IMPACT OF 5Es LEARNING MODEL ON QUESTIONING STYLE PREFERENCE AND ACADEMIC PERFORMANCE AMONG SECONDARY SCHOOL CHEMISTRY STUDENTS, KATSINA METROPOLIS, NIGERIA

By

Ematum Ramatu UMAHABA
M.Ed/EDUC/4454/2011-2012

DEPARTMENT OF SCIENCE EDUCATION,
FACULTY OF EDUCATION
AHMADU BELLO UNIVERSITY, ZARIA,

JUNE, 2016

IMPACT OF 5Es LEARNING MODEL ON QUESTIONING STYLE PREFERENCE AND ACADEMIC PERFORMANCE AMONG SECONDARY SCHOOL CHEMISTRY STUDENTS, KATSINA METROPOLIS, NIGERIA

By

Ematum Ramatu UMAHABA
B. Tech. Science Education (Chemistry) F.U.T, Minna (2010)
M.Ed/EDUC/4454/2011-2012

A DISSERTATION SUBMITTED TO THE SCHOOL OF POST GRADUATE STUDIES, AHMADU BELLO UNIVERSITY, ZARIA, IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTERS DEGREE IN SCIENCE EDUCATION.

DEPARTMENT OF SCIENCE EDUCATION
FACULTY OF EDUCATION
AHMADU BELLO UNIVERSITY, ZARIA, NIGERIA.

JUNE, 2016

DECLARATION

I hereby declare that this dissertation entitled "Impact of 5Es Learning Cycle Model on Questioning Style Preference and Academic Performance among Secondary School Chemistry Students in Katsina Metropolis, Nigeria" has been written by me and it is a record of my own research work. It has not been presented in any previous institution and application for higher degree. All quotation marks or indentation and the sources of information are specifically acknowledged by means of references.

Ematum Ramatu UMAHABA **Date**
M.Ed/EDUC/4454/2011-2012

CERTIFICATION

This dissertation entitled "Impact of 5Es Learning Cycle Model on Questioning Style Preference and Academic Performance among Secondary School Chemistry Students in Katsina Metropolis, Nigeria" by Ematum Ramatu Umahaba with Registration number M.Ed/EDUC/4454/2011-2012, meets the regulations governing the award of the degree of Master of Education in Science Education of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

-------------------------------------- ------------------------

Dr. J. O. Olajide Date
Chairperson Supervisory Committee

-------------------------------------- ------------------------

Dr. T. E. Lawal Date
Member Supervisory Committee

-------------------------------------- ------------------------

Dr. M. Musa Date
Head of Department

-------------------------------------- ------------------------

Prof. K. Bala Date
Dean School of Postgraduate Studies

DEDICATION

This dissertation is dedicated to Almighty God, the Father to the Fatherless, who has stood as my Father through it all. His grace made the work a success through Jesus Christ. To my late Father, Alhaji (Col.) Enokela Umahaba (RTD). To my Mother Mrs. Susan O. Umahaba, my Sister, Miss. Enenu Rahinatu Umahaba and to the entire Enokelites. I love you all.

ACKNOWLEDGEMENTS

First I must express my sincere gratitude to the Almighty God, my Father and my deliverer for His exceeding grace and unlimited favour which made it possible for me to be alive to accomplish this work.

My sincere thanks, gratitude and appreciation go to my Major Supervisor Dr. (Mrs.) J.O. Olajide who was so very must patient working with me. She took her time to go through the write up several times line for line, providing valuable suggestions. Her constructive critical mind and knowledge helped to impact the quality of the work. She is a mother in the making, it is a privilege to work under such a distinguished scholar. May God reward her abundantly. I also express my appreciation to my Second Supervisor Dr. Mrs. T.E. Lawal, for her constructive criticism and valuable suggestion.

I am indebted to my Mentor and Lecturer Prof. A. I. Usman, who not being my supervisor but took his time to see me through this work. For his valuable suggestions, corrections support and encouragements, I wish to say Thank you, Sir for believing in my capability. May the Almighty God bless you richly. To all lecturers in the department of Science Education and HOD; Prof. J. S. Mari, Prof. A.A.M. Shaibu, Dr. M.O. Ibrahim, Dr. (Mrs.) M. A. Lakpini, Dr.(Mrs). S.B. Olorukooba Dr. (Mrs.) B. Abdulkarim, Dr.(Very Rev) S.S. Obeka, Dr. M.M. Atadoga, Dr Falalu and finally the Head of Department Dr. M. Musa for their valuable contributions towards making this study a success. My profound gratitude to Prof. M.A. T. Sulieman (FUT Minna), Dr. A. Iyaka (FUT Minna), Mr. A. Ozigi (PG School) and other academic and non-academic staff the Department of Science Education, you all have been a wonderful source of encouragement, comfort and moral support.

I wish to express my profound gratitude to my Mother, Mrs. Susan O Umahaba who saw me through this study. Who stood by me during my deep moments, your labour will not be in vain. To my elder sister, Miss. Enenu R Umahaba who took her time to go through the write ups for grammatical errors. My appreciation goes out to my Pastor Rev. Geoffery Ireogbu for his spiritual support and for been there for me on the 30th September 2015 during an accident that almost claimed my life.

I wish to appreciate Mr. John A.Obemeata who analyzed the data’s that was used in the study. A big Thank you to Julius Daniel for typesetting this work. To my friends, Dapo Ige, Wale, G. Nwale, G. Ikechukwu, I. Babafada, Dr. W. Adegbe, H. A. Zemo; thanks for your moral support. I will not fail to acknowledge Mr. Monday Sule for been there to drive me to school always after the accident. In all, unto God be the Glory forever and ever.

LIST OF ABBREVIATIONS

5Es:	Engagement, Exploration, Explanation, Elaboration and Evaluation
ANOVA:	Analysis of Variance
BSCS:	Biological Science Curriculum Study
CPT:	Chemistry Performance Test
CIA:	Constructivist Instructional Approach
HOT:	High Order Thinking
IUPAC:	International Union of Pure and Applied Chemistry
LC:	Learning Cycle
LOT:	Low Order Thinking
NECO:	National Examination Council
PPMC:	Pearson Product-Moment Coefficient
SCIS:	Science Curriculum Improvement Study
SPSS:	Statistical Package for Social Science
SSCE:	Senior School Certificate Examination
WAEC:	West African Examination Council

OPERATIONAL DEFINITIONS OF TERMS

5Es Learning Model: Is an instructional model based on the constructivist teaching approach to learning which can be used for designing series of lessons which are conceptually and developmentally linked. This says that learners builds or construct new ideas on top of their old ideas. Each 'E' describes a phase of learning; Engagement, Exploration, Explanation, Elaboration and Evaluation.

Academic Performance: Scores that students obtained after been subjected to test or examination at the end of a program or instruction.

High level Questioning: Are questions that require more demanding and exacting thinking. There are Analysis, Synthesis and Evaluation. Examples are questions like; Apply, Compare and Contrast, Investigate, Relate etc.

Impact: A measure of the tangible or intangible effects expressed by an individual as a result of exposure to a pedagogical strategy.

Learning Model: Is a conceptual framework that describes a systematic procedure in organizing learning experiences to achieve specific learning objective and serve as a guide for learning.

Low level Questioning: Are question that requires memory, rote and simple recall answers. These questions are Knowledge, Comprehension and Application questions. Examples are questions like; What is, List, Explain, Solve, Apply etc.

Questioning Style Preference: Refers to the cognitive ability needed by a learner to answer more difficult questions.

TABLE OF CONTENTS

Page

Title Page i

Declaration iii

Certification iv

Dedication v

Acknowledgements vi

List of Abbreviations viii

Operational Definitions of Terms..ix

Table of Contents xi

List of Tables..xv

List of Figures xvi

List of Appendices..xvii

Abstract..xvi

CHAPTER ONE: THE PROBLEM

1.1 Introduction 1

1.1.1 Theoretical Framework 9

1.2 Statement of the Problem 11

1.3 Objectives of the Study 13

1.4 Research Questions..14

1.5 Null Hypotheses..14

1.6 Significance of the Study 15

1.7 Basic Assumptions..16

1.8 Scope of the Study 16

CHAPTER TWO: REVIEW OF LITERATURE

Page

2.1 Introduction 18

2.2 Teaching of Chemistry in Senior Secondary Schools 18

2.2.1 Understanding Chemistry and Problems Associated with the Teaching and Learning of Chemistry 22

2.3 Application of Constructivist Teaching Approach to Chemistry Teaching and Learning. - ……………………………………………..……………………………………………27

2.3.1 Constructivist Teaching Approach vs. Lecture Method 28

2.4 The Concept of 5Es Learning Cycle Model Approach 34

2.4.1 5Es Learning Cycle and High Order Thinking 37

2.4.2 5Es Learning Cycle and Academic achievement. 39

2.5 Questioning and Questioning Style Structure 40

2.5.1 Blooms' Levels and types of Question 43

2.5.2 Low-level Questioning 47

2.5.3 High-level Questioning Style 48

2.7 Questioning Style Preference 51

2.7.1 Questioning Style Preference and Academic Achievements in Science 52

2.8 Gender and Achievement in Science 54

2.8.1 Gender, Teaching Method and Academic Performance in Science 55

2.9 Overview of Similar Studies 58

2.10 Implications of the Literature Reviewed on the Present Study 65

CHAPTER THREE: METHODOLOGY

Page

3.1 Introduction 67

3.2 Research Design 67

3.3 Population of the Study 69

3.4 Sampling and Sampling Technique 70

3.5 Instrumentation 72

3.5.1 Chemistry Performance Test 73

3.5.2 Validation of the Instrument 75

3.5.3 Pilot Testing 77

3.5.4 Reliability of the Instrument (CPT) 78

3.5.5 Item Analysis 79

3.6 Administration of Treatment 82

3.7 Data Collection Procedure 86

3.8 Procedure for Data Analysis 87

3.8.1 Answering Research Questions 87

3.8.2 Null Hypotheses Testing 87

CHAPTER FOUR: ANALYSIS, RESULT AND DISCUSSION

4.1 Introduction 89

4.2 Data Analysis and Result Presentation 89

4.2.1 Answers to Research Questions 89

4.2.2 Hypotheses Testing 92

4.3 Summary of Findings 97

4.4 Discussion of the Results 97

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

Page

5.1 Introduction 101

5.2 Summary 101

5.3 Summary of Major Findings 103

5.4 Conclusion..104

5.5 Contributions to Knowledge...105

5.6 Recommendations...106

5.7 Limitations of the Study...107

5.8 Suggestions for Further Studies...108

References..109

Appendices...127

LIST OF TABLES

Table **Page**

1.1: Performance of Students in Chemistry at SSCE Level (WAEC) in Katsina State, from 2009 to 2015. 3

2.2: Types of Questions based on Bloom's Taxonomy 72

3.2: Sample Population for the Study 72

3.3: Item Specification Based on Blooms Taxonmy 76

3.4: Item Specifications based on Low and High Level Questioning Style 77

4.1: Mean and Standard Deviation Statistic of Students' Academic Performance......................89

4.2: Mean and Standard Deviation Statistics on Questioning Style Preference. 91

4.4: Summary of t-test Analysis of Mean Academic Performance Scores of Experimental and Control Groups...93

4.5: Result of Analysis of Variance for the Pre-test and Post-test Mean Score of Low and High Level Questioning Style Preference Students in Experimental and Control Group 94

4.5(b): Result of Scheffe's Test on Experimental and Control Groups Mean Scores Based on Questioning Style Preference..95

4.6: Result of Analysis of Variance for Male and Female Students' Mean Score with Low and High Level Questioning Style Preference. 96

LIST OF FIGURES

Figure **Page**

3.1: Research Design..68

3.3: Flow Chart Illustrating 5Es Learning Model 85

LIST OF APPENDICES

Appendix **Page**

A: Chemistry Performance Test (CPT) 127

B: Answer Sheet 133

C: Marking Scheme 134

D: 5Es Model Lesson Plan 137

E: Lecture Method Lesson Plan 166

F: Item Analysis for Chemistry Performance Test CPT....................181

G: Introductory Letter 1....................182

H: Introductory Letter 2....................183

ABSTRACT

This study investigated the Impact of 5Es Learning Cycle Model on Questioning Style Performance and Academic Performance among Senior Secondary School II Chemistry students. A Quasi-experimental pretest and posttest research design was used for the study which featured two groups (Experimental and Control group). The experimental group was exposed to 5Es learning cycle model while the control group was taught using lecture method. Sample sizes of 164 students selected from two secondary school in Katsina Metropolis were used as the study sample, drawn from a population of 10 schools with a total of 753 students. The two schools randomly selected, were selected after matching them, to find their equivalent academically. The Instrument developed; Chemistry Performance Test (CPT) with a reliability coefficient of 0.82 was used to collect data for pretest, posttest and gender equivalent used to test three null hypotheses. The data collected were analyzed using t-test Statistic, ANOVA, ANCOVA and Scheffe's test at significance level of $P \leq 0.05$. Result indicated that; (i) the experimental group performed significantly better than the control group in their academic performance after undergoing the experimental treatment with 5Es learning model as t-cal 5.04 was greater than t-crit 1.96, showing there is a significant difference. (ii) the model was found to have enhanced the experimental group students' ability to answer more difficult questions (that is their questioning style preference) as there was a significant attempt of students for high level questions after treatment with 5Es model. (iii) The treatment has no significant effect on gender which implied that the model is gender friendly. Based on these findings, it was recommended that; (i) Chemistry teachers should incorporate 5Es learning model into the main stream of pedagogy in the teaching of Chemistry at Senior Secondary School level as it seems to have high potentials for enhancing high order thinking skills, understanding and achievements on the part of the learners. (ii) There is also a need for training and retraining of science teachers towards effective use of 5Es learning model in the teaching of Chemistry at SSS level as it promotes high order thinking.

CHAPTER ONE
THE PROBLEM

1.1 Introduction

The relevance of science to national goals, aspirations and economy dictates to a large extent the huge commitment and support which Nations make and give to Science and Technology advancement. It is an essential tool for a Nation's progress and development (Chukwuneke, 2006: Akinbobola, 2009, Agboghoroma, 2009). The classification of Nations into Developed, Developing and Under-Developed is based on their Technological Advancement (Agogo, 2009, Maduawesi, Aboho and Okwuedei, 2010). This may be the reason why Achor (2006) and Ada (2008) opined that as a result of the speed at which the world is changing technologically, the need and usefulness of teaching and learning of Science should not be over looked. Students are expected to be trained to discover, invent and be part of this Scientific Community and the Teachers of Science and Technology are the means through which the skills and knowledge get to the learners.

Chemistry is most commonly regarded as the "Central Science" or the "Mother of science" owning to its confluence and influence. Okeke and Ezeannagba (2000) defined chemistry as a branch of science of matter. The relevance of chemistry as a requirement to technological advancement of a nation cannot be underrated (Babalola and Hafsatu, 2015). The Developed Countries forged ahead by recognizing the relevance of Chemistry in their National Economy as it is a core subject in the study of Medicine, Pharmacy, Engineering and Several technologically based courses. Research evidences have proved that Chemistry contributes to quality of life and Nation Building in all aspect. There have been researchers such as Eke

(2008), accepting that any Nation aspiring to be scientifically and technologically developed must have adequate level of Chemistry Education.

According to the National Policy on Education (FRN, 2013), Chemistry Education should be emphasized at the secondary school in terms of its teaching and learning. This is because; chemistry as an academic discipline plays a very significant role in unifying other science subjects. This emphasis seems not to be in place as there has been consistent decline in the performance of students in public examinations conducted by the West African Examinations Council (WAEC) and the National Examination Council (NECO) in Sciences across the Country over the years (Agogo, 2003; Samba and Eriba, 2012). Studies revealed that, Academic Performance of students in Chemistry at Senior Secondary School Certificate Examinations (SSSCE) has consistently been very poor and unimpressive (Njoku, 2005). Many factors have been suggested as contributing factor to this poor performance of students in Chemistry in particular and sciences in general. Some of these factors include: inadequate laboratory infrastructure and equipment in Chemistry (Eniayeju, 2001); poor teaching methods, lack of adequate practical equipment, Mathematical nature of Chemistry concepts and laws (Ayogu, 2001); psychosocial factors (Bankole,2001); the abstract nature of Chemistry concepts (Samba and Eriba, 2012); students and teachers related factors (Mailumo, Agogo and Kpagh, 2009); concepts difficulty (Agogo, 2003 and Agwi, 2008). Also the West African Examination Council (WAEC) Chief Examiners' Report 2005-2010, reported students' general poor performance in Chemistry in Nigeria.

In Katsina State where this study was carried out, the situation is not different as can be seen in Table 1.1, which shows the performance of students in Chemistry from 2009 to 2014.

Table 1.1: Performance of Students in Chemistry at SSCE Level (WAEC) in Katsina State, from 2009 to 2015.

Year	No. of Students in Attendance	No. of Students that Passed at Credit Level	No. of Students that Failed	% Pass	%Fail
2009	1800	355	1445	23	80
2010	1905	340	1565	18	82
2011	2033	404	1629	20	80
2012	2210	401	1809	18	82
2013	2560	528	2032	21	79
2014	2694	608	2086	23	77
2015	2111	421	1690	20	80

Source: Katsina State Ministry of Education (2015).

From Table 1.1, it could be observed that chemistry students have difficulties in the learning of Chemistry which has resulted in poor performance at Senior Secondary School level. Francisco, Nicoll andTrautmann, (1998), Gabel (1999), Ezeliora (2004) and Okoli (2006) reported that poor teaching methods adopted by Science teachers during instruction is one of the causes of students' colossal failure in Science examinations and remarked that these teaching methods and techniques do not seem to make learning sufficiently easy for students. Decanato, Ramirez, Aspee and Irma, (2006) submitted that the abstract nature and the difficulty in learning some concepts are so stable and coherent internally that conventional instruction has little effect on them. Students by nature are curious and need to be actively involved in the learning process.

Chemistry teaching is supposed to be result oriented and students centered, and this can be achieved when students are willing and the teachers are favorably disposed to using the appropriate methods and resources in teaching the students, (Adesoji & Olatunbosun, 2008). Methodology plays a very vital role in any teaching and learning situation and it primarily falls into two categories or approaches;

- Teacher-centered approach, such as Lecture method and direct instruction and

- Student-centered approach like Inquiry-based learning, Cooperative/Collaborative learning and Demonstration method.

Inquiry based instructional learning is a student-centered and teacher guided instructional approach that requires students to find out things for themselves. It is an important constructivist approach, allowing knowledge construction via asking questions. Constructivist teaching is based on the fact that skills and knowledge acquisition are not by passive receiving of information and rote learning but involve active participation of the learners through knowledge construction, hands-on and minds-on activities (Akinbobola and Ado, 2007).

Inquiry-based learning needs to be well structured and scaffolded, and inquiry cycles can be effectively applied in various educational settings. Its ultimate goal is to develop independent learners who know how to expand their knowledge and expertise through skilled use of a variety of information sources employed both inside and outside of the school (Kuncel, 2008). It requires careful planning, close supervision, ongoing assessment and targeted intervention by an instructional team of teachers through the inquiry process that gradually leads students toward independent learning (Crede, 2008). Inquiry Based Learning is primarily based on three important qualifiers about the nature of inquiry: three level of scaffolding (amount of learner self-direction), the emphasis on learning, and its scale (within-class, within-course, whole-course, and which-degree) Spronken-smith and Walker (2010). All models of Inquiry based learning emphasis the following levels of significant ways (NRC, 2000 and Maab and Artique, 2013).

- Confirmation Inquiry: - students are provided with question and procedures, and results are known in advance.

- Structured Inquiry:- students are given a problem and outline for how to solve the problem.
- Guided Inquiry:- students also figure out the solution method.
- Open Inquiry:- students formulate the problem for themselves.

For this study, Guided-Inquiry based learning was employed since it is compatible with the Constructivist Instructional Approach and the learning cycle model. The model provides a built-in structure for creating a constructivist classroom .

The Learning Cycle originally credited to Karplus & Thier (1967), who published it in the Science Teacher, has been used in science education from its conception. Probably one of the earliest and foremost supporters of the Learning Cycle was the SCIS (Science Curriculum Improvement Study) programme which adapted it and included it in its science curriculum. Although there are several "E" versions (e.g. 3E, 4E, 5E, 7E and other modifications) the basic premise is that children have an experience with the phenomena in the learning of the concept / topic. 3E (Explore-Explain-Elaborate), 4E (Engage-Explore-Explain-Evaluate), and 7E (Excite-Explore-Explain-Expand-Extend-Exchange-Examine) are also suggested (Çalık, Ayas & Coll, 2010). But the most popular versions of constructivism is the 5Es model.

For 5Es learning model, each step with "E" refers to help students' learning by the experience of linking prior knowledge to new concepts. It is seen that 5Es learning model is especially effective in the elimination of alternative conceptions (misconceptions) (Bybee, Taylor, Gardner, Powell, Westbook & Landes, 2006 and Ültay & Çalık, 2016). This is because; constructivist learning theory claims that learning is an interaction between new knowledge and pre-existing knowledge (Bybee et al., 2006), and people construct their own knowledge by using their existing knowledge.

