

WEEK 2

Subject: **Chemistry**

Class: **SS1**

Topic **Bases/alkali**

Duration: **Double Period (80 mins)**

Instructional Objectives: At the end of the lesson the students should be able to:

(i) define a base and an alkali

(ii) identify bases and alkali using their physical properties

(iii) give examples of basic substances

(iv) explain neutralization reaction

Instructional Materials

Soaps, body lotion, reduced quantity of litmus paper, common salt, water, sodium hydroxide solution, dilute hydrochloric acid, laxative like mist magnesium trisilicate.

Previous knowledge

The students use soap daily for bathing and washing. They have been taught the pH scale.

ACTIVITY 1: The teacher will ask the following thought-provoking questions to review the students' previous knowledge and create interest in them;

VI. How do you feel when washing your hands with soap solution?

VII. What is a base/alkali

VIII. What is the colour of the litmus paper when dipped into a soapy solution?

IX. What are the characteristics of bases/alkali?

X. When a base and an acid react what are the products of the reaction?

XI. What is the name of this type of reaction mentioned above?

XII. Give examples of basic substances.

These questions will create curiosity in the students and help them to identify the problem of the study. The students will be allowed sometimes to think, plan on how to investigate the problem.

ACTIVITY 2: The students will work in group of 5 to explore the concept of bases/alkali. This is the problem solving stage. The students will discuss with their peers and carry out the investigations using the materials provided as follows:

i. The students will make a soapy solution and feel it with their hands.

ii. They will use litmus paper to check the physical characteristics of bases/alkali

iii. The students will mix the solution of base and dilute hydrochloric acid.

iv. The student will use litmus paper to check the state of the solution formed.

ACTIVITY 3: The students will use their own vocabulary to explain their understanding of bases/ alkali. The teacher will listen to each group's explanation and differentiates between bases and alkali as follows:

Soluble bases are called alkali

Solutions of bases turn red litmus paper blue.

ACTIVITY 4: The students will display their understanding of bases/ alkali. The students will mix dilute hydrochloric acid and sodium hydroxide solution. They will test the nature of solution produced with litmus paper. They will give examples of bases and their uses in their everyday life.

ACTIVITY 5:The teacher will evaluate the students with these questions:

(i) What is a base?

(ii) Differentiate between a base and an alkali

(iii) What are the physical properties of bases/ alkali

(iv) Give examples and uses of alkali

(v) What is the name of the reaction between an acid and a base?

Remarks

Correct answers to the above questions show that the students have mastered the concept of bases/or alkali.

WEEK 3

Subject: **Chemistry**

Class: **SS1**

Topic: **conductivity of base and acid solution**

Duration: **Double Period (80 mins.)**

Instructional objectives: At the end of the lesson, the students should be able to

(i) define electrolysis and electrolyte

(ii) give examples of electrolytes

(iii) demonstrate the conductivity of base and acid solutions

(iv) construct a simple electrolytic cell

(v) differentiate between electrolyte, conductors, and insulators

Instructional Materials

Empty beakers, reduced quantity of; distilled water, copper strip, zinc strip, 0-04mol [2mols] sodium hydroxide solution, dilute hydrochloric acid,0-054mol[2mols] calcium hydroxide solution, solid sodium chloride pieces of wires.

Previous knowledge:

The students have been taught acids in solution, alkali and they also know the three methods of heat transfer as condition, convention and radiation.

ACTIVITY 1: The teacher will engage the students mentally by asking the following questions:

i. What are the three ways heat can be transferred?
ii. Define conduction of heat
iii. What is a conductor? Give examples
iv. What is an electrolyte?
v. Give examples of electrolytes?

These questions will arouse the student's interest and access their prior knowledge.

ACTIVITY 2: The students will work in group of 5 to explore the concept of conductivity of a bases and acid solutions. The teacher will outline the following procedures to serve as guide to the students:

(1) Half fill a beaker with sodium hydroxide solution

(2) Connect two pieces of wire to copper and zinc stripes respectively

(3) The free ends of these wires will be connected to an ammeter

(4) Place the strips of copper and zinc in a breaker half filled with sodium hydroxide solution.

