IMPACT OF PROCESS APPROACH ON QUESTIONING PREFERENCE, ACADEMIC ACHIEVEMENT AND RETENTION SPAN AMONG CHEMISTRY STUDENTS IN ZARIA METROPOLIS, NIGERIA

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DECLARATION

I hereby declare that this dissertation entitled“Impact of ProcessApproach on Questioning Preference, Academic Achievement and Retention Span among Chemistry Students in Zaria Metropolis Nigeria”has been written by me and that it is a record of my own research work. It has not been presented in any previous application for higher degree. All quotation marks or indentation, and the sources of information are specifically acknowledged by means of references.

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CERTIFICATION

This dissertation entitled “Impact of ProcessApproach on Questioning Preference, Academic Achievement and Retention Span among Chemistry Student in Zaria Metropolis Nigeria” by David Sunday Ogenyi, meets the regulations governing the award of the degree of Doctor of Philosophy in Science Educationof Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to the Almighty God the fountain of knowledge who by His strange acts made this work a success through Jesus Christ, also to my wife Mrs. Christiana Ogenyi, and children Mary, David, Daniel, Victor and Fortula I love you all.

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LIST OF ABBREVIATIONS

SSS - Senior Secondary School

CAT - Chemistry Achievement Test

FRN - Federal Republic of Nigeria

WAEC- West African Examination Council

NECO - National Examination Council

HOCS - Higher Order Cognitive Skill

SPTA - Science Process Teaching Approach

LM - Lecture Method

OPERATIONAL DEFINITIONS OF TERMS

Cognitive Taxonomy - Refers to Bloom Taxonomy and the Revised taxonomy by Anderson and Krathwohl, (2001) both were universally accepted and also define two levels of cognitive processing low level and high level thinking, Aksela, (2005).

Low-Level Cognitive Questioning Styles Refer to questions that involve the two categories of the Cognitive Domain; knowledge and comprehension, it requires students to recall material easily from what they are taught. They include questions that can be answered with yes or no, a single word or a short phrase.

High-Level Cognitive Questioning Styles Refer to those questions that require students to mentally manipulate Information they have learned and to answer with reasoned evidence they involve the operational application of the other categories of the cognitive taxonomy; analysis, synthesis and evaluation.

Cognitive questioning Preference In this study, it implies a fundamental shift in the type of questions (relative to the type of thinking skills they stimulate) students would likely want to answer as a result of the quality of authentic scientific knowledge acquired resulting from the quality of instruction received.

Retention Span Is the ability of an individual to memorise and reproduce a given fact or concept after a given period.

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ABSTRACT

This study investigated the Impacts of Process Approach onQuestioning Preference, Academic Achievementand Retention Span among Chemistry students in Senior Secondary School (SS2). A sample of 78 students selected from two secondary schools inZaria Metropolis were used as the study sample from a population of 1,241 students from 10 schools. The two schools randomly selected, were found after matching them, to be equivalent academically. One of the schools served as control group and the other serve as the experimental group which was exposed to science process teaching approach while the control group was exposed to lecture based instruction. Topics taught are state of matter, change of state, and kinetic theory of matter, Gas laws, Acid-Base reactions and chemical reaction. The choice of these concepts is considered suitable because they are some of the difficult areas student failed in exams. A researcher-developed Chemistry Achievement Test (CAT) with a reliability coefficient of 0.73, was used to collect data for pretest, posttest and post-posttest (Extended test) used to test the four null hypothesis. The data collected were analyzed using t-test statistic, Analysis of Variance (ANOVA) and Scheffe's test at a significance level of $P \leq 0.05$. Results indicated that (i) the experimental group performed significantly better than the control group in their academic achievement after undergoing the experimental treatment of science process teaching approach (ii) the level of retention was significantly high for students taught using Science Process Teaching Approachwhen compared with thosetaught usingLecture Method (iii) Science Process Teaching Approach was found to be more effective in enhancing cognitive questioning preference of chemistry students at the senior secondary school level.Based on these findings, a number of recommendations were made; (1) there is a need for the improvement of the Chemistry conditions and practices existing in Nigerian schools through the use of SPTA(2) there is a need to employ science process based instruction in the senior secondary schools as a means to reduce academic failure and enhanceretention span among science students in the senior secondary schools and (3) there is also a need for training and retraining of science teachers towards effective use of Science Process Approach in the teaching of chemistry at SSS among others

CHAPTER ONE

THE PROBLEM

1.1 Introduction

Chemistry as one of the physical sciences deals with the nature of matter; its properties and its changes in different conditions. Chemistry according to Zohar (2004) should be studied to improve man's knowledge and enhance his understanding of his environment for his survival. The subject as shown by Ezeliora (2010) is at the core of every technology that is enjoyed today. According to Ezeliora, (2010) the power of chemical science creates as a whole an enabling infrastructure that delivers food, medicine and materials which are the hallmarks of modern life. Today its significance as a core subject in the study of medicine, several technologically based courses, pharmacy and engineering is indisputably important as stipulated in the National Policy on Education (FRN, 2008). Therefore, Chemistry education has a fundamental role to play in providing solution to several technological and socio-economic issues confronting man as well as improve scientific literacy (Neshitt-Hawes, 2005 & Ezeliora 2010).

Chemistry has also been perceived by students at the various level of the educational sector particularly in secondary school as very difficult to understand (Ezeliora 2003). Majority of the students perceived Chemistry as a body of isolated facts to be memorized, lacking relevance to reality which has led to lack of interest in it by students (Ezeliora 2003). For many students, Chemistry is first a classroom affair. Echodain Ezeliora (2010) revealed that very rarely do students know that the acid work in the Chemistry laboratory is found in the farm, at home and at play. This wrong perception of Chemistry by students has resulted in low entrance by students into Chemistry and Chemistry related courses both at the secondary school and tertiary level of studies, and of course performance has not been encouraging either (Zohar, 2004; Aksela, 2005 & Ezeliora 2010). Of the many factors responsible for

students attitude and low performance in Chemistry, there are a few that have not attracted much attention. One of this is the inability of the Chemistry teacher to design, determine and enhance students' cognitive questioning preference. This was attributed to the constant use of lecture method, which has continued to conceal this basic fact, by emphasizing rote learning (Zoller, 2001 & Zohar, 2004).

Effective Chemistry teaching involves student's active participation in the teaching-learning process, the none active participation of learners has been agreed by Okebukola, (2002); Zohar, (2004) and Usman, (2006), as one of the major factors responsible for poor academic performance in the sciences. Lamenting the poor performance in the science, the WAEC chief examiner in his report, 2005, 2006, 2007, 2008, 2009 and 2010as seen in Table 1.1

Table 1.1 Performance of Students in Chemistry at SSCE (WAEC) Level in Nigeria: 2005-2010

Period	Number of Students (Present)	Number of Students (Pass)	Number of Students (Fail)	% of Students (Pass)	% of Students (Fail)
2005	182659	39125	143534	21	79
2006	228953	80355	148598	35	65
2007	250099	86150	163949	34	66
2008	289520	84520	205000	29	71
2009	326541	98215	228326	30	60
2010	367562	120560	247002	33	67

Source: Ministry Of Education, Kaduna State: 2013

and in KadunaState where this study is carried out, the situation is not different as can be seen in Table 1.2 which indicated the performance of chemistry students from 2007to 2012,

Table1.2 Performance of Students in Chemistry at SSCE (WAEC) Level in Kaduna State: 2007-2012

Period	Number of Students (Present)	Number of Students (Pass)	Number of Students (Fail)	% of Students (Pass)	% of Students (Fail)
2007	4892	2348	2544	48	52
2008	5193	1766	3427	34	66
2009	5889	1826	4063	31	69
2010	5945	2378	3567	40	60
2011	6313	2336	3977	37	63
2012	6601	2112	4489	32	68

Source: Ministry Of Education, Kaduna State: 2013

The analysis show that students have problem with chemistry subject at SSCE and poor passing grades fluctuate within the years under considerationwas categorical in attributing it to the students' inability to attempt effectively questions that require high-level cognitive domain. The reasons for this poor performance by the students could not be unconnected with teachers teaching and students' questioning preference which are frequently at the low level of the cognitive domain of educational objectives as hierarchical arranged in the Bloom (1956) taxonomy of cognitive domain (i.e. knowledge, comprehension, application, analysis, synthesis and evaluation) (Iliya 2010).

Teacher's effectiveness according to Cotton (2001) in activating performance depends on his professional ability to arouse and sustain high cognitive processes by his questioning behaviour. The cognitive level of a question is relative to the nature of the process to answer it. Questioning styles are generally classified into two broad levels, low-level and high level cognitive questioning styles. Low-level questions are termed knowledge based questions that demands that students recall information, or facts previously taught for example a law or theory (Cotton, 2001). She further explained that low-level questions assist students to remember factual information, learnt for test, read or treated by a teacher. The questions are organized to elicit from students experiences already acquired previously and retained in the

memory; they actually consist of questions that demands a yes or no, a short phrase kind of answer. Sample verbs often employed are; list, identify, define, name, recite, state among others. According to Zohar (2004)andGandu (2006), low-level cognitive questions are often designed to assess student's ability to remember facts previously leant but lament that it does not challenge learner's ability to think.

High-level cognitive questions can accurately probe students thinking skills and conceptual understanding of Chemistry and assess student's ability to solve problems. Aksela, (2005) revealed that several forms of authentic high-level questioning styles are open-ended questions, concept maps, interviews, oral presentation, synthesis and evaluative questions that demand skills. Real problems can stimulate students to hypothesize, predict, conduct thought experiment, and generate explanations and can be made to develop students higher order cognitive skills capacity in Chemistry (Zoller, 2001). For example, open-ended response assists teachers to understand more clearly how students think, the prior knowledge of students and what understanding are gained during instruction. A high-level cognitive question task in Chemistry includes student's manipulation of some materials to produce a product-written, pictorial, kinesthetic, or a combination of modes that probes conceptual understanding (Carter & Berenson, 1997). The task can be open-ended or has a discrete answer. It is usually selected to assess performance in using the process skill (Anderson & Krathwohl, 2001). They also pointed out that terms such as apply, evaluate, analyze, predict, explain, among others are often used in designing high-level cognitive questions. The effective use of high-level questioning styles could not be achieved when teachers use conventional method for the purpose of covering the syllabus on time. The science process approach refers to an activity based teaching approach that engages the use of the mental processes and can be facilitated by the effective use of cognitive questions (high and low

level questions), hence it will be employed in this study to ascertain students' cognitive questioning preference.

The science process approach activates the teaching – learning process by its activities. Aksela (2005) explained that the method directly involves the students as active participants, thus enabling the students to take responsibility for their learning and to effectively construct their own knowledge. The strategy emphasizes, that the planning, teaching and assessment are focused on the needs and abilities of the learner. The learners are actively engaged in doing most of the works by using their hands and cognitive structure in the teaching and learning process. There is considerable research evidence (Ezeliora 2010) that if learners are active in the class, they learn more effectively and exhibit greater performance. Gandu, (2006) claimed that effective learning and performance are related positively to the nature of questions the students are exposed to and preferred to answer. The level of knowledge acquisition and mastery of skills is a function of the type of question students preferred and are exposed to while using the process approach. Students' response also formed the basis for assessing the quality of learning acquired and retention of materials learnt.

Retention is the ability to store and recall information or knowledge acquired from learning, (Bichi, 2002). It occurs when the learner is able to effectively retain in memory facts or materials learnt in schools. The correct coding of incoming information stimulates the appropriate index which may be consulted to that retention. Materials are correlated to quality of retention in relation to their correctness, familiarity, meaningfulness, concreteness and image evolving characteristic (Adeniyi, 1997). Studies also have revealed that improved instructional strategy such as the use of science process teaching approach could facilitate the retention of learned concept (Ajewole &Okebukola 1998 & Samba, 1998). They further reported that the instructional strategy, employed by the teacher could facilitate or inhibit the

retention of learned concepts. A study conducted by Zoller (2001) on the effect of science process approach on student's retention of scientific concepts analyzed according to academic performance revealed that high achievers were significantly better in retaining learned materials. Bichi (2002) found that student's achievement is a function of the quality of their retention. A major variable of significance to be determined is the retention ability of learners vis-à-vis their cognitive questioning preference. Several studies have been carried on retention ability of students for two weeks but the aspect of determining of retention span of 2,4.6, weeks of students using science process approach is relatively new which is the focus of this study.

1.1.1 Theoretical Framework.

Science-Process-Based Learning, deriving its theoretical underpinnings from the American Association for the Advancement of Science (AAAS)(1960) andBruner's (1960) educational philosophyand constructivist epistemological belief, that learning is an active process in which learners construct new ideas or concepts based upon their current/past knowledgeorganizedaround intellectual/cognitive skills needed to learn concepts and broad principles used in making valid inductive inferences. The learner selects and transforms information, constructs hypotheses, and makes decisions, relying on a cognitive structure to do so. Cognitive structure provides meaning and organization to experiences and allows the individual to "go beyond the information given". Bruner (1966) states that a theory of teaching 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.

Science process based learning typically starts with a concept, which serves as a driving question compelling students to learn about the central concepts and principles of a topic while engaging in producing the product. Its practice usually corresponds closely with what happens in the real world and require that students play authentic roles and perform meaningful tasks. To create a product, students are engaged in such cognitive processes as problem solving, decision making, designing, and product making. These processes help students transform information and construct their own knowledge and interpretation. Throughout the process, students are encouraged to take charge of their learning and become autonomous for their decisions. When they accomplish their assignments and acquired the design skills, students are often endowed with a great sense of achievement.

Piaget (1967) suggested that students acquire knowledge and form meaning based on their experiences which he termed 'equilibrium'. He described equilibrium of learning as consisting of two processes, Assimilation and Accommodation. By this two processes, students constructs new knowledge from their experiences he further stated. Assimilating causes an individual to integrate new perceptual motor or conceptual matter into existing schemata or patterns of behaviour (Mari, 2001) thus if a learner has similar experiences, he or she can assimilate easily (incorporate new experiences into old experiences). For accommodation Wadsworth (1996) explains, that when confronted with a new stimulus a learner tries to assimilate it into existing schemata sometimes this is not possible, so an individual can create a new schemata in which to place the stimulus or one can modify an existing schema so that the stimulus fits into it (that is reframing the world and new experiences into mental capacity already present).

Learning as perceived by Aikenhead, (2001) is an active 'construction process' and that learning is possible only on the basis of already acquired knowledge. There is therefore a significant shift by this approach from the teacher and his lecture to the student and their

learning. Instead of telling the learner what to do, the teacher should begin by asking relevant questions, instead of answering questions that only align with their curriculum; the students should be allowed to draw conclusions on their own based on experiences acquired from activities engaged in during studies. Thus logical and conceptual growth is enhanced by creating the learning experiences that is open to new directions, that challenge the learner by making them effective critical thinkers, to develop skills and confidence to analyze the world around them, create solutions or support for developing issues and then justify their words and actions through scientific processes (Zohar, 2004).

In the Science Process Approach the scientific skills are infact learning strategies that enable students to interact with the environment. For example if students learn about theories of rock formation, they should observe and make inferences about rocks. If they are to learn about the structure of the atom, they might construct models, and test hypotheses with regard to different theories (Zoller, 2004).

In view of this the processes of science are an integral part of the learning cycle proposed by cognitive science educators. That is when the teacher engages students in the "exploration" stage of the learning cycle to encounter a new science concept; the intent of the teacher is to have the students utilize the processes of science in order to explore objects, phenomena and events. Thus students would be involved in making observations and measurements, collecting and interpreting data, and making conclusions for the purpose of investigating a scientific object, event or phenomena. In other cases, students might design experiments to test the efficacy of a particular scientific theory(Anderson & Krathwohl, 2001; Pear, 2009 & Abdulhamid, 2010).The processes of science become tools for the students in order to understandthe concepts of science. In the cognitive perspective, science processes are the learning strategies for students to learn science concepts and improve on their cognitive questioning preference (Aksela, 2005).

Studies by Okebukola, (2002)andAbdulhamid, (2010) have shown that challenges' confronting the teaching and learning of science subjects in Nigerian schools is the use of the chalk and talk method of teaching where students are passive listeners with few recipe of experiments. Susan (2001) and Aksela (2005) lament that this approach most often cater for lower order students' cognitive questioning preference, which place demands on the use of knowledge and comprehension in the Bloom cognitive hierarchy that require mere recall, use of pen and paper to respond to test items, rather than higher order cognitive level resulting in capacity building in retention, thinking skills and improve academic performance by the learner, (Jakomanyo & Masai, 2006 & Abdullhamid, 2010).

1.2 Statement of the Problem

Teachers employmethods that enable them cover their syllabuses, in most cases not paying attention to the students, especially in terms of ability of the students. Over the years, performances of students in chemistry have been reported by Abdulhamid, (2010) to be very poor. According to them the high rate of failure in chemistry is most disturbing. Also Zohar (2004) acknowledged that there is general poor performance in the science particularly in chemistry. Anderson and Krathwohl, (2001) and Aksela (2005) revealed a significant high rate of failure in chemistry, reasons given to explain the situation is the method of teaching employed by the teachers which always neglect the learners. Felder and Brent (2005) and Usman (2006), showed that the prevailing method used by most teachers in Nigerian schools is the lecture method. According to them, this method does not allow active participation by the student in the lessons and this leads to memorization and regurgitation of facts and concepts by students without the basic understanding of these concepts.

WAEC chief examiners' report (2010) attributed student's poor performance in Chemistry to methodology and the inability of students to attempt all levels of cognitive questions

effectively. Gandu (2006) and Iliya (2010) in their separate studies indicated poor students' performance in the sciences, attributing it to the low level cognitive questions the students' are exposed to and preferred to attempt during lessons and assessment. Cotton (2001) and Susan (2001) revealed that teachers spend most of their time asking low-level Cognitive question. The authors alsoargue that these questions focus on factual information that can be memorized for example (which gas aids combustion?). It is believed that this type of questions can limit students by not assisting them to acquire a conceptual understanding of the subject matter of chemistry.

The quality of learning and experience acquired and retained by the students can be determined by the range of cognitive questions the teacher designs and employ in the teaching – learning process. Anderson and Krathwohl (2001) revealed that the quality of teacher made assessment is positively correlated to students' performance in Chemistry. Cotton (2001) and Gandu (2006) insist that cognitive level of any set of questions is a significant variable in learner's academic achievement. If therefore, the issue of using high-level and low-level cognitive questions is not addressed the poor academic performance of Senior Secondary Students in WASSCE will still persist because WAEC sets their questions based on Bloom's taxonomy of Cognitive domain(WAEC Chief Examiner Report, 2010).

Hence if the students Cognitive questioning preference did not take consideration of all the levels or hierarchy of Bloom's taxonomy in the cognitive domain it can probably affect their academic achievement. Also the constant use of lecture method in other to covers syllabus on time will not allow students appreciate the effectiveness of high-level cognitive questions. Thisis because the use of lecture method in chemistry doesnot enhance acquisition of scientific knowledge or the effective learning of scientific concepts, attitude development and cognitive skills acquisition such as perception,conception**,** memory and creativity, fostered by the availability, richness and the use made of various learning materials through a

repertoireof teaching strategies in the classroom by the teacher, (Brekke,2005). Felder and Brent (2005) claimed that unless deliberate attempt is made to foster the skills through the skillful use of appropriate instructional method, academic failure is inevitable because to him, these cognitive skills underlie all academic learning. Instructional method therefore becomes an imperative and an important tool by which knowledge is dispensed, since learning outcome depends largely on it. Science Process teaching method has been shown to improve the performance of students (Brekke 2005, Lowenstein 2003 & Sizer 2003). Most of the researches on science process teaching methods are on academic achievement and on questioningstyles; no attention has been given to Cognitive questioning preference and retentionamong chemistry students in the class employing the science process teaching approach hence the present study was designed to investigate the Impact of the Process Teaching Approach on cognitive questioning preference academic achievement and retention span among chemistry students in the senior secondary school.

1.3 Objectives of the Study

The objectives of this study are to:

1. examine the Impact of Science Process Approach on cognitive questioning preference among chemistry students' at Senior Secondary School.
2. investigate the Impact of Science Process Approach on academic achievement among chemistry students' at Senior Secondary School.
3. determine the retention span of senior secondary school chemistry students at 2,4.and 6weeks duration after exposure to Science Process Approach.

1.4 Research Questions

This study sought to answer the following research questions:

1. What is the difference between the mean academic score of chemistry students taught using Science Process Approachare compared to those taught using Lecture method?

2.What is the difference between the mean cognitive questioning preference scores among senior secondary school students exposed to Science Process Teaching Approach andthose taught using Lecture method?

3.What is the differencebetween the retention ability of senior secondary school chemistry students taught using Science Process Approach when compared with those taught with Lecturemethod?

4.What is the differencebetween the retention spanof senior secondary schoolchemistry students taught using Science Process Approach when compared with those exposed to Lecture Methodat different duration?

1.5 Null Hypotheses

The following null hypotheses were formulated for testing at $P \leq 0.05$:

Ho1. There is no significant difference between the mean academic achievement of chemistry students exposed to science process teaching approach and those taught using lecture method.

Ho2. There is no significant difference between the mean score in cognitive questioning preference among chemistry students exposed to science process teaching approach and those taught with lecture method.

Ho3. There is no significant difference between the mean score in retention ability among chemistry students exposed to science process teaching approach and lecture method.

Ho4. There is no significant difference in the mean score on retention span among senior secondary school chemistry students exposedto science process approach and those taught using lecture method when subjected to an extended retention test period of 2,4 and 6 weeks.

1.6**Significance of the Study**

The findings from this study will hopefully enable the science teacher/educator recognize the uniqueness of each student learner, so that he can modify his teaching strategy to improve their cognitive processes, and contribute to the upliftment of the standard of science education in Nigerian secondary schools in the following ways. The study would hopefully:

- assist students to interact intimately with the subject matter of Chemistry through participating in productive higher cognitive processes.
- be useful and relevant to fellow researchers in the education sector who seek to improve performance among students of all categories, to push forward the frontier of knowledge on issue relating to science education and in policy formulations. Also to add new information to the existing literature.
- be beneficial to education planners and curriculum designers will benefit from the findings of this study through knowledge, that there is a significant move away from traditional method to an interactive nature of experiment and theory in chemistry hence will redefined the curriculum in sequences of potential experiences that emphasizes direct students interaction and involvement in the teaching-learning process.
- it would assist science education teachers in the use of science process teaching strategy and enhancing their cognitive questioning preference.

1.7 Scope of the Study.

This study was delimited to senior secondarychemistry students in the Zaria metropolis, Kaduna State.The study sample was delimited to SS.2 Chemistry students because the concepts selected for teaching is in the SS.2 syllabus.The topics include state of matter, change of state, and kinetic theory of matter, Gas laws, Acid-Base reactions and chemical reaction. The choice of these concepts is considered suitable because they are some of the difficult areas student failed as reported by WAEC Chief Examiner (WAEC, 2010).

1.8 Basic Assumptions

The following basic assumptions were made for this study:

1. Different individuals have different cognitive questioning preference and that they can be improved through instructional strategies.
2. The students in the school are exposed to similar educational programme obtained from the state education school syllabus.
3. The schools are exposed to equal academic environment in terms of provision of classroom, science instructional materials, equipment, among others.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

An attempt is made in this chapter to critically examine literature related to this research in Nigeria and other parts of the world in general. The discussions is organized and outlined around the following sub-headings.

- Nature and Teaching Chemistry in Senior Secondary School
- Method of Teaching Science
- Science Process Approach
- Psychological Basis for Science Process Teaching Approach
- The Concept of Cognitive Taxonomy
- Cognitive Skills
- High level Cognitive Skills
- Low level Cognitive Skills
- Questioning and using Cognitive structures.
- Cognitive Questioning Preference
- Instructional Strategy and Academic Performances in Chemistry
- Instructional Strategy and Retention Ability in Science
- Retention Span and Academic Achievement
- Overview of Similar Studies.
- Implications of Literature Reviewed on the Present Study.

2.2Nature and Teaching Chemistry at Senior Secondary School.

Chemistry like all sciences subjects is dynamic and activity oriented as it involves manipulation of equipment, through a series of activities to determine results and draw

conclusion or predict situations, the teaching of skills therefore is necessary for the acquisition of scientific knowledge. Aikenhead, (2005) affirmed that chemistry as a subject is characterized by a moving frontier and a vast array of knowledge. Young learners he said should be taught how to acquire those skills and imbibe those abilities which predisposes them to taking responsibilities for expansion of their own learning, they will then become self reliant and independent as they can easily apply the learned tools in new situations. There are however, many challenges in chemistry teaching. Emphasis in chemistry teaching primarily remain didactic, as it is practiced, has often focused on facts, vocabulary, definitions, algorithms, and basic skills, rather than on higher-order thinking through practical work or inquiry within authentic investigations (Aksela, 2005). Chemistry learning too often occurs by rote learning of factual knowledge using lecture method and avoiding the use of instructional method that provides students first-hand experience and opportunity to solve problems (Aikenhead, 2005).

Teaching has often focused more on transmission of information than on knowledge construction in small groups (Zohar, 2004). Halkka (2001) in Aksela (2005) lamented that practical activities are often "cookbooks" in nature, placing little emphasis on thinking about chemistry principles. Most activities found in laboratory manuals require students to operate with lower level cognitive skills rather than with higher level cognitive skills (Brekke, (2005). Students are often not allowed enough time for "deep processing" of information during their practical work, due to time constrains. Also, students often do not want to think for themselves they just want to know the right answer (Lawson, 2002). There is often a lack of necessary inquiry skills, i.e science process skills, (Halkka, 2003). Learners are almost always exposed to low level cognitive questions in the classroom resulting in poor performance and lack of interest in studying chemistry by students (Osborne, 2003 & Aksela, 2005).

The scientific approaches that take into account also chemistry teachers' needs regarding chemistry teaching as implemented in this study is needed to create a rich learning environment that can support secondary-level chemistry students' meaningful learning and higher level cognitive skills(Aksela, 2005). The effectiveness of the science process approach depends much on teachers' understanding of how to use them to achieve the desired educational goals in the teaching-learning process (Mari, 2001). This approach enable acquisition of intellectual and manipulative skills which are relevant since it affords learners the opportunity to discover for themselves valid scientific fact, derives relationship from theory and develop, scientific attitudes needful for academic and everyday life, especially in reporting accurately what is observed, data collected, interpret result and make inferences. According to (Mari 2001) the strength of this approach lies in the fact that it is relatively safe and often inexpensive as a few material may be needed, permits proficiency, empower skills, scientific attitude and team spirit. Here the learner will fill a sense of belonging, what hitherto was impossible seemingly was done with relative easy under guidance and direct involvement of the learner, the i-can't-do-it syndrome is inhibited, eliminating failure orientation with which the learner is familiar thus, facilitate learning by seeing and personal involvement. This makes the method student centered.

Science process approach is aesthetic as it sustains interest because of the intrinsic activities as opined by Lowenstein,(2002)that good and successful learning is founded upon its intrinsic activities and is given in consideration of the individual to be educated. The method because of its intrinsic values, it is activity oriented and do directly involve and accommodate the basic intellectual limitation of the learner. It does not involve deep and laborious thinking to carry out (Lowenstein 2002). Hence consider suitable for teaching and learning of chemistry concepts, afterall, practice makes perfect.

Nevertheless students are likely to be left out if it is restricted to the teacher alone or only limited participation may be achieved as often experienced in the lecture method which is used as a control in this study.

2.3 Methods of Teaching Science

There is no single method of teaching science that is absolute in meeting the learning needs of every individual learner in the classroom. According to Maduabum (1984) all teaching strategies have their limitations and strength, however Felder and Brent (2005) assert that a more balance approach that attempts to accommodate the diverse needs of the students in a class and allow for optimum learning is by the direct involvement of students in the teaching – learning process. They further stated that this approach is scientific and conform to the tenets of acquisition of knowledge by doing or direct participation by learners.Thus these learner–centeredapproaches employ the processes of science in gathering, transforming, and interpreting data, which according to Brekke (2005) is a major objective of teaching chemistry in the secondary school.

Chemistry according to Zollar, (2001),is the study of the nature and properties of all forms of matter. The substances which make up the environment and the different changes which such substances undergo under various conditions. It is essentially an experimental science, which is characterized by an array of activities involving body of facts through several processes to arrive at theories and their relationship. It is therefore important that chemistry is learnt, by acquiring specialized skills, competencies and attitudes, which is often tasking but needful for academic excellence and independence. These processes include:

i. Observing
ii. Ability to report accurately what is observed
iii. Organizing and recording of observed information

iv. Draw generalizations and testing them

v. Design experiments to check prediction

vi. Using models to explain phenomena

vii. Ability to sustain inquiry activity on collection of new data (falsification and verification procedures).

According to Anderson & Krathwohl (2001) at either stage of this processes, the student is involved actively in discussion and decision making, that way, they will gradually learn to think clearly, logically, critically and infact independently. Instructional strategy that encourage this central element in scientific entrepreneur as seen in chemistry should be consciously preserved and presented to the learners as they are guided to discover for themselves those facts and acquire those scientific attitudes.

Nevertheless, the teacher is responsible for guiding the teaching-learning process even though it is apparent that students learn in different ways, the experience in the classroom confirms this everyday. In addition, well accepted theories and extensive research illustrate and document learning differences as seen in Tobias (1990) and Okebukola, (2002); Zohar, (2004) and Usman, (2006). They also believe that learners bring their own individual approach, talents and interests to the learning situation, and that individual learners' environment, family background and socio-economic level affect his or her learning. Therefore the choice of appropriate teaching method is imperative to not only advance the frontier of knowledge but achievement in chemistry. Teachers should be able to cater for the existing variation among the students in the classroom. That way effective dispensation of learning will be enhanced. There are different types of such techniques viz:

- Science Process Teaching Approach
- Lecture or talk-and-chalk Methods
- Demonstration Method

- Discovery Method
- Conceptual Approach
- Discussion Method
- Laboratory Activity Method
- Enquiring Approach
- Project Method
- Practical Method
- Field Trip/Excursion Approach
- Problem-Solving and others

Zohar, (2004) cautioned that though other techniques for teaching chemistry and indeed sciences exist, but the effectiveness of any techniques depends on its unique features and on factors such as societal needs as evident in the school curriculum, the structure and nature of the subject/educational field and the domain (affective, psychomotor and cognitive) and teacher characteristics, such as motivation and the choice of materials. Also it is accepted by Felder (1993) and Bottom (2004) that while achieving some of the objectives of whole class activities, small group work panel discussions, socio-drama, small group discussion) helps meet the varying abilities, interests and needs of the total class. In this study the science process teaching approach will be employed to ascertaining its impact on students cognitive questioning preference, academic achievement and retention span oflearners in chemistry.

2.3.1 Understanding Chemistry

Meaningful learning is said to take place when students not only remember, but are able to make sense of and are able to apply, what they have learned effectively in new situation (Bransford, Brown, Anderson & Krathwohl, 2001, & Cocking 2000). Aksela (2005) revealed that the ability to transfer/apply knowledge to impact on a new situation (transfer of learning)

is affected by the degree to which students learn chemistry through understanding. Building understanding in chemistry requires students to move among three domains of thought (macroscopic, microscopic, and symbolic) in chemistry to make sense of what they learn. "Making sense" as shown by Anderson & Krathwohl, (2001) involves activation of mental models as well as high-level thinking. Thus, higher-level thinking processes are ways that students process information, apply knowledge, change preferences (as a result of improved experiences from instruction) and construct meaning. Therefore, students with good higher thinking skill could be more successful in chemistry (Anderson & Krathwohl, 2001).

Meaningful learning also takes place as observed by Minzes, Wandersee and Novak (2000) when students are able to relate new concepts and propositions to relevant existing concepts and propositions in their cognitive structure. Meaningful learning is knowledge construction, in which students seek to "make sense" of their experiences. Meaningful learning occurs gradually over time. It is an active, constructive, and cumulative process (Shuell, (1990) in Aksela 2005). Jonassen (1999), propose that learning will be only meaningful if learning is active (manipulative), constructive and reflective, intentional (goal-directed), authentic (complex and contextual), and cooperative (collaborative and conversational). He further show that learning is meaningful only if better understood, and more likely to transfer to new situations when it occurs by engaging in real-life, complex problems. For Zohar, (2004) students who do not possess a meaningful learning orientation memorize facts and that the major limitations of rote learning are poor retention and retrieval of new ideas, potential interference in subsequent learning of related concepts, and inability to transfer the new knowledge to new situation and solve problems. Success in meaningful learning according to Ausubel, Novak and Hanesian, (1978)depends on three factors: (a) a meaningful learning set, (b) relevant concepts to anchor the new ideas, and (c) inherent meaningfulness of the new concepts. If one or more of these requirements are not met, then

rote learning ensues. In this therefore, the science process approach will be employed to determine its effect on students' academic performance, cognitive questioning preference and retention span.