In this study, 5Es learning cycle instruction model by Bybee et al (2006) was used because it is one of the most effective models that can be utilized to promote students' conceptual understanding and learning of scientific concepts as opined by Ültay and Çalık,(2016). The components of the learning cycle model of a Science lesson are:

Component 1: ENGAGE-"Capture the student's attention and interest"

Component 2: EXPLORE-"Activity"

Component 3: EXPLAIN-"Link to other concepts"

Component 4: EXTEND-"Apply learning"

Component 5: EVALUATE-"Feedback"

Questioning Style Preference Refers to the cognitive ability needed by a learner to answer more difficult questions. Through questioning at various levels of cognition, teachers and students share perceptions, perspectives and reflections of items to learn or learn from. However not all questions requires the same level of cognitive thinking. It ranges from Low-level, rapid-fire questions that result to short answers to High-level, open-ended questions that lead to problem-solving, reasoning, and the ability to learn in puzzling situations (Joyce, Weil, & Calhoun, 2000). Questions teachers pose are cues to students' level of thinking expected of them. It ranges from the lowest level of mental operation, requiring simple recall of knowledge (convergent thinking), to the highest, requiring divergent thought and application of that thought.

Questioning is any sentence which has an interrogative form or function. It is the heart of teaching learning process; it plays an important role in daily instruction. Questions can prompt responses ranging from simple recall of information to abstract processes of applying, synthesizing, and evaluating information (Zepeda, 2009). Blooms and his colleagues in 1956 developed a continuum for categorizing questions and responds into Low-level questions and High-level question, following the hierarchy (Knowledge, Comprehension, application, analysis, synthesis and evaluation).

Low-level cognitive questions are questions which require students to remember, reiterate or find information that is within the text (Tienken, Goldberg & DiRocco., 2010 and Vogler, 2005). Although low-level, intext questions are easier to generate, teachers must ask questions from a variety of levels to ensure student achievement (Tienken et al., 2010). These types of questions do not encourage students to use high-level thinking, but rather require them to just recall what they have read or learned in a manner which produces a "correct" or "incorrect" response (Tienken et al., 2010; Walsh & Sattes, 2005). Research studies show that low-level questions are the easiest for teachers to produce, and, therefore, are the most common form of questioning in the classroom (Tienken et al., 2010). Although low-level questioning may not prepare students to think deeply, they do, however, set the stage for making sure students are ready for higher-level discussion (Walsh & Sattes, 2005). These questions are also called Convergent-thinking questions. Low- level questions are those at the knowledge, comprehension, and simple application levels of the taxonomy. Lower cognitive questions are also referred to in the literature as fact, closed, direct, recall, and knowledge questions.

High-level questions, although most infrequently used, are extremely beneficial for student learning. High-level questions are questions which require students to analyze, synthesize, evaluate, categorize or apply what they have read (Tienken et al., 2010; Vogler, 2005). High-level questions frequently do not have one correct answer, but rather encourage students to produce a response which is unique to their thinking and interpretation of the text (Tienken et al., 2010; Peterson &Taylor, 2012). Research has shown that asking higher-level thinking questions is fundamental to student learning (Lundy, 2008). In addition, teachers who emphasized higher-level thinking through the asking of higher-level questions promoted greater reading growth in their students (Lundy, 2008). There are also called Divergent-thinking questions (known as broad, reflective, or thought questions) are open- ended (i.e., usually having no singularly correct answer), high-level cognitive questioning (requiring analysis, synthesis, or evaluation). These questions require students to think creatively by leaving the comfortable confines of the known and reaching out into the unknown (Cotton, 2001).

Gender is another issue that affects students' performance in science education. Patrick & Ezenwa, (2000) and Duniya (2009) opined that gender issues in Science Education as it affects performance remains unsolved. Lentz (1992) and Usman (2000) in their individual studies noted that boy perform better than girls on activities that require manipulations and also boys are more mechanically and scientifically inclined than girls. Usman (2000) in their individual studies noted that boy perform better than girls on activities that require manipulations and also boys are more mechanically and scientifically inclined than girls. However, others like Mari (1994) observed from his study that female students perform better on their understanding of science process skills than male students. Bichi (2002) and Demole and Femi-Adeoye (2004) in their separate studies respectively found out that there are no gender differences in performance in science. Iliya (2011) in her study of teachers' cognitive questioning style and the effect on academic achievement of integrated science students in relation to gender revealed that the male are extrovert in nature and responds to teacher questions quickly as they are bolder than the females. Therefore, this study sort to investigate the impact of teaching model (5Es learning model) on gender in relation to academic performance and enhancing questioning style preference from low level questions to high level questions.

Academic performance is directly related to students' growth and development of knowledge, in an educational situation where teaching and learning process takes place. It is defined as the performance of the students in the subject they study in the school (Pandey, 2008). Academic achievement determines the student's status in the class. It gives children an opportunity to develop their talents, improve their grades and prepare for the future academic challenges. With the variables stated, this study will be investigating the impact of 5Es learning model on the Academic achievement of senior secondary school students and their students' Questioning Style Preference in chemistry. If 5Es learning model can enhance their Questioning Style Preference and improve their Academic Performance in Chemistry.

1.1.1 Theoretical Framework

The theoretical basis underlying this study is the use of Constructivist Instructional Approach (CIA) which is an inquiry based learning approach, attributed to the constructivism theory. There are two main forms of constructivism: cognitive and social constructivism. Cognitive constructivism draws mainly on Piaget's (1972) theory of cognitive development. Piaget proposed that individuals must construct their own knowledge and that they build knowledge through experience. These experiences allow creation of schemas or mental modes and thus lead to learning. In contrast to cognitive constructivism, social constructivists place more emphasis on the social context of learning. Vygotsky is the main proponent of social constructivism and suggested that cultural history, social context and language play an important role in the pattern and rate of development of children. Vygotsky's concept of the zone of proximal development argues that individuals can, with the help of a more experienced peer, master concepts and ideas that they cannot understand on their own (Vygotsky, 1978).

For this study Cognitive constructivism theory by Jean Piaget was considered, who articulated mechanisms by which knowledge is internalized by learners. He suggested that through processes of accommodation and assimilation individuals construct new knowledge from their experiences; it postulates that learning is a constructive process which requires the design of instruction to provide opportunities for such interaction. Constructivist learning environment also emphasizes knowledge construction instead of knowledge reproduction. An example of a guided inquiry learning approach is the Learning Inquiry Cycle Model. Grounded on the constructivist approach, 5Es learning and teaching model includes higher order thinking skills. It's a model that facilitates learning and creates beneficial opportunities for students while learning (Lorsbach, 2006).

Learning cycle is useful to teachers in designing curriculum materials and instructional strategies in science and compatible with the guided inquiry learning approach. The model is derived from constructivist ideas of the nature of Science, and the developmental theory of Jean Piaget (Piaget, 1970) and developed by Robert Karplus with the Science Curriculum Improvement Study (SCIS) in 1964. The learning cycle of Karplus has three phases. These are Exploration, Term Introduction and Concept Application. Over the years the learning cycle was revised and added several phases. So, 5Es learning cycle was formed and it was developed by the Biological Sciences Curriculum Study (BSCS). In this study, 5Es learning cycle instruction model by Bybee, Taylor, Gardner, Powell, Westbook & Landes, (2006) was adopted. The 5Es learning model of Engage, Explore, Explain, Elaborate and Evaluate is an instructional method for designing a series of experientially rich lessons that are conceptually linked and developmentally sequenced to support the ongoing, progressive refinement in student understanding as it develops over time (Bybee, 2006). The end of one phase of the learning cycle is the launching pad to the next phase. The underlying logic of the learning cycle is that individual lessons only make sense in the light of how they build on previous knowledge/lessons and how they create the cognitive need and scaffolding for subsequent lessons. Both the individual and the collective human understanding of science are built on (and in some cases reconstruct flaws in) the foundation of prior conceptions, including resistant-to-change misconceptions (O'Brain, 2011). Similarly, the intelligent CIA is designed around a cycle of learning (learning cycle) experience with diagnostic, formative and summative assessments embedded in an instructional sequence that is aligned with the curriculum objectives (NSTA, 2001).

Based on these tenets of constructivism, the purpose of this study is to examine the impact this 5Es learning cycle model on the Academic Performance and Senior Secondary Chemistry Students' Questioning Style Preference in Katsina Metropolis.

1.2 Statement of the Problem

The persistent poor performance of students in SSCE Chemistry for quite some times now has become a major concern to Science Educator, Parents and other stake holders in Science Education. Literature has revealed that students performance in Chemistry at Senior Secondary School Certificate Examination have been consistently poor, (Njoku, 2005 & WAEC Chief Examiner's Report 2005-2015). Over the years science educators have been using the lecture method of teaching with little or no activities, which makes Chemistry concept difficult for students to understand (Anthony, 2009). In supporting this view, Derek (2007) reported the seriousness of the deplorable performance of Secondary School students in Science subjects and identified persistent use of the traditional mode of instruction as one of the major short-coming affecting the learning and achievement in Science subjects. Usman (2006), reveal that the prevailing method used by most teachers in Nigerian schools is the lecture method. According to them, this method does not allow meaningful learning and active participation of the learner and this leads to rote learning. Also the WAEC Chief Examiners' report (2015) attributed the poor performance of students in Chemistry to methodology and inability of students to answer all levels of questioning correctly.

The study on Cognitive Questioning Preference was conducted at Senior Secondary School level by Gandu, (2006) in Biology. Another study was carried out by Iliya (2010), at the Junior Secondary School level in Integrated Science. In their separate studies, poor performance in the Sciences was attributed to low level cognitive questioning which the students' are exposed to and preferred to answer during lessons and assessment. It is estimated that most questions asked by teachers (approximately 60%) are low level cognitive questioning, 20% are high level cognitive questioning, and 20% are procedural (Cotton, 2001; Allington & Johnston, 2002; Applegate, Quinn, & Applegate, 2002). 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 frequent use of low-level Questioning by the teacher does not prepare students for the challenge ahead such as WAEC and other National Examination as these examinations are set based on all level Blooms taxonomy and questioning; this also results to the persistent poor academic achievement of students both in International and National Examinations (Ersoy, 2006).

Aksela (2005) employed the use of computer assisted programs to promote High Order Thinking Skills. A study by Cavallo (2003) aimed to examine students' interpretations of chemical reactions using open-ended questions (High Order Questioning) during the learning cycle, with a study sample of (60) students of the ninth primary grade, the results revealed a positive change in students understanding when implementing the learning cycle compared to the students studied using the traditional method.

So much attention has been given to the use of teaching methods to improve students' academic achievement, retention, self-efficacy, scientific literacy etc. in Chemistry among other Science subject. But the area of the using 5Es learning model in relationship to questioning style preference to improve on performance in chemistry is lacking. Since 5Es learning model sequences learning experiences so that students have the opportunity to construct their understanding of a concept over time and improve high order thinking skills. If students' Questioning Style Preference is not taken into consideration (in accordance to all levels of Bloom's taxonomy in the cognitive domain) it can possibly affect their academic performance. Also, the constant use of lecture method does not allow students appreciate the effectiveness of high level cognitive questioning as it does not promote high order thinking skill.

Therefore, this study employed the use of 5Es learning cycle model to determine its effect on Academic Performance and Questioning Style Preference of senior secondary school students in Chemistry.

1.3 Objectives of the Study

The research is designed to achieve the following objectives which are to:

1. determine whether 5Es learning cycle model has impact on the Academic performance of senior secondary school chemistry compared lecture method.
2. examine if 5Es learning cycle model will have impact on low and high Questioning Style Preference of Senior Secondary School Chemistry Students.

3. compare the academic performance of male and female chemistry students with low and high questioning style preference exposed to 5E's learning cycle model.

1.4 Research Questions

The following research questions are formulated to guide this study.

1. What is the difference between the mean (academic performance) scores of Chemistry students taught with 5Es learning model and those taught with lecture method?
2. What is the effect of exposure to 5Es learning cycle model on the mean questioning Style Preference among senior secondary school Chemistry students and those taught with lecture method?
3. What is the difference in the mean scores of male and female student's questioning style preferences who were exposed to 5Es learning cycle model?

1.5 Null Hypotheses

The following null hypotheses are formulated for testing at $p \leq 0.05$ level of significant.

HO_1: There is no significant difference between the mean score of Chemistry Students Academic Performance, when exposed to the 5Es Learning Cycle Model and those taught with lecture method.

HO_2 There is no significant difference between the mean scores of Chemistry students with low and high Questioning Style Preferences when exposed to 5Es learning model and those taught with lecture method.

HO_3 There is no significant difference in the mean scores of male and female Chemistry Students' Questioning Style Preference when exposed to 5Es Learning Model?

1.6 Significance of the Study

This study is conceived to determine if the use of Constructivist Teaching Approach employing the 5Es Learning Cycle Model will have impact on the academic performance and questioning style preference of senior secondary school Chemistry students and uplift the standard of Chemistry Education. The findings will hopefully be of benefit to; Secondary school students (frontier), Science/Chemistry Teachers and Educators, Education Planner and Curriculum Designers.

- **Chemistry Students:-** Inspiring Upcoming science student will benefit from the study if it is proved that the 5Es Learning Model of Science instructions lead to higher achievement in Chemistry. It will encourage the students to interact intimately with the subject matter of Chemistry through constructing their own knowledge from preexisting ones thereby engaging them in productive high cognitive processes and thinking. It is hoped that the students will develop better knowledge and understanding of chemistry concepts which would be very useful in both academic and career counseling.
- **Chemistry Teachers:-** it is hoped that this study would cause an increase in the interest of chemistry teachers in developing and employing new and exciting science teaching methods, as the study explores the effectiveness of Discovery Inquiry-Based Teaching Method based on the Constructivist Theory, and, thus, it keeps pace with the contemporary educational trends in using educational strategies derived from learning theories to encourage high order thinking and enhance students Cognitive Questioning Preference.
- **Science curriculum Developers and Educational Supervisors**:- due to its practical research significance because the study elements and procedures were described using a

modified learning cycle, which provides natural Science teachers and students, and educationalists in general, with the opportunity to know the procedures of the learning cycle, its application methods and its effect on the educational achievement. Hence it would help to redefine the curriculum in sequences of potential experience that emphasizes on student centered approach to learning.

1.7 Basic Assumptions

In the course of this study the following basic assumptions are made:

1. SS II students have all had some knowledge of Chemistry from their previous class SS I.
2. Questioning Style preferences can be measured by the instrument designed by sorting out.
3. The methods of instruction used in teaching Chemistry normally do not include all stages of 5Es learning cycle model strategy, as on Explanation and Evaluation are common in lecture method.

1.8 Scope of the Study

This research is limited to finding out the impact of 5Es learning cycle model on the academic performance and Questioning Style Preference of Secondary School Students in chemistry, Katsina Metropolis will be the case study. Only Government Senior Secondary Schools will be sampled because it is believed that their teaching and learning condition is relatively the same, such as Class Size, Laboratory facilities, environment etc. All Senior Secondary II chemistry students' constitute the population for this study. The choice of SS II students is considered appropriate because the students' has been exposed to basic chemistry concept from their previous class (SS I). The method of instruction is the Constructivist

Teaching Approach employing the 5Es learning cycle model adopted from by Bybee, Taylor, Gardner, Powell, Westbook & Landes, (2006).

The topics selected for this study were as follows:-

i. Periodic Table

ii. Gas laws

iii. State of Matter and Change of State

iv. Chemical Reaction

v. Mole Concept

The concept selected for the study is in the SS2 syllabus. The choice of these concepts is considered suitable because they are some of the difficult areas students get to fail as reported by WAEC Chief Examiner (WAEC, 2011). The instrument used was the Chemistry Performance Test (CPT) with reliability coefficient of 0.82. It was used to collate data's for the pretest and posttest and to sort students' questioning style preference into high level or low level questioning according to Blooms taxonomy of cognitive domain..

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Introduction

This study sought to find out the impact of 5Es Learning Cycle Model on Academic Performance and Senior Secondary School Students' Questioning style Preference in Chemistry. In this chapter, literature relevant and related to the study is presented under the following sub-headings;

2.2 Teaching of Chemistry in Senior Secondary schools

2.3 Constructivist Approach to Chemistry Teaching and Learning.

2.4 The Concept of 5Es Learning Cycle Model Approach

2.5 Questioning Style Preference

2.6 Levels and Types of Questioning According to Bloom's Taxonomy

2.7 Gender, Teaching Methods and Academic Performance in Science

2.8 Overview of Similar Studies

2.9 Implications of the Literature Reviewed for the Present Study

2.2 Teaching of Chemistry in Senior Secondary Schools

Chemistry is one of the physical sciences taught at the Senior Secondary School Level. As defined by Ababio (2005) Chemistry is the study of matter, what it is made of, how it behaves, its properties and how it changes during chemical reaction. According to Zoller, (2001), it is the study of the nature and properties of all forms of matter. Salman, Olawoye & Yahaya, (2011), describe Chemistry as the Central Science that forms the essential foundation of many disciplines such as Biology, Physics, Cosmetics, Medicine, Plant Science, Engineering and Environmental Science. The importance of Chemistry cannot be over emphasized, it appears that without chemistry there can hardly be science because, the scientific development of any nation is determined by the quality of Chemistry Education in its schools (Okafor, 2003). It has also been recognized as a very important Science subject and its importance to scientific and technological development of any nation has been widely reported (Usman, 2008). As a result of its recognition in the development of the individual and the Nation, it was made a core-subject among natural Sciences and other Science related courses in Nigerian education system, (Adesoji & Olatunbosun, 2008). It has been a pre-requisite subject for most Science oriented courses in tertiary institution and this call for the need in teaching it very effectively. There are three major branches of Chemistry considered at Senior Secondary School Level, namely; Organic Chemistry, Inorganic Chemistry and Physical Chemistry.

The knowledge of Chemistry in our ever increasing innovative world is a prerequisite because achievement in Chemistry is important for ensuring economic competitiveness. This entails that lack of conceptual understanding of Chemistry concepts beginning from Secondary School Level may impact negatively on students in a world that is becoming more global, innovative, and dynamic and requires quality and proficiency in the workforce. The main objectives of Chemistry teaching at Senior Secondary Schools are to enable the students to develop their knowledge and skills in Chemical Science and project their efforts in education so as to be useful to themselves and the society in general. In spite of the importance of Chemistry, observation of students' performance in Chemistry in the Secondary School Certificate Examination (SSCE) reveal that only a very negligible number of students perform well in the examinations (Jegede, 2003). This frequent poor performance of students in the certificate examination is just pointing to one singular fact that, something is wrong with either the quality of the subject matter which refers to; what the students are taught or the instructional method which is; way they are taught.

The main aim of teaching is to transfer knowledge to the learners. Chemistry teaching is supposed to be result oriented and students centered, using the appropriate methods and resources in teaching the students. In the teaching of Chemistry, students are exposed to learn both concepts and skills, some of which maybe abstract or difficult. Colburn (2009) and Uce (2009) noted that Chemistry teachers are aware that students often struggle with the abstract concepts they are teaching, and yet, pedagogy in most Chemistry classrooms does not address the students' needs to develop appropriate mental models of abstract Chemistry concepts. To resolve the issue, students must have the ability to work with abstract concepts (Marais & Combrinck, 2009). For the students to have a complete grasp of the abstract concepts of chemistry, teachers must choose the appropriate teaching method. Martins and Oyebanji (2000) stated teaching methods affects the response of the students and determine their interest level, motivation and involvement in the lesson.

Teaching method has been defined by Afolabi and Adesope (2010) as a specific instructional process which differs from any other by the diversities of specialized activities. This implies that each teaching method has its own peculiar characteristics and steps which differ from another teaching method. Teaching method is very important in the impartation of knowledge in teaching-learning processes and the type adopted determines to a great extent what the student assimilate. In actual fact if the appropriate method is adopted, knowledge acquired can be accelerated. It is your duty as a teacher to ensure that appropriate teaching method or a combination of two or more methods is used in order to achieve the stated aims and objectives.

Some Various Methods of Teaching used include the following:

- Lecture or the chalk and talk method
- Discussion method
- Demonstration Method
- Discovery Method (Guided Inquiry Method)
- Assignment/Project Method
- Field Trips Method (Excursion)
- Individualized Instructional Method
- Co-operative method
- Laboratory Method
- Inductive and Deductive Method
- Open Education Method
- Computer Assisted Instructions (CAI)
- Science Process Teaching Approach and Other

Atadogo & Onaolapo (2008) pointed out that teaches method have to be varied and mixed with real life situation. However, there are rules which guide the choice and selection of appropriate and adequate approaches of imparting knowledge and developing a particular skill in students. In selecting the teaching method for Science teaching, the following should be put into consideration:

- The Age, Topic, and Previous knowledge of the topic.
- Time duration for the lesson
- Class size
- The available resources for the topic.

The abstract nature of chemistry along with other content learning difficulties means that chemistry teaching and learning require a high-level skill and thinking, (Taber, 2002). For this study, the Discovery Teaching Method will be considered using the Guided inquiry-based learning which is a Constructivist approach. According to Nadelson (2009), Guided Inquiry-based Learning holds great promise in assisting students to learn science free of alternative conceptions. Furthermore, this method assists students as they connect their understandings of macroscopic and microscopic chemical phenomena to their symbolic representations (Hansen, 2006). Based on the researches by Oliver (2007) and Prince and Felder (2007), the inquiry-based teaching style presents students with a problem to be solved and causes an increase in their motivation. However, the inquiry–based learning actively involves the students in the learning process and allows the students to learn the contents on their own, which provides more opportunities for the students to gain a deeper understanding of the concepts and become better critical thinkers (Wang & Posey, 2011). In this study, the Constructivist Teaching Approach which is an Inquiry-based teaching and learning strategy of the Discovery teaching method will be employed to ascertain its impact on the Academic Performance and Cognitive Questioning Preference of learners in Chemistry.