(5) Record the amount of current shown on the ammeter

(6) Place the strip of copper and zinc in a beaker of calcium hydroxide solution and record the amount of current shown on the ammeter

(7) Repeat the same procedure with dilute the same procedure with dilute hydrochloric acid and record the amount of current show on the ammeter

The students will be given time to investigate, organize and record collected information's.

ACTIVITY 3: The students will use their own language to explain their observations and understanding of electrolysis of bases and acid solutions. The teacher will listen to each group's answers to the posed questions. The teacher will explain that solutions such as bases, acids and salts can produce a flow of electrons through a wire. They are called electrolytes. The wires that allowed the flow of electrons through them are the conductors.

ACTIVITY 4: The students will extend their understanding of conductivity of acids and bases to salts and will discover that samples of salts like sodium chloride cannot conduct electricity in solid state except when dissolved in water. The student can explore other solutions in the laboratory and extend their understanding to other new situations. The students will use their understanding and give examples of electrolytes, conductors and insulators in their environment.

ACTIVITY 5: In this stage the teacher will evaluate the students by asking the following questions:

(i) What is electrolysis, an electrolyte?

(ii) Give two examples of electrolytes

(iii) Differentiate between conductor, electrolyte and insulator

(iv) Give reasons why solid sodium chloride cannot conduct electricity.

The teacher will observe student's knowledge or skill application of the new concept and a change in thinking.

Remarks

Correct answers to the questions will show that the students have learnt the concept taught

WEEK 4

Subject: Chemistry

Class: SS1

Topic: Separation of mixture

Duration: Double Period (80 mins.)

Instructional objective: At the end of the lesson, the students should be able to

i. define and give examples of mixtures
ii. list different methods of separating mixtures
iii. manipulate different apparatus for separating mixtures
iv. state the industrial application of the different methods listed
v. give examples of immiscible liquids and substances that can sublime
vi. list simple apparatus for separating a particular type of mixture

Instructional Materials

Sieve (few pieces), separating funnel (few), cotton wool (small quantity), filter pepper (few piece), evaporating dish, Bunsen burner, ethanol (deduced quantity), iodine crystal water (reduced quantity), small quantity of kerosene, small quantity of black ink, green leaves, mortar & pestle, dropper, beakers (few pieces) and small quantity of garri, sand, sand, muddy water, common salt (Nacl).

Previous knowledge

The students have learnt pure and impure substances in their junior class. They know that the green colouring pigment in leaves of on plant is called chlorophyll.

ACTIVITY 1: The teacher engages the students by asking them the following thought provoking questions:

i. What do you understand when a substance is said to be impure?
ii. Can an impure substance be made pure and how?

iii. What are the different methods of separating mixtures?

iv. How would you get salt from sea water?

v. Is it possible to get back your kerosene from water?

vi. What happens to camphor after sometimes you left it in your box of clothes?

vii. How would you get clean water from muddy water

viii. What are the different colours that are in the chlorophyll of green leaves?

The students will be given time to think about the problems.

ACTIVITY 2: The students will work in groups of 5 to explore the concept of separation of mixtures. The teacher will only direct the students outlining the steps as follows. Evaporation, separating funnel, sublimation, filtration, sieving and paper chromatography. The students will be given time to investigate the different methods. They will manipulate the materials provided and carry out the separation of the following mixtures

(i) Mixture of salt and water,

(ii) Mixture of water and kerosene

(iii) Mixture of iodine crystal and common salt

(iv) The extracts from green leaves

The students will record their observations and draw conclusion.

ACTIVITY 3: The students will use their own language to explain their understanding of the different separation techniques. The teacher will listen to each group's explanation and shares the understanding with them

(1) Evaporation method involves heating the mixtures to dryness so that the liquid portion with a lower vapour pressure than the solid is removed from the solid portion

(2) Filtration techniques which is used to remove solid impurities from a liquid or solution.

(3) Separating funnel method used to separate immiscible liquids of different densities

(4) Sieving method that separates solids of different sizes using a mesh

(5) Sublimation method used to separate solids that change directly to vapour when heated.