Knowledge-construction by students for meaningful learning as stated by Bybee, (2004) is a challenging process which is, actually stimulated by student-centered activities involving a mental effort or activity. Mari (2001), Usman (2000) and Aksela (2005) reported that prior knowledge is central in knowledge-construction processes and that students build their scientific understanding in chemistry upon what they already know and believe. They all agree that students construct new knowledge by modifying and refining their current concepts in chemistry and adding new concepts to previous ones. Aksela (2005) concede that students interpret data based on their expectations and experiences accordingly students who are lacking a theoretical framework in chemistry will not know where to look, or how to look, to make observations appropriate to the task, or how to interpret what they see in practical work. But that the students only 'see' often what they are expected to "see". Bransford, Brown, and Cocking, (2000) and Lakpini (2006) revealed that students' preconceptions and misconceptions which are idiosyncratic may interfere with their ability to learn new things and to "make sense" of everyday and formal school-based knowledge in their knowledge construction. Effective learning therefore requires that students take control of their own learning through reflection, self-assessment and improve on their question answering ability (Brandsford, Brown & Cocking, 2000).Also Anderson & Krathwohl (2001) in Aksela (2005) acknowledge the role of social experiences in knowledge construction and its development, they agree that student learning can be facilitated by others and that student-student and student-teacher interactions within the school setup are necessary for meaningful learning.

A major barrier to students connecting knowledge in chemistry is the limited space in short-memory and frequent complexity of specified laboratory procedures (Baddeley, 2006).

The working memory is often overloaded with incoming data through practical work such as names of apparatus and materials, written instructions, theory to be recalled, new skills, and verbal instructions. Student information processing in chemistry can be presented by a model of Goldstein, (2010): New information enters student's working memory, having a limited space, and interacts with information stored in long-term memory, and transforms it into long-term memory where it is permanently stored. For example, by using visual information processing in a laboratory manual helps students gain significantly higher scores on performance measures and psychomotor skills, and also stimulates them to develop more favourable attitudes toward laboratory activities and hence improve their higher cognitive processes which translate into higher skills in solving complex life and academic problems in the classroom as well as making rational choices or preferences (Aksela 2005).

Conceptual change or mental modeling, as reported by Nersessian, (1992) occurs usually in meaningful learning, in line with this, Posner, Strike, Hewson and Gertzog, (1982) presented four prerequisites for conceptual change model:

a) Students must experience dissatisfaction with their current conceptions, because of its inability to solve an existing problem.
b) Students must develop an alternative understanding of the concept, i.e. it should be intelligible.
c) The new concept must be plausible, adequate to solve the current problem and;
d) Students must see the concept as fruitful or useful in several different situations.

Learning of key concepts and principles as they further reported is, however, often difficult, because there can be resistance to conceptual change due to everyday experiences, possible biological predispositions, and the complexity of the learning task. The student's conception may therefore be completely extinguished and replaced by a new idea depending on the status of the alternative concept held by the learner. In fact, new and old concepts can

persist side by side for prolonged periods (Zohar, 2004). Student motivation, learning strategies, and students' epistemological beliefs or teachers' characteristics can influence on students' meaningful learning and so academic performance. According to Zoller (2001), meta-conceptual awareness is a necessary component in the process of conceptual change (Johnstone, Sleet & Vianna, 1994; Gabel, 1998).

Aksela (2005) reported that various pedagogical models facilitate meaningful chemistry learning Gabel, (1998)and Torn, (2004) agree that there is, however, no one effective teaching model (strategy) that leads to conceptual understanding, but rather the linking together of Pedagogical models in an appropriate fashion. The use of graphic organizers, small groups, discourse, and technology, for example, can facilitate meaningful learning (Mintzes & Wandersee, 1998). Science process approach can be valuable during the conceptual change process. Such interaction can clarify the concepts and processes of chemistry and help students to understand the content of chemistry thereby facilitating meaningful chemistry learning.This study intends therefore to facilitate active participation of the subjects in the learning process by providing the condition that allows students take responsibility for their study by their cognitive questioning preference and retention of Chemistry concepts, employing the Science Process Teaching Approach.

2.4Science Process Teaching Approach

According to Yockey(2001), learning science and teaching students about science means more than just scientific knowledge. He also claimed that the science process skills form the bases for the science process approach and that there are three dimensions of science that are very important. The first of these is the content of science, the basic concepts, and our scientific knowledge. To Yockey (2001), this is the dimension of science that most people first think about, and it is certainly very important he stated.

The second dimensions of science in addition to science knowledge are processes of doing science and scientific attitudes that actually facilitate achievements. The processes of doing science are the science process skills that scientists employ in scientific investigation. Because science is about asking questions and finding answers to questions, these are actually the same skills that are used daily to fathom everyday questions. So, when students are taught to use these skills in science, they are also being taught these skills to enhance/improve their quality of performance and for use in the future in every area of their lives, (Yockey, 2001).

The third dimension focuses on the characteristic attitudes and dispositions of science. These include such things as being curious and imaginative, as well as being enthusiastic about asking questions and solving problems. Another desirable scientific attitude is a respect for the methods andvalues of science. These scientific methods and values include seeking to answer questions using some kind of evidence, recognizing the importance of rechecking data, and an understanding that scientific knowledge and theories change over time as more information is gathered (Baxter & Kurtz, 2001& Yockey, 2001).

The American Association for the Advancement of Science (AAAS)advocated a list of the thirteen science processes which are best thought of as a set of intellectual skills that are associated with acquiring cogent and reliable information about nature.The first eight processes viz; observation, measurement, classification, quantification, inferring, predicting, relationship and communication are called "basic processes" and are appropriate for children in the primary levels (Jinks, 1997). These basic skills as shown by Jinks, (1997) are integrated together when scientists design and carry out experiments or in everyday life when we all carry out fair testexperiments. All the eight basic skills are important individually as well as when they are integrated together. The eight basic skills can be put in a logical order of increasing sophistication, although even the youngest students will use all of the skills alongside one another at various times. In the earliest grades students will spend a larger

amount of time using skills such as observation and communication. As students get older they will start to spend more time using the skills of inference and prediction. Classification and measurement tend to be used across the grade levels more evenly, partly because there are different ways to do classifying, in increasingly complex ways, and because methods and systems of measuring must also be introduced to children gradually over time. Integrating the basic science process skills together and gradually developing abilities to design fair tests is increasingly emphasized in successive grade levels, and is an expectation of students in the secondary school level (Checkovich& Sterling, 2001).

The last five are called "integrated processes" and are more appropriate for students at the secondary schools level and above, and since they are the focus of this study.Each of the five processes is defined. In addition, comment about the inherent nature of each of the skills is stated.

1.Interpreting Data

This process refers to the intrinsic ability to recognize patterns and associations within bodies of data. Obviously there is a direct contribution of the previous process, communication, to interpreting data. The better the data is represented the more likely one will detect associations within the data.

Interpretation probably requires creative thinking that results in the invention of conceptual umbrellas that can encompass the data, (Yockey 2001).

2. Controlling Variables

This process is also a kind of group process because one may engage in several different behaviours in an attempt to control variables. In general, this skill is any attempt to isolate a single influent of a system so that its role can be inferred. The process is an attempt to achieve a circumstance or condition in which the impact of one variable is clearly exposed. The use of experimental and control circumstances, standardizing procedures and repeated measures are only a few of the ways in which variables might be controlled.

Understanding the nature of the skill requires analytical thinking in which the system under study can be reduced to a set of interacting components. The next step is to establish some circumstance that allows the scientist to observe one component in isolation.

3. Operational Definitions

An operational definition is one that is made in measurable or observable terms. An operational definition should not require interpretation of meaning nor is it relative. The meaning of the defined term must be explicit and limited to the parameters established for the definition.

An operational definition is primarily a research tool and related to the concern for controlling variables. The major function of operational definitions is to establish the parameters of an investigation or conclusion in an attempt to gain a higher degree of objectivity (Jinks, 1997).

Consider this example. An investigator suggests that by applying some treatment a class of students will improve in performance. The problem here lies with the word performance. What does it mean? And, more to the point, what does the investigator mean with the word? In order to evaluate the treatment performance must be defined in appropriate termsand very explicitly perhaps, in this case, defining performance as a score on an achievement test makes

sense. Such a definition (performance score) would be an excellent example of an operational definition.

In terms of the nature of the skill, we are again dealing with analytical issues. An individual who is skillful at making operational definitions is one who can engage in reductionist thinking that defines phenomena as a collection of components which interact.

4. Hypothesizing

Hypothesizing is, again, an intrinsic and creative mental process rather than a more straight forward and obvious behaviour. Consequently, developing this ability is probably less a product of linear training but more a function of intuitive thinking that emerges from experience.

To Baxter and Kurtz, (2001)hypothesis is a response, or potential solution, to a specific research question, or problem. For our purposes we will insist upon a rather rigid use of the term and will restrict it to the second step in the classical scientific algorithm as outlined in the next process.

The kind of hypothesis one produces is also heavily dependent upon one's world view. For instance consider the individual whose world view is based upon superstition and supernatural beliefs. This person is likely to develop hypotheses in line with the belief in response to questions, so for such persons a disaster become a function of angered gods and good times result from happier gods. The consequence of western science has been to replace the supernatural worldview with one steeped in the physics of Newton and the philosophy of Descartes. This has lead to an industrial age cosmology characterized by cause and effect and the separateness of the observed from the observer. Therefore current explanations (or hypotheses) are more likely to take the form of a causal chain forged link by link by observations which seem to lead inevitably to a conclusion(Rezba, 1999).

The nature of the skill is to recognize that objectively gathered observations are justified into an explanation as a result of having an operational cosmology, or worldview. Secondly, a good hypothesizer recognizes that explanations are inventions rather than discoveries and subject to rejection based upon facts. Beyond this no one is really sure how hypotheses are actually generated. No one really knows what goes on in the mind that results in the hypothesis but it seems reasonable to suspect that information, perceptions, and ideas are being combined and recombined until a particular combination seems to make sense, (Baxter & Kurtz, 2001).

5. **Experimenting**

This process is a systematic approach to solving a problem. Usually experimenting is synonymous with the algorithm called scientific method which follows these five basic steps:

PROBLEM---->HYPOTHESIS---->PREDICTIONS---->TEST OF PREDICTIONS---->EVALUATION OF HYPOTHESIS

In experimentation each step emerges from the previous one. The purpose of the process is to judge the extent to which a hypothesis might be true and to set a standard whereby that judgment is made. Consequently, scientists tend to think in terms of probabilities of truth rather than absolute correctness.

As a term, experimenting is frequently used in a much broader way than described here. It is not unusual to hear teachers applying the term to any activity or demonstration but, strictly speaking, experimentation should be reserved for the process of systematically evaluating hypotheses(Rezba, 1999). The science processes approach was used as a treatment in this study to ascertain its impact on students' academic performance, retention span and cognitive questioning preference in chemistry

2.4.1 Lecture Method

In this method, students are mainly passive recipients of knowledge as dispensed by the teacher, few questions are asked and notes are taken as the teacher as a repository of knowledge does most of the talking. It is teachers dominated approach to teaching, often termed a dyadic method or chalk and talk approach, (Maduabum 1984 & Mukherjee, 2002). Hence the students are passive listeners and give the impression that the teacher has monopoly of knowledge according to (Felder & Brent 2005). It does not cater for individual learners needs; it may be suitable for the fast or high ability learners but does not cater for every learner in the classroom. Besides there is objections by science educators to the use of this method in the secondary school level especially in the science which require the use of instructional aids to enable relate facts, after all, they are not trained to follow chains of reasoning (Aikenhead, 2002 & Brekke, 2005). This method is unacceptable for learners at the secondary school level who may find abstract thinking not only Laborious but objectionable as they will not be able to relates facts adequately and will certainly be left out of the lesson.

Aikenhead (2005) pointed out that this method is convenient in the University and other institutions of higher learning for impacting knowledge/information. There is however strong objection to its use in its pure form at any level, as it is not adequate for teaching certain concepts in chemistry and indeed other science, attitude are either learn or developed in adopting appropriate teaching strategy in chemistry for students achievement. Lecture method as an approach, find it extremely difficult to adapt to individual differences among students and the processes of science.

2.5 Psychological Basis for Teaching Science by Process Approach

There is no single method of teaching that is absolute in meeting the learning needs of every individual learner in the classroom. According to Mukherjee (2004) all teaching strategies

have their limitations and strength.However Felder and Brent (2005) assert that a more balance approach that attempts to accommodate the diverse needs of the students in a class and allow for optimum learning is by the direct involvement of students in the teaching – learning process. They further stated that this approach is scientific and conform to the tenets of acquisition of knowledge by doing or direct participation by learners.

These learner–centered or scientificapproach employ the processes of science in gathering, transforming, and interpreting data, which is a major objective of teaching chemistry in the secondary school. Brekke (2005) assert that through such activities, students will not only learn science concepts but that they will also practice and understand the scientist work to acquire knowledge relevant to solve problems in the classroom and about the world around them. Evidence shows according to Lowenstein (2002) that the approach makes students active participants, aids retention of materials learnt, built confidence, helps students maximize their potential and favour intrinsic motivation. This according to him is fundamental to academic achievement and effective teaching and learning of chemistry in schools.

Contemporary theories of learning such as constructivism by Bruner (1960), Aikenhead, (2001) and others indicated that learners get actively involved in the teaching-learning procedure if presented with variety of learning activities (Zohar, 2004). Also it was opined by Piaget (1967) that intelligence is a continuing process of “adaptation” and “organization” as the learner interacts with the physical and social environment. He further revealed that when learners are provided with adequate rich experiences and activities it enhances cognitive development and movement from one level of the domain to another. This experience according to Zoller (2001) will cause cognitive stimulation, seen as the availability, richness and the use made of various learning materials which are designed to foster such cognitive skills as perception, conception, memory, language, reasoning and creativity.

These can only be favoured according to Bloom (1976) if consideration is given to appropriate cognitive and affective entry behaviours in science which involve expertise in organized and systematized sequencing of tasks and topics within the syllabus. This way learning will not only be promoted but time taken to accomplish tasks will be reduced. Also Gagne (1965) opined that such procedures will provide a firm foundation in acquisition of scientific skills needed to learn concepts and broad principles.

Chemistry like all sciences subjects is dynamic and activity oriented as it involves manipulation of equipments, through a series of activities to determine results and draw conclusion or predict situations, the teaching of skills therefore is necessary for the acquisition of scientific knowledge.Anderson &Krathwohl(2001) affirmed that chemistry as a subject is characterized by a moving frontier and a vast array of knowledge.Young learners he said should be taught how to acquire those skills and imbibe those abilities which predisposes them to taking responsibilities for expansion of their own learning, they will then become self reliant and independent as they can easily apply the learned tools in new situations.

Having taught chemistry for years in secondary schools, Brekke (2005) showed that through the process teaching approach learners become equipped to do simple to complex chemistry problem solving.All they needed according to him was sufficient practice and guide by the teacher. He further reported that to provide these students with the standard mathematical course in chemistry requires extra effort by the teachers in helping them with problem solving techniques and their personal involvement in the learning process. Concept formation starts early in life and proceeds in a stepwise manner as posited by (Anderson &Krathwohl, 2001 and Aksela2005).To them the lack of appropriate experiences to reinforce it will greatly inhibit development of scientific skills and cognitive processes. Hence the deprivation of appropriate skills for scientific performance may produce poor concept development.

Concept formation consists essentially of a process of abstracting the common features of a class of objects on events that vary contextually such as volume, texture force, power and etc, the reinforcement of appropriate experiences through adequate integration of the child enhances his ability to make differentiation and identify specification in learning materials consolidating his knowledge and cognitive structure consciously as he advanced his academic frontiers.

The psychological implication of the above statement is that when students acquire scientific skills, it will make them competent in the use of their cognitive structure and preferences. Brekke (2005) revealed that the exposure ofstudents to activity oriented teaching approaches such as (Process Approach) will not only encourage interest in the interactions among sciences, technology and society but will help students become better at critical thinking, logical reasoning, creative problem solving and more especially decision making.

This should be done by direct involvement and participation of the student in the teaching-learning process through interaction of the student with the learning material. The author further stated that greater emphasis should be based on doing rather than telling. The students' active involvement will help in their cognitive development.

Hence Piaget (1967),Aikenhead(2005) and Aksela (2005) suggested that in order to encourage and promote logical processesin teaching and learning at this stage a science process approach is preferred. Hence the science process teaching approach will be used to determine its impact on students' cognitive questioning preference, academic performance and retention span in chemistry.

2.6 The Concept of Cognitive Taxonomy

The classification of cognitive level by Bloom and his associates in what is accepted today as Bloom's Cognitive Taxonomy, (Bloom, Engelhard, Furst, Hill & Krathwohl, 1956) until the

advent of the Revised Taxonomy, Anderson & Krathwohl, (2001), identified two levels of skills: low level skills and high level skills. In the taxonomy, the lower-order skills of knowledge (recall) and comprehension are perceived as crucial for the higher-order skills of application, analysis, synthesis, and evaluation which is the most universally and empirically acceptable classification and application of high level skills until, the advent of the revised taxonomy. Lorin Anderson (former student of Bloom) in 1990 led a team of cognitive psychologist to revisit and examined the relevance of the cognitive framework in the 21st century. As a result of the investigation several relevant and significant improvement were introduced to the initial framework as seen below:

1. An acceptable research on students' development and learning and teachers' planning, teaching and assessment
2. It has a primary goal to be easily applicable at primary, secondary and even tertiary levels of education.
3. It is a tool to help educators clarify and communicate what they intend students to learn
4. Emphasis is on student- oriented, learning-based, explicit, and assessment statements of intended cognitive outcomes, (Anderson & Krathwohl, 2001; Zohar (2004), & Aksela, 2005).

Also are changes in the structure and terminologies as depicted in table below;

Table 2.1 Bloom's original Taxonomy (1956) compared to the revised taxonomy (Anderson and Krathwohl, 2001).

Bloom's Original	**Level of Thinking**	**The Revised**

Taxonomy		Taxonomy
Knowledge	lower-order	Remember
Comprehension	lower-order	Understand
Application	higher-order	Apply
Analysis	higher-order	Analyze
Synthesis	higher-order	Evaluate
Evaluation	higher-order	Create

Anderson and krathwohl, (2001)

The revised structure is two-dimensional;

1. Cognitive process
2. Knowledge

The cognitive process contains six (6) categories, Remember, Understand, Apply, Analyze, Evaluate and Create. The continuum as assumed is based on cognitive complexity as in other taxonomy (Aksela 2005). She further asserted that the last four dimensions; **Apply, Analyze, Evaluate and (Synthesis) Create** are listed as high level cognitive skills.C omprehension/Understanding is assumed to be more cognitive complex than Remember and so on.

The Knowledge aspect is categorized into four (4) namely;

i. Factual
ii. Conceptual
iii. Procedural
iv. Meta-cognitive

2.6.1 Knowledge Categories

The four categories of knowledge i.e. factual, conceptual, procedural and meta-cognitive knowledge as evident in the revised taxonomy are not only fundamental for the understanding of chemistry concept but also necessary for meaningful learning in chemistry.

Factual knowledge as stated by Aksela (2005) is the foundation knowledge of discrete and isolated content elements which a student must know. They are the basic elements learned/possess by a student to be acquainted in chemistry or to solve problems. Two types of Factual Knowledge are isolated these are (a) knowledge of terminology and (b) knowledge of specific details and elements. For the most part, Factual Knowledge exists at a relatively low level of construct or thought. (Anderson & Krathwohl, 2001)

Conceptual knowledge (disciplinary knowledge)is a more organized form of knowledge and more complex, it indicates an interrelationship between the basic elements in a larger structure which allow/facilitate operational definition and understanding functions of conceptual knowledge. Accordingly three (3) subtypes of conceptual knowledge has been identified by Anderson and krathwohl, (2001)

(a) knowledge of classification and categories,

(b) knowledge of principles and generalizations, and

(c) knowledge of theories, models, and structures

They also advice that while separating Factual Knowledge from Conceptual knowledge, there is a need to teach to enable attain an indepth understanding of conceptual knowledge for learners to effectively transfer what they have learnt in chemistry to novel situations not to just recall isolated and little bits of chemistry and basic laws.

Procedural Knowledge: It is subject specific or discipline specific, It is the knowledge of how to do something according to laid down procedures. It also has three subtypes as shown by (Anderson & krathwohl 2001 & Aksela 2005):

(a) knowledge of chemistry skills and algorithms,

(b) knowledge of chemistry techniques and methods and

(c) knowledge of criteria for determining when to use appropriate procedures in chemistry.

They further revealed that these skills are concern with declarative knowledge acquisition and in concept construction. They employ knowledge of skills and algorithms, techniques and methods procedures, as well as knowledge of criteria used to determine as well as justify when to do what within specific domains and disciplines in chemistry (Anderson & Krathwohl, 2001).

Meta-cognitive Knowledge is comprehension of cognition in general, and awareness of and the knowledge about one's own cognition (Aksela 2005). It deals with;

(a) Strategic knowledge,

(b) Knowledge about cognitive tasks, including contextual and conditional knowledge, and

(c) Self-knowledge.

According to Kuhn (2001), meta-cognitive knowledge is crucial to meta-level of functioning because it is concerned with the consciousness of several varieties of strategies that students could employ in trying to carry out their own investigation. Meta-cognitive strategies are infact very essentials at different/several stages of student's experimental tasks or assignments, especially, when goal specification is imperative, also in planning their assignments, as well as while deciding on the appropriate method to use in taking measurements, monitoring and in checking the results obtained. Metacognitive knowledge involves general strategies for problem solving, inductive and deductive thinking (Anderson & Krathwohl, 2001). They further stated that if Students must achieve they needed knowledge of different cognitive tasks, as well as have knowledge of the fact that different tasks in chemistry can be more or less difficult, and may make differential demands on their cognitive system, and engage different cognitive strategies. Students also require

understanding of diverse situation and tasks in chemistry for which the process approach is most suitable. The authors further revealed that different cognitive tasks require different models and strategies or cognitive tools that will assist learners construct understanding in chemistry.

Also, Flavell, (1979) posited that Self-knowledge includes knowledge of one's strengths, abilities and weaknesses in relation to cognition and learning. He revealed that learners possess values concerning their motivation and should be encouraged on the need to develop self-knowledge and awareness of their own motivation because Mukherjee (2004) revealed that there is a link between students' motivational beliefs, their cognition, and learning. Recent research on meta-cognitive knowledge as shown by Bransford, (2000) reflects how students' knowledge about their cognition and control of their own cognition play important roles in learning. It makes learners further conscious of and accountable for their own knowledge and thought. Meta-cognition and self-regulation direct and also involve the cognitive processes of Knowledge/Remember, Comprehension/Understand, Apply, Analy ze, Evaluate, andsynthesis or create. (Anderson & Krathwohl, 2001& Aksela, 2005)

The knowledge aspect is also considered to lie along a continuum from concrete (Factual) to abstract (meta-cognitive) while the conceptual and procedural categories are considered to overlap in terms of abstractness, (Anderson & Krathwohl, 2001& Aksela, 2005)

There are also two significant deviations in terms of the verb and noun contained in the revised taxonomy;

1. They generally describe the intended cognitive process and identify the kind of knowledge the learners are expected to construct respectively.
2. The cognitive processes Evaluate and Create (synthesis in Bloom taxonomy) are ordered differently from the original Taxonomy. The verbs can be useful in the

formulation of questions and learning goals or tasks (Bloom, 1956, Aksela, 2005). The details is presented in Table 2.2

Table 2.2 Intended Cognitive Process

SkillVerb	
Applying	apply, discover, manage, relate, classify, employ, predict, show, compute, evidence, prepare, solve, demonstrate, manifest, present, utilize, direct.
Analyzing	ascertain, diagnose, distinguish, outline, analyze, diagram, divide, point out, associate, differentiate, examine, reduce, conclude, discriminate, find, separate, designate, dissect, infer, determine, explain.
Synthesizing	combine, devise, originate, revise, compile, expand, plan, rewrite, compose, extend, pose, synthesize, conceive, generalize, propose, theorize, create, integrate, project, write, design, invent, rearrange, develop, modify.
Evaluating	appraise, conclude, critique, judge, assess, contrast, deduce, weigh, compare, criticize, evaluate.

Aksela, (2005)

The skill, **Apply,** imply using a particular procedure in solving a given situation in chemistry. It involves two cognitive processes, (1) to carry out (execute) if the assignment is a well-known exercise and (2) implement when the task is a new problem (This is connected with Procedural knowledge). To proceed, the learner needed some level of understanding of the problem and expected procedures to the solution. This way, construction of Conceptual Knowledgebecomes a prerequisite to effectively apply Procedural Knowledge.It is more

frequently associated with techniques and methods than with skills and algorithms. If students, for example in the science project work are answering the question associated with the task, they are implementingscientific method for the task. (Anderson & Krathwohl, 2001)

The next high level skill, **Analysis,** involves breaking materials into their constituent parts and determines how each of the parts relate to one another, and to the overall structure or purpose in chemistry. This skill is a fundamental process and it is central to inquiry. Basically "learning to analyze" is one of the most important objectives in instruction (Aksela, 2005). Furthermore, it is desired that students are able to distinguish the relevant from the irrelevant, as well as how ideas are related to one another, and so on. It includes the cognitive processes of differentiating, organizing, and attributing.

The third skill, **Evaluate**, has to do with making rational judgments based on criteria or set standards (Anderson & Krathwohl, 2001, Aksela, 2005). The criteria here include; effectiveness, consistency, efficiency, and quality, that can be determined by a student or a teacher, or others. The standards can be either qualitative (Is this good enough?) or quantitative (Is this amount of reagent sufficient?). It involves the cognitive processes of studying and critiquing to determine whether or not the conclusion arrived at, follows from its premises, whether the result obtain is sufficient to retain or reject the set hypothesis, and to ascertain contradictions among parts in material under study.

The forth skill, **Create/Synthesis**, means building up individual/separate elements together to form a whole or new structure which is coherent and functional or to intelligently reorganize elements into a new pattern or structure not clearly present earlier, this way learners building their consensus model of phenomena in chemistry, (Aksela, 2005, Anderson & krathwohl, 2002). This certainly requires creative thinking, but this is unrestrained by the demands of the learning task or situation. The creative process may include three phases:

(a) The problem (generated), involves representing the problem and arriving at alternative hypotheses that meet certain criteria. Here the student tries to conceive/understand the task and generate possible solutions,(b) Planning, (designing), involves devising a solution method that meets a problem's criteria developing a plan for solving the problem. At this stage the student examines the several possibilities and opportunities available and devises a workable plan, and (c) Execution, (constructing), involves working a plan to solve a given problem that meets certain specifications. Execution may require the coordination of the four types of knowledge (Factual knowledge, Conceptual knowledge, Procedural Knowledge, Meta-cognitive Knowledge) for the student to successfully execute the plan. (Anderson & Krathwohl, 2001)

2.6.2 Cognitive Process

The most universally accepted classification of cognitive skills of educational objectives was that of Bloom and Associates, (Anderson & Krathwohl, 2001).Cognitive processes are skills employed by learners in the process of constructing meaning towards meaningful learning in science and particularly in chemistry. Cognitive processes are categorized into Knowledge/Remember, Comprehension/Understand, Application, Analysis, Synthesis/Create and Evaluate(Anderson & Krathwohl, 2001). The Bloom cognitive taxonomy, **(**Bloom, Frust, & Englehant, (1956). categories two levels of thinking skills viz; the lower-level and the higher-level objectives, the lower-level of knowledge and comprehension/understanding are considered as necessary for the higher-levels of application, analysis, synthesis and evaluation. The six levels as identified by the cognitive domain are ranked in increasing order of complexity with each level assumes to be more complex than the preceding level and infact the inclusion of the initial levels down the hierarchy. The lower level cognitive skills are essential for the higher level cognitive skills;

all cognitive processes are considered in detail. Each of these six major categories is associated with two or more specific cognitive processes. According to Aksela (2005) the nature of the cognitive process engaged depends on the subject matter to which it is applied. Planning a solution to a chemistry problem is not the same as planning the composition of a literary essay. It also depends on the validity of the task to which it is applied.

The six cognitive levels are described as follows;-

1. **Remember** imply retrieval of relevant knowledge from long-term memory. The knowledge could be one of the four categories of knowledge (Factual, Conceptual, Procedural, or Meta-cognitive), or a combination of it. Remember consist of recalling and recognizing. This category of the cognitive domain is vital in enhancing retention if the intention of the instruction is for students to present material learnt in the same form as the teacher taught it. The skill relevant here is remember, (Anderson & Krathwohl 2001). This level of domain is very important for meaningful learning and problem solving in chemistry as the skill is required for use in more complex situation and assignments.

Recognizing concern identifying and retrieval of relevant chemistry knowledge from long-term memory for the purpose of making comparison with new task, it involves identifying.

i. Recalling deals with retrieving information from long-term memory when it is demanded (esp. in a question). The learner then goes into long-term memory and searches out the relevant information in chemistry process it for use to solve the question, Aksela (2005).

ii Understand, according to Aksela (2005) is the construction of meaning from instructional messages in chemistry, this according to her include oral, written, and graphic communication. Understanding is achieved when learners are able to link new knowledge to prior knowledge and it involves the ability of the learner to integrate conceptual knowledge therefore provides the bases for understanding.

2. **Understanding** as shown by Anderson and krathwohl, (2005) is sub-categorized into interpreting, classifying, summarizing, inferring, comparing, and explaining.

a. Interpreting takes place when chemistry student is able to transform Chemistry information or knowledge from one form to another.

i. This information should be new or else it's remembering- e.g. a teacher should be able to interpret a graph data obtained during his laboratory work.

ii. Exemplifying concern giving specific but relevant examples of occurrences in Chemistry or the state to construct appropriate precise instances and an illustration of a general principles or concept.

b. Classifying – involves, the ability of the learner to identify, detect and categories certain occurrences or Chemistry concepts based on the relevant features or patterns e.g. classifying a particular reaction in Chemistry as oxidation reduction reaction (redox).

c. Summarizing – is said to occur when a student's is able to represent an information or theme by a single statement.

d. Inferring – occurs when a learner is able to abstract a particular feature, pattern and relationship in series of occurrences in Chemistry. It includes making a deduction from result of an inquiry or instances.

e. Comparing – occur when students are able to identify similarities and differences between ideas, objects, problems, events etc. According to Aksela (2005) is about finding a one to one correspondence between elements and patterns in one object, event or idea and those in another objects, events or idea. Comparing infact contribute to reasoning by analogy she concluded

f. Explaining – involves the skill by a student to construct a cause-and-effect model of a system in Chemistry. According to Aksela (2005), the model can be obtained from a theory in Chemistry or can be grounded in a research or experience, e.g. reactant

concentration effect on the observed rate of a reaction. It also involves the determination of how a change in one part of a system is linked to a change to another part of the same system or another and its effect on the change in the system.

3. Application, imply using a particular procedure in solving a given situation in chemistry. It involves two cognitive processes, (1) to carry out (execute) if the assignment is a well-known exercise and (2) implement when the task is a new problem (This is connected with Procedural knowledge). To proceed, the learner needed some level of understanding of the problem and expected procedures to the solution. This way, construction of Conceptual Knowledgebecomes a prerequisite to effectively apply Procedural Knowledge.It is more frequently associated with techniques and methods than with skills and algorithms. If students, for example in the science project work are answering the question associated with the task, they are implementingscientific method for the task. (Anderson & Krathwohl, 2001)

4. Analysis involves breaking materials into their constituent parts and determines how each of the parts relates to one another, and to the overall structure or purpose in chemistry. This skill is a fundamental process and it is central to inquiry. Basically "learning to analyze" is one of the most important objectives in instruction (Aksela, 2005). Furthermore, it is desired that students are able to distinguish the relevant from the irrelevant, as well as how ideas are related to one another, and so on. It includes the cognitive processes of differentiating, organizing, and attributing.