2.2.1 Understanding Chemistry Problems Associated with the Teaching and Learning of Chemistry

Chemistry like all science subject is dynamic and activity oriented. It comprises of four basis components which are; the processes used to obtain (discover or create) chemical knowledge; the general concepts and specific ideas so produced; the applications of that knowledge in understanding and changing the world; and the implications of that understanding and change for individuals and societies (Cheng & Gilbert, 2009). They also argued that understanding Chemistry requires understanding: the nature of Chemistry, its norms and methods; the key theories, concepts and model of Chemistry; how Chemistry and Chemistry-based technologies relate to each other; and appreciating the impact of Chemistry and Chemistry-related technologies on society. As a result of these, Aikenhead (2005) affirmed that young learners should be taught how to acquire these Chemistry skills and assimilate those abilities which will prompt them to taking responsibilities for expansion of their own knowledge and learning, they become self-reliant as they can easily apply the learned tools in new situations. It was again observed by Aikenhead (2005), that Chemistry learning 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.

According to Bransford, Brown and Cocking (2000), Meaningful learning occur when students not only remembers but are able to make sense of and are able to apply what they have learned effectively in new situation. Aksela (2005) disclosed that the ability to apply knowledge to impact on a new situation is effected 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) 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-order thinking. Thus, high-order thinking processes are ways that students process information; apply knowledge, change preferences (as a result of improved experiences from instruction) and construct meaning. Zohar, (2004) opined that, Students who do not possess meaningful learning orientation memories 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.

Effective learning therefore requires that students take control of their own learning through reflection, self-assessment and improve on their questioning preference (Bransford, Brown & Cocking, 2000). Knowledge-construction by students for meaningful learning as stated by Bybee *et al.*, (2006) is a challenging process which is actually stimulated by student-centered activities involving a mental effort or activity. Cuttance (2001) opined that capturing students' interest in Chemistry at Senior Secondary School level is a crucial aspect to improving the uptake of Chemistry at tertiary levels. For this reason, it is suggested that there is a need to improve the way Chemistry is taught in schools so that students are more engaged and recognize the relevance of the Science through more real-life practical activities. Minds-on as well as hands-on activities that engage students in active learning are important in any Chemistry classroom. Likewise, Njoku (2004) stressed that the teacher needs to be trained how to use activities that will make learners do and experience Science instead of just reading about Science. Contemporary learning theory indicates that students need to be actively engaged in learning tasks if they are to develop a meaningful understanding of Chemistry.

Many reasons have been attributed to the poor/fluctuating performance in chemistry in external and internal examinations. From subsequent researches, factors contributing to the persistence of students' poor performance in chemistry are: ineffective teaching methods adopted by the chemistry teacher, lack of infrastructures and teaching materials, lack of professionally qualified teachers, lack of technicians/laboratory attendants, lack of organized strategies for problem solving and poor reasoning and poor mathematics background. The WAEC also confirmed this decline in chemistry performance by the students in their WAEC

Chief Examiner's Reports (2010-2014). According to Samba and Eriba (2012), it is due to the abstract nature of Chemistry concepts. Etiubon (2007) in his research identified teaching resources and its manipulative adaptations as a factor. Similarly, Ezeliora (1999) and Eniayeju (2005) also pointed out that the use of concrete materials will facilitates better and proper understanding of Chemistry concepts. Ivowi (1997), Salau (2003) and Njoku (2004) identified students' attitude towards learning as a factor. This failure shows that secondary school students are not being prepared for the global demand in the current era. Research by (Arokoyu & Ugonwa, 2012); (Asiyai, 2006) attributed the failure to lack of adequate teaching recourses. Similarly, (Bamidele & Oleyede, 2013) assert that the poor performance was due to teachers' emphasis on content coverage and teachers' lack of interest to try new teaching method. Further studies confirmed that most science teachers do not possess the prerequisite knowledge needed for activity-based learning (Nwosu, 2004 and Jayapraba, 2013).

Dahiru (2013) pointed out poor teaching method as a factor for poor performance of Chemistry students in Katsina State, as a large proportion of Chemistry teachers resort to the use of the traditional lecture method rather than the activity-oriented or students centered strategies. He employed the use of the collaborative learning strategy on Chemistry student Academic Achievement and anxiety level. From his findings, significant difference was found when Chemistry students were exposed to collaborative learning as compared with performance of Chemistry students taught with lecture method of teaching, the difference was in favor of those students exposed to collaborative learning and their anxiety level was low. Olatoye, Aderogba and Aanu, (2011) try to compare the use of two teaching method on achievement in Chemistry, co-operative and individualized teaching methods. The result revealed that cooperative teaching method procedure has most significant effect on the achievement of students in Organic Chemistry than the individualized teaching method.

Emphasis has been placed on teaching method as a major factor for the poor performance of study in chemistry. Research findings had however, revealed that, a large proportion of science teachers, chemistry inclusive, still resort to the use of traditional/lecture method rather than the activity-oriented strategies advocated for, such as demonstration method problem-solving and others (Olorukooba, 2001).Hence the prevalent teaching method in Nigeria and Kenya is talk and chalk approach (Kurumeh, Omenka & Mohammed, 2013; Kamau, 2012; Derebssa, 2006; Ezeliora, 2004).Njelita (2007) from his research found out that innovative teaching strategies such as (inquiry, problem, solving, cooperative, demonstration methods) are better than the conventional method in acquisition of science skills. Professional teacher does not just transmit knowledge to the students, but has to adapt strategies as the need arises. This means that not only is forward planning necessary, but also reflection to determine what is working well and where remedial work or adaptations are required. A philosophical approach can enrich science not only through the planning and review stages, but also in extrapolating science activities to other elements of the curriculum and to the world of everyday experience. According to Fisher (2003), science is generative in the sense that it is about constructing meaning out of knowledge. On this ground the constructivist teaching approach (which encourages learners to be active thinker to construct their knowledge) employing the 5Es Learning Cycle developed by Bybee (2006) will be adapted to improve the poor performance of students and enhance their questioning style preference.

2.3 Application of Constructivist Teaching Approach to Chemistry Teaching and Learning.

The Constructivist Teaching Approach to education has become the leading theoretical position in education and a powerful driving force in science education. Constructivism has been proven by research to act as a powerful theoretical referent to build a classroom that maximizes student learning (Treagust, Duit & Fraser, 1996). Constructivism in the classroom incorporates three important dimensions: valuing the student's point of view, using higher level questions to elicit student thoughts and valuing the process of student thinking rather than student answer or product (Freiburg & Driscoll, 2000). Constructivism is defined as a set of beliefs about knowledge that begins with the assumption that reality exists but cannot be known as a set of truth (Tobin & Tippins, 1994).Constructivism is one of the theories of learning which became well developed in the recent year and became the most significant and dominant prospective in science education (Taber, 2006). The constructivist model focus on constructing the knowledge in the learner' mind. Constructivists believes that objective knowledge cannot exist, rather all of us are involved in constructing our own words, part of which we take as being shared by others. Constructivist believes in truth but not in a truth that has been constructed by somebody. It maintains that individuals create or construct their own new understandings or knowledge through the interaction of what they already know and believe and the ideas, events, and activities with which they come in contact. Knowledge is acquired through involvement with content instead of imitation or repetition. Constructivism is not accepting what you are told but your prior knowledge about what you are taught and your perceptions about it. The new idea is not imposed on the learner. Teaching and learning must be an interactive process that engages the learners in constructing knowledge. The learner is actively re-structuring his past and present experiences. Students' active involvement is emphasized in constructivism; the knowledge is then rooted into their memory. Learning is primarily an individualistic enterprise. This is a child-centered approach that seeks to identify, through scientific study, the natural path of cognitive development. According to this approach students come to classrooms with ideas, beliefs, and opinions that need to be altered or modified by a teacher who facilitates this alteration by devising tasks and questions that create dilemmas for students. Working through these dilemmas results in construction of knowledge. "Discovery learning" and hands-on activities, such as using manipulative; student tasks that challenge existing concepts and thinking processes; and questioning techniques that probe students' beliefs and encourage examination and testing of those beliefs are included in instructional practices. Individuals construct knowledge in transaction with the environment, and in the process both the individual and the environment are changed.

2.3.1 Constructivist Teaching Approach vs. Lecture Method

Constructivist teaching approach is different from the traditional view of learning in the sense of view of the real world. The traditional view focuses on instructional goals such as recalling facts, generalization, defining concepts and performing procedures (Almala, 2005). Therefore the view ignores the difference of preexisting knowledge of individual. On the other hand, It has been showed that constructivist teaching approach is effective in enhancing students understanding and achievement, teachers would spend less time on lecturing, drilling the students on basic concepts and rote learning (Andrew, 2007). Teachers can use the information of the students preexisting knowledge to create the instruction which can avoid the misunderstanding of concepts. In a study by Treagust, (1996) concluded that constructivism allow for greater learning success. Active participation has been shown to lead both greater understanding and greater interest in the subject. Caprio (1994) examined the effectiveness of the constructivist approach compared with the traditional lecture-lab method. It was concluded that students taught by constructivist methodology seemed more confident of their learning. They had significantly better exam grades. In the study of Hand, Treagust & Vance (1997), junior secondary school students' perceptions of implementation of constructivist approach to the teaching of science was investigated. Students were more actively involved, had more discussions, practical work, and more fun. As a result of this, constructivist teaching and learning approaches lead greater understanding of concepts. It was concluded that students were more active in the learning process. Students had opportunity to see and control their thinking and they constructed correct knowledge more confidently and became more confident in their understanding of science. In addition to these, Akkus, Kadayıfçı, Atasoy & Geban, (2003) examined the effectiveness of the instruction based on the constructivist approach by focusing on the in-class teacher- student and student-student interaction within small groups over traditional method. It is indicated by the results that students instructed by constructivist approach acquired chemical equilibrium concepts better than the students instructed by traditional method. This research study also determined that students' previous knowledge and science process skills had an influence on their understanding of the concepts related to chemical equilibrium. Carlson (2003) supports a strong emphasis on identifying, building upon and modifying the existing knowledge (prior knowledge) students bring to the classroom, rather than assuming they will automatically absorb and believe what they read in the textbook and are told in the class. Research like that of Caprico, (1994) indicates that better exam grades were obtained by students taught using constructivist methodology. Supporting this finding, Saigo (1999), White (1999) concluded that "the constructivist model has been found to slightly influence students' achievement in a positive way". The constructivist model is capable of getting students more involved in learning. Kurt & Somchai (2004) in their own research study on constructivism also found that students used for their study participated more in the classroom activities and gained in content knowledge when a constructivist approach was used. Brad (2000), in his study, found that students in the constructivist instruction showed higher degree of academic achievement than students in the traditional (lecture) instruction in all conditions. In a research study by Gatlin (1992) he found out that there was no significant difference in students' scores at the posttest between students of the constructivist group and traditional (lecture) group. He reported that students' scores of those who received the constructivist approach showed a slight decrease on the delayed posttests, while students taught using the traditional (lecture) approach showed a greater decrease over time. Students who received the constructivist instructional approach have a higher relation over time. It can be said that students taught by traditional (lecture) means, who rely on memorization to pass tests, over time often do not remember much of the information learned. Makanong (2000) corroborated Gatlin's finding in his research study when he found that there was no significant difference in achievement between students in constructivist group and traditional (lecture) group. Kurt & Somchai (2004) reported that there was no significant difference in achievement between Thailand students exposed to traditionalist (lecture) teaching method and constructivist teaching strategy in vocational electronics programs. However, they concluded that the constructivist-instructed students had higher scores on the post test and the post-posttest, compared to those of the traditionally (lecture) instructed students. This implies that students in the constructivist's group retain the concepts taught better than their colleagues in the traditionalist's lecture group.

Constructivist view learning is the product of interaction between the existing understanding and new knowledge (Parkinson, 2004). However, constructivist "emphasize reasoning, critical thinking, social negotiation, self-regulation, and mindful reflection" (Almala, 2005). According to Driver & Bell (1986) as cited in Parkinson (2004), there are six characteristics of constructivist theory of learning:

1. Learning does not only depend on the learning environment but also on the knowledge of the learner.
2. Learning involves the construction of meaning.
3. The construction of meaning is a continuous and active process.
4. Meaning, once constructed, is evaluated and can be accepted or rejected.
5. Learners have the final responsibility for their learning.
6. Students construct the meaning between experiences with the physical world through natural language.

According to these six principles which are related to Piaget's work, teachers could use this information to apply the teaching strategy using the constructivist theory of learning.

The role of the teacher is to organize information around conceptual clusters of problems, questions and discrepant situations in order to engage the student's interest. Teachers assist the students in developing new insights and connecting them with their previous learning. Ideas are presented holistically as broad concepts and then broken down into parts. The activities are student centered and students are encouraged to ask their own questions, carry out their own experiments, make their own analogies and come to their own conclusions. Constructivist teachers of science promote group learning, where two or three students discuss approaches to a given problem with little or no interference from the teacher. What happens to and with such small groups of students can be used as a whole class arrives at consensus of the various small group analyses. Constructivist teachers would rather explore how students see the problem and why their paths towards solutions seem promising to them. The role of the constructivist teacher can be seen as quite different from that of “traditional” teachers. So becoming a constructivist teacher may prove a difficult transformation since most instructors were prepared for teaching in the traditional, objectivist manner. It "requires a paradigm shift" and "requires the willing abandonment of familiar perspectives and practices and the adoption of new ones" (Brooks & Brooks, 1993).

- Become one of many resources that the student may learn from, not the primary source of information.
- Engage students in experiences that challenge previous conceptions of their existing knowledge.
- Allow student responses to drive lessons and seek elaboration of students' initial responses. Allow student some thinking time after posing questions.
- Encourage the spirit of questioning by asking thoughtful, open-ended questions. Encourage thoughtful discussion among students.
- Use cognitive terminology such as "classify," "analyze", and "create" when framing tasks.
- Encourage and accept student autonomy and initiative. Be willing to let go of classroom control.
- Use raw data and primary sources, along with manipulative, interactive physical materials.
- Don't separate knowing from the process of finding out.

- Insist on clear expression from students. When students can communicate their understanding, then they have truly learned.

The first objective in a constructivist lesson is to engage student interest on a topic that has a broad concept. This may be accomplished by doing a demonstration, presenting data or showing a short film. Ask open-ended questions that probe the students' preconceptions on the topic. Next, present some information or data that does not fit with their existing understanding. Let the students take the bull by the horns. Have students break into small groups to formulate their own hypotheses and experiments that will reconcile their previous understanding with the discrepant information. During the small group interaction time, the role of the teacher is to circulate around the classroom to be a resource or to ask probing questions that aid the students in coming to an understanding of the principle being studied. After sufficient time for experimentation, the small groups share their ideas and conclusions with the rest of the class, which will try to come to a consensus about what they learned.

Constructivist teaching approach offers a bold departure from traditional objectivist classroom strategies. The goal is for the learner to play an active role in assimilating knowledge onto his/her existing mental framework. The ability of students to apply their school-learned knowledge to the real world is valued over memorizing bits and pieces of knowledge that may seem unrelated to them. The constructivist approach requires the teacher to relinquish his/her role as sole information-dispenser and instead to continually analyze his/her curriculum planning and instructional methodologies. Perhaps the best quality for a constructivist teacher to have is the "instantaneous and intuitive vision of the pupil's mind as it gropes" and fumble to grasp a new idea" (Brooks & Brooks, 1993). Clearly, the constructivist approach opens new avenues for learning as well as challenges for the teacher trying to implement it.

Students come to science lessons with ideas about the natural world. Effective science teaching takes account of these ideas and provides activities which enable students to make the journey from their current understanding to a more scientific view. At present, constructivism is a popular idea associated with teaching and learning science. This notion is used to explain learning, guide instructional practices, and conduct research. The central point is that humans construct knowledge being transmitted into their minds. Constructivism stresses the importance of considering what is already in the learner's mind as a place to initiate instruction. Learning is regarded as an active process whereby students construct personal meaning of the subject matter through their interactions with the physical and social world. It is the student who makes sense out of the experiences. Knowledge is not just out there in textbooks and in teachers' heads ready to be transferred into the minds of the students. Instead, "out there" is where one finds information and experiences, which are formed by the mind into durable knowledge. The learning process is facilitated by the skilled teacher who engages students in thinking, questioning, testing ideas, explaining, and representing ideas. As stated in the quote above, effective science teaching must take into account what students know, then modify this knowledge so that it reflects scientific views. Designed primarily by science educators for secondary science teaching, the 5Es learning model has a classic constructivist teaching approach to enhance low order thinking skills (LOT) to high order thinking skills (HOT) and improve on students' achievement and cognitive questioning preference as the model requires Critical thinking to problem solving and construction of ideas.

2.4 The Concept of 5Es Learning Cycle Model Approach

The learning cycle is a model for teaching in all subject areas; it provides a basis for thematic and integrated instruction and offers many opportunities to measure real learning. It is proposed to help students progress from concrete to abstract thinking about context. Learning Cycle is a teaching model based on the knowledge organization process of mind. It helps student to apply concept and make their scientific knowledge constant. A well-known model of science teaching and learning is called "the learning cycle" or by an alternative model is called "the 5Es". Robert Karplus (1962) wrote the first reference to this as a part of the Science Curriculum Improved Study (SCIS) in the 1960s. In the exploration phase of the learning cycle, students discover new concepts with guide of the teacher. The students confront with their previous experiences and existing knowledge in this phase. During concept introduction, students are introduced to a new concept. In the concept application phase, student applies their new concept into new situations. Many examples of learning cycles have been described in the literature (Osborne & Wittrock, 1983). The BSCS approach to the 5Es Model is credited to Roger Bybee who developed the 5Es model which was used in the Applications of Research & Model Inquiry Lessons section of EJSE. Bybee's 5E model is as follows: Probably one of the earliest and foremost supporters of the Learning Cycle was the SCIS (Science Curriculum Improvement Study) program which adapted it and included it in its science curriculum. Although there are several "E" versions (e.g. 3E, 4E, 5E, and other modifications) the basic premise is that children have an experience with the phenomena in the learning of the concept/topic. When implementations of Constructivist approach are examined, some operators transformed three staggered circle model into five staggered circle model. This is 5Es Model. This model consists of Engage, Explore, Explain, Elaborate, and Evaluate Phases (Wilder & Shuttleworth, 2004). On psychological basis, 5Es Model is based on structuring in mind theory (Bilimleri, Eğitimi & Kılavuzu, 2004).

The five phases, as explain by Bybee, (2006), the 5Es model is based on both a conceptual change model of learning and a constructivist view of learning.

Engagement

The teacher or a curriculum task accesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities. (Bybee, Joseph, April, Pamela, Janet, Anne & Nancy, 2006).

Exploration

Exploration experiences provide students with a common base of activities within which current concepts (particularly misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation. (Bybee *et al.,* 2006).

Explanation

The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase. (Bybee et al., 2006).

Elaboration

Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities. (Bybee *et al.*, 2006).

Evaluation

The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives. (Bybee *et al.*, 2006).

2.4.1 5Es Learning Cycle and High Order Thinking

What may be relevant to science and technology education today may become obsolete tomorrow due to constant technological advancement. Students need to develop skills to help them benefit from change rather than be put disadvantaged by it. Students need to think convergent and divergent to investigate challenges and problems as well as to think in complex and creative ways. These skills are higher-order thinking skills sometimes known as critical thinking skills. Although the age of students needs to be considered, skills has shown that high-order thinking can and should be taught to students of all ages. In most primary schools, only low levels of thinking (LOT) are taught such as knowledge, comprehension and application. Students are encouraged to develop their memory, but not thinking skills. High levels of thinking (HOT) include analysis, synthesis and evaluation. Learning experiences focus around these levels develops skills in problem solving, inferring, and estimating, predicting, generalizing and creative thinking. The development of high order thinking skills can benefit all students including younger students because they are encouraged to ask questions, answer them intelligently and share their ideas with others A constructivist view of teaching and learning incorporates high-order thinking skills because it encourages exploration, inquiry and direct experience with materials and information and, in order to uncover students' preconceptions, students are encouraged to share experiences with others. The 5Es is an instructional model, based on Piagetian theory, which can be used to implement an implicit constructivist (more specifically neo-Piagetian, human or social-constructivist) view of teaching and learning. It is built around a structured sequence and designed as a tangible and practical way for teachers to implement constructivist theory. In the studies of Zoller (2000) for defining of low and high order thinking skills, Bloom Taxonomy was considered. In this Taxonomy, low order thinking skills were expressed by knowledge, comprehension and application stages and higher order thinking skills were expressed by analysis, synthesis and evaluation.

5Es learning and teaching model includes higher order thinking skills. Stimulating students to explore, to inquiry, to get experience, 5Es model transmits also the critical thinking skill to students (Ergin, 2006). This model provides students with an opportunity for participating in the process of higher order thinking (Boddy, Watson, &Aubusson, 2003). It purposefully promotes experiential learning by motivating and interesting students, as they are encouraged to engage in high-order thinking which lead to engagement in High order thinking questions also. The final stage of the learning cycle which is evaluation will engage the students in a new activity that requires them to answer high-order questioning helping them to analyze their ideas and evaluate their work (Balci & Griffith , 2005; Bybee, 2002; Eisenkraft, 2003; Liu, Peng,, Wu, & Lin, 2009; Llewellyn, 2005; Settlage, 1998; Wilson, Taylor, Kowalski & Carlson, 2010).

2.4.2 5Es Learning Cycle and Academic Achievement.