(6) Paper chromatography based on different rate of movement of substances over an adsorbent surface

ACTIVITY 4: The students will extend their understanding of the different methods of separation of mixtures to other new situations. They will discuss the applications of the different methods in daily life.

ACIVITY 5: The teacher will assess how much the students have understood the concepts by asking them the following questions:

(i) What is a mixture?
(ii) What are the different methods of separating mixtures
(iii) What method would you use to separate a mixture of palm oil from water
(iv) The paper chromatography method is used to separate what?
(v) What are the industrial applications of filtration, evaporation and sublimation method of separating
(vi) Give example of substances that can sublime

Remarks

Correct answers to the above questions show that the students have mastered the concept of separation of mixtures.

LESSON PLAN USING THE DEMONSTRATION METHOD

Lesson plan for week: 1

Subject: Chemistry

Class: SS1

Topic: Acids

Duration: Double Period (80 mins.)

Instructional objectives: At the end of the lesson,

The students should be able to:

viii. define an acid

ix. give examples of acid

x. identify an acid using the physical properties

xi. classify acids into organic and inorganic acids giving examples

xii. state the uses of acids

xiii. explain that solutions with pH less than 7 are acids and solutions with pH more than 7 are bases

xiv. clarify that a solution with pH 7 is neither an acid nor a base but a neutral solution

Instructional Materials

Unripe oranges or guava, litmus paper; vinegar, Acid solutions, water, a pH metre

Previous knowledge: The students have tasted unripe oranges before:

Activity

The teacher mentally engages the students by asking the following thought- provoking questions:

(vi) How does an unripe orange taste?

(vii) What is the colour of blue litmus paper when dipped in acid solution and water respectively

(viii) What is the colour of the blue litmus paper in vinegar and water squeezed out from unripe oranges?

(ix) Does the unripe orange also contain acid?

(x) What will happen when you mistakenly touch your skin with oil from fresh cashew nut?

These questions will review the student's previous knowledge and also create interest and curiosity in them. The student will be given time to think about the problems.

ACTIVITY 2: The teacher will show the students the following materials that will be used to demonstrate the experiment; litmus paper (blue and red), vinegar, water, dilute hydrochloric acid. The teacher will test the different solutions with litmus papers and record their observations. The teacher will also be provided use the pH metre as indicator papers to check the degree of acidity of the different solutions. The teacher will explain the observations to the students and ask questions where necessary. The teacher will now explain the observation of the experiment by stating that an acid is a substance which produces hydrogen ions when dissolved in water. Acid has the following physical characteristics:

- an acid solution turns blue litmus paper to red and has no effect on red litmus paper
- acid tastes sour
- concentrated acids are corrosive.

There are two classes of acids: organic acids occur naturally in plants and animals, examples are, fatty acid from fats and oil, lactic acid from milk, amino acid from protein, ascorbic acid from citrus fruits, etc. The acids prepared in the laboratory using mineral elements are called mineral or inorganic acids examples are: hydrochloric acid, trioxonitrate { v} acid, tetraoxosulphate {vi} acid. The teacher will explain that the PH is a measure of the acidity or alkalinity of solutions and substances' PH metres' range from 0-14 solutions in which the pH is less than 7 are acidic. Solutions in which the PH is greater than 7 are alkaline. A neutral solution has a pH value of 7. A neutral solution is one in which the concentrations of hydrogen ions and hydroxyl ions are equal. The smaller the pH value the stronger the acid and the larger the pH value the stronger the alkali. The teacher will also explain the uses of acids.

The teacher will dilute the different solutions provided and use the pH metre provided to determine the degree of acidity of the different solutions by matching the colour change with the indicators after which the teacher demonstrates it to the students with necessary explanation. The teacher after the demonstration and explanation asks students the following questions:

What is an acid?

VI. What are the classes of acids?
VII. Mention 3 physical properties of acids?
VIII. Give 3 examples of organic acids and their uses
IX. Mention 3 inorganic acids and their uses
X. What is the name of the instrument used to measure the acidity/alkalinity of a solution.