5. Synthesis means building up individual/separate elements together to form a whole or new structure which is coherent and functional or to intelligently reorganize elements into a new pattern or structure not clearly present earlier, this way learners building their consensus model of phenomena in chemistry, (Aksela, 2005, Anderson & Krathwohl, 2002). This certainly requires creative thinking, but this is unrestrained by the demands of the learning task or situation. The creative process may include three phases:

i. The problem (generated), involves representing the problem and arriving at alternative hypotheses that meet certain criteria. Here the student tries to conceive/understand the task and generate possible solutions,

ii. Planning, (designing), involves devising a solution method that meets a problem's criteria developing a plan for solving the problem. At this stage the student examines the several possibilities and opportunities available and devises a workable plan, and (c) Execution, (constructing), involves working a plan to solve a given problem that meets certain specifications. Execution may require the coordination of the four types of knowledge (Factual knowledge, Conceptual knowledge, Procedural Knowledge, Meta-cognitive Knowledge) for the student to successfully execute the plan.(Anderson &Krathwohl, 2001).

6. **Evaluation** has to do with making rational judgments based on criteria or set standards (Anderson & Krathwohl, 2001, Aksela, 2005). The criteria here include; effectiveness, consistency, efficiency, and quality, that can be determined by a student or a teacher, or others. The standards can be either qualitative (Is this good enough?) or quantitative (Is this amount of reagent sufficient?). It involves the cognitive processes of studying and critiquing to determine whether or not the conclusion arrived at, follows from its premises, whether the result obtain is sufficient to retain or reject the set hypothesis, and to ascertain contradictionsamong parts in material under study.

2.7Cognitive Skills

Cognitive skills are skills that require the working of the human mind. They are mental skill and broadly ranged from memory skills to procedural skills, from language skills to thinking

skills. To Anderson and krathwohl, (2001) they refer to the abilities to gain meaning and knowledge from experiences and information, it includes critical, logical, reflective, metacognitive, and creative thinking. It is also the ability to think about new information, processes and the capacity to correctly connect and apply it to other previously acquired knowledge/information. AKsela (2005) revealed that they are particularly essential to the accurate description and explanation of scientific phenomena. Lawson, (2002) categorized this skills as the ability to (a) accurately describe nature, (b) sensing and stating casual questions about nature, (c) recognizing, creating, and stating alternative hypothesis and theories, (d) generating logical predictions, (e) planning and conducting controlled experiments to test hypothesis, (f) collecting, organizing and analyzing relevant experimental and correctional data, and (g) drawing and applying reasonable conclusions. King, (2005),show that they are activated when individuals encounter unfamiliar problems, uncertainties, questions, or dilemmas and that the successful applications of the skills result in explanations, decisions, performances, and products that are valid within the context of available knowledge and experience that promote continued growth in these and other intellectual skills. These skills they further revealed are grounded in the individual abilities to effectively discriminate, conduct simple application and analysis, and other cognitive strategies which are linked to prior knowledge of subject matter content.

Generally these skills can be categorize into lower order cognitive skills such as recalling and listing which relates to knowledge and comprehension, and higher order cognitive skills such as problem solving, hypotheses testing, self-reflecting, decision making and evaluating which also relates to analysis, syntheses and evaluation in the Bloom's Taxonomy respectively Liu (2003). The higher level the skill is, the more challenging it is to develop. Since cognitive skills are concerned with analysis, problem solving, evaluating and decision making, they are important skills to acquire for children as well as for adults. Literature indicates there are

many theoretical and empirical studies in the field of cognitive skills development. However, the findings are often inconclusive, and sometimes confusing. Since developing cognitive skills is an important goal of education, and is of particular significance for life-long learners, it is an area that requires continuous attention and further research. Unlike physical skills, cognitive skills are internal, the development of which demands a more sophisticated learning process Mari, (2001). Appropriate teaching strategies and learning environments facilitate their growth as do student persistence, self-monitoring, open-minded, and flexible attitudes.

According to the author, King, (2005), the definition is consistent with current theories and it is related to how the skills are learned and developed. They argue that though different theoreticians and researchers use different frameworks to describe the skills and how they are acquired, but that all frameworks are in general agreement concerning the conditions under which they prosper). This study intends to examine the impact of science process teaching approach on cognitive questioning preference.

2.7.1 High Level Cognitive Skills

High level cognitive skill according to Resnick (1987) and Zohar, (2004) must suffuse the school program from the nursery on and in every school subject and that student of all categories especially the less proficient students can be taught the same strategies and processes used by more successful students

What, then, are high level skills? There is no one unified acceptable agreement on this. Besides the Blooms' Cognitive Taxonomy and the Revised Taxonomy, the concept, high level cognitive skill according to Resnick (1987), is non-algorithmic, complex, often yields multiple solutions, involves nuanced judgment and interpretation, involves the application of multiple criteria, often involves uncertainty, involves self-regulation of the thinking process, involves imposing meaning and finding structure in apparent disorder, and is effortful. While

Aksela (2005) classifies these skills into three categories: meta-components, performance components, and knowledge acquisition components. The meta-component—the highest-level thinking process—includes planning, monitoring, decision making, and evaluating. The performance component includes skills used in actual execution of the task. Knowledge-acquisition components are employed in learning new information. According to Lavonen and Meisalo (1998), both creative and critical thinking, and problem solving, include high level cognitive skills.

According to Zoller, (2001), high level cognitive skills are question asking, problem solving, decision making, critical thinking, and evaluative thinking in the context of chemistry. According to Zohar (2004), high level thinking includes constructing arguments, asking research questions, making comparisons, solving non-algorithmic complex problem, dealing with controversies, identifying hidden assumptions, as well as classic scientific inquiry skills. Zohar (2004) indicated that some key features of the skills cannot be defined adequately but that they can be recognized when they occur. Schwartzer (2002) in Aksela (2005) divided the skills into three parts: inquiry skills, data processing skills, and additional critical thinking skills. Derfel (2002), view high level skill as exemplified by such behaviors as inferring, planning, or appraising. To Okebukola, (2002), basic or low level cognitive skills include observing, measuring, inferring, predicting, classifying, collecting data, and recording data. Higher-level integrated skills needed in practical work are interpreting data, controlling variables, defining operationally, and formulating hypotheses. The basic processes are regarded as essential for understanding and are used at an integrated higher level. The knowledge acquisition components are viewed as lower-order cognitive skills. Most of the classical scientific inquiry skills, such as formulating hypotheses, planning experiments or drawing conclusions, are also classified as higher level cognitive skills (Zohar, 2004 & Aksela, 2005).

Student participation, teacher encouragement, and student-student interaction, including active practice, motivation, and feedback, are all positively related to higher level skills (Ezeliora, 2010). Chemistry education aims at improving students' high level thinking (Zoller, 2001). Factual problems can stimulate students to hypothesize, predict, conduct thought-experiments, and generate explanations. In particular, inquiry-oriented class discussions and student participation in learning and assessment processes can be used to develop students' high level cognitive skills capacity in chemistry (Zoller, 2001). According to Derfel (2002), one possible way to encourage high level cognitive skills in the chemistry laboratory is to place students in the position of designing, developing, and conducting their own experiments (for example, inquiry-based/activity-based learning). Zohar, (2004) opined that, teaching thinking is, nonetheless, expensive, it requires a lot of time, will be at the expense of covering the curriculum, and it requires radical changes in teachers' thinking and working habits. However Saprani (1998) in Aksela (2005), show that block scheduling, integration of the curriculum and thematic teacher, portfolio assessment, cooperative learning groups, and brain-based learning/teaching can help teachers to overcome possible constraints (for example, schedule, student attitudes, teacher attitudes, resources, atmosphere, and assessment) to promote high level skills in the classroom.

2.7.2 Low Level Cognitive Skill

Low level cognitive skills referred to literal recall or recognition of factual material, information or experiences previously acquired, read, taught or presented in a lesson (Aksela 2005 & Iliya 2010). Low- level cognitive skills are relevant and very important if the objective of teaching that lesson is to impart factual knowledge necessary for memory (Cooter & Flynt, 1989). In teaching chemical laws such as Charles law, kinetic theory etc. require memorization and the ability to recall facts relating to such laws by the students.

These skills provide the platform for the reinforcement of learning and impact on the retention ability of the student. Since low level skill also provides a platform for high level thinking skills teachers should design/structure cognitive tasks deliberately aimed at consciously encouraging and assisting students move their thinking to higher levels. That way student will think independently and apply learning in new ways (Derfel, 2002). The teachers should determine whether generalizations are made, to enable facilitate students' academic performance.Questions at this level are intended to solicit from student's concepts, information, feelings or experiences that were acquired in the past and stored in memory (Derfel, 2002; Iliya 2010). Verbs employed and expected behaviours are observe, define, identify, list, recite, match, complete, select, recall, count, and name. Ellis (1993) in his study revealed that several teachers preferred low level cognitive questions in order to evade a slow pace lesson, sustain students attention and exact control in the classroom. Consequently skills that test recall of learned materials, or demand explanation or require application of knowledge are regarded as low-level cognitive skills and are essential for the higher level cognitive skills (Anderson & Krathwohl, 2001). The lower-level of knowledge and understanding of the Bloom cognitive Taxonomy are considered as necessary for the higher-levels of application, analysis, synthesis and evaluation, (Bloom, Frust, & Englehant, 1956)

2.7.3Thinking Skills

Thinking is perceived by Zohar, (2004) as an intellectual activity, a high-level cognitive process required for performance in learning. The crux of education especially chemistry education is to facilitate and improve the quality of the thinking process of learners by developing their mental structure through exposing it to challenging situation to enable it effectively coordinate and process information enough to push forward the frontier of knowledge (Shuaibu, 2000; Brekke, 2005). Thinking, therefore is an imperative in science

education to achieve meaningful learning, academic and social advancement, (Anderson & Krathwohl, 2001; Bransford, Brown, & Cocking, (2000)& Lawson, 2002). The need now to promote scientific thinking should be a prime aim of chemistry instruction at the secondary level in Nigeria.

Though there is no universally accepted consensus on what items that made up the building blocks considered as the thinking skills, Lawson, (2002) and Zohar (2004) define skill as the ability to do something well. McGuinness (1999) in Aksela (2005) summaries the different taxonomies of thinking skills consistently stated in most studies as: collecting information, sorting information, analyzing information, drawing conclusions from the information, "brainstorming" new ideas, problem solving, determining cause and effect, evaluating options, planning and setting goals, monitoring progress, decision making, and reflecting on one's own progress. While Aksela, (2005) categorize thinking skills into: (a) information-processing skills, (b) reasoning skills, (c) enquiry skills, (d) creative thinking skills, and (e) evaluation skills.

Thinking skills, according to Lawson, (2002) though are specifically responsible for the accurate description and explanation of chemical phenomena has the following necessary logical condition to identify its operations: (a) accuracy in describing nature, (b) ability to fathom and ask questions about nature, (c) identifying and stating alternative hypothesis and theories, (d) generating logical predictions, (e) planning and conducting controlled experiments to test hypothesis, (f) collating, organizing, and analyzing relevant experimental and correlational data, and (g) drawing and applying reasonable conclusions.

The ability to think is related to and develops within the context of knowledge which is specific and consequent on structurally organized principles and facts that is particularly driven and supported by experiences resulting from learning, Lawson (2002). Therefore learning and understanding are essentially positioned because the choice of any logical

operations depends on particular science content and the specific content of the problem the student has to deal with. However, whether or not thinking can be learned without subject matter content is only a theoretical point since research concerning thinking skills embedded into subjects or across the curriculum is less well documented (McGuiness, 1999).

Also Zohar (2003) reported that there existed a few researches on and about thinking skills in chemistry at the secondary school level even though there are several hundreds of instructional programs and approaches for and intended to promote thinking skills in the science educational sector, this are documented by Higgins, Baumfield, Lin, Moseley, Butterworth, Downey,Gregson, Oberski, Rockett, & Thacker, (2004)and Hot, (2008) and categorized according to their supporting philosophy/theory: (a) Formal Thinking, for example "Cognitive Acceleration through Science Education," (CASE), which highlight Piaget's stage theory of development, laying emphasis on helping pupils make the transition from concrete to formal operational thinking. (b) Thinking as manipulation of language and symbols (The Thinking Together Programme) where the emphasis is on talk, discussion, and scaffolding experiences i.e. students develop understanding through communicating their ideas, (c) Thinking about thinking (metacognition), for example, the "Philosophy for Children programme" (d) Integration and infusion, which seeks to develop teachers' pedagogy at the same time as making students' thinking explicit and (e) "The Thinking in Science Classrooms project" (TSC), developed by Zohar, (2004), in which science instruction had been thought from two perspective: content and thinking, (Aksela 2005).

Higgins, Baumfield, Lin, Moseley, Butterworth, Downey,Gregson, Oberski, Rockett, and Thacker, (2004), reveal that introduction of thinking skills can be very effective at all levels of education if they are appropriately directed at meta-cognitive and self-regulatory approaches. Asserting that over 100 researches conducted on thinking skills, 61 % deals with student thinking, 3 % with teachers' thinking while thinking in science involved 34 %. The

studies show overwhelmingly a positive impact on students' performance across a range of non-curriculum procedures such as analysis or problem solving. No import of negative impact regarding such procedures was documented. Besides, there existed evidence that students effectively employ and transfer their learning to other contexts. According to Zohar, (2004), a prominent way to enhance transfer is to repeat the same thinking skill over and over again in different scientific topics or vary the form of tasks that requires a particular thinking procedure. Lawson (2005), state that science instruction should provide students with opportunities to generate and test increasingly complex and abstract hypotheses and theories in a hypothetico-deductive manner.

However, Fisher, (1995) gave some reason that facilitate the thinking process they include; (a) students' abilities, (i.e. cognitive abilities and memory), (b) students' experiences, such as, prior knowledge, age and acquaintance with context, and (c) students' attitudes, such as, drive, stress, interest, confidence, self-esteem, anxiety, determination, and resistance. In consenting Zohar (2004) stresses the importance of students' prior knowledge, motivational factors, students' learning strategies and styles, and their thinking abilities as most fundamental in the process of development. Wilson (2002), in Aksela (2005), show that certain specific features encourage the development of thinking skills among students at the senior secondary school level: (a) high topic and task relevance to the learner, (b) focusing on the student's intention by the teacher so as to supply the best "scaffolding," (c) encouraging questioning, especially use of open-ended questions, (d) encouraging thinking aloud and expressing opinions and uncertainties, and (e) using a model of the teacher as manager of the learning process.

2.8Questioning and using Cognitive Structures.

According to Keeley (2011) when students ask questions before, during and after they read or take class notes, they can help themselves in a number of ways. By asking the questions that can help them to:

- Identify their goals and to focus on their attention.
- Determine what they already know (or don't know) and thereby concentrate on getting the information they need.
- Monitor their understanding and when they don't understand, determine other strategies or get help.
- "Chunk" information for better understanding and retrieval.
- Check their work by asking: "Does this make sense"?

But there's a lot more to questioning that learners need to know. There are approximately six "levels of cognitive" or thinking. Learners need to understand information at all of these levels in order to learn and to prepare for tests thoroughly(Anderson &Krathwohl, 2001). Showing in order of least difficult to most challenging, they are:

1. Knowledge – to identify or recall information. Most of the information found in textbooks is written at the knowledge level – providing facts and supporting details (including examples and some applications). Matching, true – false and many multiple choice test questions are written at this level.

One shows that he/she has obtained this knowledge when you answer the questions:

- Who, what, when, where, how?
- Define a term.
- Describe a process.

2. Comprehension – to organize and select facts and ideas.

When they summarize information, or are able to make inferences from what they read or heard, they are functioning at the comprehension level. Fill-ins, short-answer, and most multiple choice questions are written at this level.

Questions that help to demonstrate learners' comprehension include:

- Retell in your own words ……
- What is the main idea of …….?

2. **Application –** to use facts, rules, principles. Lab and problem-oriented courses such as math, science, engineering, or psychology as well as occupation-related courses like computer science or medical assisting, often utilize this level of thinking both in class and during tests.

   Questions that help to demonstrate ability to apply course content might include:

   - How is ……. an example of ……?
   - How is …… related to …….?
   - Why is …… significant?

   Most essay type tests are designed to evaluate understanding at the highest levels of cognition. However, not all textbooks or lectures teach the information. At these levels, to be fully prepared for tests and exams learners must ask questions that will help them to think at these cognitive levels as listed below:

3. **Analysis –** to separate a whole into component parts.

   Questions that assess one's ability to analyse include:

   - What are the parts or features of …….?
   - Classify …… according to ……..?
   - Outline/diagram/web ……..
   - How does ……. Compare/contrast with …….?
   - What evidence can you give (list) for ……?

4. **Synthesis –** to combine ideas to form a new whole.

   Questions that assess ability to synthesize include:

   - What would one predict/infer from ……?
   - What ideas can one add to …..?
   - How would one create/design a new ……?
   - What might happen if you combined …… with ……?
   - What solutions would you suggest for ….?

5. **Evaluation -** to develop opinions, judgments, or decisions.

   Questions that demonstrate one's ability to evaluate include:

   - Do you agree ……?
   - What do you think about ……?
   - What is most important ……?
   - Prioritize …….?
   - How would you decide about ……?
   - What criteria would you use to assess …….?

   Learners can help themselves to process information at all of these levels of cognition by asking questions at each of these levels, and by using visual organizers to assist them "see" these kinds of relationships, (Keeley, 2011).

2.9 Cognitive Questioning Preference

One of the most important and pervasive goals of schooling is to teach students to think, Okebukola (2002). According to Blosser (1990), one objective of science instruction is the development of higher level thinking processes in students. Aikenhead, (2005) and Usman (2000) show that what learners learn is greatly influenced by how they are taught. So

if a Chemistry student can be taught to become an active thinker, learning becomes more motivating and will result in improved Chemistry understanding and performances, (Perkins 2010). To achieve this objective according to Blosser (2010), teachers need to facilitate communication with and among students. One of the methods for encouraging students to communicate is to ask them questions. Because teachers' questions can serve a variety of purposes she posited.

- to manage the Classroom (Have you finished the titration? "How many have completed problem 17?")
- to reinforce a fact or concept (" the oxidation reduction reaction in Chemistry is also called "redox" reaction, right?")
- to stimulate thinking ("What would happen if an inflated balloon is kept under a hot sun for a period of time?")
- to arouse interest.
- to help students develop a mindset.
- to assess quality of authentic knowledge acquired by students among others.

Anderson and Krathwohl, (2001) revealed that good thinking is the result of good teaching hence teachers should be concern with helping students become critical thinkers, problem solvers, and scientifically literate citizens. So if students must function as independent thinkers according to Blosser (1990) science teachers will need to create opportunities in the science classroom that would be for a greater student participation and initiative and reduce teacher domination of the learning process. This implied a fundamental shift in the role-play in the teaching-learning process where the Chemistry teacher is the facilitator and guide of the learning process rather than an information giver having monopoly of the scientific knowledge.

The crux of this shift as shown by Blosser (2010) in the teachers' role is his cognitive questioning behaviour (i.e. the types of questions teachers ask) and the student's cognitive questioning preference in the process of instruction. Questions that require student to recall data or facts have a different impact on learners than questions that stimulate the learner to process and interpret data in a variety of ways. In a research reports from review of observational studies in the Classroom of the differential effects of various types of teachers' questions over a period of over fifty years, Blosser, (1990) show that the central focus of all teachers questioning activity appeared to be the textbook. According to Blosser (2010), the teachers seem to consider that their job is to ensure students studied the text assigned. Teachers also appear to operate primarily at the "recall" level in the questions they ask, the level of the learners notwithstanding. Gandu (2006) explained that teachers cognitive questioning styles is consistently focused on low-level questions, of recall, similarly Aksela (2005) argue that it is focus almost always consistently on lower-order thinking. While Anderson and Krathwohl (2001) lament that teachers questions are generally focus on lower-order cognitive skills, of remember and comprehension of the cognitive domain.

Blosser, (2010), in her attempt to resolve the issue of non Conformity of teachers questioning behaviour with educational objectives, hypothesis, that teachers are not aware of their customary questioning pattern. One way to test the hypothesis she revealed is to use a question analysis system. According to her one commonly used system is that of Blooms taxonomy of educational objectives, ranging from knowledge to evaluation. Other systems classified questions as higher-order or lower-order. Lower-order questions are those of cognitive memory thinking and higher-order question involve convergent thinking, divergent thinking or evaluative thinking.

Blosser a science educationist came up with a system for questions used in science lesson. They were initially classified as;

- Closed ---------- Limited number of acceptable responses
- Open ---------- greater number of acceptable responses
- Managerial ------- facilitate Classroom operations
- Rhetorical --------- re-emphasize reinforcement of a point.

Open or Closed questions are relative to the type of thinking skill they stimulated she pointed out. Cognitive memory or convergent are relative to Closed questions while divergent or evaluative thinking are for open questions. Investigation has shown that this Classification system has been applied/used successfully with both pre-service and in-service science student teachers to help them analyse their cognitive questioning behaviour. Other result of the study from analysis of their questions, revealed that the use of models (audio, video) are useful, and that skill in the use of science processes seems to relate to the Complexity of questions asked, that the use of a question category system could be learnt and that the number of divergent and evaluative questions asked during lessons can be increased.

In another study involving in-service student teachers on the use of different levels of questioning styles, a mixed result was obtained by Blosser (1990). In-service student teachers who learn to use questions at different level of Complexity, their students achieve at a higher-level than students whose teachers employed instructional modules designed to improve their questioning skills asking a wide variety of questions. It was however observed that some teachers find it difficult to allocate time to working with the module provided. Teachers who are determine to re-evaluate and improve upon their questioning behaviour should necessarily locate and adopt a variety of question category system they can employ quite easily and comfortably during lesson planning and in post-lesson analysis and encourage teacher - student interaction more effectively Blosser (1990) opined. She also suggests the use of oral and written questions. If a teacher's oral questioning behaviour involves using a variety of question types and promotes different levels of thinking, so should quiz and test questions.

Students can quietly determine what the teacher values by the type of questions used to formulate their grade.

2.1 Instructional Strategy and Retention Ability in Science

Several science educators have defined retention in several ways, Bichi (2002) viewed retention as the ability to retain and later remember information or knowledge gained after learning and that it takes place when learning is coded into memory. Retention is the ability to accept information process it and store for future retrieval in response to situations demanding their application. Research studies have shown that improved instructional strategies, improve students retention.

To determine this, two fundamental assumptions were made by Cano, (2005) that underline formal education systems (a) that students retain knowledge and skills they require in school, (b) can apply them in situation outside the classroom. Research study to determine the accuracy of the assumptions has discovered that even when reports indicated that students were not using the knowledge acquired in school, a considerable portion is retained for many years and long-term retention is strongly dependent on the initial level of mastery. A study conducted by Cano (2005) revealed that university students who took a child development course and attained high grades scores of about 80%, whereas those who obtained moderate or lower grades showed average consensus on the crucial question of how much knowledge acquired in school transfers to task encountered outside formal educational settings, and how much transfer occurs.

Lakpini (2006) studied the effect of conceptual change instructionon retention of some biology concepts, and came out with the following results, the subjects taught using conceptual change instruction strategy retained more genetics concept learned than subjects taught using traditional method. She explained that the instructional strategy enables students

discuss among one another, modifying their preconceptions, and that members of a given group are able to freely express themselves and verbalize and organize their taught, resolve conflicts in their ideas and construct knowledge based on collective mentoring. She further stated that the activity oriented and student centeredstrategy has proved to be a better instructional method which significantly improves the level of retention and performance.

Iliya (2010) in her study on teachers' cognitive questioning styles and their effects on performance and retention among integrated science students Ahmadu Bello University Zaria using fifty students as sample size, reported that there is a significant difference in retention ability of students exposed to low-level and high-level cognitive questioning styles in favour of students taught using high-level cognitive questioning styles. Analysis of the result using t-test statistics showed that high-level questioning styles makes the learner synthesize the new knowledge and enhance the ability to retain what is learnt. Hence high-level cognitive questioning styles enhance effective learning and retention level of integrated science students or else there would have been equivalence in retention. This finding did not examine retention in reference to any particular instructional or teaching strategy. This study aspires to find out the extent to which learning of selected concepts are enhanced and are retained using the science process approach.

Samba's (1998) study on the efficacy of conceptual change strategy in remediating identified misconceptions in biology revealed a high correlation between performance and retention scores of the experimental group and a low correlation was recorded for control group. Ezenwa (1998) recorded significant retention from her study employing concept mapping, when compared with those exposed to guided-discovery. She explained that improved retention recorded by the group taught using concept mapping may be due to the fact that the strategy enables the students to have concepts organized and summarized in such a way that

they are easily remembered at a later time as well as makes knowledge of concepts clear and meaningful to the students.

From the review of the above literature, it is apparent that improved instruction could certainly enhance retention. This study intends therefore to facilitate active participation of the subjects in the learning process. Because the method that permitted the learner to interact directly with the learning material and making use of the process approach employing all level of the cognitive questioning techniques could facilitate the mastery and retention of Chemistry concepts, than the condition where subjects are passive listeners to the teacher. The study therefore is investigating the impact of science process teaching approach on retention span among chemistry students.

2.2 Instructional Strategy and Academic Achievement in Chemistry

The crux of chemistry teaching is to enhance the effective learning of scientific concepts and cognitive skills acquisition, fostered by the availability, richness and the use made of various learning materials through a repertoire of teaching strategies in the classroom by the teacher, (Mukherjee, 2004). Abdulhamid, (2010) claimed that unless deliberate attempt is made to foster the skills through the skillful use of appropriate instructional method, academic failure is inevitable because to him, these cognitive skills underlie all academic learning. Instructional method therefore becomes an imperative and an important tool by which knowledge is dispensed, since learning outcome depends largely on it.

Anderson and Krathwohl (2001) submitted that to dispense knowledge effectively, mastery of the subject matter by the teacher is necessary but do not guarantee automatic ability to transmit knowledge. He recommended a perfect union of the content and methodology of teaching, this way the cumulative skill deficit of the learning stages of application, analysis, synthesis and evaluation will be removed.

According to Aikenhead, (2005), appropriate research have revealed that only instructional method that directly involved the students in the learning process can achieve this feat and promote academic excellence. Instructional method that treat students simply as passive receptors or cast in passive role does only allow student take little responsibility for their own education, Zohar, (2004) explain that such lack of involvement tends to undermine the drive to think for themselves and discourage students from developing the capacity to learn by and for themselves because they are structured in such a way as to make students dependent on teachers. Good instructional methods will emphasis learning process as what students do to and for themselves under teachers' assistance. This way, students will "find out" things for themselves, by identifying a problem and seek solution to them, they will be encouraged to make inquiries and investigations, predictions, description, explanation and evaluation and draw meaningful conclusion, (Olorukooba 1983; Mari, 2004 & Usman 2006). Instructional experiences thus learnt will be significantly retained with a significant achievementin student performance (Usman 2002; Bichi, 2002 & Mari, 2004).

The choice of instructional method should depend on the prevailing circumstances of the learners, the subject matter or content, the objective or intended outcome of the lesson as this will determine the instructional material to be used and of course the teachers' aptitude to effectively employ the method to bring about the development of the desired cognitive skill in the students Zohar, (2004). The object of this study are chemistry students who have apparent academic limitation in terms of school performance, who find abstract thinking and easy comprehension of facts quite laborious due to the prevailing lecture/traditional teaching method often used in most chemistry courses in the senior secondary school in Nigeria. The continual use of the lecture method therefore will have serious consequences for the subject chemistry and learners as reported by (Zoller, 2001 & Zohar, 2004).

The students who experience this teaching method feel isolated from the teaching and learning process as though they were being addressed in an unfamiliar foreign language. They tend to get low grades and are less likely to develop interest in the course material. Aikenhead, (2005) observed that chemistry is a discipline that provides training for the hand, eyes, ears, as well as the brain and hence will require an instructional method which provides series of activities using simple and more accurate apparatus, interesting and instructive experiment to enhance their cognitive skills, sensitivity, and attitude development from direct involvement and interaction with the materials. The experiences acquired will be valid and relevant as will be evident in their improved academic achievement and skills.

Also in chemistry education, content and method continually interact, Aikenhead, (2005). This is to create learning situations being determined by the meaning they have for learners, the number of cognitive skills intended to be learned, the possibility they offer for the organizations into topics, themes, being guided by aims and objectives, to allow for concept formation, (meaningful learning) by the opportunities they offer for measuring and recording their progress towards the behavioural objectives. He further explained that these are the test the teacher must operate in the classroom activities when the specific objective, unattainable at previous levels becomes not only real but essential. To him it is at classroom level that the teacher must be aware of the areas of thoroughness of awareness emphasized for effective learning. Because many of the behavioural objectives which reside in the area of skills or values will depend for their attainment more upon how the pupils learn than upon what they learn. That is, there are circumstances in which method becomes more important than content.

This is because learners can master the details of a subject, and also need to understand how the material being presented relates to their prior knowledge and experience, but only exceptional teachers routinely provide such broad perspectives on their subjects. In

consequence many learners who have the potential to become outstanding creative researchers fall by the wayside because their cognitive processes do not allow them to keep up with the pace of their chemistry courses. Susan and Glenda (1990) further explained that teaching method is therefore most necessary to achieve the desired methods that address the chemistry students learning dimensions. The systematic use of the science process approach in a class may therefore be sufficient to meet the needs of all of the students, as the students would all be taught in a manner suitable, thereby promoting effective learning among the learners and positive attitudes towards chemistry. And sometimes compels them to exercise and hence strengthen their less developed skills, ultimately making them better scholars and scientist.

Aikenhead (2005) and Usman (2006) observe that the degree of the academic performance of a student is directly related to the quality of instructional technique he experiences. According to the authors, students seldom rise above the quality of instruction they receive, as it determines the quality of knowledge impacted and materials learnt. Instructional techniques he further explained allow students learn how to learn, open them up to the vast spectra of knowledge, expose the learner to significant cognitive processes such as comprehending relationship between variables, make accurate value judgment, display analytical ability and selective transfer of knowledge to new situation through effective integration of various department of scientific knowledge. This according to Aikenhead (2005) is an empirical indication of the significant inter-play between instructional techniques and academic achievement. Lakpini (2006) also observed that a good number of teachers are highly deficient in the subject they teach. Adeniyi (1986) showed that this categories of teachers are also deficient professionally and find the choice of appropriate instructional techniques relative to their students' needs laborious and traumatic and thus impede effective

transmission of knowledge necessary for academic achievement as well as poor student performance.

The need for high academic achievement and belief in learning differences is then a rationale for instructional method decision (Irvine & York 1995). It is particularly important to explore the rich values of instructional techniques through an understanding of the demand on it to objectively bring about learning in students by exposing them to areas of emphasis and values in chemistry. Shaw (2002) show that the knowledge of the effective use of instructional method should motivate teachers to apply successfully new method with the goal of accommodating the needs of their students in the classroom based on the understanding that a specific technique is successful because it provided the opportunity for approaching a task in a way that is important and necessary for all learners. For example, the science process approach is successful not just because it is an alternative to lecture method but because it allow the chemistry student the opportunity to process externally, to work with their peers, and to share responsibility for a task he stated. He also claimed that the science process approach also offer opportunities for correction that are made naturally in some student's minds and for the chance to study a topic indepth, which is appreciated by almost all students. Indeed, instructional methods that have promoted academic performance can trace a relationship to its ability to cater for students' preferred learning patterns.

Also Okebukola (2002) explained that teachers who understand the academic strength of their learners and strive for intentional variety in instructional methodology will actively value, encourage and achieve academic excellence in the classrooms. Therefore, knowledge of the learners' academic needs, he said, will help teachers examine their own instructional practices in chemistry and become sensitive to providing diverse learning experiences which will benefit all students. In other words, improved instructional methodologies and practice will result in improved instruction for all and an acceptable level of

performanceacademically. A teacher who then brings outstanding skills and competencies to his work will offer the learner greater opportunities for success, (Tomlinson 1999). The teachers who are successful want to know all they can about their students so that the learning opportunities and structures they provide are responsive to students' needs. These teachers he observed know that to provide effective instructions, they must develop methodologies sensitive to the needs of the learners they works with to foster success, academically.

The science process teaching approach therefore offers a value - neutral approach for understanding the learners' needs. The assumption is that everyone can learn and achieve academically as shown by Irvine and York (1995) that "all students are capable of learning" teachers' should respond appropriately to individual learning needs – using appropriate instructional method.