Studies show that 5Es Learning Cycle approach is also a teaching strategy in enhancing students understanding and achievement. Caprio (1994) published a study that compared a class which he taught with traditional (lecture) methodology in 1985 to one in which he taught with 5Es Learning Cycle method in 1994. The students in both groups had the same prerequisites, and the same exam was used for comparison. The exam grades were much higher for the class taught with the constructivist methodology. "The control (traditional) group's average grade was 60.8 percent, while the experimental (5E-learning cycle) group averaged 69.7 percent" (Caprio, 1994). In addition to the test scores, the experimental group had a high energy level and gave positive feedback on the course. Research has indicated that student attitudes toward science improved through the use of the 5E model (Balci *et al.*, 2006; Bybee, 2009; Bybee *et al.*, 2006a; Bybee *et al.*, 2006b; Ergin, Kanli, & Unsal, 2008). The 5Es model has been proven to motivate students in learning, while helping students to develop high level thinking skills in science and it has proven to contribute positively to students' academic achievement in science (Balci *et al.*, 2006; Bybee *et al.*, 2006a; Bybee *et al.*, 2006b; Ergin *et al.*, 2008).The 5Es cycle has even been further modified to show different forms and versions. Most empirical studies on the effectiveness of learning cycle when used as an instructional strategy found significant improvement in students' achievement, retention, attitude and correction of misconceptions. Studies by Baser (2008), Pulat (2009), Lee (2003), Lord (1999), Nuhoglu & Yalcin (2006), and Whilder & Shuttleworth (2004) found that students' achievement improved after the instruction of 5Es learning cycle. Specifically, the empirical study by Lee (2003) found out that the students acquired knowledge about plants in daily life easier and understood the concepts better when taught with learning cycle. Pulat (2009) in another study determined the impact of 5Es learning cycle on sixth grade students' Mathematics achievement and attitude towards the subject. The results showed that the students' mathematics achievement improved after the instruction of learning cycle.

Studies by Ajaja (1998) and Nuhoglu & Yalcin (2006) showed that learning cycle enhanced the retention of science knowledge. They specifically emphasized that learning cycle make knowledge long lasting and that students become more capable of applying their knowledge in other areas outside the original context. There appears to be scarcity of literature on the effect of learning cycle on retention when separated from achievement as a whole. Research by Madu & Amaechi, (2012) shows that, the effect of learning cycle model was found to be significant on teaching most of the concepts and the aspects involved in elasticity but not on teaching work and energy. Felicia & Peter, (2013), in their research on enhancing students' achievement in Chemistry through the learning cycle, observed that the learning cycle enhances students' achievement and it also favors both boys and girls, giving credence to the learning cycle as a gender sensitive approach. However, from observation so far no research has been done on how the learning cycle can enhance students' cognitive questioning preference. In the light of this, the study sort to find out how learning cycle model can enhance students' thinking and cognitive questioning preference. The model specifically adapted for this study is the Bybee's 5Es model (2006).

2.5 Questioning and Questioning Style Structure

The Questioning process is an essential part of instruction in that it allows teachers to monitor student competence and understanding as well as increase thought-provoking discussion. Questioning is the crucial marker that distinguishes the contemporary discussion classroom from the traditional lecture course. Ideally, questions ought to stimulate students' interest, guide their thinking, and cultivate a questioning disposition in them (Cotton, 1988; Berci & Griffith, 2005; Myhill and Dunkin, (2005); International Center for Leadership in Education, 2001-2006). Quality assessment is based on the quality of questions. It is important to present students with questions that encourage reasoning and that allow them to draw from their prior knowledge rather than accepting “yes or no” responses. Questioning is, ideally, “at the heart of teaching and learning” (Berci & Griffith, 2005). Teachers use questions to control classroom interactions, including stimulating the level of thinking which occurs (Blosser, 2000).

The context and type of the level of questions have important act for developing the students’ cognitive skills. For this reason, the questions teachers ask should focus on students' cognitive skills. Besides measuring students' success, the questions should make students think free of the context. Therefore, questions asked should critically examine their assumptions, both scientific and social. At the same time, questions should be leading to the construction of new cognitive schemes. Continually involving students in their own learning experience and providing them with valuable feedback is a necessity in promoting progressive learning (Stiggins, 2008). Teachers spend much time talking with students -lecturing, giving directions, and asking and answering questions. To ensure understanding and application of knowledge, teachers commonly engaged students in question and answer session. Questions can prompt responses ranging from simple recall of information to abstract processes of applying, synthesizing, and evaluating information (Zepeda, 2009). Currently, questioning is the most ubiquitous phenomenon detected in classroom, as well as one of the most practical instructional devices used by most of the teachers (Cotton, 2003). To vitalize the classroom questions, teachers should design questions which can expand students’ knowledge and promote creative thinking. A number of researchers (Brown & Wragg, 2001; Cotton, 2003; Richard, 1996; Morgan, 1991) state the following functions that teacher questioning serves in the classroom:

- Asking questions helps teachers to follow up and elaborate on what a student has said.
- Students can openly express their ideas through answering teacher questions.
- Asking questions enhances students' interest and keep them actively involved.
- The act of questioning let students benefit from various explanations of the material by their peers.
- Questioning is a good tool for evaluating student learning and reviewing the lesson as necessary.
- Asking questions enables teachers to control class discipline and student behavior.

Brookfield & Preskill (1999) presented seven points on how to maintain momentum of discussion and all of them focus on questions. While six of them, namely (i) questions that ask for more evidence (ii) questions that ask for clarification (iii) linking or extension questions (iv) hypothetical questions (v) cause and effect questions (vi) summary and synthesis questions, could be obvious enough from the twelve skills/indices presented above, the remaining one type namely (vii) open questions is not quite obvious. Although open questions could come under skill/index eleven, namely, framing questions that require the learner to use high cognitive thought or think at high cognitive levels, Biggs (2003) checked that open discussions should be controlled (limited) so that subject matter may remain as the focus.

Biggs (2003) noted that questions could be of various types but important distinctions were: High – level or low – level questioning. High-level questioning center on high-level verbs such as theorizing, reflecting, hypothesizing, while low-level questioning seek factual answers. Benjamin Bloom's taxonomy is valuable when determining the types of questions that teachers should ask their students. Bloom stated that there are six different levels of thinking: Knowledge, Comprehension, Application, Analysis, Synthesis, and Evaluation (Cruickshank, 2009).

2.5.1 Levels and types of Question according to Bloom's taxonomy

In 1956 Benjamin Bloom headed a group of educational psychologists engaged in identifying the levels of intellectual behavior important in learning. The taxonomies they developed include three over lapping domains: the Cognitive (intellectual), Psychomotor (physical), and Effective (attitudes and emotions). Each taxonomy is an organization strategy in which lower categories are subsumed in high ones. In the cognitive domain, knowledge, the lowest level in Bloom's taxonomy, must be mastered before comprehension, the second level, can be attempted. In fact, comprehension is an intellectual process that uses knowledge. These six levels have been adapted in formulating schools goals, assessing learner progress, and developing questions. Bloom's six cognitive levels range from simple recall or recognition of facts through increasingly more complex and abstract intellectual tasks. The following brief definitions are followed by several sample verbs that reflect the appropriate intellectual activity:

1. **Knowledge:** requires that students recognize or recall information. Remembering the key intellectual activity. (Define, recall, memories, name, duplicate, label, review, list, order, recognize, repeat, reproduce, state).
2. **Comprehension:** requires the students to demonstrate sufficient understanding to recognize and arrange materials mentally; demands a personal grasp of the material. (Translate, explain, classify, compare, contrast, describe, discuss, express, restate in other words, review and select).

3. **Application:** requires that students apply information, demonstrate principles or rules, and use what was learned. Many, but not all educators believe that this is the first of the higher-level thought processes. (Apply, classify, solve, use, show, diagram, demonstrate, record, illustrate, translate, choose, dramatize, employ, operate, practice, schedule, sketch, write).
4. **Analysis:** Educators agree that this and all the following categories require higher-level thinking skills. Analysis requires students to identify reasons, uncover evidence, and reach conclusions. (identify motives and causes, draw conclusions, determine evidence, support, analyze, deduce, categorize, compare, contrast, criticize, differentiate, justify, distinguish, examine, experiment).
5. **Synthesis:** Requires that students perform original and creative thinking. Often many potential answers are possible. (Write or arrange an original composite, essay or story, make predictions, solve problems in an original way, design a new invention, arrange, assemble, collect, compose, construct, create, design, develop, formulate, manage, organize, plan).
6. **Evaluation:** Requires that students judge the merit of an idea, solution to a problem, or an aesthetic work. These questions might also solicit an informed opinion on an issue. (Judge, value, evaluate, appraise, argue, assess, attach, choose, compare, defend, estimate, rate, select).

In describing these six different levels of comprehension, also called the cognitive domain, Bloom stated that the first three were representative of low-order thinking, or content, whereas the last three were representative of high-level thinking, or process. J. P Guilford offered another way of looking at cognition with description of Convergent and Divergent production. Mapping Guilford's concept onto Bloom's taxonomy, Convergent thinking (low-level thinking) applies to Bloom's first three levels of cognitive behavior that is knowledge, comprehension, application, and Analysis. Divergent thinking (high-level thinking) applies to Bloom's last three level of cognitive behavior; synthesis and Evaluation (Woolfolk, Winne & Perry, 2003). Benjamin Bloom's taxonomy of educational objectives forms the basis explicitly or implicitly, upon which many educators classify their questions (1965).

Effective teachers appeal to each level of thinking to encourage students to draw conclusions, relationships, and applications of information they receive during class. Questions teachers pose are cues to their students' level of thinking expected of them, ranging from the lowest level of mental operation, requiring simple recall of information, to the highest level requiring higher thought and application of the thought (Derfel, 2002). It is important that teachers are aware of the levels of the thinking of their students such as low to high-level of operations. Researchers like Cotton, (2001); Derfel, 2002) identified two broad types of teacher questioning; The Low-level and High-level questioning style preference. Questioning style Preference can be classified according to Bloom's taxonomy as shown in Table 2.1.

Table 2.1: Types of Questions Based on Bloom's Taxonomy

Questioning Category	Blooms' Category	Students' Activity	Typical Stem Work
LOWER LEVEL QUESTION	Knowledge	Remembering Facts Terms Definition Concepts Principles	What, List, Name, Define, Describe.
	Comprehension	Understanding the meaning of a material.	Explain, Interpret, Summarize, Give examples..., Predict, Translate
	Application	Selecting a concept or skill and using it to solve a problem.	Compute, Solve, Apply, Modify, Construct
HIGHER LEVEL QUESTION	Analysis	Breaking materials down into its parts and explaining the hierarchical relations.	• How does .... apply? • Why does....work? • How does... relate to ...? • What distinction can be made about ... and ...?
	Synthesis	Producing something original after having broken the material down into its component parts.	• How does the data support...? • How would you design an experiment which investigates..? • What predictions can you make based upon the date?
	Evaluation	Making a judgment based upon a pre-established set of criteria.	• What judgments can you make about ...? • Compare and Contrast criteria for ...?

Source: Instructional Development; Center for Teaching Excellence (2006)

Usually questions at the low levels are appropriate for:

1. Evaluating students' preparation and comprehension.
2. Diagnosing students' strengths and weaknesses.
3. Reviewing and/or summarizing content.

Questions at high levels of the taxonomy are usually most appropriate for:

1. Encouraging students to think more deeply and critically.
2. Problem solving.
3. Encouraging discussions.
4. Stimulating students to seek information on their own.

2.5.2 Low-level Cognitive Questioning

Low-level cognitive questioning are those which ask the student merely to recall and are also referred to in the literature as fact, closed, recall, and knowledge questions (Cotton, 1988). There are questions which ask the students to recall verbatim or in his/her own words material previously read or taught by the teacher. At this level, questions are design to solicit from students' concepts, information, feelings or experiences that were gained in the past and stored in memory (Derfel, 2002). All questions that test recall of learned materials, explanations or application of knowledge in Bloom's taxonomy of educational objectives falls under low level cognitive questioning style. Low level questioning are knowledge, comprehension and application questions which require low level of thinking. There are usually at the lowest level of cognitive processes and answers are frequently either right or wrong (Erickson, 2007). Answers to this kind of questions are usually within a very finite range of acceptable accuracy.

2.5.3 High-level Cognitive Questioning

High-level cognitive questioning are defined as those which ask the student to mentally manipulate bits of information previously learned to create an answer or to support an answer with logically reasoned evidence and are also called open-ended, interpretive, evaluative, inquiry, inferential, and synthesis questions (Cotton, 1988). High-cognitive questions are those which ask the students to mentally manipulate bits of information previously learned to create an answer or to support an answer with logically reasoned evidence. Questions at this level encourage students to think intuitively, creatively and hypothetically, to use their imaginations to expose a value system or to make judgments. Simple keys words and desired behaviors are; apply a principle, build a model, evaluate, explain, compare, discriminate, generalize and predict. This type of questions requires students to think creatively by learning the comfortable confines of the known and reaching out into the unknown (Derfel, 2002). This are questions that test high order thinking questions in the area of Analysis, Synthesis and Evaluation in Bloom's taxonomy of educational objectives. This type of questions often requires students to analyze, synthesize or evaluate a knowledge base and then project or predict different outcomes (Erickson, 2007).

2.6 Cognitive Preference Skills

As early as 1964, Cognitive Preference was introduced as a way of describing an individual's preference for applying, relating or questioning information. Omoifo (2002) defined Cognitive Preference as the mode of perpetual organization and conceptual categorization of information or task presented. In the process of curriculum transaction depending upon individual idiosyncrasy a characteristic pattern of information processing is discernible. As noticed by Harris: Most of the achievement testing in schools focuses on the can does class of behaviors, these is the knowledge, skill, ability types of objectives. But there may be other objectives, the achievement of which is evidenced by what the student typically does do. These are the attitude, interest cognitive style types of objectives perhaps more effective than cognitive (Harris, 1974).

This ‘does do’ class of behavior is a personal or population attribute that helps an individual to selectively attend information. The construct of cognitive preferences was proposed by Heath (1964) and investigated by Tamir (1988) and Lazarowitz & Penso (1992) Heath suggested the following modes of Cognitive Preferences: These modes are:

Recall (R)

Acceptance of Scientific information for its own sake, without consideration of its implications or applications. A preference for recall indicates learning names, numbers, definitions, formulae and reported observations

Principles (P)

Representation of scientific explanation of fundamental scientific principles of relationships. A preference for principles indicates identifying relationships between variables, or rules that can be applied to classes of objects, organisms, phenomena or variables, or explaining phenomena.

Questioning (R)

Critical questioning of information for completeness, general validity or limitations. A preference for questioning indicates analyzing and commenting on the validity of scientific information and/or generating suggestions and hypotheses for further research.

Application (A)

Application of scientific information in problem solving in general, social and scientific contexts of real life in particular. A preference for application indicates using scientific information to solve problems in commerce, industry, farming and daily life.

Since the classical study by Heath (1964), studies have been increasingly in vogue worldwide. Tamir (1985) using the technique of meta-analysis has succinctly provided the status of research on cognitive preferences. Concerted efforts were made in India to study cognitive preferences. Saxena (1986) compared the cognitive preference styles of students studying physics under two different educational practices. The results have shown that irrespective of the types of the educational practices, students have strongest preference for recall and least preference for critical questioning. While Rathore & Singh (1987) studied cognitive preferences and academic achievement of tenth grade biology students. Based on their findings, opined that the most preferred mode, in general, is recall, though with the increase of academic achievement, preference for recall decreases. Bagchi & Uddin (1990), based on their study on cognitive preferences of secondary science teachers in India, found that the overall pattern of cognitive preferences that emerged is Recall-Principles-Application-Questioning. Joe (1983) study of Biology students' cognitive preferences in Rivers State showed that achievement in Biology correlated significantly with all the four cognitive preferences. Ogunyemi & Eboda (1974) obtained similar results with physics students in Ibadan. All the two studies showed that recall and application students were low achievers while the principle and questioning students were high achievers. Ogunyemi & Bettie's (1974) study in mathematics showed no statistically significant difference in mathematics achievement amongst students of same or different preferred mathematical proportion expression modes. Atwood (1967) investigated the relationship between CHEM Study achievement and cognitive preference. He discovered that students with strong preference for recall were not as successful in CHEM study course as those who should preference for principle, critical questioning of information and those for practical application.

The purpose of encouraging students to develop high order thinking skills directs teachers and curriculum developers in science (Zohar, 2004). Scientific education is a fertile ground to develop higher order thinking (Zohar & Dori, 2003), particularly critical thinking among students (Pizzini, Abel & Shepardson, 1988). In the recent years there has been an emphasis on activities such as learning tasks that aim to accelerate higher order thinking skills as critical thinking, especially in Biology, Chemistry and Science for all. Studies have shown that cognitive preferences, learning achievements, and students' creative thinking ability are interrelated (Tamir, 1985).

2.7 Questioning Style Preference

One of the objectives of science instruction is the development of high level thinking processes in students. The most important and pervasive goals of schooling is to teach students to think, Okebukola (2002). Questioning students in a way that let their mind run free leads to good response and good learning (Cotton, 2001). Questions which focus students' attention on salient elements in the lesson result in better comprehension, than questions which do not (Stiggins & Liston, 2006). Dillon (2005), in his study observed that the cognitive level of questions posed is related to students' attitudes toward the subject matter. According to him, students who prefer low level cognitive questions perform better in recitations and on tests where lower cognitive questions are posed. Those students who prefer high level cognitive questions perform equally well with high or low-level cognitive questioning in recitations and tests. Therefore teachers who vary their questioning behaviors and use approaches other than questioning during classroom discussions are positively related to students' achievement.

2.7.1 Questioning Style Preference and Academic Achievements

Questions are said to play numerous roles in the classroom, from stimulating student thought to assessing student knowledge (academic achievement). While determining the quality of instruction at an institution, assessing the learning products play an important role. The context and type of the level of questions have important act for developing the students' cognitive skills. So if a chemistry student can be taught to become an active thinker, learning becomes more motivating and result in improving chemistry understanding and performances, (Perkins, 2010). Therefore, it can be said that the assessment of students' cognitive levels play very crucial role in learning and teaching process. Quality assessment is based on the quality of questions. The question levels which are asked in the examinations play an important role while assessing students' achievement and developing their critical thinking skills. High-level questions can lead students to think more creatively and multi-dimensional (Brualdi, 1998). Students, who are continuously encountered with the low level questions, are tented to be low thinkers (Çepni&Azar, 1998).

For this reason, the questions teachers ask should focus on students' cognitive skills. Besides measuring students' success, the questions should make students think free of the context. Therefore, questions asked should critically examine their assumptions, both scientific and social. At the same time, questions should be leading to the construction of new cognitive schemes which leads to good academic achievement. Teachers usually ask low-level questions at the school examinations thus making students get high marks from these examinations (Hosseini, 1993). Because of the frequent use of low level questions, students are not encouraged to challenge their cognitive schemas and this will not take them a step forward. These things cause students to have low achievement both in international and national exams (Ersoy, 2006). In many classrooms, even when teachers pose high-level questions, students tend to show more comfort responding with low-level answers. According to Lev Vygotsky's sociocultural theory, students perform at their best when they are working within their zone of proximal development (Berk, 2009). The Zone of Proximal Development (ZPD) refers to a level of understanding in which a child is challenged but still able to comprehend and perform a particular skill. Effective teachers appeal to each level of thinking to encourage students to draw conclusions, relationships, and applications of information they receive during class. In a research finding Brualdi, (1998) and Cotton (2001) found that high cognitive questioning is superior to lower cognitive questioning. According to them, student taught with high-level cognitive questioning performed better than those taught with low level cognitive questioning. Teachers must be sure that they have a clear purpose based on their questioning rather than encouraging knowledge type of questions. Research on the relationship between the cognitive level of teachers' questions and the academic achievement of their students has proved frustrating to many on the field of education, because it has not produce definite results. Quite a number of research studies have found high cognitive questions superior to low cognitive questions, many have found the opposite, and still others have found no difference. The same is true of research examining the relationship between the cognitive level of teachers' questions and the cognitive level of students' responses.

Good questionings foster students' academic achievement and build the learner varying and evaluative thinking rather than determining what has been learned in a narrow sense. In a research by Blosser, (2010), she attempted to resolve the issue of the nonconformity of teachers questioning behavior with educational objective and hypothesis; she revealed that teachers are not aware of their customary questioning pattern. Gandu (2006) explained that teachers cognitive questioning style is consistently focused on low level questions, of recall. Similarly, Aksala (2005) argue that it is focus almost always on low order thinking. Iliya (2011) in her research on teachers' cognitive questioning style on achievement of junior secondary school Integrated Science student revealed that when student are taught using low level and high level cognitive questioning style, they do not differ significantly in their performance. She also recommended that teachers should learn to use both low level and high level cognitive questioning style in the classroom. Ogenyi (2014), in his study on cognitive questioning preference on academic achievement and retention of student in chemistry disclosed that teaching methods can improve students thinking skill to enhance and cause a shift in student cognitive questioning preference from low to high cognitive questioning preference. According to Albergaria (2010), revealed that Chemistry teacher's frequent use of fact-based questioning strategy does not encourage divergent thinking and does not enhance student's question competence. However questioning she said is considered fundamental to Science and Science inquiry.

Taking a lead from Ogenyi (2014), this study was conceived to investigate and examine the impact of 5Es learning cycle model on the academic achievement and cognitive questioning preference among Senior Secondary School Chemistry student.