Remarks

Correct answers to the above questions show that the students have mastered the concept of acids.

WEEK 2

Subject: **Chemistry**

Class: **SS1**

Topic **Bases/alkali**

Duration: **Double Period (80 mins.)**

Instructional Objectives: At the end of the lesson the students should be able to:

(v) define a base and an alkali

(vi) identify bases and alkali using their physical properties

(vii) give examples of basic substances

(viii) explain neutralization reaction

Instructional Materials

Soaps, body lotion, litmus paper, common salt, water, sodium hydroxide solution, dilute hydrochloric acid, laxative like mist magnesium trisilicate.

Previous knowledge

The students use soap daily for bathing and washing. They have been taught the pH scale.

ACTIVITY 1: The teacher will ask the following thought-provoking questions to review the students' previous knowledge and create interest in them;

XI. How do you feel when washing your hands with soap solution?

XII. What is a base/alkali

XIII. What is the colour of the litmus paper when dipped into a soapy solution?

XIV. What are the characteristics of bases/alkali?

XV. When a base and an acid react what are the products of the reaction?

XVI. What is the name of this type of reaction mentioned above?

XVII. Give examples of basic substances

These questions will create curiosity in the students and help them to identify the problem of the study. The students will be allowed sometimes to think, plan on how to investigate the problem.

ACTIVITY 2: The teacher will demonstrate the following to the students:

How to make soapy solution and feel it with the hands, use litmus paper to check the physical characteristics of bases/alkali, mix the solution of base and dilute hydrochloric acid and use

litmus paper to check the state of the solution formed. The teacher will explain the meaning of bases/ alkali and differentiate between differentiates between bases and alkali as follows:

Soluble bases are called alkali

Solutions of bases turn red litmus paper blue. The students will be allowed to ask the teacher questions where necessary

The teacher will further demonstrate how to mix dilute hydrochloric acid and sodium hydroxide solution, test the nature of solution produced with litmus paper and give examples of bases and their uses in everyday life. The teacher will test the students understanding of the lesson by asking them the following questions:

(vi) What is a base?

(vii) Differentiate between a base and an alkali

(viii) What are the physical properties of bases/ alkali

(ix) Give examples and uses of alkali

(x) What is the name of the reaction between an acid and a base?

Remarks

Correct answers to the above questions show that the students have mastered the concept of bases/or alkali.

WEEK 3

Subject: **chemistry**

Class: **SS1**

Topic: **conductivity of base and acid solution**

Duration: **Double Period (80 mins.)**

Instructional objectives: At the end of the lesson, the students should be able to

1. define electrolysis and electrolyte
2. give examples of electrolytes
3. demonstrate the conductivity of base and acid solutions
4. construct a simple electrolytic cell
5. differentiate between electrolyte, conductors, and insulators

Instructional Materials

Empty beakers, distilled water, copper strip, zinc strip, 2mols sodium hydroxide solution, dilute hydrochloric acid, 2mols calcium hydroxide solution, solid sodium chloride pieces of wires.

Previous knowledge:

The students have been taught acids in solution, alkali and they also know the three methods of heat transfer as condition, convention and radiation.

ACTIVITY 1: The teacher will engage the students mentally by asking the following questions:

1. What are the three ways heat can be transferred?

2. Define conduction of heat

3. What is a conductor? Give examples

4. What is an electrolyte?

5. Give examples of electrolytes?

These questions will arouse the student's interest and access their prior knowledge.

ACTIVITY 2: the teacher explains the concept of conductivity of a base and acid solutions. The teacher will outline the following procedures to serve as guide to the demonstration of the activities:

1. Fill half a beaker with sodium hydroxide solution
2. Connect two pieces of wire to copper and zinc stripes respectively
3. The free ends of these wires will be connected to an ammeter

4. Place the strips of copper and zinc in a breaker half filled with sodium hydroxide solution.
5. Record the amount of current shown on the ammeter
6. Place the strip of copper and zinc in a beaker of calcium hydroxide solution and record the amount of current shown on the ammeter
7. Repeat the same procedure with dilute the same procedure with dilute hydrochloric acid and record the amount of current show on the ammeter

After this, the teacher will demonstrate the experiment, show the observations and explain electrolysis of bases and acid solutions. The teacher will ask students questions and listen to students' questions and answer. The teacher will explain that solutions such as bases, acids and salts can produce a flow of electrons through a wire. They are called electrolytes. The wires that allowed the flow of electrons through them are the conductors.