Shaw (2002) observed that professional success in teaching can therefore be defined in terms of effective application of necessary and appropriate specific instructional approach to achieve greater academic successes among students in the classrooms. Brekke (2005) see instructional techniques as an attempt at making instructional methodologies problem – centred and an integrative approach which provides an interactive opportunities for skill acquisition, capacity building and academic performance. To the author, there is an acceptable correlation between academic achievement and instructional methodologies on one hand and professional skill in its application on the other hand to bring about learning and thus improve academic achievement among students. This study was conceived and investigatedto examine the Impact of the process teaching approach on academic achievement among chemistry students in the senior secondary schools.

2.3 Retention Span and Academic Achievement

Goldstein, (2010)associated retention span withLong-term memory, it is so defined to focus not only on its functionality but on its duration as well because Long-term memory is involved with the long storage of, manipulation and efficient processing of information. Martinez, (2000)conceived retention span as a process, in which information is encoded, saved and retrieved. Encoding or registration allows information that is from the outside world to reach our senses in the form of chemical and physical stimuli, it involves receiving, processing and combining of received information. Storage entails the maintenance of information over a period of time; it is the creation of a permanent record of the encoded information. While retrieval is the process of recall or recollection of information that was stored in response to some cue for use in a process or activity. It is the ability to locate the desired information and return it to our consciousnessthat issignificant to achievement in the cognitive domain.

Retention span as seen by Beer, (2010) is a tool employed by learners to assist them performs efficiently and effectively in all aspects of lives and particularly in the school. This essential tool is needed by learners to maintain and manipulate information in the mind for a brief and long period of time. Abu-Rabia, (2003) posit that it is the ability to actively hold information in the mind needed to do complex tasks such as active thinking, comprehension and learning. Goldstein, (2010) believe that it is responsible for maintaining and manipulating information during cognitive activity and that it is related to a wide range of high-level cognitive abilities such as thinking skills, problem-solving, and learning. The cognitive processes involved provide for the integration, processing, disposal, and retrieval of learned material for higher order cognitive processes. Baddeley, (2000)suggests that retention span is related to academic performance in the domain of the physical sciences, and that it(academic achievement) is enhanced by a number of abilities, storage capacities, processing efficiency,

the ability to combine storage and processing, the ability to inhibit irrelevant information, the quality of knowledge representations, and the ability to use efficient strategies in the face of interfering processes and distractions.Thus, appropriate coding of incoming information provides the index that may be consulted so that retention takes place without an elaborate search in the memory (Bichi, 2002).The nature of the memory to be coded contributes to the level of retention(Bichi, 2002). Retention according to Cano, (2005) takes place when learning is coded into memory and that understanding and retention are products of meaningful learning so when teaching is effective and meaningful to the students (practice or review) it inclines to build and maintain memory for a task.This memory he further revealed is characterized by a large capacity. It can hold and accept a large amount of new information at one time. Because learning experiences typically involve new information, the capacity of the memory makes it convenient to assimilate a large chunk of information simultaneously (Martinez, 2000). Learners at school need this memory on a daily basis for a variety of tasks and may assist in remembering task relevant information and improve performance on cognitive tasks.

Teaching students to use memory strategies by employing appropriate teaching strategy will not only improve students thinking skills on complex tasks (of prediction, modeling, experimentation, evaluation) but will also assist learners to attain a deep understanding of conceptual knowledge and will result in developing cognitive facilities to explore objects, phenomena and events in line with educational objectives in the cognitive domain, (Novak, 2005).This study therefore intended to employ the use of the science process approach to determine its Impactonstudent’s retention spanand academic achievement in chemistry.

2.4 Overview of Similar Studies

Deficiencies in the outcome of traditional science teaching have been the cornerstone of arguments supporting an activity-based approach such as the Science Process Approach to teaching of science and chemistry in this age (Aikenhead 2005). Majumdar (1991) in Aikenhead (2005) argued that traditional science teaching has failed to produce an adequate and qualified cadre of scientists, technologist and engineers in the U.K. and U.S.A. while Okebukola (2002) and mukherjee (2004) reported that traditional science education has succeeded at mystifying the general public by sustaining such legends as objectivity and certain truth.

Shaw (2002) also show that learners tend to experience difficulty when mentally moving between the theoretical world of pure science concepts as seen in traditional science education characterized by logical reasoning with evidence and their everyday world of commonsense concepts characterize by social interaction and consensus. He further opined that if this method of science instruction expects these students to learn chemistry content in enough depth to use it in every day situation rather than memorize it for the benefit of an examination then it has to assume a more rigorous task as the science process approach, which according to Aikenhead (2005) has the evident interaction between lesson content and teaching methods.

To Aikenhead (2005) traditional science teaching methods tend to be characterized by convergent thinking and lecture-demonstration. Science process approach, on the other hand, demands a wider repertoire of teaching strategies such as small group work, student centred class discussion, problem solving, decision-making, student demonstration and the use of other community resources.

There are a number of researches identifying the effects of this teaching approach on academic achievement among the chemistry students at this level. Aikenhead (2005) investigated and documented student's capabilities at conducting effective small group

discussions and laboratory demonstration on chemistry concepts and related issues in science. He found out that their understanding of the interaction between content and experiment was enhanced significantly. The learners made modest but significant gains in thinking skills such as applying science content to everyday situations, also critical and creative thinking in decision making, was enhanced. Infact these skills were explicitly practiced and evaluated. In defending this investigation, Anderson and Krathwohl (2001) explained the efficacy of the science process approach. In an article entitled "how to make science relevant", they reported that, it is the performance of interactivity, rather than the exact format, whether it be group discussion, student experimentation or role playing, which is central to improved skill development and academic performance among learners that was the primary goal of science process approach to teaching of chemistry.

According to Aikenhead (2005) interactive learning approach are often identified as being essential to the science process instruction. In the research he conducted among the college students, the evidence, suggested that:

a. In terms of learning science content and developing positive attitudes towards achieving academically, the science process approach was far more effective than the lecture methods.
b. Group assignment did stimulated thought and interest and develop greater commitment on the part of the learners.
c. It promoted an effective understanding of the processes of science and (skill acquisition) in terms of application, analysis and evaluation.
d. In terms, of retention of scientific concepts, the strategies of science process approach to teaching was most effective.

Pedersen (1992) carried out another research where chemistry students were taught using the science process approach by implementing a six-week instructional model that directly

involved students' participation. Students were required to define a chemistry concept, research it, construct an arguable position, participate in a 'public meeting', attempt to reach a consensus with the class and finally involve oneself in a course of action. The experimental student group significantly outperformed the control students in three areas; attitude towards chemistry, skills acquisition and problem-solving perceptions and chemistry performance was quite significant, Pedersen also observed during the research the significant effect of student-centre discussion when teaching and hence drew the following conclusion:

1. That student becomes more capable at applying science concepts to new situation.
2. Students are better able to apply information, to relate information to other situations, to act independently, and to make decisions.
3. Attitude towards chemistry classes, towards perceived usefulness of those classes, and towards science careers, were much more positive.
4. Students displayed much higher frequencies of creativity
5. Cognitive skill development/performance was twice to three times better in the activity oriented classes.

Zohar, (2004) in agreeing with the findings of Pedersen, indicate that the acquisition of traditional science content was significantly better for the experimental group compared with the control group. Efforts of science process approach to teaching of chemistry is better where traditional approaches fail because student start with their own problems, collect their own data, apply it to their problems and make decisions regarding their action. He further reported that the science process instruction consistently appears to augment the learners' performance he concluded. The science process instruction does make an appreciable difference to the learner's understanding of chemistry, to their thinking skills, and their attitude towards science in general. Although the learners understandings and attitude can be resistant to change, the high degree of interest and enthusiasm that student express when

taught using the science process instruction indicates that future developments towards the approach will receive encouragingly positive reaction from this group of students.

Advocates of lecture method of instruction warn that time spent using the science process approach does not adequately compensate for the knowledge acquired. To them fewer science concepts will be learned and general performance will suffer. The question here is that, is there any validity to these claims by the lecture method advocates? The answer is an emphatic "no" because their claim was based on mere assumption as refuted by a field study carried out by Aikenhead (2005) in North America on "science a way of knowing", performance comparisons were made between students who had studied chemistry through the science process approach and those taught using the traditional lecture instructions for one academic year, they found that students exposed to science process approach took shorter time to learn science concepts, have higher cognitive performance, more positive attitudes and higher retention level than their counterparts taught using the traditional lecture method.

In another related study in North America it was revealed that the claim of the lecture method advocates do not stand up to scrutiny as one might expect. These results according to Aikenhead were particularly threatening to the advocates of the lecture method.

Aikenhead (1988) explain that the research conducted was to determine how learners respond to how course materials relates to their experiences, interest and future careers. This was done by inducing students to adopt a more strategic interactive approach to learning through the use of the science process approach. The teacher who acts as a motivator employs the use of concrete practical and hands-on-materials, pictures, diagrammes, flow charts, and questioning techniques throughout the study period, while in the control class, the lecture method was adopted where the teacher actually dispense knowledge rather than inducement. The students apply course materials in new situations to solve real problems and their response to teacher's assignment was quite unique.

A comparison was made at the end of the academic session, using the course grades earned by the two groups, the performance difference between the groups of learners was marked distinguishable as it indicates that 85% of those taught using the science process approach scored 63% and above, while 67% of those taught using the traditional lecture method scored 37 – 49%. The result revealed that most students were observed to undergo a developmental progression from a belief in the certainty of knowledge and omniscience of authorities to an acknowledgement of the uncertainty and contextual nature of knowledge and acceptance of personal responsibility for determining truth. The inclination and the ability to gather supporting evidence for judgments and openness to change in the face of new evidence are forthcoming. Benold (2005) in comparing these result/findings with the highest developmental level common at this stage, he agreed that the individual students display thinking patterns resembling those of expert scientist. The research findings raised a number of questions about high school teaching, about standard measures of performance, and about science teachers' perceived mission in science education. The research findings do indicate that secondary school chemistry teaching and learning will not suffer any set back by the use of science process approach and hence the fear that it will significantly diminish the amount of science content acquired by students and thus compromise their performance seems to be unwarranted Aikenhead, (2005) further stated.

Also Özgelen (2012) while investigating Turkish primary students' scientific process skills under the theoretical framework of cognitive domain at Mersin University Turkey, revealed that science process approach can enhance learning outcomes by facilitating efficient delivery of instructional strategies and enhances cognitive problem solving and decision-making processes of the learner. A total of 306 sixth and seventh grade students from public, private, and bussed schools were sampled via convenience sampling techniques. The Turkish Integrated Process Skill Test made up of 25 multiple choice items was used to measure

conceptual framework of scientific process skills and related cognitive processes of information processing skills, reasoning skills, inquiry skills, critical thinking skills, inferential and evaluativeability in task accomplishments. Result obtained from data analysisusing descriptive and inferential statistics show generally low scores. However, results indicated significant differences between sixth and seventh grade students at private and public schools. In addition, significant differences emerged among sixth grade students at each school type. Private school students had higher scores compared to public and bussed school students.

Similarly, a significant difference was determined between sixth grade students at public and bussed schools. At the seventh grade level, private school students scored significantly higher than students at public and bussed schools. Past studies show that science process teaching technique is an important factor affecting students' achievements. Baser and Durmus, (2010) asserted that the degree of the academic achievement of a student is directly related to the quality of instructional technique he experiences. According to the authors, students seldom raises above the quality of instruction they receive, as it determines the quality of knowledge impacted and materials learnt. Instructional techniques he further explained allow students learn how to learn, open them up to the vast spectra of knowledge, expose the learner to significant cognitive processes such as comprehending relationship between variables, make accurate value judgment, display analytical ability and selective transfer of knowledge to new situation through effective integration of various department of scientific knowledgeScience process skills are related to higher order cognitive processes as it supports students' thinking, reasoning, inquiry, evaluation, problem solving skills, creativity as well asuseful for teaching well structured skills**.**

Martins (2008) while classifying integrated science questions in the NISP pupil textbook into the various levels of the cognitive domain of Blooms taxonomy of educational objectives in

his research show that, of the 266 questions asked in the integrated science NISP pupils textbook one, two and three, just one questions was in the affective domain, none was in the psychomotor domain, while 265 questions were in the cognitive domain. 96 questions of the total number of questions were classified into knowledge level, 129 questions were in the comprehension level. 30 questions are at the application level, and 5 questions were at the analysis level, one question was however classified under evaluation while no question was classified under synthesis. The distribution of the questions in study generally was at the lower levels of the cognitive questioning style of knowledge and comprehension. Seldom do teacher's questions cater for the higher-levelcognitive questions of analysis, synthesis and evaluation resulting in poor performance.Thisstudy is determined to show that science process teaching approach is not only useful for teaching well structured skills but that they also provide the support students needed to tackle higher-level cognitive thinking strategies.

Also Mani (1982) and Usman (2001) studied classroom behavior of teachers in terms of question/assessment in the classroom in the NISP implementation, at Ahmadu Bello University Zaria Nigeria, a close look at the items showed that the examination is mainly made up of items designed to test students recall, comprehension and simple application of information while items of higher cognitive process skills such as synthesis and evaluation were completely left out. The national curriculum framework developed by the National Council of Educational Research and Training (NCERT) in 2005 recommends a paradigm shift from rote memory to 'learning by doing and learning by understanding'. It suggests that curriculum should help students to develop their own thinking and ideas through experience, action and reflection by the use of appropriate instructional method that exposes learners to higherorder cognitive processes and higher academic gains.**To create the bubbling thirst and the curiosity in the student minds, the learner must notbe a passive listener but an active participant of the classroom. They should learn theprocess aspect of science. To**

arrive at such results, the conventional methods seem tobe insufficient. The most prevalent method is the Cognitive approachwhere the learners construct their own knowledge for better retention and application ina needed situation. So, the students in a science process classroom acquire allthe process skills in science like observation,classification, hypothesizing and others.

Jyoti (2014) studied the factors affecting cognitive preference styles in biology at the Regional Institution of Education, Ajmer, India revealed that Science Process instruction is not only useful for teaching well-structured skills, but they also provide the support the students need to tackle high-level thinking strategies and independent practice. A cluster sampling techniques was employed, 468 students from Board of High School and Intermediate Education, 491 from Central Board of Secondary Education and 118 from National Open School were the sample size. A reduced version of Biological Cognitive Preference Inventory originally developed by pinchers was used.After the treatment, a step-wise regression analysis was performed in relation to a range of factors (age, nature of schooling, educational practice, gender, achievement in biology and parental education) affecting cognitive preference styles in biology of 12th grades aged 17yrs. It was found 1. that there was a consistently high relationship of education practices to cognitive preference styles. 2. the achievement levels of the students are highly related to cognitive preference styles especially for principles and questioning and that among the determinant of the cognitive preference pattern, the questioning is the most preferred mode for higher achievers. They also have an affinity for principles. 3. enquiry-oriented educational practices have strong impact on cognitive preference. Students learning science through enquiry approach are inclined more towards principles and application mode of cognitive preference.

In another study by Susan, (2001) and Cotton, (2001) they both admitted that higher level cognitive questioning style require higher order thinking to appropriately respond rather than mere memory and hence increase students' performance. They further stated that high-level cognitive questions expose the learner to new territories of knowledge as it requires the students to employ previous knowledge to facilitate the construction (and synthesis) of new knowledge. Question potentially help to exhume what the student already know his misconception of certain chemistry concepts and determine students underlying assumptions and belief about other scientific concept. Therefore cognitive questions should be unambiqous, properly and correctly worded and purposeful to enable students have direction and know what response is expected. The difficulty level should be relative to the students' level of cognitive development (Cotton, 2001). The more high level cognitive questions students are frequently exposed to in chemistry classes, the higher the students' cognitive questioning preference, the greater the performance level is expected to be.

However, low- level cognitive questions are relevant and very important if the objective of teaching that lesson is to impart factual knowledge necessary for memory (Cooter & Flynt, 1989). In teaching chemical laws such as Charles law, kinetic theory etc require memorization and the ability to recall facts relating to such laws by the students. This question types provide the platform for the reinforcement of learning and impact on the retention ability of the student. Since low level question also provide a platform for high level thinking skills teachers should design/structure questions deliberately aimed at consciously encouraging and assisting students move their thinking to higher levels. That way student will think independently and apply learning in new ways (Derfel, 2002). The teachers should determine whether generalizations are made, to enable facilitate students' academic performance.

Iliya (2010) studied teachers' cognitive questioning styles and their effects on performance and retention among integrated science students at Ahmadu Bello University Zaria reported that there is a significant difference in retention ability of students exposed to low-level and high-level cognitive questioning styles in favour of students taught using high-level cognitive questioning styles. Analysis of the result using t-test show that preference for high-level questioning styles makes the learner synthesize the new knowledge and enhance the ability to retain what is learnt. Hence students' preference for high-level cognitive questioning styles indicate effective learning and retention level of integrated science students or else there would have been equivalence in retention. This finding did not examine retention in reference to any particular instructional or teaching strategy. This study aspires to find out the extent to which learning of selected concept are enhanced and are retained using the science process approach.

Other factors such as specialization over a number of years seem to affect students' performance as the international science study shows Keeves (1990). The conclusion to be drawn here is not that the issue of time in the use of science process approach in secondary school chemistry teaching is irrelevant to performance but rather, the narrow definition by teachers representing a traditional perspective, is irrelevant to the objective espoused by its defenders. The fear over the students missing essential chemistry content may be a manifestation of a fear of losing control over the curriculum, over students or more personally it may be a fear of losing one's vision of oneself as a science teacher whose mission is to socialize secondary school students into a scientific discipline as their counterpart. Such a mission offers a seductive *raison dieter* for maintaining the status quo in science education (Mitschke 1993).

The review above allows the following conclusions:

1. Students from the science process approach classes compared with the traditional/lecture method classes significantly improve their understanding of chemistry, and the interactions among science, technology and society, depending on what content is emphasized and evaluated by the teacher.
2. Products of the activity-centered instruction significantly improve their attitudes towards chemistry, toward science classes and towards learning as a result of the teaching which incorporate student interactively.
3. They make modest but significant gains in thinking skills such as apply science content to everyday situations, critical and creative thinking, decision making and improved question answering skill, as long as these skills will be explicitly practiced and evaluated.
4. The students' performance on chemistry (subject matter) at any level of science education will not be significantly compromised by teaching chemistry using the science process approach.

From the review of the above literatures, it is revealed that improved instruction could certainly enhance retention especially, those instructional activities that permits students direct and active interaction with learning materials would facilitate the mastery and retention of chemistry concepts than the situation/conditions where students are passive listeners to the teacher, Aikenhead (2005). This study was conceived therefore to facilitate active participation of the subjects in the learning process by providing the condition that allows students take responsibility for their study by their cognitive questioning preference and retention of Chemistry concepts, employing the Science Process Teaching Approach.

2.5 Implications of the Literature Reviewed on the Present Study.

The literature reviewed show that a study on cognitive questioning styleswas conducted at Senior Secondary School level by Gandu, (2006) and **Jyoti (2014)**in Biology. Another study was carried out at the junior secondary school level in integrated science by Iliya (2010) and a few others such as Susan, (2001); Cotton, (2001)and **Jyoti (2014)**but none of them employ the use of any teaching methods. This study on cognitive questioning preference in chemistry employing the use of science process approach is imperative to determine its effect on academic achievement and students' retention of scientific concepts. More importantly is the fact that study in this area are relatively new; therefore this study is intended to determine the effect of Science Process Teaching Approach on students cognitive questioning preference in chemistry at the senior secondary school level.

The literature revealed that subjects exposed to the science process approach using cognitive questioning styles tend to achieve higher academically than those not exposed (Pedersen, 1992; Anderson & Krathwohl, 2001; Zohar, 2004;Aikenhead, 2005&Özgelen, 2012). The implication of this is that if the learners are to have significant improvement in academic performance and understand the subject matter of chemistry, they should be expose to activities that emphasizes the development of their skills and enable actual interaction with the instructional materials and scientific apparatus that characterize the chemistry course. The suitability of a method can be established only by the extent the recipients understand, respond to the tasks and the evidence of the learning outcome.

Contents of the literature reviewed suggested that the chemistry student needed to be involved directly in the learning processes to enable them comprehend and apply science concepts and principles. This implies that this approach allow learners take responsibility for their education and hence enhance their understanding and academic performance.

The literature revealed that certain methods impede performance and inhibit cognitive skills development thus making the learners failure-oriented, destroy their self-image and does not motivate them to learn. The implication is that identifying the apparent academic limitation of the learners and the use of appropriate instructional teaching method that emphasizes scientific approach to teaching to meet those needs will enhance their academic performance in chemistry. It will also enable the students use reasonably well cognitive skills learnt in other areas as a result of the rich experiences they are exposed to using the science process approach.

The studies by Pedersen, (1992); Anderson & Krathwohl, (2001); Susan, (2001); Cotton, (2001); Zohar, (2004); Aikenhead,(2005) Özgelen,(2012) and **Jyoti (2014)**reviewed in this chapter covered a broad range of issues on cognitive questioning preference, academic achievement in science and retention ability of students in chemistry at the senior secondary school level. From the studies reviewed also the aspect of the use of Science Process Approach carried out was not concerned with students' cognitive questioning preference and retention span of chemistry students at senior secondary school level. The study therefore was indebted andinvestigated the Impactof Process Approach on student's cognitive questioning preference, academic achievement and retention span of chemistry students at SSS 2 level in Zaria Metropolis Kaduna State, Nigeria.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The aim of this study was to investigate the Impactof Process Approach onQuestioning preference, Academic Achievement and Retention Span amongChemistry Students in Zaria Metropolis Nigeria. Inthis chapter, the methods employed in conducting the study were described under the following sub – headings;

- Research Design
- Population of the Study
- Sample and Sampling Techniques
- Instrumentation
- Validity of the Instrument
- Pilot Study
- Reliability of the Instrument
- Treatment Administration
- Data Collection Procedures
- Data Analysis.

3.2 Research Design.

The pretest, posttest and post posttest quasi – experimental and control group design was used as proposed by Kelinger (1973). Thesubjects were pretested to ascertain their academic equivalence, the pretestwas also used to determine the type of cognitive questions the students answered whether high or low level questions. The groups with no significant difference were assigned into the experimental and control groups respectively using the balloting method. The experimental group was taught using the Science Process Approach

while the control group was taught same chemistry concepts using lecture method. After the treatment, the posttest was administered to the two groups to evaluate the effectiveness of the treatment on their cognitive questioning preference. To also determines the retention span, of subjects in concepts taught a post – posttest was administered at three separate period or intervals of two (2) weeks, four (4) weeks and six (6) weeks respectively, after the posttest. The design is illustrated in figure 3.1;

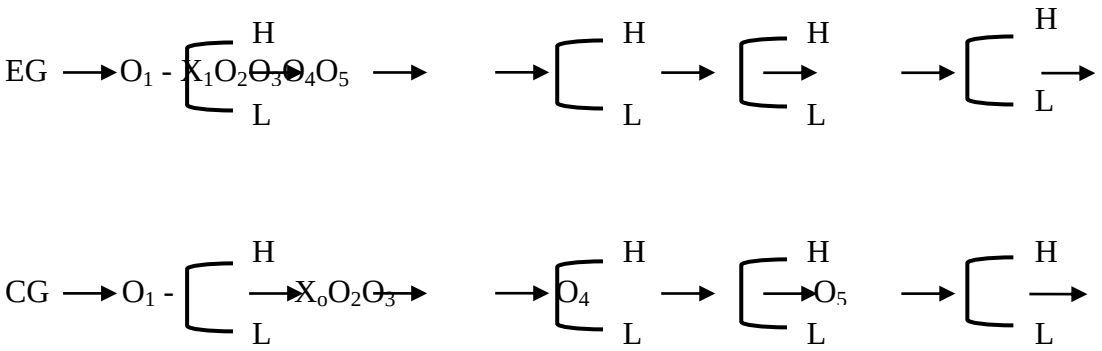


Figure 3.1 Research Design Illustration

Where:

E G – Experimental Group (taught with SPTA).

CG – Control Group (taught with lecture method).

H - High level questioning preference

L - Low level questioning preference

X_1 – Science Process Teaching Approach

X_0 – Lecture Method

O_1 – Pretest

O_2 – Posttest

O_3 – Post Posttest1 (2 weeks)

O_4 – Post Posttest2 (4 weeks)

O_5 – Post Posttest3 (6 weeks)

3.3 **Population of the Study**

The population of this study is from state government owned senior secondary schools SSS2 offering Chemistry located within the Zaria Metropolis, Kaduna State. The spatial extent of the study area; Zaria Metropolis encloses Zaria and Sabon Gari Local Government Area of Kaduna State and is bounded to the North West by Giwa LGA, due to this spatial coverage, Zaria Metropolis habitats schools that spread across Zaria and Giwa Education Zones demarcated by the Kaduna State Ministry of Education for easier management. In essence, population for the study is from schools within the geographic entity of Zaria Metropolis where both Education Zones are juxtaposed.There were Ten (10) state governmentowned senior secondary schools offering Chemistry within the area. The target population consisted of senior secondary school (SS2) students offering Chemistry with an average age of 16yrs. The total number of students in the population was 1, 241.Since the study involved public schools, they have uniform condition of staff and equipment and same academic calendar.The details of the schools in the population are presented in Table 3.1.

Table 3.1 Population of the Study

S/No	Name of the School	Type of School	No. of SSS students	Total
1	Govt. Sec. Sch. Muchia	State Government	110	110
2	Govt. Sec. Sch. Bomo	State Government	234	234
3	Govt. Sec. Sch. Basawa	State Government	9898	
4	Govt. Sec. Sch. Chindit Barracks	State Government	270	207
5	Govt. Girls Sec. Sch. D/Bauchi	State Government	113	113
6	Govt. Technical College Zaria	State Government	75	75
7	Govt. Sec. Sch. Shika	State Government	122	122
8	Govt. Sec. Sch. Jama'a	State Government	87	87
9	Govt. Sec. Sch. Kwangila Snr	State Government	83	83
10	Govt. Sec. Sch. Samaru Snr	State Government	112	112
Total	-	-	-	1,241

Source:(Kaduna State Ministry of Education: Education Inspectorate Unit, 2011).

3.4 Sample and Sampling Techniques

To select the samples for the research, simple random sampling technique was usedemploying balloting method, the first four schools were picked for the study from the Ten (10) schools listed in table 3.1. The following schools: Government Secondary School Bomo, Govt. Secondary schools Shika, Govt. Secondary school Chindit Barracks and Govt. Secondary school Muchia were selected;allschools were located within the Zaria Metropolisof Kaduna State. A class was chosen each using purposive sampling from each of the schools and a pretest was dully administered to the four schools for the purpose of comparability of ability level, and the result was subjected to analysis of variance, no

significant difference was obtained, based on the result two of the schools were chosen randomly using balloting method. However, in determining which school serves as experimental and control group, a simple random sampling technique was used. Thus, Government Secondary School Chindit Barracks Zaria was randomly assigned experimental group while Government Secondary School Muchia Zaria was assigned control group respectively using the balloting method. The table of the sample for the study is presented in Table 3.2.

Table 3.2 Samplesfor the Study

S/No	Group	Schools	Subject (N)
1	Experimental group	Gov't. Sec. Sch. Chindit Barracks Zaria	40
2	Control group	Gov't. Sec. Sch. Muchia	38
		Total	78

In each of the schools the science class (an intact class) was used for the study. This is because the schools have only one science class each in the SS2 offering sciences. There were forty students in the class that was used as the experimental group and thirty eight students in the control group class. Aclass of minimum of thirty subjects as a sample size is considered a viable representation for experimental research in line with central limit theorem recommendation,(Tuckman, 1975). Thesample size for the two groups was 78 students, consisting of 40 students in the experimental group and 38 students in the control group.From theresult of the pretest administered to both experimental and control group, the students

were classified into the low level and high levelcognitive questioning preference subjects respectively. The result of the pretest is shown in (Appendix.F)

3.5 Instrumentation.

For the purpose of data collection the Chemistry Achievement Test (CAT) was developed by the researcher and was validated by experts in science education and SSS graduate teachers teaching Chemistry at the SS 2 level in secondary school.

3.5.1 Chemistry Achievement Test (CAT)

Chemistry Achievement Test (CAT) was developed by the researcher to assess the conceptual understanding of Chemistry topics taught to the subjects. The test items were made up of 30 multiple choice and short answer type questions. The questions cover all the levels of Bloom (1956) cognitive taxonomy of knowledge, comprehension, application, analysis, synthesis and evaluation domains. The questions were made up of two cognitive type questions i.e. high level (i.e. application, analysis, synthesis and evaluation) and low level questions (i.e. knowledge, comprehension), (Anderson and Krathwohl, 2001; Zoller, 2004 and Aksela, 2005). A table of specification was employed to ensure even distribution of the items in the instrument SeeTables 3.3below.

Table 3.3 Specification for Item Based on Bloom's Taxonomy in the Cognitive Domain

S/no	Cognitive Taxonomy	Wt %	Kinetic theory	Gas laws	State of matter	Change of state	Chemical reaction	Acid-base reaction	Total
1.	Knowledge	14%	14	12	7	4		19	5
2	Comprehension	14%	9	21	13	28	5	20	6
3	Application	20%	27		1	2	16		4
4	Analysis	20%		25	11	26	8	6	5
5	Synthesis	14%		24	10	15	29	23	5
6	Evaluation	18%	3		22	17	30	18	5
	Total	**100%**	**4**	**4**	**6**	**6**	**4**	**5**	**30**

The Chemistry Achievement Test (CAT) was administered to both the experimental and control group as pretest to determine the academic equivalence/achievement level of the subject, as posttest and post- posttest to compare the groups for significant differences (if any) after treatment and retention ability respectively. A marking scheme was designed for marking the sample as follows: - Each of the items and sub – items in the questions was assigned one (1) mark each. Total score for CAT is 40 marks. (SeeAppendix- B).

A typical question for use in this study is as given below;

Qus. 1. Burning _____ in Chlorine, in the presence of _____ as the _____, yields _____ gas which dissolves readily in water to give _____ acid. State the formula.

Qus. 2. To what temperature must a gas at 273K be heated in order to double its volume and pressure?

A. 298K B. 546K C. 819K D. 1092

3.6Validity ofthe InstrumentCAT

A panel of experts made up of two science educators and three secondary school teachers, assessed the content and face validity of the Chemistry Achievement Test. The assessors were requested to examine the instrument to see whether the items:

i. ascertain the reliability of the instrument before use in the final study
ii. to determine whether the study is feasible or not
iii. to ascertain suitable time duration required by the students to complete the test items.
iv. to eliminate ambiguity and assess clarity of the items
v. to determine discrimination level and difficulty of the test items.

Difficulties and problems area that were observed in the test were carefully noted from the result of the pilot test. During the validation, Question 20 was shown to be difficult, it was reframed while Question 27 was observed to be bulky due to its several sub-questions (a-d), it was suggested by the panel that question 27 and its sub-questions should be reframed and converted into questions 27, 28, 29 and 30. The corrections were made accordingly and the instrument was employed for the research work.

3.7Reliability of the Instrument CAT

To test for reliability of the instrument CAT, the test-retest method within interval of two (2) weeks in line with Tuckman, (1975) was employed and Pearson Product-Moment Correlation Coefficient (PPMCC) was used to determine the reliability of the instruments and test items

which was found to be r = 0.73 which indicate high correlation between the tests. The result obtained therefore show the suitability of the test items for the study (See Appendix - E)

3.8 Pilot Testing

The pilot test was carried out to find out the reliability of the instrument and the ability level of the students.Chemistry Achievement Test (CAT) was administered on thirty (30) SS.2 Chemistry students of Government Secondary School Kwangila, Zaria. The pilot trial school was not part of the study; this is to prevent the study subjects from having an idea of the instrument. The data obtained were analyzed using the Pearson Product-Moment Correlation Coefficient (PPMCC) to establish the reliability of the instrument. Thus the coefficient of CAT was calculatedto be 0.73.The students completed the test items in one hour thirty minutes ($1^1/_2$hrs). Data collected from the pilot study was used for item analysis.

3.8.1Item Analysis

The procedure for item analysis was as follows;

3.8.2 Facility Index (FI)

The facility index or difficulty index show the difficulty level of each of the items based on the percentage of subjects who got an item correct. The facility index for the instrument CAT was determined using Frust (1958) formula:-

$$F = \frac{RU + RL \times 100}{N}$$

Where;

F = facility Index

RU = No. of upper 27% of those who got the items correctly.

RL = No. of lower 27% who got the items correctly.

N =Total number of subjects in each of the upper and lower groups (not the total respondents of the test).