2.8 Gender and Achievement in Science

For a country to advance in science and technology, the general society needs to increase in knowledge and competence, scientifically and technologically. Barton (1998) observed that one of the most popular and most powerful phrase connections to science education reform in the last decade has been “Science for all”. Science for all learners envisions a classroom where all students are able to productively engage in learning scientific concepts, skills, and habits of mind to enable them to become productive citizens, informed voters, and wise consumers. Providing high quality science instruction for all learners requires the combined efforts of policy makers, administrators, teachers, institutions of higher education, and community members alike. Available statistics on enrolment in secondary schools as well as institution of higher learning showed that much fewer females than males engage in science and technology (Okeke, 2001, Aigboman, 2002). The female should participate and contribute alongside their male counterparts in the scientific domain and hence development the nation. The field of science has been traditionally male-dominated and gaps continue to exist in science and mathematics assessments between males and females, most notably in the fields of physical science and technology.

2.8.1 Gender, Teaching Method and Academic Performance

It is apparent that the traditional didactic style of teaching is not effective for many students, nor is the view that boys are good at mathematics and science and girls are good at reading and writing. Iliya (2011) in her study investigated the aspect of teachers cognitive questioning style as a factor for gender difference, her findings revealed that the male are extrovert in nature and responds to teacher questions quickly as they are bolder than the females. Cleveland (2011) proposes six strategies to help boys learn, which in reality would apply to girls as well, but perhaps for different reasons:

1. Active involvement
2. Compelling situations
3. Direct experience

4. Enjoyable setting

5. Frequent feedback

6. Informal learning

7. Patterns and connections

8. Reflection

Without active involvement, there is no engagement in the learning process. Understanding cannot be transmitted, it must be constructed. Being actively engaged in the learning process helps students create meaning and purpose. Compelling situations assist students in making authentic connections to learning. Research has shown that females often become more involved in science concepts when they are connected to the personal and social perspective, i.e. other people can benefit from their findings. Likewise, males are often engaged when challenging problem-solving skills are required. For females, direct experience can often assist in filling gaps created by limited prior personal experiences, but actually engaging in hands-on, inquiry experiences increases both attention and memory.

Active inquiry, investigation, problem solving, and engineering can result in multiple solutions, and frequent feedback can serve as encouragement to continue on the current path, or perhaps consider other alternatives. Informal learning requires the seizing of teachable moments and flexibility on the teacher's part, but can often result in the most lasting memories. Creating patterns and connections assists with consolidation and synthesis of bits and pieces of information that may be apparent to the planner of the lesson, but not always to the student. Brain research has demonstrated that such connections assist in creating meaningful "chunks" that endure over time and can be expanded as new information becomes available. Without reflection on a learning experience, the core concepts can be lost. With reflection, new insights can emerge that will often lead to further exploration. The use of a lesson design such as the 5Es that actively engages students and encourages on-going formative assessments will help meet individual student needs.

Mitrevski & Zajkov (2012), study compared effectiveness of non-traditional versus traditional lecture-based teaching method on students' Critical thinking test in physics observed that lab physics and practical work teaching method is not effective in terms of stimulating critical thinking skills, because the data have indicated no statistically significant difference between groups. Also, the findings of the study indicate that the gender difference does not exist in terms of students' achievement on critical thinking test. Chinwe & Chukelu (2011) observed that there was no significant interaction between the teaching methods and gender. The findings of this study revealed that male students has a higher mean score than their female counter parts, although the difference was not significant. That was further confirmed that gender was not a significant factor on students' acquisition of science process skill when taught with practical activity method. This result also agrees with the findings of (Ibitoye, 1998 and Abonyi, 1998) who found no significant difference in the achievement of male and female in science subjects. The findings also revealed that there was no interaction between teaching methods and gender of the subjects to influence students' acquisition of science process skills. This shows that the interaction affect between teaching methods and gender of the students were not significant, implying that gender did not combine with teaching methods to affect the students' acquisition of science process skills. This result is in agreement with the findings of Iloputaife (2001) and Ibe (2004) who found no significant interaction between instructional method and gender on performance.

Considering three teaching method; the traditional lecture method, interactive method with individual use of materials and interactive method with group use of materials, Adedayo (2008), observed a significant interactive effect of gender and method of teaching on students' performance. Further analysis showed that the use of interactive method with group use of materials favours the males which interactive method with individual use of materials favours the females. Usman (2000) revealed no gender difference on both academic performances of male and female students in science. The gender differences that exist in science performance have been linked to the way Science is being taught in the classroom (Aigboman, 2002). Gender differences in science have been discussed for years. These differences, if any, can be grouped into two main categories: differences in science ability and differences in attitude towards science. In other to balance this two, teaching method that promotes a student's-centred classroom, higher order thinking skills and cognitive abilities should be encouraged.

The issue of gender difference is still a controversy, ever though the literature revealed above were on gender in relation to teaching methods, academic performance and teachers questioning style in science. The aspect of gender in relation to cognitive questioning preference and performance has not been investigated. Therefore, this study aims at finding out if 5Es learning method has any effect on the academic performance of male and female students with relation to their cognitive questioning preference.

2.9 Overview of Related Studies

This study investigated the impact of constructivist approach based on 5Es learning model adapted from Bybee (2006) on questioning style preference and academic performance among senior secondary school chemistry students in Katsina metropolis, Nigeria. Note that an active learning environment plays an important part in achieving meaningful and retentive learning, since it allows students to improve their problem-solving, creative and critical thinking, (Neo & Neo, 2009).

Ibrahim (2014), investigated the impact of 5Es learning model on attitude, retention and performance of students with varied abilities. The target population was pre-NCE biology students of colleges of education in the North-West Zone, Nigeria which included Katsina, Kaduna, Jigawa, Kebbi, Kano, Sokoto and Zamfara. The research design was Quasi-experimental and control group design employing pretest and posttest and post-posttest with a sample size of 110 students. Two instruments were used; Genetics Performance Test (GPT) to analysis performance and retention and Students Attitude to Genetic Questionnaire (SAGQ) to analyze attitude. Analysis of Co-Variance and Kruscal Wallis test statistics were used to analysis the data's obtained. From the finding, pre-NCE biology students exposed to 5Es learning cycle in the concept of genetics of all ability levels performed significantly better than those in the control group taught with lecture methods and the learning cycle is gender friendly as both male and female students of all ability levels performed equally well and had also no difference in their retention ability. This study investigated the impact of 5Es leaning model on performance, attitude and retention among pre-NCE (tertiary level) biology students of varied ability in North-West Zone, Nigeria but this present study investigated the impact of 5Es learning model on questioning style preference and academic performance of senior secondary school students (secondary level). This study was on Biology but this present study is on Chemistry. Limited to Katsina Metropolis, Katsina State, Nigeria.

Isa (2012), conducted a study on the effect of constructivist based instructional approach based on 5Es learning model on academic achievement, retention and attitude to physics among secondary school students of different ability levels in Kano state, Nigeria. Target population was physics students in Kano Metropolis and stratified random sampling technique was used. The research design was Quasi experimental design using the pretest posttest with control group and the instruments used to gather data’s were; Physics Performance Test (PPT) and Physics Students Attitude Questionnaire (PSAQ). T-test, one way analysis of variance (ANOVA) and Man Whitney U-test statistics were used to test the null hypothesis stated to guard the study. From the findings of this study, students exposed to constructivist instructional approach achieved, retained the learnt concept and developed positive attitude to physics than their counterpart taught with conventional lecture method. And the approach was suitable for students with varied ability levels. This research focused on senior secondary school physics student in Kano metropolis and the impact of 5Es on performance, attitude and retention while this present student focuses on students’ cognitive questioning preference and performance in Chemistry among Senior Secondary School Students in Katsina, Metropolis.

Udogu and Njelita (2010) investigated the effect of Constructivist Based Instructional model on students’ conceptual change and retention on some difficult concepts in chemistry, Anambra State, Nigeria. Quasi experimental, non-equivalent group control design involving two intact classes was used. The target sample population was SS2 Chemistry students with a sample size of 170 students from four secondary schools purposefully in Idemili South Local Government Area of Anambra State. A Teacher Made Achievement Test Chemistry (TMATC) was used as the instrument drawn from some chemistry concepts namely; Electrolysis, radox reaction, calculations involving mass and chemical equilibrium. Analysis of Co-variance statistical tool was used to test the null hypothesis. From the finding, it was observed that experimental group performed better than the control group. This was an indication that constructivist based approach is effective in enhancing meaningful learning among chemistry students.

Also another study on chemistry students was carried out by Kilaruz (2005), who compared the effectiveness of 5Es learning cycle model a constructivist instructional based approach over traditional design chemistry instruction (Lecture method) on ninth grade students understanding of acid-base concept in Ankara, Turkey. Quasi experimental design with control group was employed for the study. Acid-base concept achievement test (ABCAT) was administered to both groups in order to assess their understanding of concept related to acid-base. Students were also given Attitude Scaled towards Chemistry Questionnaire (ASCQ) at the beginning and end of the study. Science Process Skill Test (SPST) was administered to measure their Science Process Skills. Hypotheses were tested by using Analysis of Co-variance (ANCOVA) and t-test. Result indicated that instructional based on constructivist approach caused significantly better acquisition of scientific concepts related to acid-base. Students showed statistically equal development in attitude towards chemistry as a school subject due to the treatment with 5Es learning cycle.

Yadigaroglua and Demircioglub, (2012) conducted a study to investigate the effect of activities developed based on 5Es model on grade 10 students understanding of general properties of gases in chemistry. The study was conducted in a high school in Akcaabat province of Trabzon, Turkey in 2010-2011 academic years. The study used the quasi-experimental design. 40 grade 10 students in two classes were selected for the study. While one of the classes was randomly assigned as experimental group (13 boys, 7 girls), the other was determined as control group (11 boys, 9 girls). In the study, Concept Achievement Test (CAT) was used to collect the data. The collected data were compared by using the independent sample t-test. A statistically significant difference in favor of experimental group was detected. It is essential that teachers should develop their skills for designing constructivist learning environment.

From the three studies revealed by Udogu and Njelita (2010), Kilaruz, (2005), and Yadigaroglua and Demircioglub, (2012) on the effectiveness 5Es learning model on senior secondary school chemistry students in Anambra state of Nigeria and high school chemistry students in turkey, performance and conceptual change was put into consideration. Students questioning style preference was not considered. The area of chemistry concept was covered in these studies also differ from the aspect of chemistry covered in this present student. Therefore, this study put to check students questioning style preference and how it can be improved upon by 5Es learning model.

However, 5Es learning model arouses curiosity of student and enable then to actively use their knowledge and skills (Ergin, 2006). It has the ability to increase students' levels of high order thinking skills as observed by Boddy, Wetson and Anbussson (2003), in a trial study titled; 5Es learning model: A referent model for constructivist teaching and learning conducted on year 3 class of primary school. Data were collected and analyzed using two different methods to compare and validate findings. The unit of work taught based on 5Es learning model was found to be interesting and fun by the students and motivated students learning and activated students higher order thinking. This study employed 5Es model to activate students' high level thinking, since the model arouses learner curiosity; which in turn enhances academic performance and students' ability to answer more difficult classroom and examination questions (high level questions). This view is also supported by a research by Amber and Emily, (2015), conducted on the use of high level questioning to increase students achievements. The research explored the impact of asking students higher-level questions during guided reading instruction to increase reading comprehension and engagement. Baseline data was collected before students were presented increasingly higher-level questions over the course of six-weeks and a post-assessment was given to monitor students' growth in the areas of comprehension and engagement. Week by week student comprehension engagement increased and at the completion of the intervention, students demonstrated an overall increased ability to engage with and comprehend what they had read. The intervention of introducing higher-level questioning into guided reading instruction, proved effective. This study was supported by the findings of (Tienken, Goldberg & DiRocco, 2010), that low-level questions are easier to develop, so the majority of learning that takes place in the classroom naturally focuses on low-level thinking skills. To counter this, the researcher based their observation on (Caram & Davis, 2005) findings; that when planning for instruction, teachers must focus on preparing questions that require higher-level thinking from their students. This study applied the use of 5Es model to activate students' curiosity and enhance students' ability to answer high level questions and improve their performance in chemistry.

Iliya (2011), studied Teachers' Cognitive Questioning Style and its effects on performance and retention among Junior Secondary School Integrated Science students in Giwa Local Government of Kaduna State, Nigeria. The study took a quasi-experimental pretest, posttest and post posttest design. Conducted in junior secondary school, 100 Junior Secondary School 2 (JSS 2) students randomly selected from two schools to form the sample population. They were taught integrated science and evaluated using low level and high level questioning style respectively. Integrated Science Achievement Test (ISAT) was used to collect data's and null hypotheses were tested using t-test statistics. Analysis of the result show that preference for high level questioning styles makes learners synthesize the new knowledge and enhance the ability to retain what is learnt. Hence, students' preference or ability to answer difficult questions (high level questioning style) indicates effective learning and retention in reference to any particular instructional or teaching strategy. But this present study aspires to investigate the extent to which learning of selected chemistry concept and ability of answer more difficult questions (cognitive questioning preference) are enhanced and retain using 5Es learning model in senior secondary school level at Katsina metropolis, Nigeria.

Study conducted by Ogenyi (2014), investigated the use of instructional approach and its effects on students cognitive questioning preference. The study titled the impact of science process approach on students questioning preference, academic performance and retention span among senior secondary school chemistry students. The study was carried out in Zaria local government of Kaduna state, Nigeria. Research design was Quasi-experimental and target populations were SS2 chemistry students in Zaria metropolis. The experimental group was exposed to science process instructional approach while the control was taught with lecture method. Chemistry Achievement Test (CAT) was used to collect data's and t-test, analysis of variance (ANOVA) and Scheffe's were used to test the null hypotheses. Results from the study indicated that science process instructional approach was found to be more effective in enhancing students' cognitive questioning preference of chemistry students at the senior secondary school level, causing a shift to high level questions from low level questions as their ability to answer more difficult questions was enhanced. But this study taking a lead from Ogenyi's investigates the impact of 5Es learning cycle on questioning style preference among chemistry study at senior secondary school in Katsina metropolis while Ogenyi's conducted his research the impact of science process approach among chemistry study in Zaria metropolis.

This will employ a different learning approach from Ogenyi's to observe its impact on Chemistry Students Questioning style Preference and Performance. Same chemistry concepts used by Ogenyi was used but a different instructional strategy (5Es learning model) was used to teach the concept.

In conclusion, the findings on 5Es learning model of most studies reviewed were carried out on performance, attitude, retention and conceptual change in the area of physics, biology and chemistry. Questioning style preference was not considered. The study on cognitive questioning preference revealed employed the use of science process approach and teachers cognitive questioning style. Constructivist instructional approach base on 5Es was not considered. The aspects of chemistry covered for the study were taught using science process approach by Ogenyi. It is in the light of this, this study investigate the impact of 5Es learning model students' Questioning Style preference and academic performance among chemistry students in Katsina metropolis, Nigeria.

2.10 Implications of Literature Reviewed to the Present Study

The related literature reviewed so far has given some insight into the effects of constructivist instructional approach on academic performance, attitude, retention and conceptual change in difference science subjects. It also gave an insight to the impact of instructional method (science process approach) and teachers' cognitive questioning style on performance in difference places, home and abroad, at different levels of education and different science subjects. This has some implication on the present study.

1. Majority of the studies revealed by Ibrahim (2015), Isa (2012), Udogu and Njilita (2010) and Kilaruz (2005) showed that subjects exposed to constructivist instructional approach based on 5Es learning model recorded higher academic performance, positive attitude

and retention span when compared with those taught using lecture method. It is in the light of this, that this study considered it necessary to enhance chemistry learning and teaching using 5Es learning model and students' ability to answer difficult questions (high level questioning).

2. Literature reviewed further revealed that students' questioning style preference can be improved by teaching methods and teachers' cognitive questioning style (Ogenyi, 2014 and Illiya, 2011). It is in the view of these that this study was conducted by employing 5Es learning model to improve students' cognitive thinking skills which in turn causes a shift in students' questioning style preference for high level questioning.
3. Boddy et al (2003) and Amber & Emily (2005) emphasized on high order thinking skills. Since 5Es learning model encourages students' critical thinking, it is in view of this advantage that this study was conducted.
4. Furthermore, researches on 5Es learning model revealed were conducted in the North-West Zone and Anambra State of Nigeria and Turkey. But this study considered it worthwhile to limit its scope to Katsina Metropolis, Katsina, Nigeria.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This study investigated the impact of 5Es Learning Cycle Model on Questioning Style Preference and Academic performance of Senior Secondary Schools Chemistry Students in Katsina Metropolis. In this chapter, a description of the methodology to be employ for the study is presented under the following sub-heading.

- Research Design
- Population of the Study
- Sampling and Sampling Technique
- Instrumentation
- Validation of the Instrument
- Pilot Study
- Reliability of the Instrument
- Administration of Treatment
- Data Collection Procedure
- Procedure for Data Analysis

3.2 Research Design

The Research Design adopted for this study was the pretest-posttest Quasi Experimental and control group design proposed by Kelinger (1973). This is suitable because of the summed up advantages listed by (Lakpini, 2006) which is as follows;

a) The superiority of one instructional strategy over the other can easily be tested

b) It gives indications of concept attainment ability of understanding gained by students after they have been exposed to a particular teaching treatment.

c) The pretest scores giving indication as to whether the groups are equal in the concepts they hold before interaction was given.

For this study, the subjects were pretested to ascertain the academic equivalence and to determine the type of questioning style the students were comfortable with individually by sorting out of students scripts, whether high or low questions. The group with close academic equivalence and no significant difference was assigned into the experimental and control group respectively using the balloting method. The Experimental Group was taught using the 5Es Learning Cycle Model for six (5) weeks according to the scheme of work and Chemistry Concepts chosen for the study, while the Control Group was taught same Chemistry Concepts by the use of lecture method for the same period. After the treatment, the posttest was administered to the groups to evaluate the effectiveness of the treatment on their Academic Performance and Questioning Style Preference before and after exposure to the Learning Cycle instructional Model of the students' in the experimental group was observed.

An illustration of the Research Design is shown in Figure 3.1;

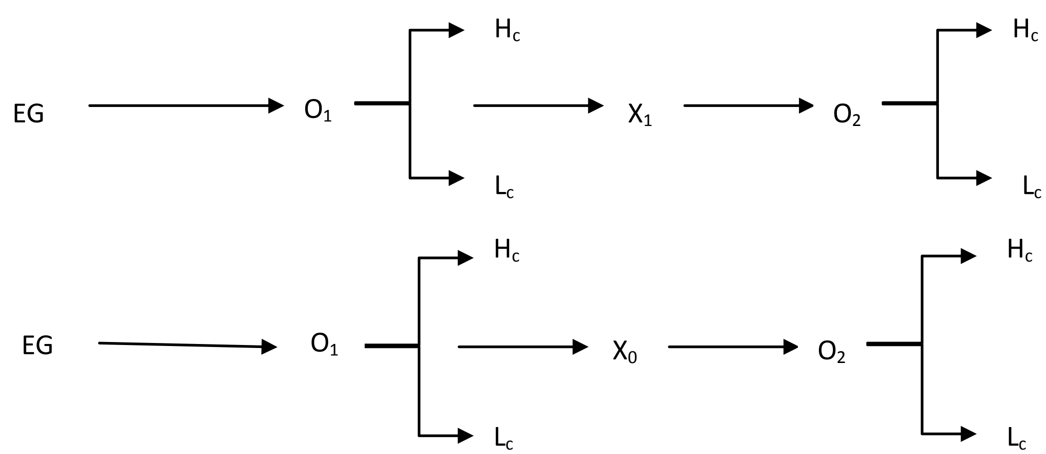


Figure 3.1 Research Design

KEY:

EG - Experimental Group (Will be Taught with 5Es Learning Cycle Model)

CG - Control Group (Lecture Method)

H_c - High Level Questioning Style Preference

L_c - Low Level Questioning Style Preference

X_1 - Treatment with 5Es Learning Cycle Model

X_0 - Treatment with Lecture Method

O_1 - Pretest

O_2 - Post-test

3.3 Population of the Study

The target population for this study is all Senior Secondary School Chemistry Students in Katsina metropolis and the parent population comprise of all SS II Chemistry Students in the Ten (10) public Senior Secondary Schools in Katsina Metroplis, Katsina State, Nigeria. Out of the Ten schools, three (3) were single sex (that is, either male or female) while seven (7) were Co-Educational (mixed schools). Public Schools were used because their teaching and learning condition are relatively the same, such as; Uniform condition of staff, Class Size, Academic calendar, Environment, and Laboratory Facilities etc. SS II students were considered suitable for this study by virtue of their age and academic experience, since they must have already spent one year in the learning of Senior Secondary Chemistry as a subject. The chronological age range of the students is between 15-17 years old. According to Katsina Zonal Educational Board (2015), there are a total of 753 students offering in the zone. The details of the schools in the targeted population are presented in Table 3.1.