The teachers will demonstratively show students the conductivity of acids and bases to salts and will show them that samples of salts like sodium chloride cannot conduct electricity in solid state except when dissolved in water. The teacher gives examples of electrolytes, conductors and insulators in their environment.

The teacher will evaluate the students by asking the following questions:

(v) What is electrolysis, an electrolyte?

(vi) Give two examples of electrolytes

(vii) Differentiate between conductor, electrolyte and insulator

(viii) Give reasons why solid sodium chloride cannot conduct electricity.

The teacher will observe student's knowledge or skill application of the new concept and a change in thinking.

Remarks

Correct answers to the questions will show that the students have learnt the concept taught

WEEK 4

Subject: Chemistry
Class: SS1
Topic: Separation of Mixture
Duration: Double Period (80 mins.)
Instructional objective: At the end of the lesson, the students should be able to

1. define and give examples of mixtures
2. list different methods of separating mixtures
3. manipulate different apparatus for separating mixtures
4. state the industrial application of the different methods listed
5. give examples of immiscible liquids and substances that can sublime
6. list simple apparatus for separating a particular type of mixture

Instructional Materials

Sieve (few pieces), separating funnel (few), cotton wool (small quantity), filter pepper (few piece), evaporating dish, Bunsen burner, ethanol (deduced quantity), iodine crystal water (reduced quantity), small quantity of kerosene, small quantity of black ink, green leaves, mortar & pestle, dropper, beakers (few pieces) and small quantity of garri, sand, sand, muddy water, common salt (Nacl).

Previous knowledge

The students have learnt pure and impure substances in their junior class. They know that the green colouring pigment in leaves of on plant is called chlorophyll.

ACTIVITY 1: The teacher engages the students by asking them the following thought provoking questions:

1. What do you understand when a substance is said to be impure?
2. Can an impure substance be made pure and how?
3. What are the different methods of separating mixtures?
4. How would you get salt from sea water?
5. Is it possible to get back your kerosene from water?
6. What happens to camphor after sometimes you left it in your box of clothes?
7. How would you get clean water from muddy water
8. What are the different colours that are in the chlorophyll of green leaves?

The students will be given time to think about the problems.

ACTIVITY 2: the teacher explains the concept of separation of mixtures, Evaporation, separating funnel, sublimation, filtration, sieving and paper chromatography and demonstrate how each of them exists. The teacher will further demonstrate and show the students the different methods, by manipulating the materials provided and carry out the separation of the following mixtures

1. Mixture of salt and water,
2. Mixture of water and kerosene
3. Mixture of iodine crystal and common salt
4. The extracts from green leaves

The teacher will list and explain the following to the students:

1. Evaporation method involves heating the mixtures to dryness so that the liquid portion with a lower vapour pressure than the solid is removed from the solid portion
2. Filtration techniques which is used to remove solid impurities from a liquid or solution.
3. Separating funnel method used to separate immiscible liquids of different densities
4. Sieving method that separates solids of different sizes using a mesh
5. Sublimation method is used to separate solids that change directly to vapour when heated.
6. Paper chromatography based on different rate of movement of substances over an adsorbent surface

The teacher will discuss the applications of the different methods in daily life. Finally the teacher will assess how much the students have understood the concepts by asking them the following questions:

1. What is a mixture?
2. What are the different methods of separating mixtures
3. What method would you use to separate a mixture of palm oil from water
4. The paper chromatography method is used to separate what?
5. What are the industrial applications of filtration, evaporation and sublimation method of separating
6. Give example of substances that can sublime

Remarks

Correct answers to the above questions show that the students have mastered the concept of separation of mixtures.