Items with facility indices of between 0.3 and 0.8 were recommended and considered by Satterly (1986), Frust (1958), Oyebanji (1978) and Lapini (2006), as adequate for selecting good test items for achievement test. In this study therefore, the items with facility indices in the range of 0.3 to 0.8 wereused for the study.

3.8.3Discrimination Index (DI)

The discrimination index for each of the items were computed by subtracting the number of students in the lower group who score the item correctly from the number in the upper group who got the item correctly. The number was divided by half the number of the students;

$$D = \frac{RU - RL}{1/2N}$$

D –Discrimination Index

RU – number among upper 27% who score the item right

RL – number among the lower 27% of subjects who score the items correctly.

1/2N – number of subjects in each of the upper and lower groups.

According to Frust, (1958) and Usman (2008), items in a test with discrimination indices between 0.3 to 0.49 were considered moderately positive whilethose with discrimination indices of 0.49 are highly positive and if solely used,the well – informed subjects will get the test items right than the poor ones. The discrimination index ranging between 0.3 – 0.7 obtained for the items in this study were therefore used.

3.9 Administration of Treatment

The procedure for treatment administration was as follows;

3.9.1Treatment for the Experimental Group

The experimental group wasdivided into two sub-groups based on their cognitive questioning preference. One group consisted of students of low level cognitive questioning preference while the second groupconsisted of students of high level cognitive questioning preference. The two groups were exposedto Science Process Approach instructions for four hours period a week for six weeks contact session. Theexperimental groups was taught by the researcher for the period stated. There were two lessons of one hour twenty minutes each week. Students in the experimental group are discussing a problem in chemistry sudden explosion of a balloon for a example. Though the teacher knows the "answer" to the problem, he focuses on helping students restate their questions in useful ways. He prompts each student to reflect on and examine his or her current knowledge. When one of the students comes up with the relevant concept, the teacher seizes upon it, and indicates to the group that this might be a fruitful avenue for them to explore. They design and perform relevant experiments. Afterward, the students and teacher talk about what they have learned, and how their observations and experiments helped (or did not help) them to better understand the concept.

This process was aimed at enhancing learning based on (1) increased student involvement, (2) multiple ways of knowing, (3) sequential phases of cognition. When students are able to relate new concepts and propositions to relevant existing concepts and propositions in their cognitive structure, knowledge is made more relevant and meaningful.Thisinvestment in the learning process led to active construction of meaningful learning rather than passive acquisition of facts transmitted from the teacher.

The lesson notes for both experimental and control groups are presented in Appendix (C) and (D) respectively.The activity was based explicitly on explaining such concepts. For maximum interaction between the researcher and the subjects, a class of forty subjects served as experimental group. The instruction adhered to the following guidelines:

1. present the new cognitive strategy; introduce the concrete prompt, model the skills, think aloud as choices are made.

2. regulate difficulty during guided practice; start with simplified materials and gradually increase complexity of task, complete part of the task for the students, provide use cues, provide the material in steps, anticipate students errors and difficult areas.

3. provide varying context for students practice; teacher led practice, engage in reciprocal teaching here students work in small group.

4. provide feedback; offer teacher led feedback, provide check list/provide models of expert work.

5. increase students responsibility; diminish student support/gradually increase complexity

b. practice putting all the steps together (consolidation) check for students mastery.

6. provide independent practice; provide extensive practice.

b. facilitate application to new examples

The lesson flow chart for the Science Process Teaching Approach is presented in Fig. 3.2

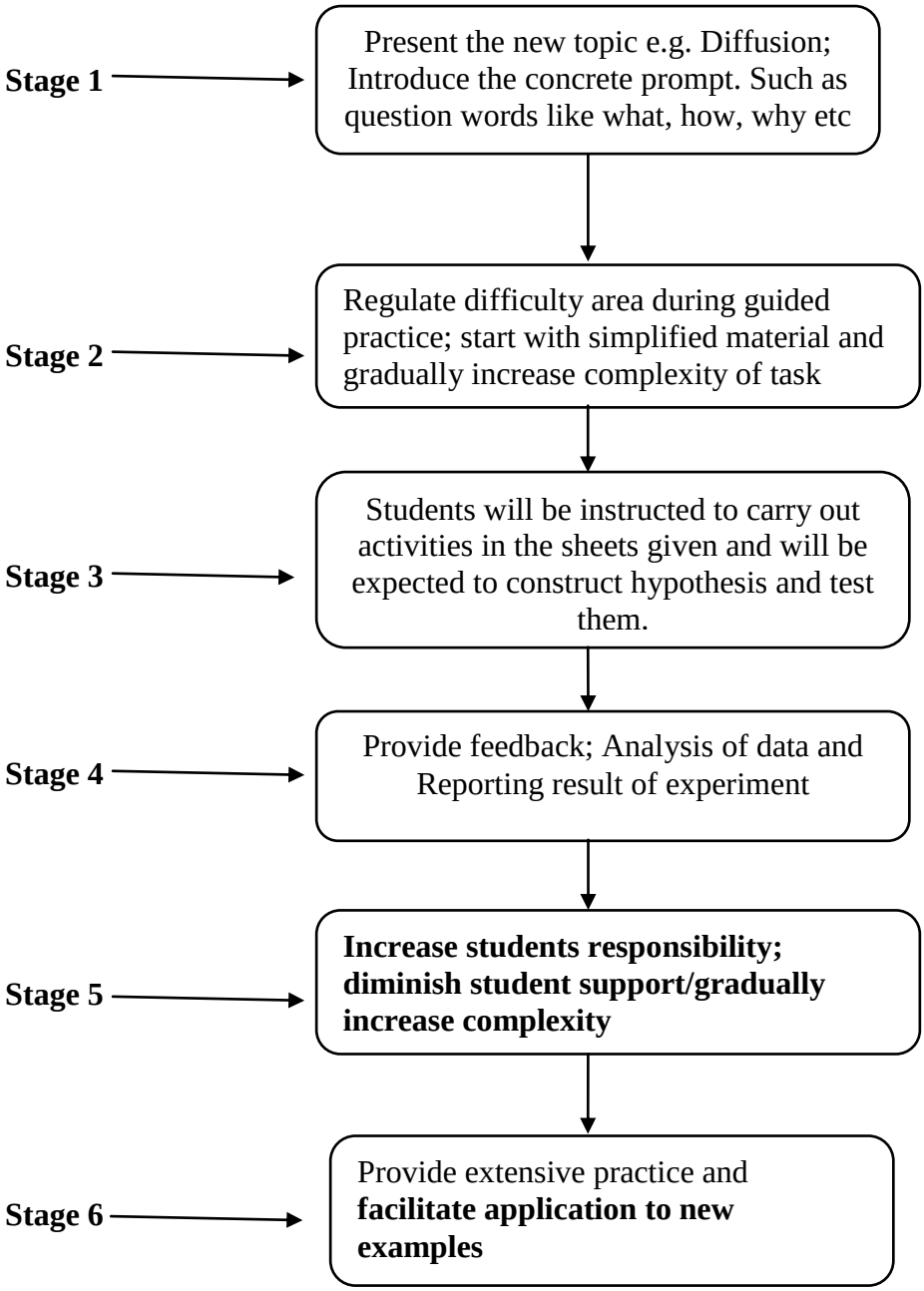


Fig 3.2 Flow Chart of Science Process Teaching Approach Adapted from NSTA and Anne, (2014)

3.9.2Teaching of the Control Group

The control group wastaught same topics in chemistry for the same period as the experimental group for sixweeks contact session by the researcher using the lecture method. These involve verbal presentation of the concepts under chemistry. The students listened to the teacher and jot down important points presented on the chalk board. Students were allowed to ask questions at intervals and the teacher responded to students' questions. The details of the lesson note is presented in Appendix (D)

3.1Data Collection Procedure

The groups pretest, posttest and post-posttest scores were used as data for the study. The pretest was administered on the two groups (experimental and control groups) after the two groups were taught the same Chemistry concepts by the researcher. While the experimental group was exposed to science process – based instruction employing appropriate questions covering the six (6) hierarchies of Bloom taxonomy in the cognitive domain, this involved questions like identify, explain, arrange, compare, differentiate while teaching the subjects. The control group was taught using the lecture method. After a period of six (6) weeks treatment, the posttest was administered to the two groups by the researcher.

The researcher marked the scripts based on the marking scheme described earlier with total of 40 marks. The scores from the scripts were collated and subjected to data analysis using the Statistical Package for Social Science (SPSS). The subject's retention span was determined after two, four and six weeks respectively through the use of the post – posttest procedure. The items were re-shuffled each time to prevent 'test wiseness' before administration and re-administration.

3.2Procedure for Data Analysis

The data collected from this study was used in two folds;

3.2.1 Answering Research Questions

The research questions were answered using descriptive statistics in form of mean scores and standard deviation.Each of the research questions is stated and statistics used to analyses it.

1. what is the difference between the mean academic score of chemistry student taught using Science Process Approach when compared with those taught using Lecture method?

In answering this question, descriptive statistics in form of mean scores and standard deviation were used.

2.What is the difference between the mean cognitive questioning preference scores among senior secondary school students when exposed to Science Process Teaching Approach and Lecture method?

Mean scores and standard deviation were used to answer the question stated.

3. what is the differencebetween the retention ability of senior secondary school chemistry students taught using Science Process Approach when compared with those taught with Lecturemethod?

In answering this question, descriptive statistics in form of mean scores and standard deviation were used.

4. what is the differencebetween the retention span of senior secondary schoolchemistry students taught using Science Process Approach when compared with those exposed to Lecture Method at different duration?

Mean scores and standard deviation were used to answer the question stated.

3.2.2The Hypotheses Testing

The hypothesisstated were analyzed to test the significant difference among the variables of the study using t-test and Analysis of Variance (ANOVA) at probability level of $P \leq 0.05$for retaining or rejecting the stated hypothesis. Each of the hypotheses was tested along with the description of the statistical tool used for testing each.

Ho_1. There is no significant difference between the mean academic achievement of chemistry students exposed to science process teaching approach and those taught using lecture method.

The t-test statistics was used to test for any significant difference in the post test mean scores of those taught using science process teaching approach and those taught using lecture method.

Ho_2. There is no significant difference between the mean score in cognitive questioning preference among chemistry students in the experimental group and control group.

The Analysis of variance statistics (ANOVA) was used to test for any significant difference in the mean scores of those taught using science process teaching approach and those taught using lecture method.

Ho_3. There is no significant difference between the mean score in retention ability among chemistry students exposed to science process teaching approach and lecture method.

The t-test statistics was used to test for any significant difference in the post test mean scores of those taught using science process teaching approach and those taught using lecture method.

Ho_4. There is no significant difference in the mean score on retention span among senior secondary school chemistry students exposedto science process teaching approach and those taught using lecture method when subjected to an extended retention test period of 2,4 and 6 weeks.

The Analysis of variance (ANOVA) statistics was used to test for any significant difference in the post posttests mean scores of those taught using science process teaching approach and those taught using lecture method.

CHAPTER FOUR

ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction.

In this chapter, the result obtained from the analysis of the data collected and the discussions of the results are presented. The data collected were analyzed using the Statistical Package for Social Science (SPSS). The chapter is presented in the following subheadings.

- Data Analysis and Result Presentation
- Summary of Findings
- Discussion of the Result

4.2 Data Analysis and the Results

Thedata collated from the study using the instrument (CAT) were analyzed, the result obtained were used to answer the following research questionsand hypotheses testing.

4.2.1 Answering Research Questions

Research Question 1. What is the difference between the mean academic score of chemistry student taught using Science Process Approach when compared with those taught using Lecture method?

Table 4.1: **Mean Scores and Standard Deviations between Experimental and Control Groups on Academic Achievement**

Variables	N	Mean	Mndff	SD	SE
Experimental	40	18.32	13.54	5.40	0.45
Control	38	4.78		4.56	0.37

The result in Table 4.1 reveals that the experimental group recorded a mean score of 18.32 and a standard deviation of 5.40 on academic achievementwhile the Control group hada mean score of 4.78 and standard deviation of 4.56, the large difference in the scores of 13.54 is descriptive of the effect of science process teaching approach on improving the academic achievement of the subjects in favour of the experimental group this gain in academic achievement is basically due to the treatment.

Research Question 2.What is the difference between the mean cognitive questioning preference scoresamong senior secondary school students exposed to Science Process Teaching Approach andthose taught using Lecture method?

Table 4.2Mean Scores and Standard Deviationson Cognitive Questioning Preference of the Experimental and Control Groups

Variables	Test levels	Exptal. Means	SD	M dff	Control Means	SD
LOW	Pre-test	4.85	2.52	2.05	2.80	3.46
	Post-test	6.03	1.493	3.69	2.34	1.89
HIGH	Pre-test	0.78	1.29	-0.42	1.20	2.02
	Post-test	13.25	4.19	12.12	1.13	1.71

Table 4.2shows the mean scores obtained by the subjects who attempted the low and high level cognitive questions at the pretest stages is 4.85 and 0.78 for the experimental group while 2.80 and 1.20 was recorded for the control group. The posttest result revealed a mean score of 6.03 and 13.25 for the experimental and a mean score of 2.34

and 1.13 for the control group respectively. Scores obtained at the pretest stage show a preference for low level questions for both groups before the treatment; only few of the high level questions were either attempted or scored correctly as evident in the mean difference of -0.42.The posttest result revealed a remarkable difference in the mean scores (12.12) between the groups in favour of the experimental subjects. The difference can be attributed to the treatment (SPTA) received by the experimental subject which improved their cognitive skills and enhanced their preference for high level cognitive questions. The experimental subjects also attempted low level questions as well as more high level questions successfully as evident in their mean scores of 13.25 and 6.03. The shift from low to high level questions by the students in the experimental group as observed from the mean scorescan be attributed to the instructional method (SPTA) employed during the study.

Research Question 3. What is the differencebetween the retention ability of senior secondary school chemistry students taught using Science Process Approach when compared with those taught with Lecturemethod?

Table 4.3: Mean Scores and Standard Deviations on Retention Ability of the Experimental and Control Groups.

VariablesN		Mean	Mdff	SD	SE
Experimental	40	19.00	13.16	4.47	0.45
Control	38	5.84		5.76	0.37

The analysis of data in Table 4.3showsthat the experimental group who learnt through Science Process Teaching Approach attained highermean score of 19.00 on retention, than the control group with a mean score of 5.84 who were taught employing the traditional lecture method. The difference in the mean scores on retention ability between the two groups of 13.16 indicated an improvement in their retention ability.

Research Question 4. What is the differencebetween the retention span of senior secondary schoolchemistrystudents taught using Science Process Approach when compared with those exposed to Lecture Method at different duration?

Table 4.4:Mean Scores andStandard Deviationson Retention at 3 Intervals of the Experimentin the Experimental and Control Groups.

Tests	Experimental SD Mdff			ControlSD	
	Mean			Mean	
Post-test	18.68	5.38	15.35	3.33	3.41
Post-post test1	19.00	4.45	13.16	5.84	5.76
Post-post test2	17.88	4.72	14.80	3.08	2.79
Post-post test3	17.87	5.42	13.26	4.61	3.72

The result of analysis inTable 4.4 on retention span at three intervals of 2, 4 and 6 weeksrevealed that the experimental group had mean scores of 19.00, 17.88 and 17.87 while the control group recorded mean scores of 5.84, 3.08 and 4.61 respectively for the same duration. Also for each of the extended period of the test administration a mean

difference of 13.16, 14.80 and 13.26 was obtained. The mean difference recorded at each stage of the experiment on retention span revealed a consistency in scores with negligible score differences for the experimental subjects compared to the control group with quite very low scores in each of the stages. This remarkable difference as evident in the mean differences can be attributed to the use of the activity oriented and student centered Science Process Approach instructional strategy whichenhancesthe retention span of the subjects exposed to the treatment.

4.2.2Hypothesis Testing

Effect of Science Process Teaching Approach on Academic Achievement.

The Null hypothesis tested stated thus;

Ho_1There is no significant difference between the mean academic achievement of chemistry students exposed to science process teaching approach and those taught using lecture method.

The t – test statistics at $P \leq 0.05$ was used to determined if there was any significant differencein the mean scores of the experimental and control groups in academic achievement after exposure to science process teaching approach. A summary of thet - test of the students on Academic Achievement scores is presented in Table 4.5

Table 4.5 Results of t-tests Analysis of Mean Academic Achievement Scores of the Experimental and Control Groups.

Variables	N	Mean	SD	SE	t-value	DF	P	R
Experimental	40	18.42	5.40	0.46				
					43.84	76	0.00	S
Control	38	4.27	4.55	0.37				

Significant at P≤0.05

The result of the t-test in Table 4.5 show a t-value of 43.84 and a P-value = 0.00 which is less than P≤0.05 revealedthat students who were exposed to the experiment performed significantly better in academic achievement than those in the control group. The implication here is that the experiment significantly increased the performance of students exposed to Science Process Teaching Approach who participated in the academic achievement test while their counterparts in the control group did not improve correspondingly. The null hypothesis is therefore rejected.

Effect of Science Process Teaching Approach on Cognitive Questioning Preference

The Null hypothesis tested stated thus

Ho_2There is no significant difference between the mean score in cognitive questioning preference among chemistry students in the experimental group and control groups.

Analysis of Variance (ANOVA) was used to analysesthis hypothesis at$P\leq 0.05$. The result is presented in Table 4.6

Table 4.6Result of Analysis of Variance of the Mean Scores of Low and High Cognitive Questioning Preference Students in the Experimental and Control Groups

Groups	Cognitive Levels	Source	Sum of Squares	DF	Mean squares	F	SigR
Experimental	LOW	Between Group	73.47	4	18.36	6.00	0.00 S
		Within Group	597.25	195	3.063		
		Total	670.72	199			
	High	Between Group	4,255.48	4	1,063.87	73.36	0.00 S
		Within Group	2,827.80	195	14.50		
		Total	7,083.28	199			
Control	LOW	Between Group	61.12	4	15.28	2.41	0.05 S
		Within Group	1,237.97	195	6.34		
		Total	1,299.09	199			
	HIGH	Between Group	43.57	4	10.89	2.08	0.08S
		Within Group	1,020.60	195	5.23		
		Total	1,064.18	199			

From the results in Table 4.6, it was found that the f – calculated for the experiment is 73.36and 5.99 at P = 0.00, while for the control is 2.40and 2.08 at P = 0.05, the result obtained in table indicates that there is significant different in the cognitive questioning preference of students in the experimental school exposed to science process teaching approach. Also the record of the P – value recorded is less than $P \leq 0.05$ at df = 4,195

indicating a significant shift in the preference for high level questions among the experimental group as a result of the treatment compare to the control group with P – value of 0.05 indicating significant difference. The stated null hypothesis is therefore rejected

Effect of Science Process Teaching Approach on Retention Ability.

The Null hypothesis tested stated thus

Ho_3There is no significant difference between the mean score in retention ability among chemistry students exposed to science process teaching approach and those exposed to lecturemethod.

The two sample t-test procedure was used in testing the retention ability of students in the two groups (control and experimental) at the different stages of the experiment. The result revealed that students who were subjected to the experiment had higher retention abilitythan those in the control group at ($P\leq 0.05$) confidence level.The result is presented in Table4.7

Table 4.7Results of t-test Analysis on Retention Ability between the Experimental and Control Groups.

Variables	N	Mean	SD	SE	t-value	DF	PR	
Experimental	40	19.00	4.46	0.45				
					24.85	76	0.00	S
Control	38	5.84	4.64	0.37				

Significant at $P\leq 0.05$

The result of the aggregate test (t-value = 24.85) revealed that students who were exposed to the experiment had a significantly higher retention than those in the control groupbecause P=

0.00 is less than P≤0.05 indicating a significant difference.The null hypothesis is therefore rejected.

Effect of Science Process Teaching Approach on Retention Span.

The Null hypothesis tested stated thus;

Ho_4There is no significant difference in the mean scores ofretention span among senior secondary school chemistry students exposedto science process teaching approach and those taught using lecture method when subjected to an extended retention test period of 2,4 and 6weeks.

The One Way Analysis of Variance was used for the analysis. Summary of the result is presented in Table 4.8

Table 4.8: Results of Analysis of Variance on Retention Span of the Experimental AndControl Groups.

Groups	Source	Sum of squares	DF	Mean square	F	Sig	R
Experimental	Between Group	5,225.88	4	1,306.47	58.74	0.00	S
	Within Group	4,336.89	195	22.24			
	Total	9,562.78	199				
Control	Between Group	258.65	4	64.66	3.61	0.01	S
	Within Group	3,384.07	189	17.91			
	Total	3,647.72	193				

The result in Table 4.8 revealed that students who were subjected to the experiment had a higher retention span than those in the control group at the extended stage of 2, 4, and 6 weeks of the experiment ($P \leq 0.05$). The result of the test therefore show that students who were exposed to the treatment had a significant higher retention than those in the control group ($P \leq 0.05$). The null hypothesis is therefore rejected.

To determine the group with significant difference, Scheffe's test was used. The summary of the result ispresented in Table 4.9

Table 4.9: Results of Scheffe's Post-hoc Test onExperimental and Control Groups mean scores based on Retention Span

Stages of experiment	Groups	Mean	SD	SE	t-value	DF	PR
Pre-Test	Experimental	5.63	3.31	0.52	3.17	76	0.00 S
	Control	2.70	4.80	0.76			
Post test	Experimental	18.68	5.37	0.85	15.26	76	0.00 S
	Control	3.33	3.40	0.53	15.26		
Post post test1	Experimental	19.00	4.45	0.70	11.31	76	0.00 S
	Control	5.84	5.76	0.93	11.24		
Post post test2	Experimental	17.88	4.72	0.73	16.78	76	0.00 S
	Control	3.08		0.45	17.09		
Post post test3	Experimental	17.87	5.42	0.86	12.49	76	0.00 S
	Control	4.61	3.72	0.60	12.55		

The resultsin Table 4.9reveal that students who were subjected to the experiment had a higher retention that than those in the control group at the deferent stages of the experiment ($p<0.05$). The null hypothesis is therefore rejected

4.3 **Summary of Findings**

At the end of the studying, the following findings were obtained.

1. The analysis of the posttest score revealed that the experimental group students perform significantlybetter in academic achievement than their counterparts in the control group after undergoing the experimental treatment of science process teaching approach.
2. It was found that the use of science process approach in teaching chemistry is more effective than conventional lecture method in enhancing students' cognitive questioning preference for high level cognitive questions and hence improves performance.
3. Theresult obtained revealed a significant gain in the retention ability of students exposed to science process teaching approach.
4. The analysis of the extended test result show asignificant high level of consistency in scoreson retention of students exposed to science process teaching approach over an extended period of 2, 4 and 6 weeks after the posttest.

4.4**Discussion of the Results**

The findings of the results are discussed as follows:

From the findings in Table 4.5the experimental group performed significantly better than the control ($P\leq 0.05$) in their posttest scores. This shows that the process based instruction is effective in enhancing the acquisition of scientific skill and cognitive

process in subjects under study. This result supports the observation by Anderson & krathwohl (2001), that subject's cognitive processand academic achievement can be enhanced through effective instructions. Other studies by Mukherjee (2007) and Lawson (2002) have also shown that time spent on teaching the science students higher skills result in gains in their academic achievement. The suitability of the science process teaching approach as a means of promoting academic performance may be attributed to the nature of the instruction which is learner – centered and thus, provides a variety of activities for the subjects to control their own activities and take responsibility for their action in the process of learning (Aksela, 2005). The approach encourages students to independently state hypothesis, design testable experiments, identify and control variables, collect and interpret data, envisage possible sources of error and ways tomodify the experiment. These require thinking skills which did positively affect the students' academic performance. The relatively poor performance of the subjects in the control groupis an indication that the lecture method adopted in teaching science by science teachers is not effective in promoting cognitive processes in students in the senior secondary schools as observed by Lawson (2002), Aikenhead (2005) & Mukherjee (2007) that subjects do not acquire cognitive skills unless concerted efforts are made to identify and use instructional strategies that promotes its development and lecture method does not do this.

The result in Table 4.6 show that there is a significant difference at 0.05 confidence level between the mean scores of the experimental and control groups in cognitive questioning preference in favour of the experimental group after exposure to treatment. This indicate that the science process teaching approach is potentially effective in influencing subjects preference for high level cognitive questions and a paradigm shift

from low to high level cognitive questions. Thus the pedagogical model (strategy) activates the teaching – learning process by making it more relevant and more attractive to chemistry students (Lavonen, & Meisalo,2004)). Also Aksela (2005) explained that the method directly involve the students as active participants, thus enable the students take responsibility for their learning and to effectively construct their own knowledge. The strategy emphasizes, that the planning, teaching and assessment are focused on the needs and abilities of the learner. The learners are actively engaged in doing most of the workby using their hands and cognitive structure in the teaching and learning process. There is considerable research evidence (for example, Ezeliora 2010) that if learners are active in the class, they will learn more effectively and exhibits greater performance. Gandu, (2006) show that effective learning and performance are related positively to the nature of questions the students are exposed to and preferred to answer. The level of knowledge acquisition and mastery of skills is a function of the type of question students preferred and are exposed to while using the process approach. Students' response also formed the basis for assessing the quality of learning acquired and retention of materials learnt. This findings is in agreement with those of Solomon (1988), Pedenson (1992), Meyer (1992) and Aikenhead (2005), that the acquisition of traditional science content was significantly better for the experimental group compared with the control group and that the science process teaching approach consistently appears to augment the science students achievement in chemistry (Shaw, 2002).

The result obtained in Table 4.7 indicated that student who were subjected to the science process approach had a significantly higher retention than those in the control group ($P \leq 0.05$). This has shown that the science process teaching approach is effective in enhancing theability to retain concept by students in chemistry. This result agrees with

the findings of Gandu (2006) and Iliya (2010) who both found out in their study that students exposed to high level cognitive questions employing an appropriate instructional method enhances student's retention ability in learning chemistry. Also Lawson (2001) from his study agrees that students' retention ability can be enhanced through effective instruction. Other studies by Aksela (2005) and Shaw (2002) have also shown that time spent on teaching science students process skills results in gain in their retention ability. The suitability of the method (SPTA) as a mean of promoting retention ability may therefore be attributed to the nature of the instruction which is learner centered and thus provided a variety of activities for the subjects to take responsibility for their own studies in the process of learning. Also the nature of the level of questions makes the learner to synthesize the new knowledge and ability to retain what is taught (Susan 2001 & cotton 2001). Hence science processapproach is important for effective learning and retention of scientific concepts.

The relative poor retention recorded in the control group is an indication that the lecture method adopted in teaching scientific concepts by science teachers is not effective in promoting retention ability in students in the secondary school. This is supported by the findings of Zohar (2001), Mukherjee (2007) and Aikenhead (2001) that subjects do not acquire retention unless concerted efforts are made to identify and use instructional strategies that promote its development.

Results of analysis presented in Table 4.8 and 4.9 indicate a significant difference in the mean scores on retention span at the different stages of 2, 4 and 6 weeks by levels of the study in favour of the experimental group exposed to science process teaching approach. The results show that the students were significantly better in retaining the chemistry concepts taught than those in the control group exposed to the conventional lecture method. This agrees with the findings of Susan, (2001) who

reported that knowledge retention was highest and most consistent over time for the students who received their information via science process approach. This was also supported by the findings of Cotton (2001) who found that students had greater gains in retention when directly engaged in the learning process as they are exposed to science process teaching. Anderson and Krathwohl (2001) noted that for learners, using scientific methods that provide very rich experiences from rich activities in the science classroom bring about equal knowledge retention.

The result of this study is also an indication that students perform significantly better in classroom where science process approach is employed by science teachers as conceded to by Zohar (2002) **that using science process teaching approach in a classroom, learners learn more, and enjoy the learning because they are actively involved in the learning process. Learning is active when it concentrates on thinking and understanding, rather than on rote memorization. Science processes concentrates on how to think and understand and hence learning become active and is transferable to other domain of knowledge. The author further revealed that in science process classrooms, learners create and organize principles that they can take with them to other learning settings. By grounding learning activities in an authentic, real world context, science process approach stimulates and engages learners to question things and apply their natural curiosity to the world. Learners also acquire scientific skills more effectively because they are provided opportunities in learning activities which bring about gains academically and promotes retention. A**s atool it is used by learners to help them perform efficiently and effectively in the classroom and all aspects of lives. The gains in retention also could be attributed to the treatment the experimental students received during the study, if the treatment had no effect, the two groups are expected to have

equivalent performance and scores are significantly correlated with performance on task and retention ability.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

In this chapter, the summary of the procedure for data collection and the findings from the study are presented. The conclusions and recommendations arising from the findings are also outline.

5.2 **Summary**

This study investigated the effect of science process teaching approach on academic achievement, cognitive questioning preference and retention span of chemistry students in senior secondary school (SSS).

A total of 78 subjects (40 in the experimental group and 38 in the control group) were used for the study. The experimental group was exposed to science process teaching approach for six (6) weeks. They were selected by simple randomization. The two schools were: -

- Government Senior Secondary School chindit Barracks
- Government Senior Secondary School Bomo

The instrument used was Chemistry Achievement Test (CAT), it was used to collate data as pretest, Posttest and post-posttest used in answering the research questions and to test the stated hypothesis. CAT is a 30 items multiple choice instruments, the CAT with a reliability coefficient of 0.73 was used to collect relevant data which were analysed using t – test statistics and Analysis of variance (ANOVA) at 0.05 level of confidence (was adopted) for retaining or rejecting the hypothesis. The SPSS package was used to analyse the data obtained. The distribution of the scores at the pretest show that a high proportion of the subjects show greater preference for low level questionsin the cognitive domain which probably result in low academic achievement at SSCE examination. At SSS2 and at an

average age of 16years they were theoretically expected to have a preference for high level questions using the appropriate teaching method.

Three types of data were collected using the Chemistry Achievement Test (CAT) asfollows:

1. Pretest achievement scores was administered to subjects in the four selected schools, the data collated was analyzed using Analysis of Variance (ANOVA) to establish two groupsthat are equivalent academically and to determined the cognitive questioning preference of the sampled subject before commencement of treatment.

2. Posttest achievement scores of both groups obtained was analyzed using t-test statistics to establish significant difference in the mean scores of the two groups which could be attributed to the treatment and to determine if there was a significant shift in the cognitive questioning preference from low level to high level (among the two groups) and in which of the group is the shift significant.

3. Post-posttest achievement scores of both the Experimental and Control groups collated at three (3) interval of 2, 4 and 6 weeks respectively were analyzed using the Two Ways Analysis of Variance (ANCOVA) to determine retention span and to establish which of the two groups retained the learned scientific concepts more at the extended period.

The result of data analysis were presented and discussed, contributions to knowledge were identified, conclusions were drawn from the results obtained and recommendations were made for further studies.

5.3 **Summary of Major Findings**

The following findings were obtained

1. Theanalysis of the posttest indicates that the experimental group performed better than the control group in their academic achievement after undergoing the experimental treatment of science process teaching approach.
2. The level of acquisition of retention was high through science process teaching approach than the use of the lecture methods.
3. Science process teaching approach was found to be more effective in enhancing the cognitive questioning preference of chemistry students at the senior secondary school level.

4.That knowledge retention was highest and most consistent over time for thestudents whoreceived their information via Science Process Teaching Approach.

5.4Conclusion

Based on the results obtained from this study, the following conclusions can be made:

The analysis of the result show that the experimental subjects acquired higher skills and hence performed significantly better because of the treatment. This is an indication that science process teaching approach is effective in improving students thinking skills and academics achievement. This also revealed that the traditional lecture method commonly employed for instruction in schools is not quite suitable for meaningful learning and teaching science concepts.

Cognitive ability of the experimental students in line with Bloom (1986) classification was enhanced significantly after treatment. This shows that science process teaching approach is effective in promoting cognitive skills of science students. This may also imply that the science process approach can be used as an effective instructional tool for eliminating

poor performance and a fundamental step towards enhancing students' performance in science learning.

The experimental group students show significant improvement in their cognitive preference for high level cognitive question than the control group after the treatment. This shows that cognitive questioning preference of science students can be enhanced through appropriate use of teaching method and training. This also is an indication that unprofitable teaching methods may be responsible for students' low performance in chemistry in the secondary schools.

That students exposed to science process teaching approach retained scientific concepts taught them better than their counterparts taught using lecture method. This imply that students in the experimental group show greater gain and has greater retention span as they have consistently significantly high mean score after a period of 2, 4 and 6 weeks. This indicate that science process teaching approach promotes meaningful learning and retention in the sciences particularly chemistry in the senior secondary schools. The mode of instructions should therefore be predominantly activity oriented, learner-centered and process-based teaching that would aid effective transition from low to high achievers, promote retention span and preference for high level cognitive questions because of its potentials to enhance achievement in chemistry as revealed in this study among senior secondary schools students.