Table 3.1: Population of the Study

S/No	Institution	Status	Enrolments		Total
			Male	**Female**	
1	Government College Katsina (Pilot)	Co-Educational	45	25	70
2	Katsina College Katsina	Co-Educational	48	33	81
3	Government Day Secondary School Kofar-Sauri	Co-Educational	57	54	111
4	Government Secondary School Kofar- Yandaka	Co-Educational	59	24	83
5	Government Girls College Katsina	Female only	-	58	58
6	Suncais (Senior) Katsina	Male only	55	-	55
7	Government Day Secondary School Kambarawa	Co-Educational	47	18	65
8	Government Day Secondary School Kofar-Kaura	Co-Educational	66	36	102
9	Government Secondary School, Katsina	Co-Educational	40	21	61
10	Desahara College	Boys only	67	-	76
	Total		**484**	**269**	**753**

Source: Katsina Zonal Educational Board (2015)

3.4 Sampling and Sampling Technique

To select the sample, initially four schools were selected from the population of the study in listed in Table 3:1, through Simple Random Sampling using draw-from the hat method. According to William (2005) random sampling is a sampling procedure which assures that each element in a population has equal chance of being selected. The four schools were: Government Day Secondary School Kofar-Kaura, Katsina College Katsina, Government Day Secondary School Kofar-Sauri and Government Secondary School Kofar- Yandaka; all schools were located within Katsina Metropolis of Katsina State. A pretest was administered to the subjects of the four schools chosen for the purpose of comparability of academic ability level and questioning style preference. Two schools with close academic performance equivalence were selected as the sample of this study. The result obtained from the pretest was subjected to Analysis of Variance (ANOVA), the four schools showed no significant difference. To ascertain the schools with significant difference, the result was subjected to Scheffe test. Three schools showed significant differences, out of which two schools were randomly picked. Simple Random Sampling technique by balloting was used to select the Experimental and Control Group. The first school picked was labeled Experimental and the second picked was labeled Control group. The first pick which was Government Day Secondary School, Kofar-Yandaka, was assigned the Experimental group while the second pick which was Katsina College Katsina was assigned the Control group, both schools are co-educational schools.

From each of the schools, the two intact classes of SS II offering Chemistry was used so as to reduce the work load of the schools Chemistry teachers so that he/she doesn't have to go through the concept to be taught over again. The Experimental group consist of Eighty three students while the Control consist of Eight one students. A class of minimum of thirty students is considered a viable representation for experiment research in line with Central Limit theorem recommendation, Tuckman (1975) and Frankel & Wallen (2000). The sum total of the sample size of the two groups is One hundred and sixty four (164) students. From the result of the pretest administered to both experimental and control group, the students result were classified into low level and high level questioning style preference subjects respectively. The sample for the Study is presented in Table 3.2.

Table 3.2: Sample for the Study

S/No	Institution	Status	Group	Enrolment		Total
				Male	Female	
1.	GDSS, Kofar-Yandaka	Co-educational	Experimental	59	24	83
2.	Katsina College, Katsina	Co-educational	Control	48	33	81
	Total			**107**	**57**	**164**

3.5 Selection of Concepts to be taught

The following concepts were selected from selected from the Senior Secondary Education Curriculum developed by the Nigerian Educational Research and Development Council (2006),

i. Periodic Table

ii. Gas laws

iii. Chemical Reaction

iv. Mole concepts

v. State of Matter and Change of State

The choice of these concepts is considered suitable because they are some of the difficult areas students get to fail as reported by WAEC Chief Examiner (2014) and Ogenyi

(2014). The concepts are the basic foundation of chemistry; therefore proper understanding of these concepts is very important for chemistry students. In addition, Ogenyi (2014) stated that students find these concepts difficult earlier because they were not taught in most cases or the teaching method used by the teaching was not appropriate.

3.6 Instrumentation

The Research instrument developed by the researcher for the purpose of this study is the Chemistry Performance Test (CPT).

Chemistry Performance Test

The instrument was developed by the researcher to assess the conceptual understanding of Chemistry by the students. The Questions were drawn from past WAEC questions papers and Senior Secondary School Chemistry Textbooks. The Performance test was based on the objectives of the topics selected as stated in the SSS Chemistry syllabus. The test item were made up of two parts containing fifty (50) test items of both low and high-level questions; **Part 1**- Multiple Choice test item with four alternative (one correct answer and three distractor) and **Part 2**-Short answer test Item. The questions covers all six levels of Bloom (1956) cognitive taxonomy; Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation in the domain. The questions are made up of two cognitive type of questioning style that is Low level questioning (Knowledge, Comprehension and Application) and High Level Questioning style (Analysis. Synthesis and Evaluation), (Tienken et al., 2010) and Ogenyi, 2014). The item constructed was validated for appropriateness and cognitive level by experts in Science Education with a minimum qualification of PhD and tutor of Chemistry at the SS 2 level in secondary school with a qualification of B.Sc. To ascertain the internal consistency of the CPT item, a pilot testing of the test was carried out on 30 SS 2 Students in one of the secondary schools other the ones used in the study. From the instrument, examples of low level questions and high level question are shown below.

Low Level Questions

Sample Question 1: Define a standard solution? (**Knowledge**)

Sample Question 2: Which of the following expressions correctly represents Charles law?

A. PV=K

B. V=KT

C. R & 1/VP

D. PV=RT (**Comprehension**)

Sample Question 3: State Charles' law and draw a sketch to graphically illustrate Charles' law.

(Application)

The above questions are questions that require students to remember, define, reiterate or find information that is within the text. There are fact, closed, direct, recall and knowledge questions.

High Level Questions

Sample Question 1: Potassium and Sodium show similar properties because they;

i. Belong to the same group in the periodic table

ii. Have equal number of electron in their outer-most shells

iii. Both exist in the + 1 oxidation state in the compound

iv. Belong to the same period in the periodic table

A. All are correct

B. I and IV are correct

C. III and IV are correct

D. I, II, III are correct **(Analysis)**

Sample Question 2: How does the collision theory affect the rate of chemical reaction?

(Synthesis)

Sample Question 3: Reaction occurs when the colliding reactant particles have?

(Evaluation)

This questions above requires students to think creatively, analyze, synthesis, evaluate, categorize of apply what they have learn. The CPT designed is shown in Appendix A.

3.6.1 Validation of the Instrument

In an attempt to establish the validity of the Chemistry Performance Test (CPT) in relation to the aim of the study, the 50 test item of Low and High-level questioning was subjected to scrutiny by one Secondary School Chemistry teachers with B.Sc. in Chemistry (Katsina State) and two PhD holder of the rank of Senior Lecturer in the Department of Science Education, Ahmadu Bello University, Zaria. The Assessors examined the;

- Content validity of the instrument.
- Language component of the instrument.
- Appropriateness of the items in line with the objective.
- To eliminate ambiguity and clarity of statements in the instrument and
- Criticize and make valuable suggestions necessary for improving the instrument.
- To determine the difficulty and discrimination level of the items.

The experts made constructive criticisms and corrections on basis of content and face validity of the instrument. After which discrepant items were selected out of the 50 items presented living 30 items that made the test instrument. **Part 1**; having 12 multiple choice test item and **Part 2**; having 18 Short answer test Items. Item Specification table was employed to ensure fair distribution of the types of Questioning style in the instrument, (See Table 3.3 and 3.4). The Chemistry Performance Test (CPT) was administered to both the Experimental and Control group as Pretest and Posttest. An Answer sheet was also provided for the purpose of the exercise with the bio-data of the students as in Appendix B. A Marking Scheme was also design with a sum total mark of 50 marks as shown in Appendix C. The questions were based on the Chemistry Concepts selected from the Senior Secondary Education Curriculum developed by the Nigerian Educational Research and Development Council (2006):

i. Periodic Table
ii. Gas laws
iii. Chemical Reaction
iv. Mole concepts
v. State of Matter and Change of State

Table 3.3 Item Specification for CPT based on Bloom Taxonomy of Cognitive Domain

S/no	Topic	KN	COM	APP	ANA	SYN	EVA	Total
1	Periodic Table	11			1,10		5,13	**5**
2	Gas law	8,9	6	16,26	12			**6**
3	Rate of Chemical Reaction				7	29,30	21	**4**
4	Mole Concept	3,18		17			19,20	**5**
5	State of matter and change of state	2,20	15,25	4	22,24	14,27	23	**10**
	Total	**7**	**4**	**4**	**6**	**3**	**6**	**30**

Table 3.4 Item Specifications Based on Low and High Questioning Style

Cognitive Questioning Levels	Classification based on Bloom's Taxonomy	Question numbers from CAT	Total number of questions
Low Level Cognitive Questions	Knowledge	2,3,8,9,11,18,20	**7**
	Comprehension	6,15,25	**3**
	Application	4,16,17,26	**4**
High Level Cognitive Questions	Analysis	1,7,10,12,22,24	**6**
	Synthesis	14,27,29,30	**4**
	Evaluation	5,13,19,21,23,28	**6**

The Chemistry Performance test (CPT) was administered to both the experimental and control group as pretest to determine the academic equivalence /performance levels and cognitive questioning preference of the study subjects and as posttest to compare the group for significant difference after treatment. Their questioning style preference was determined by sorting out each study subject script into low and high questioning style preference after pretest and posttest according to Ogenyi (2014) and Blooms taxonomy of cognitive domain as in Table 3.4. A typical questions reviewed in this study is as seen below;

Sample Question 1. Potassium and Sodium show similar properties because they;

i. Belong to the same group in the periodic table

ii. Have equal number of electron in their outer-most shells

iii. Both exist in the + 1 oxidation state in the compound

iv. Belong to the same period in the periodic table

A. All are correct

B. I and IV are correct

C. III and IV are correct

D. I, II, III are correct

Sample Question 2: Consider the following reversible reaction which occurs at the temperature of 298k. $N_2(g) + 3H_3(g) \longrightarrow 2NH_3(g)$; Propose two factors that will increase the formation of $NH_{3.}$

3.7 Pilot Testing

The pilot Study was carried out using the instrument, Chemistry Performance Test (CPT) on Thirty (30) SS II, Chemistry students of Government Day Secondary School, Kambarawa, Katsina State. The trial school is not part of the sample school of the study to prevent the students from having an idea of the instrument. The purpose of the pilot study was to ascertain the feasibility and reliability co-efficient of the instruments constructed through a trial run. Data collected from the pilot study was used for Reliability of the instrument and item analysis. The CPT consisting of 30 questions were administered to the students, instructions on how to answer the questions were read and explained verbally by the researcher and students were allowed ask questions for further clarification. A period of 1hour 30mins was allocated for the test to ensure that students answer the questions carefully. From this also, the actual time for the CPT was obtained by observing the time duration it took majority of the student to finish. After collecting the test items of the CPT, answer sheets were marked and scored over 50marks according to the marking scheme designed to help in uniformity of scores awarding.

3.7.1 Reliability of the Instrument (CPT)

The data obtained was analyzed to establish the reliability of the instrument. Thus the coefficient of the CPT was calculated to be 0.82.

The test-retest method was used to test the reliability of the instrument (CPT) within the interval of two weeks in line with Tuckman, (1975) and Pearson Product Moment Correlation (PPMC) was used to determine the reliability of the instrument and test items. The reliability coefficient of the instrument was found to be r = 0.82, which indicate high correlation between the test. The result obtained therefore shows the suitability of the test item for the study. The pilot study provided data for the item analysis. The collected data was analyzed to determine the difficulty and discriminating indices of each of the 30 test items.

3.8 Item Analysis

Item analysis is the process of examining class-wide performance on individual test items. There are three common types of item analysis which provide teachers with three different types of information. They are; Difficulty index, Discrimination Index and Analysis of Response Options. But in the case of this study, only two item analyses will be used which are; Difficulty index and Discrimination index, because not all of the test item items are multiple choice questions. Item Analysis table is presented in Appendix E.

3.8.1 Difficulty Index

The Difficulty index show the difficulty level of each of the items based on the percentage of students who got an item correct. The range is from 0% to 100%, the higher the value, the easier the item. Ranges above 0.75 are very easy items and might be a concept not worth testing. Ranges below 0.25 indicate difficult items and should be reviewed for possible confusing language or the contents needs re-instruction. The recommended ranges of difficulty is from 30-70%, item having Range below 30% and above 70% are considered difficult and easy items respectively (Miller, Linn & Gronlund, 2009). But normally the items having the item difficulty between 30% to 80% are included in the test (Singh, Sharma & Upadhya, 2012 and Lapikni, 2006)). Inclusion of very difficult items in the test depends upon the target of the teacher in order to identify top scorers. Teachers produce a difficulty index for a test item by calculating the proportion of students in class who got an item correct. For this study therefore, the items with difficulty indices in the range of 20% to 80% were used for the study. The difficulty level of the instrument (CPT) was determined using;

DL= Ru+Rl/Nu+Nl

Where,

Ru = the number students in the upper group who responded correctly

Rl = the number students in the lower group who responded correctly

Nu= Number of students in the upper group

Nl= Number of students in the lower group

The Difficulty index of the Chemistry Performance Test (CPT) falls between the range of 20% to 80% and three items fall below 20%, which indicate that the three items are very difficult. Therefore, these three items were reviewed for possible confusing language and areas of controversy then the contents were re-constructed.

3.8.2 Discrimination Index

The Index of discrimination is a basic measure of the validity of an item. It is the measure of an item's ability to discriminate between those who scored high on the total test and those who scored low. It is computed from equal-sized high and low scoring groups on the test by Subtract the number of successes by the low group on the item from the number of successes by the high group, and divides the difference by the number of a group. The range of this index is +1 to -1. To promote stability, there need to be as many students as possible in each group, At the same time, it is desirable to have the two groups be as different as possible to make the discrimination clearer. According to Kelley as cited in Popham (1981), the use of 27% maximizes these two characteristics. Values of 0.4 and above are regarded as high and less than 0.2 as low (Ebel, 1954). Discrimination index is estimated using the following formula:

Discrimination index = RU-RL/NU(or)NL

Where;

DL = index of discrimination

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

RL = number among lower 27% of students who score the items correctly

NU or NL = Number of examinees in the upper or lower group respectively

As a rule of thumb, in discrimination index, 0.40 and greater are very good items, 0.30 to 0.39 are reasonably good but possibly subjected to improvement, 0.20 to 0.29 are marginal items and need some revision, below 0.19 are considered poor items and need major revision or should be eliminated (Ebel & Frisbie, 1986). A negative discrimination index between –1.00 and zero results when more students in the low group answered correctly than the student in the high group. Zero DI means equal number of high and low students that answered correctly, so the item did not discriminate between the groups. A positive DI occurs when more students in the high group answer correctly than the low group.

Items with index of discrimination between 0.3 to 0.49 are moderately positive as shown by Frust, (1958) and Usman (2008), and items with index of discrimination of 0.49 are positive as more of the well- informed students than the poor ones will get items right. The index of discrimination for the Chemistry Performance Test (CPT) Instrument falls within 0.29 to 0.71. Therefore, the discrimination indices are highly positive, which implies that the CPT is suitable for the study.

3.9 Administration of Treatment

The experimental group and control groups were sorted out, to ascertain the numbers low and high level questions attempted by each subjects after the pretest using the CPT.

The procedure for treatment administration was as follows;

Treatment for the Experiment Group

The Experimental groups were exposed to Constructivist method of instruction based on the 5Es learning model, for 1hour 30mins period (45mins per period/ twice a week) for five weeks contact session. One intact chemistry class containing 83 students was used. The groups was taught by the researcher for the period stated. The experimental group students were exposed to constructing their own knowledge; this is aimed at enhancing learning based on helping students build their own understanding of the concept to be taught from experience and new ideas. By allowing the students construct their own knowledge and build their own understanding, knowledge is been made more relevant, retained and meaningful. This learning process lead to active construction of meaningful learning rather than passive acquisition of facts transmitted from the teacher.

The instructor adhered to the following guidelines:

1. Introducing the lesson by setting a level of anticipation.

   For example in teaching Rate of Chemical Reaction, settling a level of anticipation for the students, the students were asked to come to class with calcium vitamin C tablets. All students were looking forward to what will be done with the tablets.

2. Engaging students by capturing their attention, interest, promoting curiosity and elicit prior knowledge. This create a connection between the past and present learning

experience, expose prior conceptions and organize students' thinking towards the learning outcomes of current activities.

Engaging process

The teacher begins the lesson by asking the students to take the calcium tablets and drops one in cold water and one in warm water. The students observe, which one dissolves quicker? This implies that a given reaction can occur at different rates if the conditions of the reaction are different. From the above demonstration, calcium tablet dissolves slowly in cold water and rapidly in warm water.

3. Exploration phase to provide students with common base of activities within which current concepts (misconceptions), processes and skills are identified and conceptual change is facilitated. Learners will complete hands-on activities with guidance that enable them make use of prior knowledge to generate new ideas, explore questions and possibilities and conduct a preliminary investigation.

Exploration process

Students participate in activities to explore the concept. This exploration provides students with a common set of experiences from which they can initiate the development of their understanding. Students are put to groups to carry out practical activities with chemical and are made to record their results and make hypothesis. This provides the base for the teachers' explanation of the concept. Details on page 156.

4. Teacher directs students' attention to specific aspects of the engagement and exploration experience by explanation. Learners explain their understanding of concepts and processes. New concepts and skills are introduced as conceptual clarity and cohesion are sought by the teacher

Explanation

The teacher clarifies the concept and defines relevant vocabulary as needed. Students interpret data, construct inferences, make predictions, and build explanations. Teacher explains that the speed or rate of chemical reactions differ greatly. Some reactions are fast and others are slow. Detail on page 157.

5. Elaboration activity applies learning. Learners apply concepts in contexts, and build on or extend understanding and skill.

   Elaboration process

   Students elaborate and build on their understanding of the concept by applying it to new situations and problems. Teacher asks the students to connect the relationship between their observations and teacher's explanation.

6. In the Evaluation phase, Learners' knowledge, skills and abilities are assessed. Activities permit evaluation of student development and lesson effectiveness.

   Evaluation

   Students' complete teachers' activities that will ascertain their understanding of the concept with a short 5mins quiz. Teacher asks students to explain how each of the factors studied affects rate of reaction.

The lesson flow chart for the 5Es instructional model is presented in Fig. 3.2.

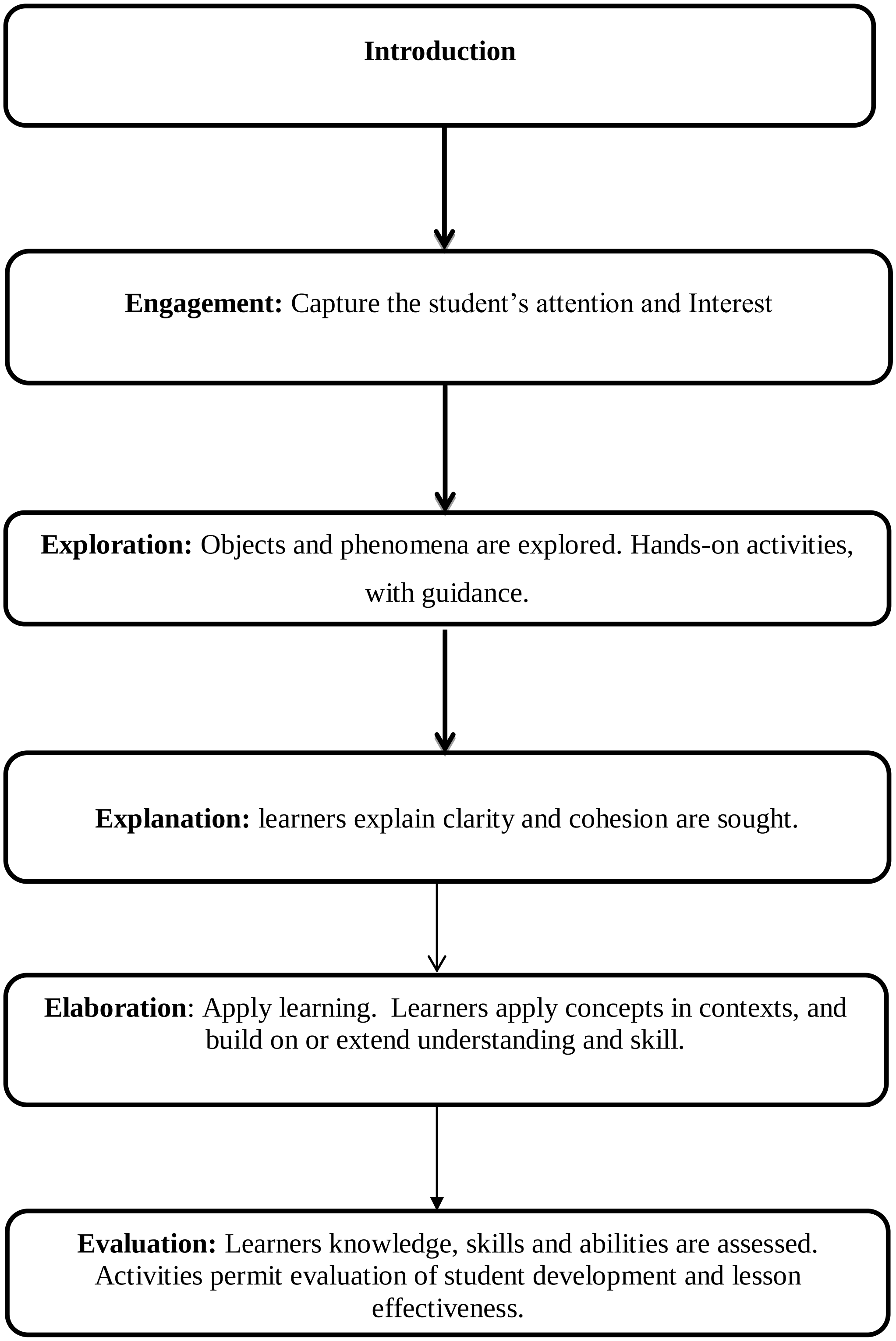


Fig 3.2: Flow Chart illustration the 5Es Learning Model
Source: BSCS. Bybee, (2006).

Teaching the Control Group

The Control Group were taught same topic in Chemistry for the same period as the experimental group by a Research Assistant who is the chemistry teacher of the control school, using lecture method for effective result, using the second intact class containing 81 students. This involves verbal presentation of the concept to be taught. The students were expected to listen to the teacher and take down note presented on the chalk board. Their questioning preference was also sorted out into low and high questioning style preference after pretest and posttest. Students were allowed to ask questions at intervals and the teacher responded to the students' questions.