5.5Contributions to Knowledge.

This research workwas initiated, to determine the most effective ways to improvestudents'skills in dealing with cognitive questioning types in the classroom through the use of science process teaching approach. It was observed that:

(a) Most studies in this area was to determine effects of high level and low level questioning styles on academic achievements or teachers question type on students' performance but not

on cognitive questioning preference, in this research works however, the Science Process Teaching Approach was employedto determine students cognitive questioning preference and was also used to enhancea paradigm shift in students preference for high level cognitive questions from low level cognitive questions.Theimplicationof this shifton academic achievement of students in the secondary schools was very significant as obtained from findings hence the method is a pragmatist approach to improving academic achievement among chemistry students and indeed in the sciences.

b. Result from the research also agreed with the findings that knowledge retention was highest and most consistent over time for the students who received their information via Science Process Teaching Approach. It was noted that for learners, exposed to methods that provide very rich experiences from rich activities in the science classroom bring about equal knowledge retention and that students had greater gains in retention when directly engaged in the learning process as they are exposed to Science Process Teaching Approach.

c. The research instrument Chemistry Achievement Test developed by the researcher for the studycan be employed as a credible instrument for testing ability level of students, to determine cognitive questioning preference and retention span.The instrumentcan also be adopted or adapted for use in similar studies or other science education based researches to move forward the frontier of knowledge.

d. In this area of study that is in Zaria Metropolis this study is the first of its kind more especially on retention span and cognitive questioning preference with respect to exposure to science process teaching approach.

e. The findings of the study also provided additional evidence on how to enhance students' performance in science.

f. Also the findings added new information to the existing literature which can be used by curriculum planners in science education.

5.6Recommendations

Based on the findings of this study, the following recommendations are made:

1. Since the level of students' cognitive processes and skills affects the learning of science concepts, there is therefore the need for science teachers to systematically and periodically assess or determine this ability of their students. One way of doing this is by the use of Cognitive questions. This is with a view to adapting curricular contents, achievement goals, instructional methods and educational strategies to improve their cognitive questioning preference.
2. The science process approach tends to have stimulated higher cognitive gains in the experimental group than the control group. There is a need to employ science process based instruction in the senior secondary schools as a means to reduce academic deficiency and enhance the retention span among science students in the senior secondary schools.
3. The study also revealed differences in acquisition of cognitive skills between experimental and control groups, in favour of the experimental subjects. One implication of this study is the superiority of science process approach over the lecture method. As this study has shown, instructional methods tend to be achievement related, there is need therefore to use a variety of methods in science teaching to ensure that ample opportunity is provided to assist students develop conceptually and consequently, enhance understanding of science lessons.
4. Nigerian universities should be encouraged to design educational programmes that will equip teachers in training with skills for the use of science process teaching

approach and in organizing science process – based activities. Teachers are known to teach the way they are taught/trained.

5.7 Limitations of the Study

The following limitations were noted in the course of this study:

1. The study was restricted to chemistry students in government owned schools; the geographical coverage is Sabon Gari Local Government Area of Kaduna State thus limiting generalization made from the study.
2. Language was a problem. The researcher often had to resort to the native dialect to explain and teach some concepts.

5.8 Suggestions for Further Studies

1. Similar studies could be carried out on several classes with larger sample sizes and data collected on each class, analysed separately to observe any significant difference in gains academically, which may exist among the various classes. Such study would help to broaden an understanding of the interrelationship which might exist among students cognitive processes vis–a–vis instructional methodologies.
2. This study can be replicated in rural schools to determine if there are differences in the cognitive ability between students in the schools located in the rural areas and those located in the urban areas.
3. It is needful to extend the study over a period of one to two years to ascertain the sustenance or otherwise of the effects of science process teaching approach in promoting cognitive gains in students. This will also help to establish if long period of exposure to science process approach will help to remedy poor academic achievements in the sciences and chemistry in particulars.

4. Similar studies could be carried out at the tertiary institutions such as Colleges of Education (COE), Polytechnics, Monotechnics and Universities.
5. This type of study could also be conducted in other science discipline such as biology, physics, Basic sciences and Agriculture among others.

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APPENDIX A

CHEMISTRY ACHIEVEMENT TEST (C.A.T) TIME ALLOWED: 2 HOURS

INSTRUCTIONS

ATTEMPT ALL QUESTIONS

DO NOT START UNTIL YOU ARE TOLD TO DO SO

SCHOOL:……..……. EXAM NO:……

1. A soda water manufacturer wants its sodas not to freeze in very cold weather. Which of the following methods would be most likely to solve this problem?

a. Decrease the amount of gas in the soda

b. Decrease the amount of sugar in the soda

c. Increase the amount of sugar in the soda

d. Store the soda in bottles rather than in cans

2. Customers in Jos were complaining that cans of diet cola were freezing and bursting in the cold season temperatures. Cans of regular cola were not freezing. What would you tell the makers of diet cola to do to stop it from freezing and why?

……

……

……

3. Select from the PH values 1, 5.5, 7, 8 and 11 the one you consider most applicable to each of the following solutions?

a. Lime water …….

b. Household soap ……

c. Hydrochloric acid…….

d. Lemon juice …….

e. Sodium chloride ……..

4. On a sunny day, it was observed that an inflated balloon kept outside under the sun suddenly exploded.

a. Identify and state the various gas laws and theory involved in this reaction.

b. Explain the processes resulting to the explosion of the balloon.

5. (i) Formulate the ideal gas equation by drawing an analogy to the combined gas laws.

ii. Design a diagram to give a picture of the relationship between gas molecules, temperature, pressure, volume and how it affected the reaction (explosion)

6. Give one reason for the observed increase ionization energy from left to right of the periodic table…….....

.....……

7. In terms of kinetic theory, explain:

a. Expansion of a gas

b. Low density of a gas

c. Pressure of a gas

8. Explain Boyle's law in terms of kinetic theory ……...

……..

9. Which of the following expressions correctly represents Charles law?

a. PV = K

b. R & 1/VP

c. PV = RT

d. V = KT

10. A gas sample initially at 35^0 is cooled to -42^0C. Calculate the ratio of the initial volume to the final at constant pressure.

a. 1:2

b. 2:3

c. 3:4

d. 5:6

11. To what temperature must a gas at 273K be heated in order to double its volume and pressure?

a. 298K

b. 546K

c. 819K

d. 1092K

12. Explain in terms of kinetic theory why there is an increase in pressure in a motor tyre on a sunny day?.....

……

……

13. Evaluate the temperature of a given mass of a gas initially at 0 ^{0}C and 9 atmospheres, if the pressure is reduced to 3 atmospheres at constant volumes?

a. 91K

b. 182K

c. 273K

d. 819K

14. Which of the following cannot be explained by the use of the kinetic theory?

a. Dalton's atomic theory

b. Boyle's law

c. Gay Lussac's law

d. Expansion of gasses

15. What volume of hydrogen will be produced if 100 cm^3 of ammonia is completely decomposed at constant temperature and pressure?

The equation for the reaction is: $2NH_{3(g)} \longrightarrow N_{2\,(g)}\ 3H_{2(g)}$

a. $50cm^3$

b. $150cm^3$

c. $200cm^3$

d. $300cm^3$

16. Why is sodium chloride solution regarded as a mixture? …….

……..

17. How would you prove that sodium hydroxide is a base without using litmus paper test, give an equation for there action…….....

……..

.....

18.Write briefly in your own words; Acidified water exhibits a high conductance than pure water……

……

……

19. A given volume of oxygen diffuses through a porous plug in 8.0 secs. How long will it take the same volume of sulfur (iv) oxide to diffuse through under the same conditions (O = 16, SO_2 = 64)

a. 5.7 secs.

b. 8.0 secs.

c. 11.3 secs.

d. 16.0 secs.

20. A gas X diffuses through a porous plug in 60 seconds while the same volume of hydrogen diffuses in 15 seconds under the same conditions, calculates the relative molecular mass of X and what is X.

a. 4.0

b. 8.0

c. 16

d. 32

21. Which of the following gases is higher than air?

a. HCL

b. CO_2

c. SO_2

d. NH

22. Burning _____ in Chlorine, in the presence of _____ as the _____, yields _____ gas which dissolves readily in water to give _____ acid. State the formula.

23. If an element **X** with electronic configuration 2,8,3, combines with another element **Z** with electronic configuration 2,8,6, the compound formed will have the formula …… (ii). Justify the formula.

24. Consider the reaction presented by the following equation: $H_{2(g)} + I_{2(g)} - 2HI_{(g)}$ the number of effective collisions of molecules of the reactions decreases as:

a. The temperature is raised

b. The pressure is increased

c. The volume of the system is increased

d. A catalyst is introduced into the system

25. When ice is changing to water, its temperature remains the same because the heat gained is?

a. Used to separate the molecules

b. Loss partially to the atmosphere

c. Used to increase the volume of ice

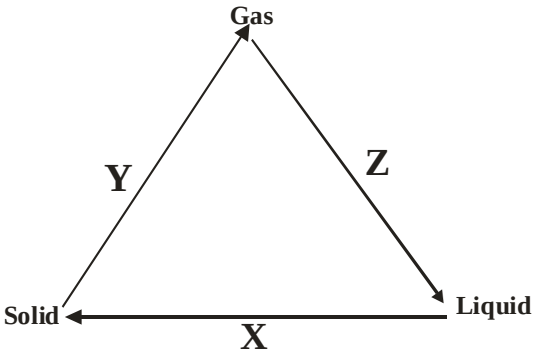
d. Less than the activation energy

26. Name the process involved in the (i) Spread of the smell of a perfume across a room

(ii) Decrease in the yellow of a liquid after exposure in an open vessel.

27. (i) State two differences between the properties of solids and gases

(ii) What process does each of X, Y and Z represent in the changes shown below.



28. (i) State Charles' law

(ii) Draw a stretch to graphically illustrate Charles' law.

b. 60cm^3 of hydrogen diffused through a porous membrane in 10 minutes. The same volume of gas G diffused through the same membrane in 37.4 minutes. Determine the relative molecules of G. [H = I].

29. Consider the reaction represented by the following equation:

$H_{2(g)} + CI_{2(g)} \longrightarrow 2HCI_{(g)}$

Explain how the rate of formation of HCI(g) would be affected by

i. Increase in temperature

ii. Decrease in pressure

30. Given different examples, mention one metal in each case which produces hydrogen on reacting with:

i. Dilute mineral acid

ii. Cold water

iii. Steam

iv. Hot, concentrated alkali.

APPENDIXB

MARKING SCHEME

1. C
2. Markers of diet cola should increase the amount of sugar in diet cola
3. a – 11

b – 8

c – 1

d – 5.5

e – 7

4. Charles law and kinetic theory

Charles law states that the volume of a fixed mass of a gas is proportional to its absolute temperature if pressure is kept constant

Kinetic theory postulated

a. Gases consist of molecules moving in random motion colliding with each other and with the walls of the container and in the process exerting pressure on the walls
b. Forces of attraction or repulsion between gas molecules are negligible
c. Volume occupied by molecules compared to the container is negligible
d. Collision between gas molecules is elastic

5. Temperature is a measure of the average kinetic energy

$PV = K$ - Boyles law

$\frac{V}{T} = K$ - Charles law

$\frac{PV}{T} = K$ - combine gas equation

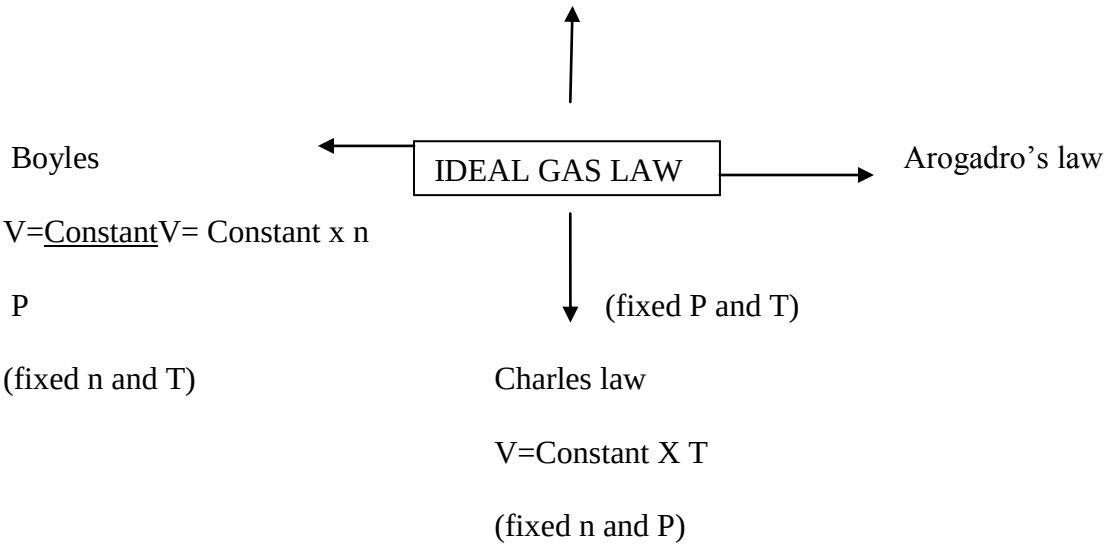
For n moles of a gas

$\frac{PV}{T} = nR$

Where R = is a gas constant

$PV = nRT$ → Ideal gas equation

(c) When gas molecules get heated in the balloon, the average kinetic energy of the gas molecules increase and consequently expansion of the gas molecules occurs and since the balloons has a limit of expansion it burst because it cannot withstand the pressure of the gas molecules



6. Ionization increases across the period because across the period effective nuclear charge increases, atomic radius decreases thus increasing the attraction the nucleus has for the valence electrons

7**. (a) Expansion of gas**: - When gas molecules are heated, their average kinetic energy increases, inter molecular distances also increase and thus expansion also occurs.

(b) Low density of gas: Small mass of a gas occupies a large volume because of negligible force of attraction between gas molecules. This is attributed to the low density of the gas.

(c) Pressure: Gas molecules are in continuous motion colliding with the walls of the container and exerting force on a unit area (pressure)

8**. Boyle's law:** When the volume of a container is small, the frequency of collision of gas molecules is high and the pressure become high but when the volume is increased, the frequency of collision decreases the pressure decreases.

9. D

10. C

11. D

12. There is an increase in pressure because when the air type becomesheated the rate of collision rapidly increases increase because the kinetic energy increase

13. A

14. A

15. D

16. (a) A decrease amount of air decreases the number of molecules expanding at constant T X P and so the ballon size increases.

(b) If temperature and volume of the tyre remains constant, an increase in amount of air increases the rate collusion with the wall of the container.

17. a

18. a

19. c

20. d

21. d

22. Burning hydrogen in chlorine, in the presence of activated charcoal as catalyst, yields hydrogen chloride gas, which dissolves readily in water to give hydrochloric acid.

$H_2(g) + CL_2$ activated charcoal $2HCL(g)$

23. X_2Z

24. c

25. d

26. i-diffusion

ii-evaporation

27. i. a. Solid has a fixed shape while gas take the shape of the container put into

b. The particle of solid are held together by strong attractive forces while gas particles can move from one place to another.

ii. X- freezing

Y- sublimation

Z- Condensation

28. The volume of a given mass of gas is directly proportional to its absolute temperature if pressure is constant.

29. i. Will increase rate of forward reaction

ii. It will decrease the rate of forward reaction

30. i. Na

ii. Sulphur

iii .Li

iv. CL

APPENDIX C

LESSON NOTE FOR EXPERIMENTAL GROUP

Mode of teaching	-	Science Process Approach
Lesson topic	-	State of Matter
Time	-	Double period (80 minutes)
Class	-	SS 2
Number of pupils	-	40
Average age of pupils	-	16 years
Topic	-	Change of State

Instructional material: Iodine pellets, H_2O, Ice cubes, beakers, glass crucibles and bursen burner etc.

Behavioural objectives

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

(a) Design a clear diagram showing the pathways of the reaction/processes in the experiment just carried out.

(b) Explain the major differences in the two experiments in activity 2 above.

(b) Evaluate in their words, the process of change in gases, liquids and solids.

(c) Explain the importance of this changes to man.

Previous knowledge

The students are familiar with liquid, solid and gases from SS 1.

Introduction: The lesson took the form of brief presentation and informing the class the topic of the lesson for the day, provision of the required experimental material as well as organizing students and resources for effective learning, provision of clear instructions on

students' activities. The key concepts and ideas which students are required to remember will be summarize on the chalk board.

Presentation: The teacher presented the lesson through the following activities

Activity 1:

Sample A is Ice Cubes

Sample B is Water

Sample C is Iodine pellets

1, Take three cubes of sample A from the coolant and drop in a dry beaker and warm the sample gradually on bursen burner with a metal gauze until the sample A. melts completely. What was your observation?

2. Keep heating the liquid formed to boiling point for about five (5) minutes. Record your observations. Also weigh $10cm^3$ of sample B. and pour into another clean beaker, place on the burner heat to boiling.

3. Cover the boiling beakers containing samples A and B with glass crucible or glass lid and remove the source of heat and allow to stand on the working desk to cool. Note the process going on. Repeat the activity in S/no 1and 2 above and record your observation(s), design a diagram explaining the processes in the experiments

4. Pick some ice cubes into a beaker and allow to stand at room temperature i.e. without heating it for thirty (30) minutes. Observe and record your findings, compare the result with experiment s/no1 above (show the difference clearly).

Activity 2 SUBLIMATION

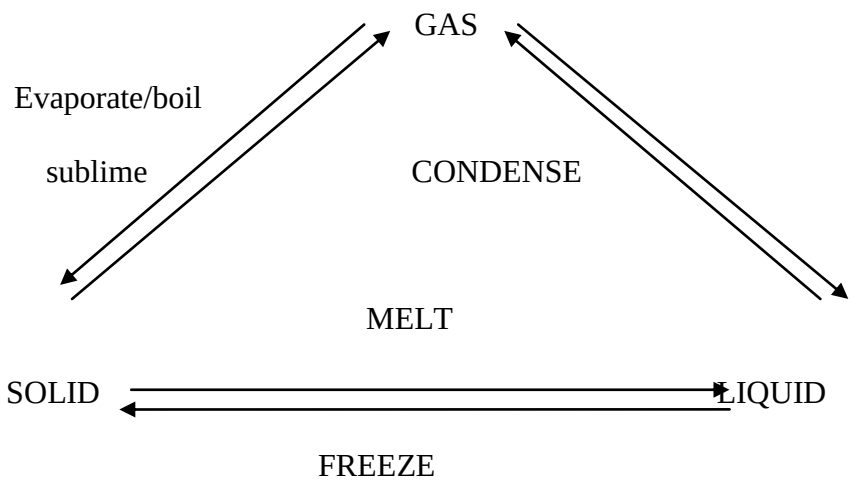
a. Into a dry clean beaker, weigh 1g of sample C Iodine pellets, cover the beaker with a glass lid and place on a bursen burner and observe carefully the reaction. Record accurately your observation.
b. If the entire sample has vanished, remove the source of heat and allow the beaker and its content to stand for 10 minutes.
c. Repeat the activity 1 and 2 once more, this time very carefully, record and give a vivid analysis of your findings in all the three steps accurately.

Evaluation

The teacher asked the following questions;

1. Design a clear diagram showing the pathways of the reaction/processes in the experiment you just carried out.
2. What are the major differences in the two experiments in activity 2 above and why?
3. Evaluate the process of change in gases, liquids and solids.
4. What is the importance of this changes to man.

Conclusion:



Substances can exist as solid, liquid and as a gas. Changes of state are brought about by a change in temperature as a substance change from a gas state to liquid state then to solid, through the process of **condensation/freezing** its particles become energetic and lose their random motion gradually to finally get arranged in an orderly pattern. Similarly when the temperature of the substance is increased, the particles gain energy enough to resume their random movement to change state either through **melting**, **evaporation** and or **boiling**. The process of change of state from solid directly to gas without going through the liquid state is called **Sublimation**.

LESSON NOTE FOR EXPERIMENTAL GROUP

Mode of teaching - Science Process Approach

Lesson topic - Kinetic theory of matter

Time - Double period (80 minutes)

Class - SS 2

Number of pupils - 40

Average age of pupils - 16 years

Topic - Diffusion

Instructional materials

Gas jars, cylinder, glass tube, liquid bromine, cotton wool, water, Perfume jar, Conc NH_3, Conc HCl, perfume, Conc Cu_2So_4

Behavioural objectives

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

(a) What diffusionis from their observation.

(b) Explain scientifically, the process of diffusion in gases, liquids and solids.

(c) Relate the importance of diffusion to man and consequences on his environment.

(d) Compare/contrast diffusion in gases/liquids, liquid/solids, gas/solids.

Previous knowledge

The students are familiar with the different states of matter i.e. liquid, solid and gases from SS 1 and have conducted test on the state of matter.

Introduction

This involved revision of previously learnt lesson and provision of materials for the lesson, organizing students and resources for effective learning, provision of clear instructions on students activities, managing student task and thinking as well as summarizing the key concepts and ideas which students are required to remember on the chalk board.

Presentation of lesson

The students were divided into five (5) groups of eight (8) students each to carry out the following activities.

Step I

Activity sheet 1DIFFUSION IN LIQUID.

The students were instructed to carry out the activity in the sheet.

To observe the diffusion of a gas

(a) Place a few 10 drops of liquid bromine at the bottom of a gas jar. Cover the jar with a glass cover; leave it to stand for a few minutes.

(b) Carefully record accurately what you observed and give two reasons for your answer.

Step II

Activity sheet IIDIFFUSION IN GAS.

The students were also instructed to carry out the activity in the sheet.

A. To show the relative rates of diffusion of two gases of different densities

a. Place a glass tube open at both ends as shown in the diagramme, soak a ball of cotton wool in concentrated aqueous ammonia, and another in concentrated hydrochloric

acid. Stuff one at each open end of the tube. Then close both ends with rubber bungs and wait for a few minutes.

b. Carefully record accurately what you observed.

c. Identify solid ‘C’with expected reaction equation

d. Explain in you words what you think happened.

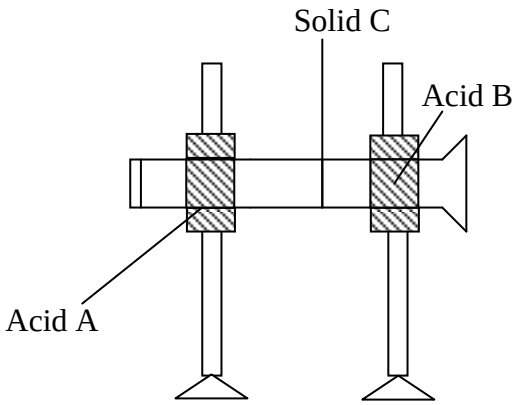


Diagram A

B. To show diffusion in liquids

i. In another clean 100cm^3 cylinder, weigh and pour 30cm^3 of concentration copper (II) tetraoxosulphate (VI) into it i.e. (the cylinder).

ii. Use a water bottle and run water gently through it side until the cylinder is 80cm^3 (i.e. you add 50cm^3 of water).

iii. Use a colour pen and markthe separation between the clean water and the blue colour of Cupper (ii) tetraoxosulphate (VI). Allow to stand for about 20 minutes.

iv. Record carefully what you observed happening.

v. Explain in your own words if there was any change from the others you have done and why?

Step III

Activity sheet III. DIFFUSION IN SOLIDS.

The students were instructed to carry out the activity in the sheet.

To show diffusion in solids

i. Tie the two bars of soap (i.e. the green and the yellow) together using lace provided and allowed to stand for 20 minutes.

a. Record observation made.

b. Explain your results in your own words.

Evaluation

Answer the following questions:

(a) What is diffusion?

(b) List and explain two (2) differences each between diffusion in gas/liquids, liquids/solids, solid/gases

(c) Why is diffusionfaster in gas than in liquids or solids?

(d) Relate the importance of diffusion to man.

Conclusion:

The teacher concluded the lesson by briefly summarizing what the students have learnt on diffusion and movement of particles due to average kinetic energy. That matter is made up of tiny particulars such as atoms, molecules and ions. Kinetic theory stated that these particulars are continually moving and that their ability to move is because they have some energy called kinetic energy. But that the speed and the way this particles move is different for different state of matter (solid, liquid and gas). The lesson is to determine whether they actually move and how fast and why they move (translate) in the different state of matter.

Re-evaluation of results

The teacher re-evaluatedstudents responses and ascertain its correctness in relation to the concept taught, a summary was made on the chalkboard, students compare results and make corrections for effective learning.

LESSON NOTE FOR EXPERIMENTAL GROUP

Mode of teaching - Science Process Approach

Lesson topic - Gas Laws

Time - Double period (80 minutes)

Class - SS 2

Number of pupils - 40

Average age of pupils - 16 years

Topic - Verification of Gas Laws

Instructional materials

Beaker, water, balloons, thermometer, retort stand, Bunsen burner, stirrer, bicycle pump, ice water and chart.

Behavioural objectives

At the ends of the lesson, the students should be able to

a. Explain kinetic theory of gases.

b. Evaluate the effect of increased temperature on gases volume.

c. Analyse the different behaviours of the gases in the experiment.

d. Solve different problems relating to kinetic theory

Previous knowledge

The students are familiar with kinetic theory of matter, osmosis, diffusion etc.

Introduction:

The teacher introduce the lesson (usingconcrete prompts such as;what is a gas, how does temperature relate to gasesetc.) verification of gas laws.

Presentation of lesson

The students will be divided into 8 groups of five (5) students each to carry out the following activities.

Step 1

Activity Sheet 1:EFFECT OF TEMPERATURE ON VOLUME OF GASES.

The students were instructed to carry out the activity in the sheet.

To observed effect of increased temperature on a gas volume:

a. Fill the balloon with air and placed it on a beaker of water on a Bunsen burner with thermometer clamp to a retort stand immersed in the water and heat gently starring the water for few minutes.

b. Carefully record accurately what you observed and give two reasons for your answer.

Step II:

Activity Sheet II: The students were instructed to carry out the activities in the sheet

To show the effect of reduced temperature on volume of a gas

a. Remove the inflated balloon carefully along with the thermometer and placed on a beaker of ice water for 5 minutes

b. Record carefully your observation.

c. Give one reason for your answerbased on kinetic theory.

Step III:

Activity Sheet III: Effect of pressure on volume of gases, the students was instructed to carry out the activity in the sheet.

To show effect of pressure on gas volume

a. Inflate a bicycle pump with air to half its length and try to exert pressure after blocking the exit with your palms.

b. Try to increase the volume by pulling the handle the full length.

c. Record what you observe in (a) above.

d. Record your observation in (b) above.

e. Give one reason each for your answer.

Conclusion

The teacher concludes the lesson by summarizing what the students have learnt on behaviour of gases.

Quantities in the Measurement of Gases

In discussions involving gases, four parameters or quantities, are important and must be considered, these are

i. The volume of the gas,

ii. The pressures,

iii. The temperature,

iv. The mass or number of moles

Volume: This is measures in cm^3 and dm^3 (in the older books litre was used)

Pressure: This is measured in atmosphere (atm), or in mm of mercury or torrs, where

1 atm = 760 mm Hg = 760 torrs,

or in Newton/metres^2, (N/m^2) or (Nm^{-2}) where

1 atm = 1-01 325 Nm^{-2},

or in pascal, Pa, where

1 atm = 101 325 Pa.

The pascal and the Newton/meter^2 are equivalent units, i.e. 1 Pa = 1Nm.

Temperature: This is measures in t^0C, i.e. in degrees Celsius, or TK, i.e. the Kelvin temperature or absolute temperatures. T^0C is converted to TK by adding 273^0C to the Celsius temperature. Thus; the conversion is done by using the formula, $TK = 273 + t^0C$.

Example 1

Convert 83^0C to the absolute temperature scale

Solution

$TK = 273 + t^0C$

$= 273 + 83^0C$

$= 356K$

Example 2

Converts 298 K to the Celsius temperature scale.

Solution

$TK = 273 + t^0C$

$\therefore T^0 = (TK - 273)^0C$

$= 298 - 273$

$= 25^0C$

Example 3

The pressure of a given mass and volume of gas is given as 22mm Hg. Convert this pressure to:

i. torrs,

ii atmospheres

iii. Newton/metre^2 or pascals

Solution

i. mm Hg is the same as torrs

:. 22 mm Hg = 22 torrs.

ii. 760 mm Hg or 760 torrs = 1 atm

:. 22 mm Hg = $\frac{1}{760} \times \frac{22}{1}$ = 0.029 atm

iii. 1 atm = 101 325 newton/metre^2 or pascal

:. $\frac{22}{760}$ atm = $\frac{101\ 325}{1} \times \frac{22}{760}$ = 2933 Nm

Note: The points to note in example 3 are

i. mm Hg is the same as torrs and represents the height of a column of mercury that the pressure can support;

ii. an atmosphere is the average barometer pressure at sea level;

iii. Newton/metre^2 and pascal are the same;

iv. in most cases, the conversion factor to be used will always be given.

Evaluation

Answer the following questions

1. Evaluate the effect of increased temperature on gases volume.

2. Analyse the different behaviours of the gases in the experiment.

3. The pressure of a given mass and volume of gas is given as 22mm Hg. Convert this pressure to:

i. torrs,

ii . atmospheres

iii. Newton/metre^2 or pascals

4. State the kinetic theory of gases.

Re-evaluation of results

The teacher re-evaluated students responses to ascertain its correctness in relation to the concept taught and a summary was made on the chalkboard to enable students compare results and make corrections for effective learning and retention.

LESSON NOTE FOR EXPERIMENTAL GROUP

Mode of teaching - Science Process Approach

Lesson topic - Gas Laws

Time - Double period (80 minutes)

Class - SS 2

Number of pupils - 40

Average age of pupils - 16 years

Topic - Boyle's Laws

Instructional Materials

Liquid mercury, meter rule and a transparent narrow glass tube close at one end, $CaCl_2$ retort stand and clamp, chart.

Behavioural Objectives

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

a. List any two (2) kinetic theory of gases

b. State the mathematically equation of Boyle's law

c. Explain in their words the Boyle's law

d. Solve problems relating to the law.

Previous Knowledge

The students are familiar with the kinetic theory of gases.

Introduction

The teacher introduced the lesson by informing the students of the work of Robert Boyle's 1662 using the kinetic theory of gases.

Presentation of Lesson

The students were divided into five (5) groups of eight (8) students each to carry out the following activities. The key points were summarized on the chalk board.

Step I

Activity Sheet I

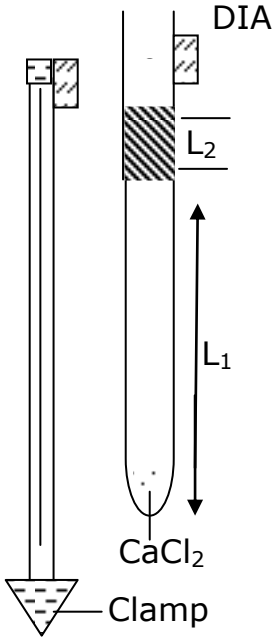
The students were instructed to carry out the activity in the sheet.

STUDENT'S ACTIVITIES TOWARDS BOYLE'S LAW

TASK → Teaching Boyle's Law through SPTA

MATERIALS — Liquid mercury, meter rule and a transparent narrowed glass tube close at one end,

ACTIVITIES — $CaCl_2$, retort stand and clamp



CLAMP

Tube is held vertically at eye level

↓

Some $CaCl_2$ is dropped inside tube

↓

Mercury is poured to trap some air as shown by the diagram

↓

From glass L_2 and L_1 are measured and recorded

↓

More mercury is added to the tube

↓

L2 and L1 are recorded again

↓

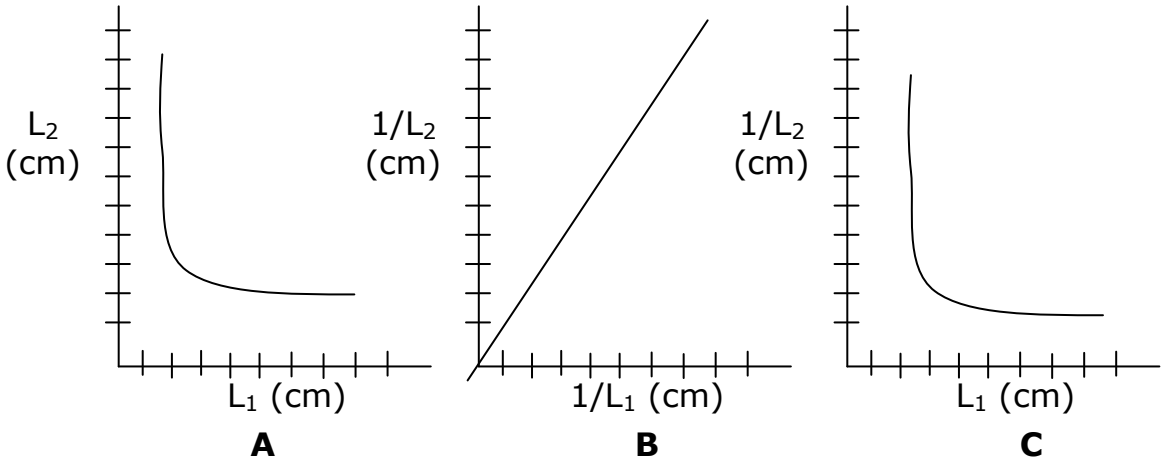
Repeat the procedure until it is not more than 30cm

II

Complete the table below

Stages	**L1(cm)**	**L2(cm)**	**1/L2**	**1/T1**
1				
2				
3				
4				
5				

Use your table above to plot the graphs whose axes are drawn below:



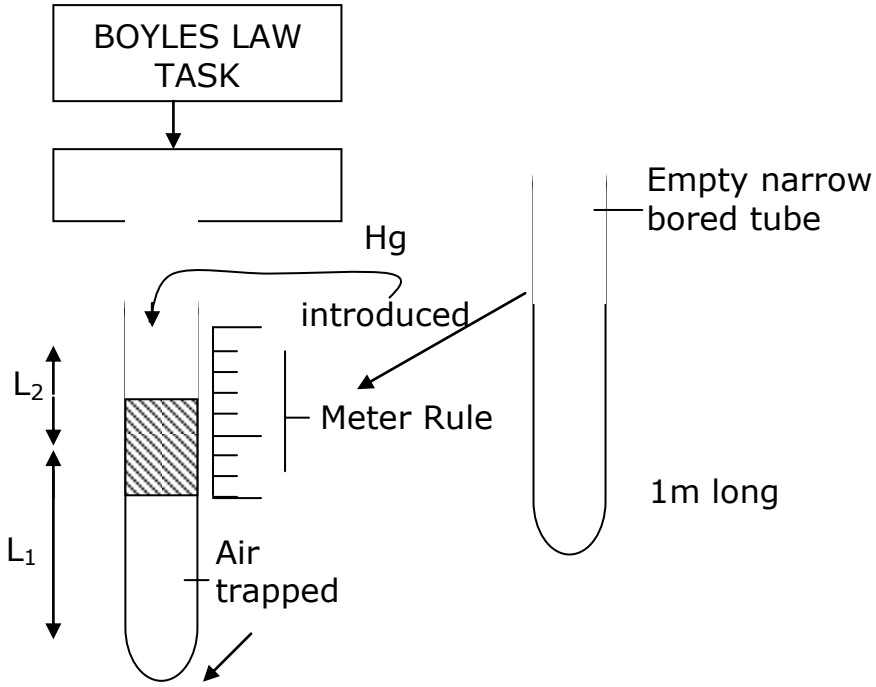
i. Which of the graphs gave a rough straight line propose an equation for the relationship between L_2 and L_1

ii. If L_2 is in pressure unit and L_1 is in volume, write your equation in terms of volume and pressure.

Step II

The students were instructed to carry out the activity in the sheet.

ACTIVITY SHEET 2. FLOW CHART



L_1= ?

L_2 = ?

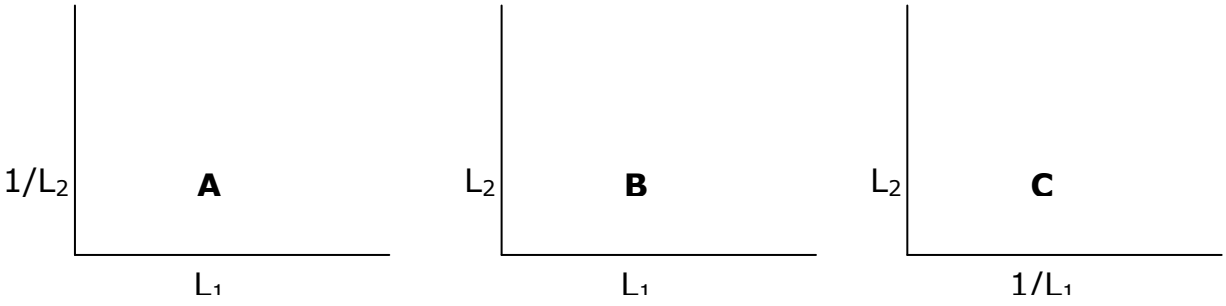
L_2 is increased to twice the original value L_1 = ?

L_2 is increased to 3 times the original value L_1 = ?

Tables

Obs	L_2(cm)	L_1 (cm)
1		
2		
3		
4		
5		
6		

Graph to be tried



Evaluation

Answer the following questions:

a. Explain in their words the Boyle's law

b. A gas occupies 200 cm^3 at 510 mm of mercury. If temperature remains constant, what will its pressure be when the volume is increased to 131 cm^3?

b. List any two (2) kinetic theory of gases

c. State the mathematical equation of Boyle's law

Conclusion:

The teacherconcluded the lesson by briefly summarizing what the students have learnt on Boyle's law.

Boyle's law states that for a given mass of gas, at constant temperature (T), the volume (V), is inversely proportional to its pressure (P)

Boyle's law is stated mathematically as;

$$V \propto \frac{1}{P}, \text{ if T is constant}$$

If V_1 is the volume of a given mass of gas at pressure P_1 and V_2 is the volume of the same mass of gas at pressure P_2 then it can be shown that

$$P_1V_1 = P_2V_2$$

If the temperature, T, remains unchanged. This is the most useful form of Bole's law

Example 1

A gas has a volume of 500 cm^3 when a pressure of 76 mm of mercury is exerted on it. What will its volume be if the pressure on it is changed to 73 mm of mercury, assuming the temperature remains constant?

Solution

Since the temperature is constant, the volume pressure relationship is that expressed by Boyle's law, i.e.

$P_1V_1 = P_2V_2$

$V_2 = \frac{P_1V_1}{P_2}$

Substituting the given values,

i.e. P_1 = 76 m of Hg, V_1 = 500 cm^3, P_2 = 73mm of Hg,

$V_2 = \frac{76 \times 500\ cm^3}{73} = 521\ cm^3$

Note that the volume is roe since the pressure is less.

Example 2

A gas occupies 200 cm^3 at 510 mm of mercury. If temperature remains constant, what will its pressure be when the volume is increased to 131 cm^3?

Solution

Since the volume is increased, the pressure will be less, also, since the temperature remains the same and it is the same mass of gas, we can apply Boyle's law, i.e.

$P_1V_1 = P_2V_2$

$\alpha_2 = \frac{P_1V_1}{V_2}$

Substituting V = 200 cm^3, P = 510 mm of Hg, V = 131 cm^3, we get,

$P_2 = \frac{510 \times 200}{131}$ mm of Hg

= 779 mm of Hg

Re-evaluation of results

The teacher re-evaluated students responses to ascertain its correctness in relation to the concept taught and a summary will be made on the chalkboard to enable students compare results and make corrections for effective learning and retention.

LESSON NOTE FOR EXPERIMENTAL GROUP

Mode of teaching	-	Science Process Approach
Lesson topic	-	Gas Laws
Time	-	Double period (80 minutes)
Class	-	SS 1
Number of pupils	-	40
Average age of pupils	-	16 years
Topic	-	Charles Laws

Instructional Materials

Liquid mercury, meter rule, a beaker, stirring rod, thermometer, water, capillary tube acts as cylinder, mercury pellets, retort stand, clamp, chart and $CaCl_2$.

Behavioural Objectives

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

1. Draw and interpretscientific tables relating to experiments
2. Plot and explain graphs through report
3. Propose a relationship between V_2 and T_2 at constant pressure
4. Derive the general gas equation.

Previous Knowledge

The students can explain Bolye's law.

Introduction

The teacher introduced the lesson by informing the students that the topic was Charles Law and by the provision, arrangement as well as managing of instructional materials and students for the lesson.

Presentation of Lesson

The students were divided into five (5) groups of eight (8) students each to carry out the following activities

Step I

Activity Sheet I

The students were instructed to carry out the activity in the sheet.

STUDENT ACTIVITIES IN VERIFYING CHARLES LAW

TASK — Teaching Charles law through SPTA

MATERIALS — Liquid mercury, meter rule a beaker stirring rod, thermometer water, capillary tube acts as cylinder mercury pellets, retort stand and clamp $CaCl_2$

ACTIVITIES

Clamp Thermometer, meter rule and tube is held vertically at eye level in beaker water

↓ Some $CaCl_2$ is dropped inside the tube

Mercury is dropped/poured to trap some air as shown in the diagram

↓

Both V_1 and T_1 are measured and read and recorded

↓

Add ice to the water in the beaker, stirring all the time, until temperature reads 0^0C Note the volume V_1 and record

↓

Heat the water to gain temperature by about 15^0C then remove flame, stir the water. Read temperature T_1 and V_1 volume of air at that temperature and record

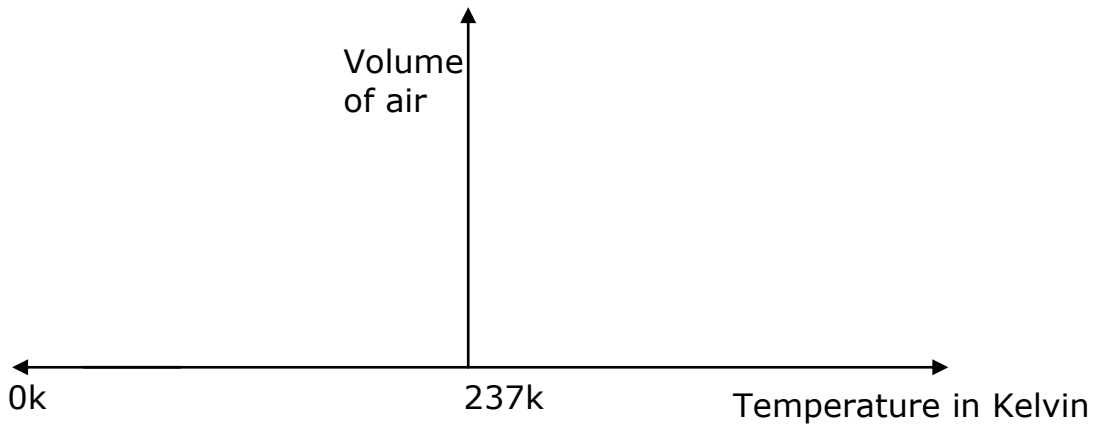
↓

Repeat the procedure five or six times and record your readings in table as shown

II

Stages	Volume of trapped air (Vmm)	Temperature of trapped air	
		0^0C	TIC
1	1		
2			
3			
4			
5			

Use your table above to plot a graph whose axis are drawn below.

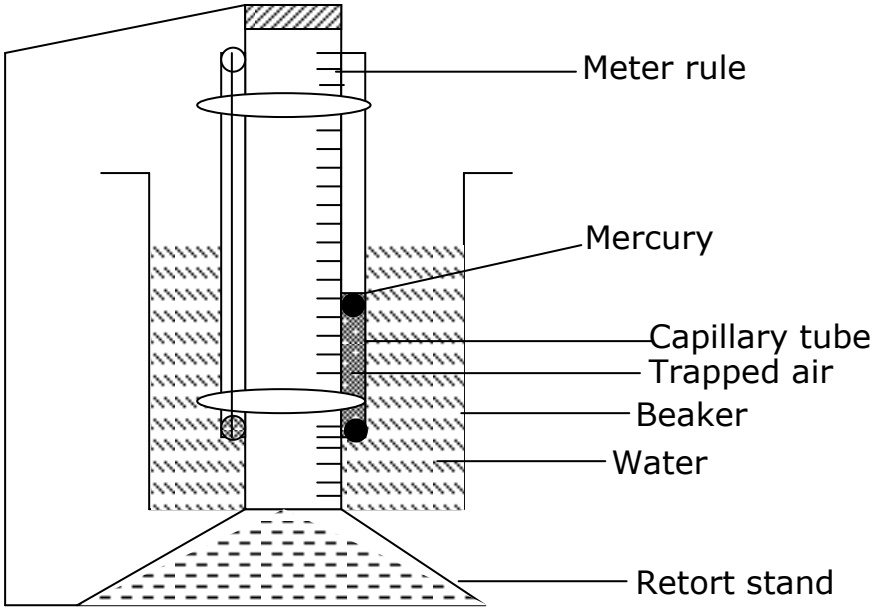


1. State your observation scientifically.
2. Discuss the increase and decease of volume of the gas as temperature is altered.
3. Propose an equation for the relationship between volume and temperature V and T
4. If pressure is kept constant write an equation in terms of V and T

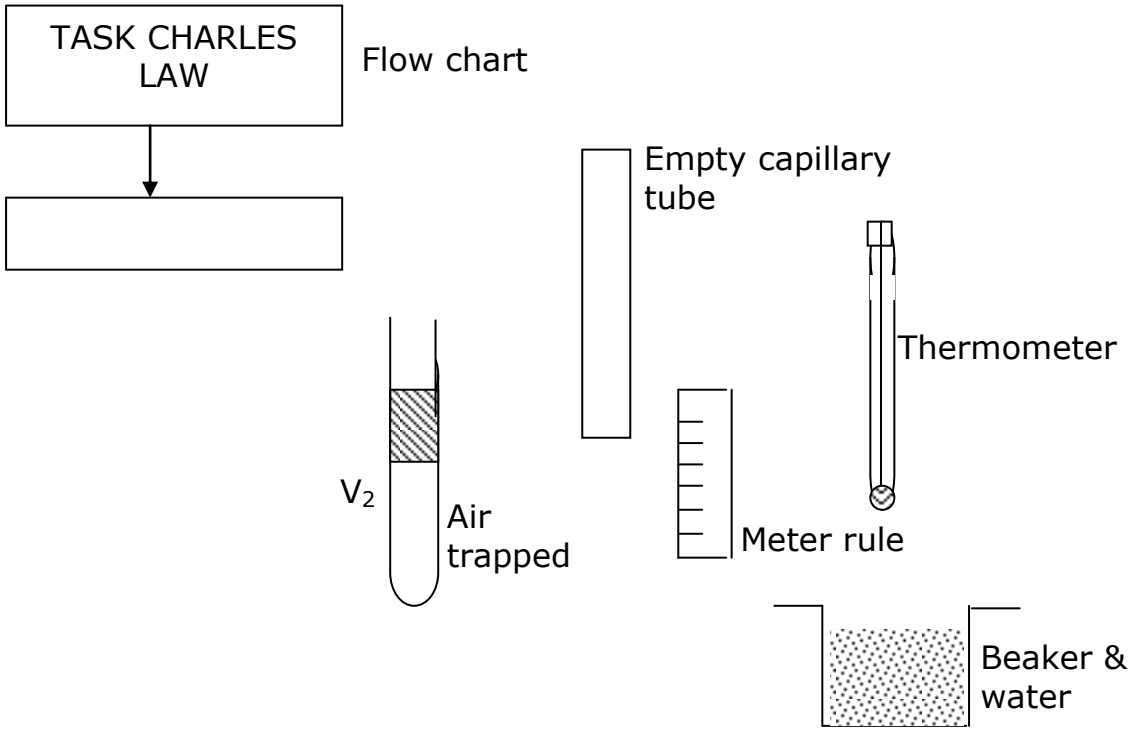
Step II

The students were instructed to carry out the activity in the sheet.

Activity II



SCIENCE PROCESS TEACHING APPROACH



V_1 is increased to twice the original value i.e. from V_1 – V_2 and carryout similar activity repeat about 5 or 6 times.

1. Draw a table

2. Plot a graph
3. Propose a relationship between V_2 and T_2 at constant pressure
4. Write any equation.

Conclusion:

Charles law states that for a given mass of gas is constant pressure, the volume is directly proportional to its absolute temperature.

Mathematically, it can be stated as follows:

$V \quad \alpha \quad T$, at constant pressure

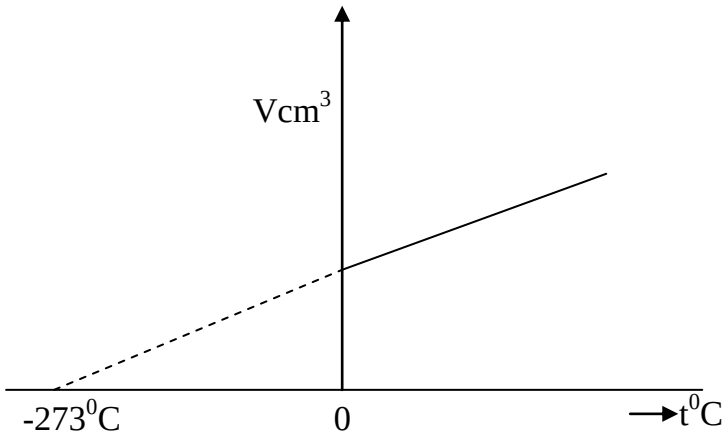
$V = \text{constant} \times T$

$\frac{V}{T} = \text{constant}$

If V_1 is the volume of a given mass at temperature T_1, and V_2 is the volume of the mass of gas at temperature T_2, then,

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ at constant pressure

The graphical representation of Charles law is as follows:



Volume of a gas is a function of Celsius temperature

The graph shows that at -273^0C, the gas has theoretically no volume. -273^0C is known as the absolute zero temperature. However, gases liquefy before his temperature is reached. (Note that the graph is plotted using the Celsius temperature, t^0C). What would happen if TYK is plotted against volume?

Examples

E.g 1

The teacher concluded the lesson by briefly summarizing what the students have learnt on Charles law with examples.

Example 1

A fixed mass of gas of volume 546 cm^3, at O^0C, is heated at constant pressure. What is the volume of the gas at 2^0C?

Solution

Since pressure is constant, we can see Charles law i.e.

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Where $V_1 = 546\ cm^3$, $T_1 = 0 + 273 = 273K$;

$T = 2^0C + 273^0C = 275K$

Substituting, $V_2 = \frac{V_1T_2}{T_1} = \frac{546 \times 275}{273} = 550\ cm^3$

Example 2

A fixed mass of gas occupied $40cm^3$ at O^0C. Find the temperature at which its volume becomes 54.7cm, assuming that its pressure remains constant

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Where $V_1 = 40\ cm^3$, $T_1 = 0 + 273 = 273K$; $54.7\ cm^3$

$$T_2 = \frac{V_2T_1}{V_1}$$

Substituting, $T_2 = \frac{54.7 \times 273}{40} = 373.3$

$= (373 - 273)^0C$

0r $= 100.3^0C$

Verification of the gas equation

The relationship between pressure (P), volume (V), temperature (T) and the number of moles(n) of any gas is expected as

$$P \times V = n \times R \times T$$

$$\text{or } PV = nRT$$

The expression is called an equation of state or the ideal gas equation. It states that the product of the pressure (P), and volume (V), equals the number of moles (n), Times a constant (R), times absolute temperature (T). He equation holds true only if the enraptures is expressed in K.

The numerical value of the constant R is 0.082, only if pressure, P\, is expressed in atmosphere, volume V, in dm^3, n in moles and temperatures, T in the absolute temperature scale K.

Example 1

4.0 moles of an ideal gas are at a temperature of -23^0C and a pressure of 300 torrs. What volume in dm will the gas occupy at that temperature? (R = 0.082)

Solution

Using the ideal gas equation,

$$PV = nRT$$

Where P = 300 torrs; n = 4; R = 0.082; T = 273 + (- 23) = 250K

We get on substituting, 300 x V = 4 x 0.082 x 250

$$V = \frac{4 \times 0.082 \times 250}{300}$$

$$= 0.273 \text{ cm}^3$$

Example 2

How many moles of a gas will occupy 4.0 cm^3 at 1 atmosphere pressure, and O^oC?

Solution

Using the ideal gas equation

$$PV = nRT$$

Where P = 1 atm; V = 4.0 dm^3, T = 0 + 273K = 273L; R = 0.082

We get, 1 x 4.0 = n x 0.082 x 273 by substitution.

On making n the subject of the formula, we get,

$$n = \frac{4.0}{0.082 \times 273}$$

$$= 0.179 \text{ mole}$$

Note: The ideal gas equation can also be used to calculate any of the parameters of gas. Thus

$$P = nRT$$

or $$\frac{P}{T} = nR$$

For a fixed number of moles, nR is constant. Therefore,

$$\frac{PV}{T} = \text{a constant}$$

If V_1 is the volume of a given mass of gas at pressure, P_1, and the temperature, T_1 and V_2, is the volume of the same mass of gas at pressure, P_2, and temperature, T_2, then we can get the following equation.

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

This gives a very useful method of conversion which combines Boyle's law and Charles law.

Example 3

A gas has a volume of 500 cm^3 when a pressure of 1000 newton/$metre^2$ is exerted on it. What will be its volume if the pressure is changed to 150mm Hg at the same temperature? (760 mm Hg = 101 325 newton/$meters^2$)

Solution

In all solutions, the units for volume must be the same. (This also applies to the units of pressure and temperature).

:. 1000 Nm^{-2} = $\frac{1000 \times 760}{101\ 325}$ = mm Hg

$$= \frac{760000}{101325} \text{ mm Hg}$$

Using the formula, $\frac{P_1V_1}{} = \frac{P_2V_2}{}$ we get,

$$\frac{}{T_1} \qquad \frac{}{T_2}$$

$V_2 = \frac{P_1V_1}{P_2}$ (since the temperatures are the same and $T_1 = T_2$)

Where P_1 = 1000 newton = $\frac{76000}{101325}$ mm Hg; P_2 = 150 mm Hg; V = 500 cm^3

On substituting the above values, we get

$$V_2 = \frac{760000}{101325} \times \frac{500}{150} = 25cm^3$$

Example 4

A certain mass of gas has a value of 241 cm^3 at 18^0C and 753 mm Hg pressure. What would its volume be at s.t.p.?

Solution

s.t.p, means standard temperature and pressure. At s.t.p., temperature is 273 K and pressure is 760 mm Hg or 1 atmosphere.

Using the ideal gas equation, $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$, we get

$$V_2 = \frac{P_1V_1T_2}{T_1P_2}$$

Where P_1 = 753 mm Hg; V_1 = 241 cm^3

T_1 = (18 + 273) K = 291K; P_2 = 760 mm; T_2 = 273K

On substituting these values, we get.

$$V_2 = \frac{753 \times 241}{291} \times \frac{273}{760} = 224cm^3$$

Evaluation

Answer the following questions:

1. Draw and interpretscientific tables relating to experiments
2. Plot and explain graphs through effect reporting
3. Propose a relationship between V_2 and T_2 at constant pressure
4. Derive the general gas equation.
5. Derive the general gas equation from the Charles and Boyle's law.

6. State the mathematically equation of Charles law

Re-evaluation of results

The teacher re-evaluated students responses in the class to determine its correctness in relation to the concept taught and a summary will be made on the chalkboard to enable students compare results and make corrections for effective learning and retention.

LESSON NOTE FOR EXPERIMENTAL GROUP

Mode of teaching - Science Process Approach

Lesson topic - Chemical Reactions.

Time - Double period (80 minutes)

Class - SS 2

Number of pupils - 40

Average age of pupils - 16 years

Topic - Acid - Base reactions

Instructional Material: HCl_{aq}, H_2SO_{4aq} Zn, Mg, KOH_{aq}, $CaO_{(s)}$, $NaCO_3$ and K_2CO_{3aq} etc.

Behavioural Objective: At the end of the lesson, the students should be able to:

a. Carry out simple Acid – base chemical experiments appropriately.
b. Explain scientifically reaction types and determine products to be produced.
c. State chemical equations and product equations of chemical reactions.

Previous Knowledge: The students have conducted some preliminary test on some metals.

Introduction: Introduction of the lesson took the form of revision of the previous lesson and provision of the required experimental material as well as organizing students and resources for effective learning, provision of clear instructions on students' activities. The key concepts and ideas which students are required are to remember will be summarize on the chalk board.

Presentation: The teacher presented the lesson through the following activities

Activity 1: ACID REACTION WITH METALS

Sample A is HCl_{aq} Acid

Sample B is H_2SO_{4aq} Acid

Sample C is $Zn_{(s)}$

Samples D Mg_s, E. KOH_{aq}, F. CaO_s, G.$NaCO_{3aq}$, H. K_2CO_{3aq}.

1. Take some quantity of sample C Zn_s in a spatula and drop in a test tube and add a $1cm^3$ of sample A and allow to stand for a few minutes.

2. Add $1cm^3$ of sample B to a few quantity of sample D in a test tube and allow to stand for a few minutes.

3. Repeat the activity in S/no 1and 2 above and record your observation(s), explain and write out a probable chemical equations for the reaction. Record your findings

ACID REACTION WITH METALS

Acid reacts with metals like zinc, iron and magnesium to liberate hydrogen gas. Such reactions are due to the displacement of hydrogen ions in the acids by the metals. However dilute trioxonitrate (V) acid is an exception to this rule.

Equation: - Acid + metal ⟶ Salt + Hydrogen

$2HCL_{aq} + Zn_s \; ZnCl_{2aq} + H_{2(g)}$

$H_2SO_{4aq} + Mg_sMgSO_4 + H_{2(g)}$

Activity 2 ACID REACTION WITH BASE

a. To $1cm^3$ of sample E KOH_{aq} add also $1cm^3$ of sample B drop wise
b. To few solids sample F CaO_s add $1cm^3$ of sample A drop wise and allow to stand for five (5) minutes.
c. Repeat the activity 1 and 2 once more, this time very carefully and record your observation and findings in all the three steps accurately.

ACID REACTION WITH BASE

Acid + Base ⟶ Salt + Water

$H_2SO_{4aq} + 2KOH_{aq}K_2SO_{4aq} + 2H_2O_{(l)}$

$2HCl_{aq} + CaO_sCaCl_{2aq} + H_2O_{(l)}$

All bases reacts with acids to form salts and water as observed in the above reaction equations.

Activity 3 REACTION WITH CARBONATES

a. To $1cm^3$ of sample G $NaCO_{3aq}$ add also $1cm^3$ of sample A drop wise
b. To $1cm^3$ of sample F K_2CO_{3aq} add 1cm3 of sample B drop wise and allow to stand for five (5) minutes.
c. Repeat the activity 1 and 2 once more, this time very carefully and pass the glass pipe into lime water CaOH solution each time and record your observation and findings in all the three steps accurately.

REACTION WITH CARBONATES

Acid + trioxocarbonates (V) ——→ Salt + Water + Carbon (IV) Oxide.

BASES REACTION WITH ACIDS

E.g. 1

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

$MgO_s + HNO_{3aq} \rightarrow Mg(NO_3)_{2aq} + H_2O_{(l)}$

$CuO_s + H_2SO_{4aq} \rightarrow CuSO_{4aq} + H_2O_{(l)}$

The three (3) reactions listed above indicate the chemical properties of and characteristics of acids.

E.g. 2

REACTION WITH AMMONIUM SALT

Alkalis reacts with ammonium salts in the presence of heat to generate Ammonium gas. This reaction can be used as a test for Alkalis.

$Ca(OH)_{2aq} + 2NH_4Cl_{aq} \rightarrow CaCl_{2aq} + H_2O(l) + 2NH_{3g}$

$NaOH_{aq} + NH_4NO_{3aq} \rightarrow NaNO_{3aq} + H_2O(l) + NH_{3g}$

Evaluation:

Answer the following questions;

1. Write out the reaction equation when sodium hydroxide reacts with ammonium nitrate (V) acid.
2. Compare and contrast five chemical properties of acids and base.
3. Indicate appropriate balanced chemical equation reactions (if any).

Re-evaluation of results

The teacher re-evaluated students responses in the class to determine its correctness in relation to the concept taught and a summary was made on the chalkboard to enable students compare results and make corrections for effective learning and retention.

Conclusion: Students were instructed to read and study conductance of Acid, Base and Salts.

APPENDIX D

LESSON NOTE FOR CONTROL GROUP

Mode of teaching	-	Lecture Method
Lesson topic	-	State of Matter
Time	-	Double period (80 minutes)
Class	-	SS 2
Number of pupils	-	38
Average age of pupils	-	16 years
Topic	-	Change of State

instructional material: Iodine pellets, H_2O, Ice cubes, beakers, glass crucibles and bursen burner and chart etc.

Behavioural objectives

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

(a) Design a clear diagram showing the pathways of the reaction/processes in the experiment you just carried out.

(b) Explain the major differences in the two experiments in activity 2 above.

(b) Evaluate in their words, the process of change in gases, liquids and solids.

(c) Explain the importance of this changes to man.

Previous knowledge

The students are familiar with liquid, solid and gases from SS 1.

Introduction: Introduction of the lesson took the form of revision of the previous lesson and studentswere informed that the topic for the day is CHANGE OF STATE

Presentation: The teacher presented the lesson as following.

Step 1:

1, The teacher at his desk inform the students that since they are familiar with ice cubes in their various houses and or had come in contact with the sample elsewhere, what happens when it is kept for some time on the table at the room temperature? It will be observed to melt. Also when it is heated it will become water. The process is a change of state from solid to liquid. If this water is heated to boiling, a vapour will be observed going off that also is a change in state from liquid to gas. If the heating of the water continued, the pot or beaker of water will be empty.

SOLID $\rightleftharpoons$ LIQUID $\rightleftharpoons$ GAS

Step 2

The teacher presented a chart containing the process of sublimation of Iodine and content was explained, that when Iodine is heated it does not change to liquid as observed in the case of ice cubes but that it goes into the gas phase, the process is called **Sublimation**.

SOLID $\rightleftharpoons$ GAS

Evaluation

The teacher asked the following questions;

1. Design a clear diagram showing the pathways of the reaction/processes in the experiment you just carried out.
2. Explain the major differences in the two experiments in activity 2 above.
3. Evaluate in their words, the process of change in gases, liquids and solids.
4. Explain the importance of this changes to man.

Conclusion and Chalk Board Summary:

Substances can exist as solid, liquid and as a gas. Changes of state are brought about by a change in temperature as a substance change from a gas state to liquid state then to solid, its particles become energetic and lose their random motion gradually to finally get arranged in an orderly pattern. Similarly when the temperature of the substance is increased, the particles gain energy enough to resume their random movement to change state.

LESSON NOTE FOR CONTROL GROUP

Mode of teaching – Lecture method

Lesson - Kinetic theory of matter

Time – Double period (80 minutes)

Class - SS 2

Average age of pupils - 16 Years

Number of pupils - 38

Topic - Diffusion

Instructional materials

Gas jars, cylinder, glass tube, liquid bromine, cotton wool, Conc NH_3, Conc. HCl, water, Perfume, Conc Cu_2So_4.

Behavioural objectives

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

(a) What is diffusion

(b) Explain in their words, the process of diffusion in gases, liquids and solids.

(c) Relate the importance of diffusion to man.

(d) Compare/contrast diffusion in gases/liquids, liquid/solids, gas/solids.

Previous knowledge

The students are familiar with the different states of matter.

Introduction

The teacher will ask the students the following questions:

(a) What is matter

(b) Name the different particulars making up matter.

Presentation

The teacher informed the students that the topic of discussion today is diffusion.

Step I

The teacher defines diffusion as the movement of solute particular through a medium, from a region of higher concentration to a region of lower concentration. The medium could be water, vacuum or solid, and that the level and speed of the movement depends on:

i. The average kinetic energy of the particles of the solute

ii. The medium through which it is moving.

As a result of (i) and (ii) above diffusion occurs in gases, liquids and solids but at different rate, while some take a very few minutes, as in gases, liquids others take days or even years as in solids, and give example of gold bar and silver bar when placed together, it was discovered that diffusion occur after a very long time.

Step II

The teacher at the work bench advised students to observe carefully, as he demonstrates diffusion in gases, liquids and solids respectively.

Step III

The teacher asked students to explain what they have observed and the differences in the diffusion.

Evaluation

The teacher evaluated the lesson by asking the students the following questions:

(a) What is diffusion

(b) List and explain two (2) differences each between diffusion in gas/liquids, liquids/solids, solid/gases

(c) State why diffusion is faster in gas than in liquids or solids.