The lesson plan for both Experimental and Control Groups are presented in Appendix D and E.

3.10 Data Collection Procedure

The group pretest and post test scores were used as data's for the study. The pretest was administered on the two groups (Experimental and Control groups). There-after, the two groups were taught the same Chemistry concept by the researcher. The control group was taught using lecture method while the experimental group was exposed to the 5Es learning cycle instructional model employing appropriate questions covering the six hierarchy of Bloom's taxonomy of cognitive domain, this involve questions such as Identify, explain, compute, compare and contrast. After a period of five weeks treatment, the post test was administered to the groups by the researcher.

The researcher marked the scripts based on the marking scheme. The scores from the scripts were collated and were subjected to data analysis using SPSS statistical package

3.10.1 Procedure for Data Analysis

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

3.10.2 Answering Research Questions

The research questions were answered using descriptive statistics in form of mean scores and standard deviations.

Research Question 1: What is the difference between the mean Academic Performance scores of Chemistry students taught with 5Es learning model and those taught with lecture method?

In answering this research question, Mean and Standard Deviation Statistics were used.

Research Question 2: What is the effect of exposure to 5Es learning cycle model on the mean Cognitive Questioning Style Preference among Senior Secondary School Chemistry students and those taught with lecture method?

Mean Scores, Standard Deviation Statistic and Percentage were used.

Research Question 3: Is there difference in the mean scores of male and female student's Cognitive Questioning Preference who were exposed to 5Es learning cycle model?

Mean and Standard Deviation Statistic were used.

3.10.3 Null Hypotheses

The hypothesis stated were analyzed to test the significant difference among the variables of the study using t-test, Analysis of Variance (ANOVA), Analysis of Co-variance(ANCOVA) and Scheffe's at probability level of $P \leq 0.05$ for retaining or rejected the stated hypothesis. Each of the hypotheses was tested as shown below along with the description of the statistical tool used for testing each.

HO_1: There is no significant difference between the mean score of Chemistry Students academic performance, when exposed to the 5Es learning cycle model and those taught with lecture method.

The t-test statistics was used to test for any significant difference in the post test mean scores of those taught using 5Es learning model and those taught using lecture method.

HO_2 There is no significant difference between the mean scores of chemistry students with low and high Cognitive Questioning Preferences exposed to 5Es learning model and those taught with lecture method.

For this hypothesis, one way Analysis of Variance (ANOVA) statistics was used to test for any significant difference in the mean scores of those expose to 5Es learning model and those taught with lecture method. To show the group that shows significant difference, Scheffe's test was used.

HO_3 There is no significant difference in the mean scores of Male and Female Chemistry students' cognitive questioning preference when exposed to 5Es learning model.

ANCOVA was also employed to test this hypothesis.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

This study is titled “Impact of 5Es learning model on academic performance and questioning style preference of secondary school chemistry students in Katsina metropolis, Nigeria”.

In this chapter, the result obtained from the analysis of the date collected and the discussions of the results are presented. The Statistical Package of Social Science (SPSS) IBM 20th Edition was used for the analysis.

The work is presented in the following subheadings;

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

4.2 Data Analysis and Result Presentation

The data collected from the study using the instrument (CPT) were analyzed, the result obtained were used to answer the following research questions and hypotheses testing’s.

4.2.1 Answers to Research Questions

Research Questioning 1: Sought to find out the difference between the mean academic performance scores of chemistry students taught with 5Es learning model and those taught with lecture method?

The result is presented in Table 4.1.

Table 4.1: Means and Standard Deviations Statistic of Experimental and Control Groups Academic Performance.

Group	**N**	**Test**	**Mean**	**SD**	**Mndff.**
Experimental	83	Pre-test	10.75	3.04	
					8.73
	83	Post-test	19.48	3.72	
Control	81	Pre-test	11.41	3.19	
					2.94
	81	Post-test	14.35	2.39	

Table 4.1 shows that the experimental group recorded a pretest mean score of 10.75 and a posttest mean score is 19.48 with mean difference of 8.73 while the control group recorded a pretest mean score of 11.41 and posttest of 14.35 with a mean difference of 2.94.This implies that there is a mean difference between pretest and posttest experimental and pretest and posttest control group.

The large mean difference in the score of 8.73 for the experimental group compared to that of the control group 2.94, which means that 5Es learning model has improved the academic performance of the students in the experimental group, Therefore, higher mean score of experimental group is due to the treatment administered.

Research Question 2: What is the effect of exposure to 5Es Learning Model on the mean Questioning Style Preference among Senior Secondary School Secondary School Chemistry students and those taught with Lecture Method?

The result is presented in Table 4.2.

Table 4.2: Means and Standard Deviations Statistics on Questioning Style Preference of Experimental and Control groups.

Variable	Test level	Experimental Mean	Exptal Mean %	SD	Mndff	Control Mean	Control Mean %	SD
Low	Pretest	7.84	15.60	3.66	1.04	6.80	13.60	2.55
	Posttest	10.60	21.2	2.32	3.01	7.31	14.62	2.15
High	Pretest	3.35	6.70	1.59	0.90	2.45	4.90	1.50
	posttest	8.88	17.76	1.92	5.33	3.15	6.30	1.28

Table 4.2 the mean scores and percentages' obtained by the study subjects who attempted the low and high questioning style at the pretest level are 7.84 (15.60%) and 3.35 (6.70%) for the experimental group while for the control group are 6.80 (13.6%) and 2.90 (4.90%). The posttest result revealed means scores of 10.60 (21.2%) and 8.88 (17.76%) for students in the experimental group who attempted low and high questioning style and mean scores of 7.31 (14.62%) and 3.15 (6.30%) for the control group respectively. Scores obtained at the pretest levels shows a preference for low level questions for both groups, only a few of the high level questions were attempted and scored correctly as evident in the mean difference of 0.90. The posttest reveals a remarkable difference in the mean scores of 5.33 between the groups in favour of the experimental subjects.

The experimental subjects also attempted low level questions as well as high level questions successfully as evident in their mean score and percentage of 10.60 (21.2%) and 8.88 (17.76%). The difference can be attributed to the treatment (5Es learning model) received by the experimental group which improved their cognitive skill, high order thinking and enhanced their preference for high level questioning style.

Research Question 3: Is there difference in the mean scores of male and female students' cognitive questioning preference, who were exposed to 5Es learning model?

The result is presented in Table 4.3.

Table 4.3: Posttest Mean Scores and Standard Deviation of Male and Female Student's Questioning Style Preference.

Group	Sex	Level	N	Mean	SD	Mndff.
Experimental	Male	Low	31	12.94	4.21	
						1.18
		High	28	11.76	4.59	
	Female	Low	14	10.88	4.09	
						1.17
		High	10	12.05	4.96	

Table 4.3 results showed that the mean scores in cognitive questioning preference on account of Gender. The experimental group, male and female students with low and high cognitive questioning preference, shows a mean difference of 1.18 and 1.17 respectively. From the above result, the difference between the male and female students with low and high cognitive questioning preference is 0.01. This is to show that the treatment (5Es learning cycle model) according to the mean difference of male and female students is gender friendly as its favour both male and female students and enhances their cognitive questioning preference.

4.2.2 Hypothesis Testing

For the purpose of this study the following null hypotheses where tested at $P \leq 0.05$ as follow.

HO_1: There is no significant difference between the mean scores of Chemistry Students' Academic Performance, exposed to 5Es Learning Model and those exposed to Lecture Method.

The t-test statistics at $P \leq 0.05$ was used to determine if there was any significant difference in the mean scores of the experimental and control groups in academic performance after exposure to 5Es learning model. A summary of t-test of the students on Academic Performance scores is presented in Table 4.4.

Table 4.4: Summary of t-test Analysis of Mean Academic Performance Scores of Experimental and Control Groups.

Variable	N	Mean	SD	SE	Df	t-cal	t-crit	Sig (P)	R
Experimental	83	15,11	3.04	0.33					
					162	5.04	1.96	0.001	S
Control	81	12.87	2.61	0.29					

*Significant at $P \leq 0.05$

Table 4.4, shows a t-calculated value of 5.04 which is higher than the t-critical value of 1.96 at Df 162 and P-value of 0.001 which is less than P=0.05. This revealed that the study subjects who were exposed to 5Es learning model in the experimental group performed significantly better in academic performance than those in the control group taught with lecture method.

This implies that the treatment with 5Es learning model significantly enhanced the academic performance of the students in the experimental group compared to their courter-part in the control group. Therefore, the null hypothesis which says that there is no significant difference between the mean scores of Chemistry students' Academic Performance is hereby rejected.

HO_2: There is no significant difference between the mean scores of chemistry students (in the experimental and control group) with low and high cognitive questioning preferences exposed to 5Es learning cycle model and those taught with lecture method.

One way ANOVA statistical techniques were used to test hypothesis two. This involves Pretest and Posttest of students' level of cognitive preference exposed to 5Es learning model and those taught with lecture method. Summary of the result is presented in Table 4.5.

Table 4.5: Results of One-way ANOVA for the Pre-test and Post-test Mean Score of Low and High Level Questioning Style Preference Students in Experimental and Control Group

Groups	Cognitive level	Source	Sum of square	Df	Mean square	F	Sign.	R
Experimental	Low	Between group	73.48	4	18.37	6.00	0.001	S
		Within group	597.25	195	3.10			
		Total	670.73	197				
	High	Between group	4255.49	4	1063.87	73.37	0.001	S
		Within group	2827.80	195	14.50			
		Total	7083.28	197				
Control	Low	Between group	61.12	4	15.29	2.42	0.056	NS
		Within group	1237.20	195	6.35			
		Total	1299.10	197				
	High	Between group	43.57	4	10.89	2.08	0.076	NS
		Within group	1020.60	195	5.24			
		Total	1064.22	197				

*Significant at $P \leq 0.05$

From the result Table 4.5, reveals that the experimental group pre-test and post-test of students attempt to answer low and high level questions, there is significant difference in their questioning style preference of students mean scores attempt to answer more difficult questions. Also in the control group, pre-test and post-test of low, there is significant difference but for high level pre-test and post-test in the control group, there is no significant difference. Because the P-value of experimental pre-test and post-test, low and high is 0.001 which is less than P = 0.05. On the Control group low, pre and post-tests, there is significant difference since significant level is 0.056 greater than to P = 0.05 while the control high preference style pre and post records a significant level of 0.076 which is greater than P = 0.05 meaning that there is no significant difference on high level questioning style preference students in pre and post-test mean scores.

From the result in the experimental group, it shows that there is significant difference in the questioning style preference in favour of low questioning style preference students. Therefore, the null hypothesis which says there is no significant difference is rejected in favour of low questioning style preference students in the experimental group compared to those in high meaning that there is a significant shift from low level to high level questioning style preference.

To show the group that shows significant difference, Scheffe's test was used as shown in Table 4.5(b).

Table 4.5(b): Results of Scheffe's Test on Experimental and Control Groups Mean Scores Based on Cognitive Questioning Preference

Group	Preference level	Test level	Sum of Square	Mean Square	Sig.	R
Experimental	Low	Pre-test	73.47	18.37	0.001	S
		Post-test	597.20	3.06		
	High	Pre-test	4255.47	1064.90	0.001	S
		Post-test	2827.81	14.50		
Control	Low	Pre-test	61.14	15.28	0.056	NS
		Post-test	1237.99	6.35		
	High	Pre-test	43.56	10.87	0.076	NS
		Post-test	1020.62	5.24		

The result from the Scheffe's test in Table 4.5(b) reveals that pre-test and post-test of experimental group students with low and high questioning style preference show a P-value of 0.001 which is less than p-value of 0.05 meaning that there is significant difference in their questioning style preference. While the pre-test of control group students with low and high questioning style preference show a p-value of 0.056 which greater than p-value of 0.05 indicating that there is no significant difference in questioning style preference but in the control group of high with p-value of 0.076 which is greater than p-value of 0.05 which indicates that there is no significant difference between pre-test and post-test of control group. This implies that there is a gain for the low questioning style preference students of the experimental group which may be attributed to the treatment given with the 5Es learning cycle model.

HO_3: There is no significant difference in the mean scores of male and female students' questioning style preference when exposed to 5Es learning cycle model.

Analysis of Co-variance was employed to test this hypothesis. Result is presented on Table 4.6.

Table 4.6: Results of Analysis of Co-variance for Male and Female Students' Mean Score Questioning Style Preference exposed to 5Es Learning Model.

Source	Type III Sum of Square	Df	Mean Square	F	Sig.	R
Corrected model	68.19	3	22.73	10.21	0.001	S
Intercept	7378.77	1	7378.77	3313.87	0.001	S
Sex	5.42	1	5.42	2.44	0.121	NS
Group	65.77	1	65.77	29.54	0.001	S
Sex*Group	2.68	1	2.68	1.20	0.274	NS
Error	356.26	160	2.23			
Total	8569.31	164				
Corrected Total	424.45	163				

*Significant at $P \leq 0.05$

From the result in Table 4.6, the impact of the treatment on gender shows a significant level 0.121 which is greater than P = 0.05, this implies that there is no significant difference of the treatment on Gender meaning treatment is gender friendly. Among the two groups (low and high level questioning style Preferences), the significant level is 0.001 which is less than P = 0.05 meaning there is significant difference. But for gender and group exposed to the treatment (5Es learning cycle model) in relation to questioning style preference, it shows a significant level of 0.274 which is greater than p = 0.05, meaning that there is no significant difference. Therefore the treatment is gender friendly. Hence the hypothesis which state that, no significant difference is hereby failed to be rejected, therefore retained.

4.3 Summary of Findings

Based on the result of this study, the following findings were made.

1. There is significant difference between students exposed to 5Es learning model compared to those taught with lecture method in favour of the experimental group.
2. There is significant difference between low and high level questioning style preference students exposed to 5Es learning cycle model and those taught with lecture method in favour of experimental group. Meaning that the use of 5Es learning cycle model in teaching chemistry is effective compared to lecture method in enhancing students' questioning style preference for high level cognitive questions and hence encourages high order thinking and improves academic performance.
3. There is no significant difference between male and female students of low and high questioning style preference students exposed to 5Es learning cycle model. Which implies that 5Es learning cycle model is gender friendly.

4.4 Discussion of the Results

The findings of the results are been discussed as follows;

From the findings in Table 4.4, the experimental group performed significantly better than the control group. This shows that 5Es learning cycle model is effective in enhancing the acquisition of high order skills and cognitive process on the subjects under study, stimulating them to explore, to inquire and to get experience of their own. This result supports the observation by Martins and Oyebanji (2000), that teaching methods affects the response of students and determine their interest level, motivation and involvement in the lesson. Other studies by Mukherjee (2007), Lawson (2002) and Anderson and Krathwohl (2001), have also shown that learners cognitive process and academic performance can be enhanced through effective method of instructions. The suitability of 5Es learning cycle model as a means of promoting high order thinking skills and academic performance may be attributed to the nature of the instruction which is inquiry based and student-centered and thus provides a wide range of activities for the students to control, take responsibility for their action in the process of learning and form their own idea from already existing facts (Aksela, 2005). It present students with a problem to be solved and causes an increase in their motivation (Oliver (2007) and Prince & Felder (2007). The 5Es learning model instructional method actively involves the students in the learning process and allows the learner to gain a deeper understanding of the concepts and become better critical thinker (Wang & Posey, 2011). The learning cycle model is based on the knowledge organization process of mind when students apply concepts and make their scientific knowledge constant due to the engagement by capturing their attention and interest, exploring the student by providing students with a common based of activities that helps them to use prior knowledge to generate new ideas. Explanation which requires linking to other concepts elaboration which the teachers challenge and extends students conceptual understanding and skills. Evaluation which requires a feedback from the student on the concept taught.

The relatively poor performance of the subjects in the control group is an indication that the lecture method adopted in teaching science by science teachers is not effective in promoting cognitive processes in students in Senior school as observed by Lawson (2002), Aikenhead (2005) and Mukherjee (2007) that subjects do not acquire cognitive skills unless concerted effects are made to identify and used instructional strategic that promotes its development and lecture method does not as it is not student centered.

The result in Table 4.5 shows that there is a significant difference at $p \leq 0.05$ 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 implies that 5Es learning cycle model is potentially effective in influencing students' preference for high level cognitive questions and a paradigm shift from low to high level cognitive questions. Thus model provides students with an opportunity for participating in the process of higher order thinking (Boddy, Watson & Aubessm, 2003). It purposively promotes experimental learning by motivating and interesting students, as they are encouraged to engage in high order thinking which leads to engagement in High order thinking questions also this is achieved because students are directly involved in the teaching and learning process, thus enables the students take responsibility for their learning and to effectively construct their own knowledge (Aksela, 2005). When learners are actively involved in a lesson, they will learn more effectively and exhibits greater performance because their cognitive structure is evolved (Ezeliora, 2010).

Effective learning and performance are related positively to the nature of questions the students are exposed to and preferred to answer (Gandu, 2006). Good questionings Foster students' academic achievement and build the learner varying and evaluative thinking rather than determining what has been learned in a narrow sense. Ogenyi (2014) dissolved that teaching methods can improve students thinking skill to enhance and cause a shift in student questioning style preference from low to high questioning style preference. Thus, from the experimental group, there was a gain in the low questioning style preference student, bringing about a shift and preference from low to more high level questions which is attributed to the treatment of 5Es learning model given.

The result in Table 4.6 shows that at significant confidence of $P \leq 0.05$, there is no significant difference in the mean scores on the questioning style preference of students in relation to gender, as the treatment with 5Es was noticed to be gender friendly. This result supports the observation by Felicia and Peter (2013) that learning cycle enhances students' achievement and it also favours both boys and girls, giving credence to the learning cycle as a gender friendly and sensitive approach. This finding is in agreement with the report of Usman (2002), Bichi (2002), Ogunboyede (2003), Gandu (2006) who independently reported that male and female students perform the same in academic achievement when exposed to activity based teaching method such as 5Es learning cycle.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The aim of this study was to investigate the impact of 5Es learning cycle on Questioning Style Preference and Academic Performance among Senior Secondary School Chemistry students in Katsina Metropolis, Nigeria. 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 presented as follows.

5.2 Summary

This study investigated the impact of 5Es learning cycle model on Questioning Style Preference and Academic Achievement among Chemistry Students' in Senior Secondary School (SSS).

A total of 164 subjects (83 in the experimental group and 81 in the control group) were used for the study. The experimental group was exposed to 5Es learning cycle model for (5) five weeks. They were selected by simple randomization. The two sample schools were;

- Government Secondary School Kofar-Yandaka
- Katsina College Katsina

A simple random sampling technique by balloting was used to select the experimental and control group respectively. The instrument used was Chemistry Performance Test. It was used to collate data as pretest and posttest which was also used in answering the research questions and to test the stated null hypothesis. The CPT was a 30 items multiple choice and short answered test items consisting of all six levels of cognitive taxonomy. The CPT with a reliability coefficient of 0.82 was used to collect relevant data which were analyzed using t-test, One way ANOVA, ANCOVA and Scheffe's test at significant confidence of 0.05 (was adopted) for retaining or rejecting the hypothesis. The SPSS package was used to analyze the data obtained. The distribution of the scores at the pre-test reveals that a high proportion of student's shows greater preference for low level questions in the cognitive domain which can be said might be the cause of low academic achievement at SSCE examination. At SS 2 and at an average age of 16 years, 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 CPT as follows;

1. Pretest performance scores was administered to students in the four selected schools, the data collected was analyzed using Analysis of variance (ANOVA) to establish two groups that are equivalent academically and to determine the questioning style preference of the sampled subjects before commencement of treatments.
2. Posttest performance scores of both group obtained was analyzed using t-test and one way ANOVA respectively 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 questioning style preference from low level to high level among the two groups and which of the groups is the shift significant.
3. Posttest performance scores of male and female students were analyzed using ANCOVA to establish a significant difference in gender when exposed to the treatment. If the treatment is suitable for male only, female only or if it is a gender sensitive approach. 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. The analysis of the posttest scores indicates that there is a significant difference between students exposed to 5Es learning cycle model compared to those taught with lecture method in favour of the experimental group. That is to say, the experimental group performed better than the control group in their academic achievement after undergoing the experimental treatment of 5Es learning cycle model.
2. There is a significant difference between low and high level questioning style preference students exposed to the treatment with 5Es learning model and those taught with lecture method in favour of the experimental group. 5Es learning cycle model was found to be more effective in enhancing the questioning style preference (ability to answer more difficult questions) of chemistry students at the Senior Secondary School level.
3. The paradigm shift from the preference for low level questioning took place in both low and high level preference students when exposed to 5Es learning cycle model. This implies that, the treatment was more beneficial to the low level cognitive preference students because the treatment enhanced their preference for high questions relatively.
4. There is no significant difference between male and female students of low and high cognitive questioning preference exposed to the treatment with 5Es learning model. This indicates that 5Es learning cycle model is gender sensitive as it is suitable for both male and female subjects.

5.4 Conclusion

Based on the results obtained from this study, the following conclusion can be made; the analysis of the result shows that the experimental subjects acquired higher order thinking skills and hence performed significantly better as a result of the treatment with 5Es model. This is an indication that 5Es learning cycle model is effective in improving students cognitive thinking skills which in turn enhances their questioning preference and academic performance. This also revealed that lecture method commonly used by teachers in secondary schools is not quite suitable for meaningful teaching and learning of science concept as it is not a student centered 'approach'.

Cognitive ability of the experimental group (in line with Bloom (1986) classification was enhanced significantly after treatment which was reflected in their academic performance. This implies that 5Es learning cycle model is effective in promoting high order thinking skills of science students, especially in chemistry. Based on this, 5Es learning cycle can be used as an effective instructional tool for eliminating poor performance and a fundamental step towards enhancing students' performance in science learning as its encourages headers to construct their own knowledge out of the prior knowledge.