(d) Relate the importance of diffusion to man.

Conclusion

The teacher concluded the lesson by summarizing what was learnt on diffusion, and told students to go and read on kinetic theory of gases.

LESSON NOTE FOR CONTROL GROUP

Mode of teaching – Lecture method

Lesson - Gas Law

Time – Double period (80 minutes)

Class - SS 2

Average age of pupils - 16 Years

Number of pupils - 38

Topic - Verification of Gas Law

Instructional materials: Chart and Diagram

Behavioural objectives

At the ends of the lesson, the students should be able to

a. Explain kinetic theory of gases.

b. Evaluate the effect of increased temperature on gases volume.

c. Analyse the different behaviours of the gases in the experiment.

d. Solve different problems relating to kinetic theory

Previous Knowledge:

Students are familiar with kinetic theory of matters (Osmosis, Diffusion)

Introduction:

The teacher introduced the lesson by informing the students of the topic as verification of gas laws.

Presentation of Lesson:

The teacher informed the class that gas laws explain the physical behaviour of gases under certain condition and that this behaviour can be explained using the kinetic theory of gases.

Step I

The teacher presented a chart, explaining the theory.

Step II

The teacher explained to the students using diagram to show the effect of temperature on gas volume. That the volume of a gas increases with increase in temperature and that pressurealso has its effect on a given volume of gas.

Step III

The teacher explain to the student the behaviours of gas molecules under given temperature and pressure using the concept kinetic theory of gases which today form the bases of certain laws to be studied later.

Explanation

Quantities in the Measurement of Gases

i. The volume of the gas,

ii. The pressures,

iii. The temperature,

iv. The mass or number of moles

b. 1 atm = 760 mm Hg = 760 torrs,

or in Newton/metres^2, (N/m^2) or (Nm^{-2}) where

1 atm = 1-01 325 Nm^{-2},

or in pascal, Pa, where

1 atm = 101 325 Pa.

The pascal and the Newton/meter^2 are equivalent units, i.e. 1 Pa = 1Nm.

Temperature: This is measures in t^{0}C, i.e. in degrees Celsius, or TK, i.e. the Kelvin temperature or absolute temperatures. T^{0}C is converted to TK by adding 273^{0}C to the Celsius temperature. Thus; the conversion is done by using the formula, TK = 273 + t^{0}C.

Example 1

Convert 83^0C to the absolute temperature scale

Solution

TK = $273 + t^0$C

= $273 + 83^0$C

= 356K

Example 2

Converts 298 K to the Celsius temperature scale.

Solution

TK = $273 + t^0$C

:. T^0 = $(TK - 273)^0$C

= $298 - 273$

= 25^0C

Example 3

The pressure of a given mass and volume of gas is given as 22mm Hg. Convert this pressure to:

i. torrs,

ii atmospheres

iii. Newton/metre^2 or pascals

Solution

i. mm Hg is the same as torrs

:. 22 mm Hg = 22 torrs.

ii. 760 mm Hg or 760 torrs = 1 atm

:. 22 mm Hg = $\frac{1}{761} \times \frac{22}{1}$ = 0.029 atm

iii. 1 atm = 101 325 newton/metre^2 or pascal

:. $\frac{22}{760}$ atm = $\frac{101\ 325}{1} \times \frac{22}{760}$ = 2933 Nm

Evaluation

Thelesson was evaluated by asking the following questions

1. Evaluate the effect of increased temperature on gases volume.
2. Analyse the different behaviours of the gases in the experiment.
3. The pressure of a given mass and volume of gas is given as 22mm Hg. Convert this pressure to:
   i. torrs,
   ii atmospheres
   iii. Newton/metre^2 or pascals
4. State the kinetic theory of gases.

Conclusion:

The teacher summarizes the lesson learnt.

Assignment

The teacher instructed the students to study the Boyles and Charles Law

LESSON NOTE FOR CONTROL GROUP

Mode of teaching – Lecture method

Lesson - Gas Law

Time – Double period (80 minutes)

Class - SS 2

Average age of pupils - 16 Years

Number of pupils - 38

Topic - Boyles Law

Instructional materials: Diagram and Chart

Behavioural Objectives

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

a. List any two (2) kinetic theory of gases

b. State the mathematically equation of Boyle's law

c. Explain in their words the Boyle's law

d. Solve problems relating to the law.

Previous Knowledge:

Students are familiar with kinetic theory of gases

Introduction:

The teacher introduced the lesson by stating the relationship between volume and pressure of a given gas.

Presentation of Lesson:

The teacher stated Boyle's law on the chalk board and informed the students that according to Boyle's law, the volume of a gas increases as the pressure decreases and vice versa. The relationship is independent of the nature of gas and that it can be expressed mathematically

$V \alpha \frac{I}{P}$

$\therefore V = \frac{K}{P}$ or $PV = K$

Step II

Where V = volume or Pressure P

K = A mathematical constant

So for a given mass of gas the product of its pressure and its volume is always constant.

Step III

The teacher described a simple experiment this, if a mass of gas is enclosed in vessel with a moveable piston as shown in chart, if a certain weight is placed on the piston, the pressure will be increased, while the volume reduces and vice versa. That is volume is increasingly proportional to pressure which is the Boyle's law.

Evaluation

The lesson was evaluated by asking the students the following questions:

a. Explain in their words the Boyle's law

b. A gas occupies 200 cm^3 at 510 mm of mercury. If temperature remains constant, what will its pressure be when the volume is increased to 131 cm^3?

b. List any two (2) kinetic theory of gases

c. State the mathematically equation of Boyle's law

Conclusion

The teacher summarized the lesson.

Assignment

Students were instructed to go and study Charles law.

LESSON NOTE FOR CONTROL GROUP

Mode of teaching – Lecture method

Lesson - Gas Law

Time – Double period (80 minutes)

Class - SS 2

Average age of pupils - 16 Years

Number of pupils - 38

Topic - Charles Law

Instructional materials: Diagram and Chart

Behavioural Objectives

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

1. Draw and interpret scientific tables relating to experiments
2. Plot and explain graphs through report
3. Propose a relationship between V_2 and T_2 at constant pressure
4. Derive the general gas equation.

Previous Knowledge:

Students are familiar with kinetic theory of gases

Introduction:

The teacher introduced the lesson by stating the relationship between volume and temperature in gases.

Presentation of Lesson:

The teacher stated Charles law on the chalk board and informed them that according to Charles law, the volume of a gas increases as the temperature increases and vice versa. The relationship is independent of the nature of gas and that it can be expressed mathematically

$V \alpha T$

$\therefore V = KT$ or $\frac{V}{T} = K$

Step II

Where V = Volume

T = Temperature

K = Constant

So for a given mass of gas the product of its temperature and its volume is always constant.

Step III

The teacher described a simple experiment thus; if a mass of gas is enclosed in a balloon as shown in the chart, if the temperature is increased, the balloon size increases this is due to increase in volume of a gas due increase kinetic energy. That is volume is increasingly proportional to temperature which is the Charles law.

Evaluation

Answer the following questions:

1. Draw and interpret scientific tables relating to the experiments
2. Plot and explain graphs through effect reporting
3. Propose a relationship between V_2 and T_2 at constant pressure
4. Derive the general gas equation.
5. Derive the general gas equation from the Charles and Boyle's law.
6. State the mathematically equation of Charles law

Conclusion

The teacher summarized the lesson.

Assignment

Students were instructed to go and read up materials on acids and bases.

LESSON NOTE FOR CONTROL GROUP

Mode of teaching – Lecture method

Lesson - Chemical Reaction

Time – Double period (80 minutes)

Class - SS 2

Average age of pupils - 16 Years

Number of pupils - 38

Topic - Acid – Base Reaction

Instructional Material: Charts, textbooks and diagrams

Behavioural Objective: At the end of the lesson, the students should be able to:

a. Carry out simple Acid – base chemical experiments appropriately.
b. Explain scientifically reaction types and determine products to be produced.
c. State chemical equations and product equations of chemical reactions.

Previous Knowledge: The students are familiar with preliminary test of some metals.

Introduction: The teacher informed the students of the topic as reaction involving Acids and Bases. The key concepts and ideas which students are required to remember will be summarize on the chalk board.

Presentation: The teacher presented the lesson as follows.

Step 1:

ACID REACTION WITH METALS

Acid reacts with metals like zinc, iron and magnesium to liberate hydrogen gas. Such reactions are due to the displacement of hydrogen ions in the acids by the metals. However dilute trioxonitrate (V) acid is an exception to this rule.

Equation: - Acid + metal $\longrightarrow$ Salt + Hydrogen

$2HCL_{aq} + Zn_s \rightarrow ZnCl_{2aq} + H_{2(g)}$

$H_2SO_{4aq} + Mg_s \rightarrow MgSO_4 + H_{2(g)}$

Step. 2

ACID REACTION WITH BASE

All bases reacts with acids to form salts and water as observed in the reaction equations below.

Equation :- Acid + Base ⟶ Salt + Water

$H_2SO_{4aq} + 2KOH_{aq} \rightarrow K_2SO_{4aq} + 2H_2O_{(l)}$

$2HCl_{aq} + CaO_s \rightarrow CaCl_{2aq} + H_2O_{(l)}$

Step 3

REACTION WITH CARBONATES

Acid + trioxocarbonates (V) ⟶ Salt + Water + Carbon (IV) Oxide.

BASES REACTION WITH ACIDS

E.g. 1

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

$MgO_s + HNO_{3aq} \rightarrow Mg(NO_3)_{2aq} + H_2O_{(l)}$

$CuO_s + H_2SO_{4aq} \longrightarrow CuSO_{4aq} + H_2O_{(l)}$

The three (3) reactions listed above indicate the chemical properties of and characteristics of acids.

E.g. 2

REACTION WITH AMMONIUM SALT

Alkalis reacts with ammonium salts in the presence of heat to generate Ammonium gas. This reaction can be used as a test for Alkalis.

$Ca(OH)_{2aq} + 2NH_4Cl_{aq} \rightarrow CaCl_{2aq} + H_2O\ (l) + 2NH_{3g}$

$NaOH_{aq} + NH_4NO_{3aq} \rightarrow NaNO_{3aq} + H_2O\ (l) + NH_{3g}$

Evaluation:

The teacher asked the students to

1. Write out the reaction equation when sodium hydroxide reacts with ammonium nitrate (V) acid.
2. Compare and contrast five chemical properties of acids and base.
3. Indicate appropriate balanced chemical equation reactions (if any).

Conclusion: Students were instructed to read and study conductance of Acid, Base and Salts.

APPENDIX E

SUMMARY TABLE FOR ITEM ANALYSIS OF THE INSTRUMENT

ITEMS	HIGH	LOW	RIGHT	DIFFICULTY INDEX	DISCRIMINATION INDEX	ITEM RELIABILITY
1	13	2	28	0.47	0.85	0.600
2	16	2	32	0.53	0.88	0.630
3	16	3	41	0.68	0.81	0.576
4	16	11	53	0.88	0.31	0.297
5	15	4	27	0.45	0.73	0.576
6	15	5	37	0.62	0.67	0.515
7	16	0	25	0.42	1.00	0.766
8	16	3	38	0.63	0.81	0.590
9	15	3	33	0.55	0.80	0.533
10	15	3	20	0.33	0.80	0.679
11	15	1	29	0.48	0.93	0.597
12	16	0	30	0.50	1.00	0.794
13	16	9	40	0.67	0.44	0.462
14	16	1	21	0.35	0.94	0.810
15	16	1	30	0.50	0.94	0.665
16	16	2	22	0.37	0.88	0.783
17	16	0	27	0.45	1.00	0.690
18	16	1	25	0.42	0.94	0.760
19	16	2	34	0.57	0.88	0.674
20	16	1	29	0.48	0.94	0.742
INSTRUMENT'S RELIABILITY INDEX= 0.742, ITEMS' CONSISTENCY INDEX = 0.925						

APPENDIX F

Table 3.6 ANOVA of pretest of the four selected schools mean academic scores.

		Sum of Squares	Df	Mean Square	F	Sig.
Score1	Between Groups	2665.950	9	29.550	1.441	.288
	within Groups	205.000	10	20.500		
	Total	470.950	19			
Score2	Between Groups	201.783	9	22.420	.965	.517
	Within Groups	232.417	10	23.242		
	Total	434.200	19			
Score3	Between Groups	175.800	9	19.533	.	.
	Within Groups	.000	10	.000		
	Total	175.800	19			
Score4	Between Groups	200.633	9	22.273	1.273	.354
	Within Groups	175.167	10	17.517		
	Total	375.800	19			

ANOVA of pretest of the four selected schools mean academic scores.

Source of Variance	Sum of Square	Mean Square	Df	F-Critical	P	Remark
Between Groups	126.321	43.107	3			
Within Groups	945.717	11.526	82	3.73	0.585	*NS
Total			85			

***Not Significant at p≤0.05. F=cal- 2.72**

APPENDIX G

The two sample t-test was used to the cognitive ability of the students in the experimental group and those in the control group. The test took into consideration all the stages of the experiment. The result is summarized in Table 4.1

Table 4.1: test of cognitive ability by levels of experimental and control schools

Test levels	School	Mean	Std. Deviation	Std Error	t-value	DF	p
Pre-test	Experimental	5.63	3.310	0.523	1.715	76	0.090
	Control	4.00	5.206	0.736			
Post test1	Experimental	18.98	4.554	0.720	11.907	76	0.000
	Control	5.63	5.329	0.865			
Post post test2	Experimental	18.68	5.240	0.828	10.298	76	0.000
	Control	5.737	5.763	0.935			
Post post test3	Experimental	17.85	4.737	0.749	16.6431	76	0.000
	Control	3.05	2.770	0.449			
Post post test4	Experimental	17.85	5.333	0.843	12.655	76	0.000
	Control	4.61	3.724	0.604			

Table shows significant differences ($p < 0.05$) between the control school and the experimental school in all the stages (with the exception of the score for pre-test of the test involving cognitive ability.

Table 4.2 summary of cognitive ability test by experimental and control schools

Schools	Mean	Std. Deviation	Std error	t-value	DF	P
Experimental	18.32	4.957	0.392	24.852	310	0.000
Control	4.78	4.648	0.377			

In the overall summary, the students in the experimental group were significantly different from those in the control group ($p < 0.0$). the finding here is that the experimental significantly increased the cognitive ability of students who were exposed to the experimental compared to those who were not exposed to it. The null hypothesis is therefore rejected.

In table 4.3, the performance levels of the two schools (control and Experimental) were compared. The same approach was used as in table 4.1. The result of the test is summarized in the table

Table 4.3 Test between experimental and control schools no low and high performance

Test levels	Status	Schools	Mean	Std Deviation	Std Error	t-value	Df	P
Pre-test	Low	Experimental	4.85	2.527	0.400	3.133	88	0.002
		Control	2.80	3.464	0.490	3.243		
	High	Experimental	0.78	1.291	0.204	-1.155	88	0.251
		Control	1.20	2.020	0.286	-1.210		
Post test1	Low	Experimental	6.03	1.493	0.236	9.566	76	0.000
		Control	2.34	1.893	0.307	9.508		
	High	Experimental	13.25	4.186	0.662	16.573	76	0.000
		Control	1.13	1.711	0.278	16.883		
Post test2	Low	Experimental	6.73	1.358	0.215	7.320	76	0.000
		Control	3.50	2.413	0.391	7.222		
	High	Experimental	11.93	4.364	0.690	10.292	76	0.000
		Control	2.39	3.774	0.612	10.331		
Post test3	Low	Experimental	5.90	1.722	0.272	10.657	76	0.000
		Control	1.89	1.590	0.258	10.679		
	High	Experimental	11.83	3.713	0.587	16.348	76	0.000
		Control	1.18	1.557	0.253	16.648		
Post test4	Low	Experimental	6.10	1.374	0.217	6.803	76	0.000
		Control	3.13	2.373	0.385	6.716		
	High	Experimental	11.93	4.526	0.716	13.450	76	0.000
		Control	1.47	1.606	0.261	13.724		

The result as indicated in the table revealed that students in the experimental group were significantly different in the different levels of performance that those in the control group ($P < 0.05$).

A summary of the aggregate test of the students with the different levels of performance is presented in Table 4.4

Table 4.4: Summary test between experimental and control schools on low and high performance

Performance school		Mean	Std Deviation	Std. Error	t-value	DF	P
Lower levels	Experimental	6.19	1.19	0.120	16.452	310	0.000
	Control	2.72	2.170	0.176			
High level	Experimental	12.23	4.210	0.333	27.388	310	0.000
	Control	1.55	2.386	0.194			

In the overall summary of the test, students who were exposed to the experimental performed significant better in the two performance levels than those in the control group ($P < 0.05$). The implication here is that the experimental significantly increased the performances of students who participated in the test while their counterparts in the control did not improve correspondingly. The null hypothesis therefore rejected.

The two sample t-test procedure was used in testing the retention ability of the students in the two groups (Control and Experimental) at the different stages of the experimental. The result of the test is summarized in table 4.5

Table 4.5: test of retention by levels of experimental and control schools

Stages of experimental	School	Mean	Std. Deviation	Std. error	t-value	DF	P
Pre-Test	Experimental Control	5.63 2.70	3.310 4.805	0.523 0.760	3.170	76	0.002
Post test1	Experimental Control	18.68 3.33	5.375 3.407	0.850 0.539	15.255 15.255	76	0.000
Post post test2	Experimental Control	19.00 5.84	4.455 5.763	0.704 0.935	11.314 11.240	76	0.000
Post post test3	Experimental Control	17.88 3.08	4.723	0.738 0.453	16.780 17.094	76	0.000
Post post test4	Experimental Control	17.87 4.61	5.420 3.724	0.868 0.604	12.487 12.546	76	0.000

The result revealed that students who were subjected to the experiment had a higher retention that than those in the control group at the deferent stages of the experiment ($p<0.05$) the aggregate test of the retention ability is presented in table 4.6.

Table 4.6: summary of retention test by experimental and control schools

Schools	N	Mean	Std deviation	Std error	t-value	DF	P
Experiment	160	18.36	4.986	0.394	27.223	312	0.000
Control	154	4.20	4.178	0.337			

The result of the aggregate test revealed that students who were exposed to the experiment had a significantly higher retention than those in the control group ($p<0.05$). The null hypothesis is therefore rejected.

An orthogonal comparison of the stage was carried out using the one way analysis of variance the summary of the test is presented in Appendix N

APPENDIX H

Table 4.7: Analysis of variance on cognitive ability by levels of the experimental in the experimental and control school

Schools	Source	Sum of squares	DF	Mean square	F	Sig
Experimental	Between Group	5,199.120	4	1,299.780	59.064	0.000
	Within Group	4,291.200	195	22.006		
	Total	9,490.320	199			
Control	Between Group	208.028	4	52.007	2.302	0.060
	Within Group	4,404.868	195	22.589		
	Total	4,612.896	199			

Table 4.8: Mean scores on cognitive ability by levels of the experiment in the experimental and control schools

Test levels	Experimental			Control		
	Mean	Std. Deviation	Std. Error	Mean	Std. Deviation	Std. Error
PRE-TEST	5.65	3.310	0.523	4.00	5.206	0.736
POST-POST TEST1	18.98	4.554	0.720	5.63	5.329	0.865
POST- TEST1	18.68	5.240	0.828	5.84	5.763	0.935
POST-POST TEST2	17.78	4.737	0.749	3.05	2.770	0.449
POST-POST TEST3	17.85	5.333	0.843	4.61	3.724	0.604
POST-POST TEST4	15.78	6.906	0.488	4.59	4.791	0.337

Table 4.9: Result of scheffe test on significant difference in cognitive ability between stages of the experimental

(I) test	(i) Test	Mean Difference (I-J)	Std . Error	Sig
Pre-test	Post-test	-13.350(*)	1.049	.000
	Post-post test	-13.050(*)	1. .049	.000
	Post-post test	-12.150(*)	1. 049	.000
	Post-post test	-12.225(*)	1. 049	.000
Post- test	Pre-test	13.350(*)	1. 049	.000
	Post-post test	.300	1. 049	.999
	Post-post test	1.200	1. 049	.860
	Post-post test	1.125	1. 049	.886
Post- test	Pre-test	13.050(*)	1. 049	.000
	Post-test	-300	1. 049	.999
	Post-post test	.900	1. 049	.946
	Post-post test	.825	1. 049	.961
Post-post test	Pre-test	12.150(*)	1. 049	.000
	Post-test	-1.200	1. 049	.860
	Post-post test	-900	1. 049	.946
	Post-post test	-075	1. 049	1.000
Post-post test	Pre-test	12.225(*)	1. 049	.000
	Post-test	-1.125	1. 049	.886
	Post-post test	-825	1. 049	.961
	Post-post test	-075	1. 049	1.000

- the mean difference is significant at the .05 level.

A SCHOOLS = CHINDIT BARRACK

Table 4.10: Analysis of variance on performance levels by levels of the experiment in the experimental and control schools

Schools	Performance Levels	Source	Sum of Squares	DF	Mean squares	F	Sig
Experimental	LOW	Between Group	73.470	4	18.368	5.997	0.000
		Within Group	597.250	195	3.063		
		Total	670.720	199			
	High	Between Group	4,255.480	4	1,063.870	73.363	0.000
		Within Group	2,827.800	195	14.502		
		Total	7,083.280	199			
Control	LOW	Between Group	61.120	4	15.280	2.407	0.050
		Within Group	1,237.974	195	6.349		
		Total	1,299.094	199			
	HIGH	Between Group	43.578	4	10.894	2.081	0.085
		Within Group	1,020.605	195	5.234		
		Total	1,064.183	199			

Table 4.11: Mean scores on performance levels by stages of the experiment in the experimental and control school

Performance Levels	Test levels	Experimental			Control		
		Means	Std deviation	Std error	Means	Std deviation	Std error
LOW	Pre-test	4.85	2.527	0.400	2.80	3.464	0.490
	Post-test1	6.03	1.493	0.236	2.34	1.893	0.307
	Pose-post test2	6.73	1.358	0.215	3.50	2.413	0.391
	Pose-post test3	5.90	1.722	0.272	1.89	1.590	0.258
	Pose-post test4	6.10	1.374	0.217	3.13	2.373	0.385
	Total	5.92	1.836	0.130	2.74	2.542	0.179
HIGH	Pre-test	0.78	1.291	0.204	1.20	2.020	0.286
	Post-test1	13.25	4.186	0.662	1.13	1.711	0.278
	Pose-post test2	11.93	4.364	0.690	2.39	3.774	0.612
	Pose-post test3	11.83	3.713	0.587	1.18	1.557	0.253
	Pose-post test4	11.93	4.526	0.716	1.47	1.606	0.261
	Total	9.94	5.966	0.422	1.46	2.301	0.162

Table 4.12: Result of scheffe test on significant difference in performance between stages of the experiment

Dependent variable	(i) tests	(J) tests	Mean Difference (i-J)	Std. Error	Sig
Low performance	Pre-test	Post-test	-1.175	.391	.065
		Postposttest	-875(*)	.391	.000
		Postposttest	-1.050	.391	.130
		Postposttest	-1.250(*)	.391	.041
	Post-test	Pretest	1.175	.391	.065
		Postposttest	-700	.391	.527
		Postposttest	.125	.391	.999
		Postposttest	-075	.391	1.000
	Post-post test	Pretest	1.875(*)	.391	.000
		Post test	.700	.391	.527
		Postposttest	.825	.391	.353
		Postposttest	.625	.391	.636
	Post-post test	Pretest	1.050	.391	.130
		Posttest	-125	.391	.999

		Postposttest	-825	.391	.353
		Postposttest	-200	.391	.992
	Post-post test	Pretest	1.250(*)	.391	.041
		Posttest	.075	.391	1.000
		Postposttest	-625	.391	.636
		Postposttest	.200	.391	.992
High performance	Pre-test	Posttest	-12.475(*)	.852	.000
		Postposttest	-11.150(*)	.852	.000
		Postposttest	-11.050(*)	.852	.000
		Postposttest	-11.150(*)	.852	.000
	Post test	Pretest	12.475(*)	.852	.000
		Postposttest	1.325	.852	.000
		Postposttest	1.425	.852	.659
		Postposttest	1.325	.852	.593
	Post-post test	Pretest	11.150(*)	.852	.659
		Posttest	-1.325	.852	.000
		Postposttest	.100	.852	.659
		Postposttest	.000	.852	1.000
	Post-post test	Pretest	11.050(*)	.852	1.000
		Posttest	-1.425	.852	.593
		Postposttest	.100	.852	1.000
		Postposttest	.100	.852	1.000
	Post-post test	Pretest	11.150(*)	.852	.000
		Posttest	-1.325	.852	.659
		Postposttest	.000	.852	1.000
		Postposttest	.100	.852	1.000

- The Mean difference is significant at the .05 level.

a SCHOOLS = CHINDIT BARACK

Table 4.13: Analysis of variance on retention ability by levelsof the experiment in the experimental and control schools

Experimental	Source	Sum of squares	DF	Mean square	F	Sig
	Between Group	5,225.881	4	1,306.470	58.743	000.0
	Within Group	4,336.899	195	22.241		
	Total	9,562.780	199			
Control	Between Group	258.657	4	64.664	3.611	0.007
	Within Group	3,384.070	189	17.905		
	Total	3,647.727	193			

Table 4.14: Mean scores on retention by stages of the experiment in the experimental and control school

Test levels	Experimental			Control		
	Mean	Std Deviation	Std Error	Mean	Std Deviation	Std Error
Pre-test	5.63	3.310	0.523	2.70	4.805	0.760
Post-test1	18.68	5.375	0.850	3.33	3.407	0.539
Post-post test2	19.00	4.445	0.704	5.84	5.763	0.935
Post-post test3	17.88	4.723	0.738	3.08	2.794	0.453
Post-post test4	17.87	5.420	0.868	4.61	3.724	0.604
Total	15.81	6.932	0.490	3.89	4.344	0.312

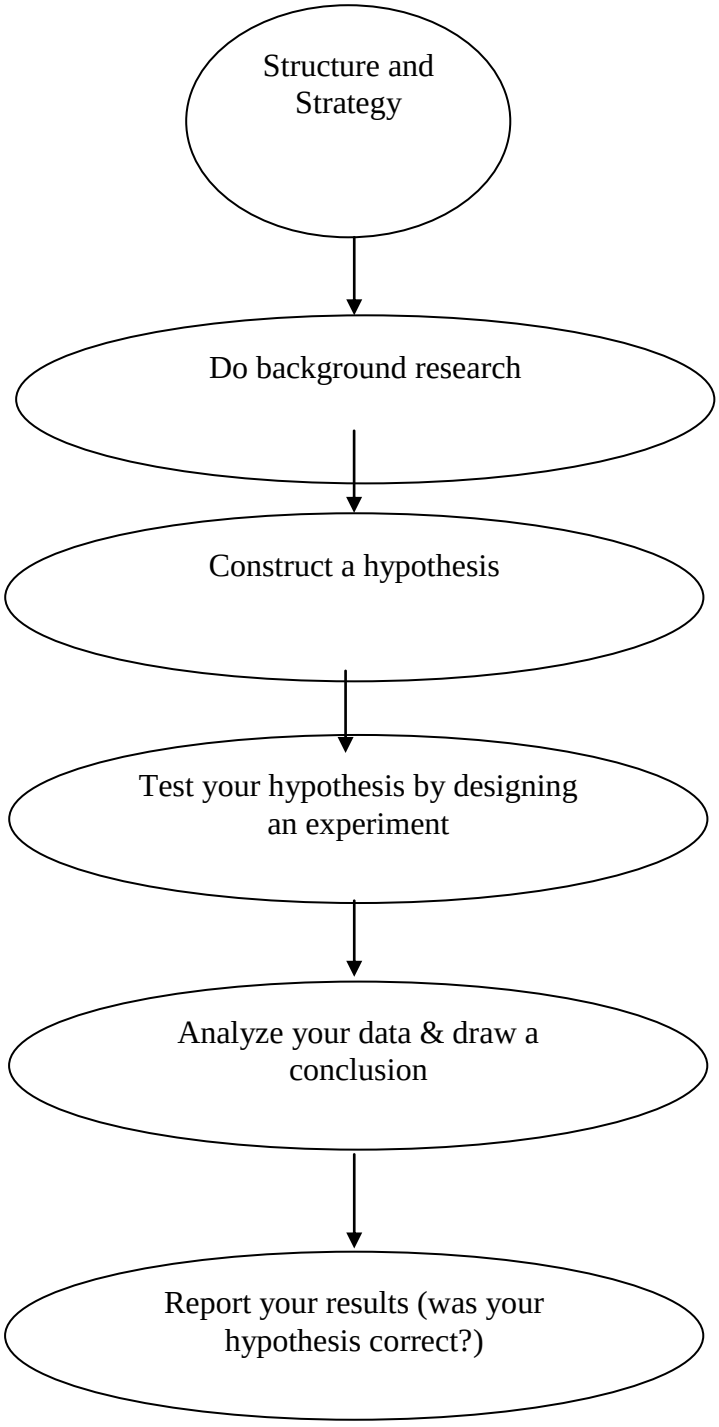
Scheffe's Test

(i) test levels	(J) Test levels	Mean Difference (I-J)	Std Error	Sig
Pre-test	Post-test	-13.050(*)	1.055	.000
	Post-post test	-13.375(*)	1.055	.000
	Post-post test	-12.253(*)	1.048	.000
	Post-post test	-12.247(*)	1.061	.000
Post-test	Pre-test	-13.050(*)	1.055	.000
	Post-post test	-325	1.055	.999
	Post-post test	.797	1.048	.965
	Post-post test	.803	1.061	.966
Post-post test	Pre-test	13.375(*)	1.055	.000
	Post-test	.325	1.055	.999
	Post-post test	1.122	1.048	.887
	Post-post test	1.128	1.061	.889
Post-post test	Pre-test	12.247(*)	1.048	.000
	Post-test	-797	1.048	.965
	Post-post test	-1.122	1.048	.887
	Post-post test	.006	1.055	1.000
Post-post test	Pre-test	12.247(*)	1.061	.000
	Post-test	-803	1.061	.966
	Post-post test	-1.128	1.061	.889
	Post-post test	-006	1.055	1.000

The mean difference is significant at the .05 level.

APPENDIX I

SCIENTIFIC METHOD



This flow chart diagrams the steps of the scientific method, (NSTA and Anne, 2014)

The Scientific Method

The scientific method is a system of exploring the world around us, asking and answering questions, and making predictions. Scientists use the scientific method because it is objective and based on evidence. A hypothesis is fundamental to the scientific method. A hypothesis can take the form of an explanation or a prediction. There are several ways to break down the steps of the scientific method, but it always involves forming a hypothesis, testing the hypothesis, and determining whether or not the hypothesis is correct.

Typical Steps of the Scientific Method

1. Make observations.
2. Propose a hypothesis.
3. Design and conduct an experiment to test the hypothesis.
4. Analyze the results of the experiment to form a conclusion.
5. Determine whether or not the hypothesis is accepted or rejected.
6. State the results.

If the hypothesis is rejected, this does *not* mean the experiment was a failure. In fact, if you proposed a null hypothesis (the easiest to test), rejecting the hypothesis may be sufficient to state the results. Sometimes, if the hypothesis is rejected, you reformulate the hypothesis or discard it and then go back to the experimentation stage.

APPENDIX K

Table 1.1 Performance of Students in Chemistry at SSCE (WAEC) Level in Nigeria: 2005-2010

Period	Number of Students (Present)	Number of Students (Pass)	Number of Students (Fail)	% of Students (Pass)	% of Students (Fail)
2005	182659	39125	143534	21	79
2006	228953	80355	148598	35	65
2007	250099	86150	163949	34	66
2008	289520	84520	205000	29	71
2009	326541	98215	228326	30	60
2010	367562	120560	247002	33	67

Source: Ministry Of Education, Kaduna State: 2013

Table 1.2 Performance of Students in Chemistry at SSCE (WAEC) Level in Kaduna State: 2007-2012

Period	Number of Students (Present)	Number of Students (Pass)	Number of Students (Fail)	% of Students (Pass)	% of Students (Fail)
2007	4892	2348	2544	48	52
2008	5193	1766	3427	34	66
2009	5889	1826	4063	31	69
2010	5945	2378	3567	40	60
2011	6313	2336	3977	37	63
2012	6601	2112	4489	32	68

Source: Ministry Of Education, Kaduna State: 2013