The experimental group showed significant improvement in their cognitive questioning style preference for high level cognitive question than the control group after treatment. This shows that questioning style preference of science students can be enhanced through appropriate used of teaching method, strategies, models and training. This is also an indication that teacher centered teaching methods may be responsible for low performance and inability of students' to answer high level questions in Chemistry.

Exposure of male and female students to the treatment show that the two groups of gained tremendously from the treatment. This implies that the treatment is suitable for male and female students meaning it is gender sensitive and not bias. Therefore, 5Es learning cycle has potentiality for enhancing student academic performance, questioning style preference and it is gender friendly.

5.5 Contributions to Knowledge

This research work was initiated to determine the most effective ways to improve students' skills in dealing with cognitive questioning types in the classroom and examination through the use of 5Es learning model. It was observed that;

a. Most studies in this area were to determine effects of high level and low level questioning style on academic achievement or teachers questioning style on students' performance. A study has also been done using teaching method such as science process teaching approach to enhance cognitive questioning style preference. In this study however, 5Es learning model was employed to determine students' cognitive questioning style preference and was also used to enhance a paradigm shift in students' preference for high level cognitive questions from low level cognitive questions. The implication of this shift on academic performance of student in senior secondary school was very significant as obtained from finding hence the method is an inquiring based approach which is student centered meant to improve academic performance among science students.

b. The 5Es Model used for this study encourages students' constructing their own knowledge from pre-exciting knowledge and high order thinking skills. This implies that, the treatment with 5Es model enhanced students' ability to answer or attempt more difficult questions (high level questions) rather than low level questions they are comfortable with.

c. In this area of study, that is Katsina Metropolis, this study is relatively the first of its kind, especially on cognitive questioning style preference with respect to exposure to 5Es learning cycle model.

d. The researcher instrument, Chemistry Performance Test developed for this study can be employed as a credible instrument for testing the cognitive questioning preference of students. The instrument can also be adopted or adapted for use in similar studies or other science education based researches to move forward the frontier of knowledge.

e. Also the finding of this study has added new information to the frontier of knowledge in the existing literature.

f. The lesson plan designed for this lesson if adopted or adapted to teach chemistry can enhanced students better understanding of chemistry. Since it utilizes the a educational applications of teaching models (5Es model) to obtain educational results that develop thinking and improve experience in order to create a generation capable of thinking skillfully and creatively (High order thinking) and to solve problems with minimum time and effort.

5.6 Recommendations

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

1. There is a need for the improvement of chemistry learning and teaching conditions and practices existing in Nigerian secondary school through the use of different effective teaching and learning method and model such as 5Es learning model which is an inquiry based approach to teaching and learning instead of the conventional lecture method.

2. Since the level of students' cognitive processes and skills affects the learning of science concepts, there is therefore the need for science teacher to systematically and periodically assess or determine this ability of their student. One way of doing this is by the use of questioning style preference. This is with a view to adapting circular contents, achievement goals, instructional method and educational strategies to improve their questioning style preference.
3. Nigerian universities and colleges of education as well as secondary school educational planner should be encouraged to design educational programs that will equip teachers in training with skills for the use of individual differences such as cognitive questioning preference for effective teaching and learning of chemistry.

5.7 Limitations of the Study

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

1. The study was restricted to only two government schools and to chemistry students. A widen scope of the study might influence the study. The geographical coverage in Katsina metropolis of Katsina state only thus limiting generalization made from the study.
2. The late resumption of students in Katsina State during the courses of the study effect commencement of the study due to the 2015 Nigeria elections.
3. Language was a problem as researcher often had to resort to the native dialect (Hausa) to explain some concept to the study subject.
4. Large sample size due to the use of intact classes in the sample schools.

5.8 Suggestions for Further Studies

1. Similar studies could be carried out at tertiary institutions such as colleges of education, Polytechnics, Mono-technics and Universities.
2. It is needful to extend the study over a period of two or three years to ascertain the substances or other wise of the effects of 5Es learning model in promoting cognitive gains in students. This will also help to establish if a long period of exposure to 5Es learning model will help to remedy poor academic achievement in science and chemistry in particular.
3. The use of other teaching method such as Demonstration Method, Science Process Teaching Approach, Discovery Methods, Problem Solving Methods and Practical Methods should be employed to determine it effect on cognitive questioning style preference of science students.
4. This study can be replicated in rural schools to determine if there are difference in the cognitive ability between students in the rural schools and those in urban areas.
5. This type of study would also be conducted in other science discipline such as Physics, Agricultural Science, Biology and Basic Science among Others.

Reference

Ababio, O. Y. (2005). *New School Chemistry for Senior Secondary Schools*. Africans First Publisher's Limited Book House trust, 1 African first Avenue Onitsha, Nigeria.

Abonyi, O.S. (1998). Effect of an Ethnoscience Base Instructional Package On Students' Conception of Scientific Phenomena and Interest In Science. *Unpublished Doctorate Thesis, Department Of Science Education, University Of Nigeria, Nsukka.*

Achor, E. E. (2006). *Issues in Science and Society*. Nsukka, Nigeria: Great A. P. Express Publishers Ltd.

Ada, N. A. (2008). The Challenge of Curbing Examination Malpractice in Nigeria's Educational System. *Paper presented at the 5th Faculty of Education National Conference*, *Benue State University.*

Adedayo, O.A. (2008). Differential Effectiveness by Gender of Instructional Methods on Achievement in Mathematic at Tertiary Level. *Educational Studies in Mathematics*. 37(1).

Adesoji F.A. and Olatunbosun S. (2008). Student, Teacher and School Environmental factors as Determinants of Achievement in Senior Secondary School Chemistry in Oyo State, Nigeria. *The Journal of International Social Research,* 1(2), 45-52.

Afolabi, S.S. and Adesope, A.O. (2010). *General Principle, Methods and Strategies of Teaching.* (A Basic Text for Colleges and Universities). Ibadan. Everlasting Publishers.

Agboghoroma T. E. (2009). Interaction Effects of Instructional Mode and School Setting on Students' Knowledge of Integrated Science. *International Journal of Science Research in Education,* 2(2), 67-75.

Agogo, P.O. (2003). A Practical Guide to the Teaching of Difficult in Nigerian Secondary School. Knowledge Review: *A Multi-disciplinary Journal*. 6(3), 32-34.

Agogo, P.O. (2009). *Topics in Primary Science Education in Nigeria*. Makurdi: Azaben Press.

Agwai V (2008). Strategies for improving students interest in learning scientific concepts. *Journal of Research Education* (2), 225-230.

Aigboman, D.O. (2002). Science for All: Implication for the Teaching and National Development. Anibik Press, Benin City, Nigeria.

Amber A. R and Emily M. E. (2015). Use of High-Level Questioning to Increase Student Achievement in Reading. *Masters of Arts in Education Action Research Papers.(8),* 127.

Aikenhead, G. (2005). Consequences of Learning Science. A Research Perspective *Engineering Education Journal.* (13),39-50.

Ajaja, O. P. (1998). An Evaluation of Differential Effectiveness of Ausubel, Bruner and Karplus Methods of Teaching Biology in Nigerian Secondary Schools. Unpublished PhD. Thesis of University of Benin.

Akinbobola A.O. (2009). Facilitating Nigerian Physics Students' Attitude towards the Concept of Heat Energy. *Journal of Science Paedagog Experiments.* 15(2), 353-366.

Akinbobola, A.O. & Ado, I.B. (2007). Hands-on and Minds-on Strategies for Teaching of Force: Guided Discovery Approach. in E. Udo, U. Uyoata, N.E.U. Inyang, H.Yero, & G.Bello (Eds.), *Hands-on and Minds-on Strategies in the Teaching of Force.* Proceeding of the Science Teachers Association of Nigeria (STAN) *Primary Science Workshop. Uyo:* Afahaide & Bros. Printing & Publishing Company. 65-72.

Akkus. H., Kadayıfçı, H., Atasoy, B. and Geban (2003). Effectiveness of instruction based on the Constructivist Approach on Understanding Chemical Equilibrium Concepts. *Research in Science and Technological Education,* 21(2), 209-227.

Aksela, M. (2005). Effect of computer-assisted inquiry (ICT) on Higher Order Thinking Skills in Chemistry. PhD Dissertation Published, University of Helsinki. Finland.

Albergaria, P.A.(2010). Questioning Pattern and Teaching Strategies in Secondary Education. Procedia Social and Behavioural Science. Magazine Article Published by Elsevier. 2(2), 751-756.

Allington, R. L., and Johnston, P. H. (2002). *Reading to Learn*: Lessons from Exemplary Fourth-Grade Classrooms. New York, NY: The Guilford Press.

Almala, A.H. (2005). A Constructivist Conceptual Framework for a Quality e-Learning Environment. Distance Learning, *ProQuest Educational Journal. 2*(5), 9-12.

Anderson, L. W., and Krathwohl, D. R. (2001). *A Taxonomy for Learning, Teaching, and Assessing:* A Revision of Bloom's Taxonomy of Educational Objectives. New York: Longman.

Andrew, L. (2007). Comparison of Teacher educators' Instructional Methods with Constructivist Ideal. *The Teacher Educator*, 43(3), 157-185.

Anthony, A. D. (2009). The Effect of Simulation Games on Senior Secondary School Students' Performance and Attitude towards Balancing of Chemical Equations. An MPHIL= Dissertation presented to the Dept. of Science Education, Winneba Ghana.

Applegate, M. D., Quinn, K. B., and Applegate, A. J. (2002). *Levels of Thinking Required by Comprehension Questions in Informal Reading Inventories.* The Reading Teacher, Published by the International Reading Association. Nevada, USA.

Arends, R. (1994). *Learning to Teach.* McGraw Hill, Inc. New York.

Arokoyu, A. A. and Ugonwa, R. C. (2012). Assessment of Resource Availability for Chemistry Instruction in Secondary Schools in Rivers State. *Journal of Emerging Trends in Educational Mathematics Education Research and Policy Studies.* 3(3), 346-351.

Asiyai, R. I. (2006). An Appraisal of the Adequacy of the Physical Resources for Teaching Chemistry in Secondary Schools. Resources for Science Technology and Mathematics Education. *In Uchenna Nzewi (Ed.), Proceedings of the 47th Annual Science Teachers' Association of Nigeria Conference.*

Atadoga, M.M. and Onaolapo, M.A.O. (2008). *A Handbook on Science Teaching Method.* Sabon Gari: Zaria, Kaduna State, Nigeria: Shola Press. (1), 38-37.

Atwood, R. K. (1967)."A Cognitive Preference Examination Using Chemistry Content". *Journal Research Science Teaching.* 1(5), 34-35.

Ayogu, Z. U. (2001). Enriching Science, Technical and Mathematics Education. Enriching Science, Technology and Mathematics Education. The Role of New Media. *In Matt. A.* . *Akala (Ed.), 41th National Conference Proceedings of the Science Teachers Association of Nigeria*. 396-398.

Babalola V. T. and Hafsatu A. U. (2015). Application Of Epistemological Codes Methods in the Teaching And Learning of Chemistry at the Secondary School Level of Nigerian Education, *Singaporean Journal of Business Economics, and Management Studies,* 4(8):36-48.

Bagchi, J. P. And Uddin, H. (1990). Cognitive Preferences of Indian Secondary Science Teachers. *International Review of Education*, 36(4), 453-467.

Bamidele, E. F. and Oleyede, E. O. (2013). Comparative Effectiveness of Hierarchical, Flowchart and Spider Concept Mapping Strategies on Students' Performance in Chemistry. *World Journal Of Education. 3 (1), 66-76.*

Balci, S., Cakirogluss, J. and Tekkayass, C. (2005). Engagement, Exploration, Explanation, Extension, and Evaluation (5Es) Learning Cycle and Conceptual Change Text as Learning Tools. Biochemistry and Molecular Biology Education, 3(4), 199-203.

Barton, A.C. (1998). Teaching Science with Homeless Children. Pedalogy, Representation and Identity. *Journal of Reseach in Science Tearching*, 35(4), 379-394.

Ben-Ari, M. (2001). Constructivism in Computer Science Education. *Journal of Computers in Mathematics and Science Teaching*, 20(1): 45-73.

Berci, M. E. and Griffith, B. (2005). What Does It Mean To Question? *Journal Archiving and Interchange Tag Set*, 36(4), 405-430.

Berk, L. (2009). *Child Development.* (8^{th} Edition). Massachusetts: Pearson Education, Inc. New Jersey, United State.

Baser, E.T. (2008). Cited in Pulat S (2009). Impact of 5Es Learning Cycle on Sixth Grade Students' Mathematics Achievement and Attitude towards Mathematic. M.Sc. Thesis of Middle East Technical University. Ankara, Turkey.

Brookfield, S.D. and Preskill, S. (1999). *Discussion as a way of Teaching*. The Society for Research into Higher Education (SRHE) & Open University Press, Buckingham.

Bichi, S. S. (2002). Effects of Problem Solving Strategy and Enriched Curriculum on Secondary Schools Students Achievement in Evolution Concept. Unpublished PhD Dissertation, A.B.U. Zaria.

Biggs, J. (2003). *Teaching for Quality Learning at University*. The Society for Research into Higher Education (SRHE) & Open University Press, Buckingham.

Biological Sciences Curriculum Study (BSCS). (2006). *BSCS Science: An Inquiry Approach*. Dubuque, IA: Kendall/Hunt Publishing Company.

Blank L. M. (2000). A Metacognitive Learning Cycle: A Better Warranty for Student Understanding. *Journal of Science Education.* 84(4), 486-506.

Bloom, B. S. (1965). Taxonomy of Educational Objective Hand Books. Cognitive Domain. David Mckay Company, New York.

Blosser, P.E. (2010). *How to ask the Right Questions*. Arlington, VA: National Science Teachers Association.

Boddy N. Watson K. and Aubusson P. (2003). A Trial of the Five E's: A Referent Model For Constructivist Teaching and Learning. *Research in Science Education.* 2(7), 59-61.

Brad, H. (2000). Teacher-Centered Instruction versus Student-Centered Instruction. *American School Board Journal*. 1(1), 1-5.

Bransford, J., Brown, A. and Cocking, R. (Eds.) (2000). *How People Learn: Brain, Mind, Experience, and School.* Washington, Dc: National Academy Press.

Brown, G. and Wragg, C. (2001). *Questioning in the Primary Schools.* London: Routledge Falmer.

Brooks, J. G. and Brooks, M. G. (1993). *In Search of Understanding: the Case for Constructivist Classrooms.* Alexandria, VA: Association for the Supervision and Curriculum Development.

Brualdi, A.C. (1998). Classroom Questions, Practical Assessment Research and Evaluation. *Peer-Reviewed Electronic Journal.* 6(6).

Bunce, D. M. (1999). Research on Chemistry.in D.Gabel (Ed),*Handbook of Research on Science Teaching and Learning,* New York, Macmillian.

Bybee, R.W. (1997). Improving İnstruction in Achieving Scientific Literacy: From *Purposes to Practice*. Portsmouth, NH: Heinemann.

Bybee, R. W. (2002). *Learning Science and the Science of Learning*. Arlington, VA: NSTA Press.

Bybee, R. W. (2003). BSCE 5Es Model Reprinted from *BSCE Biology*. A Human Approach Published By Kendall/Hunt Publishing Company.

Bybee, R. W. (2004). *Scientific Inquiry and Science Teaching.* In Flick, L. and Lederman N. G. (Eds.), Scientific Inquiry and Nature of Science Implications for Teaching, Learning, and Teacher Education. *Series of Science and Technology Education* Library, Dordrecht: Kluwer. (25),1–14

Bybee, R. (2006). Enhancing Science Teaching and Students Learning: A BSCS Perspective. Paper *Presented at the ACER Research Conference, Canberra, ACT.*

Bybee, R. W. (2009). *The BSCS 5Es Instructional Model and 21st Century Skills*: A Commissioned Paper Prepared for a Workshop on Exploring the Intersection of Science Education and the Development of 21st Century Skills.

Bybee, W. R., Joseph, A. T., April, G., Pamela, V. S., Janet C.P., Anne W. and Nancy, L. (2006). *"The BSCS 5E Instructional Model: Origins, Effectiveness, and Applications."* Colorado Springs, CO: BSCS.

Bybee, R., Taylor, J., Gardner, P., Powell, J., Westbook, A., and Landes, N. (2006). *The BSCS 5E Instructional Model: Origins and Effectiveness.* Colorado Springs, CO: Biological Sciences Curriculum Studies.

Çalık, M., Ayas, A., and Coll, R.K. (2010). Investigating the effectiveness of usage of different methods embed-ded with four-step constructivist teaching strategy. *Journal of Science Education and Technology*, 19(1), 32–48.

Carlson, K. (2003). *Constructivism: What it Means for My Own Teaching*. Center for Development of Teaching and Learning. National University of Singapore.

Caprio, M. W. (1994). Easing into Constructivism, Connecting Meaningful Learning with Student Experience. *Journal of College Science Teaching*, 23(4),45-55.

Cavallo A. (2003). Students' Interpretations of Chemical Reactions Using Open-Ended Questions During The Learning Cycle. *International Journal of Science Education*, 25(5), 58-71.

Çepni, S. and Azar, A. (1998). Analysis of High School Physics Exam Questions. *3rd National Science Education Symposium.* Penang, Malaysia.

Cheng, M., and Gilbert, J. K. (2009). Towards A Better Utilization of Diagrams in Research into the Use of Representative Levels in Chemical Education in J. K. Gilbert and D. Treagust (Eds.), Multiple Representation in Chemical Education (4), 55 - 73. Springer.

Chinwe, N. and Chukelu, U. C. (2011). Effects of Biology Practical Activities on Students' Process Skill Acquisition. *Journal of Science Teaching Association of Nigerian. 36 (1&2), 43 – 51.*

Chukwuneke, B.U. (2006), Problems and Prospects of Repositioning Science Education in Nigeria for Rapid National Development Multidisciple. *Journal of Research Development*. 7(1), 16–22. Educational Reforms in Nigeria for the New Millennium.

Cotton, K. (1988). *Instructional Reinforcement*. Portland, OR: Northwest Regional Educational Laboratory.

Cotton,K.(2001). *Classroom Questioning*. Northwest Regional Educational Laboratory. School Improvement Research Series (SIRS). OR: Portland.

Cotton, K. (2003). *Classroom Questioning*: School Improvement Research Series. Portland, OR: Northwest Regional Educational Laboratory.

Colburn, A. (2009). *The Prepared Practitioner Science Teacher*, 76(6), 10.

Cooter, M.M., and Flynt, R., (1995). Cooperative Learning: An Approach for Large Enrollment Courses. *Journal of Chemical Education*. 72,162-164.

Cutttance, P. (2001). *School Innovation: Pathway to the Knowledge Society*. Canberra: Department of Education, Training and Youth Affairs.

Cleveland, K. (2011). Teaching Boys. "*Science for All".* Alexandria, VA: ASCD.

Crede M. (2008). Study habits, skills, and attitudes: the third pillar supporting collegiate academic performance. *Perspect. Psychol. Sci*., 3: 425- 453.

Cruickshank, D. (2009). *The Act of Teaching.* (5th Edition). New York: McGraw-Hill.

Dahiru, S. Y. (2013). Effects of Collaborative Learning on Chemistry Students' Academic Achievement and Anxiety Level in Balancing Chemical Equations in Secondary School in Katsina Metropolis, *Nigeria. Journal of Education and Vocational Research*. 15(2), 43-48.

Denmole, B.T. and Femi-Adeoye, K.O. (2004). Effects of Concept Mapping Technique on Senior Secondary School Students' Achievement And Retention of Ecology Concepts. *Journal of the Science Teachers' Association of Nigeria,* 39(1&2), 32-38.

Decanato de, L, Ramirez de, M.M.S, Aspee, M, and Irma, S. (2006). Concept Maps: An Essential Tool for Teaching and Learning to Learn Science: Focus on Learning Problems in Mathematics, http://www.Encyclopedia.com/doc /IGI -160922508 .html. (accessed April 21, 2014)

Derebssa, D. S. (2006). Tension between Traditional and Modern Teaching–Learning Approaches in Ethiopian Primary Schools. *Journal of Cooperation in Education.* 9(1), 123-140

Derek, C. (2007). Students' Attitudes Toward Chemistry Lessons: The Interaction Effect Between Grade Level And Gender, *Research Education*, 20(5)**,** 73-18.

Derfel. (2002). *Selman's Five Stages of Perspective* Taking. Retrieved on Nov. 21, 2013 from Http://Everything2.Com/Title/Comfortable. Five Stages of Perspective Taking.

Domin, D. S. (1999). A Review of Laboratory Instruction Styles. *Journal of Chemical Education*, 7(6), 543–547.

Driver, R. and Bell, B. (1986). Students" Thinking and the Learning of Science: A Constructivist View. *The School Science Review.* 67(24), 443–456.

Dillon, J. T. (2005). The Effect of Questions in Education and Other Enterprises. *Journal of Curriculum Studies* 14(2), 127-152.

Duniya, J. N. (2009). Comparative Laboratory Approaches and Expository Method on Acquisition of Science Process Skills and Performance by Analogy Students of Polytechnics. In a Proposal Seminar Paper Presented to the Department of Science Education, Ahmadu Bello University, Zaria, Nigeria.

Ebel, L. R (1954). Procedures for Analysis of Classroom Tests. Educational and Psychological Measurement. SAGE Publications.

Ebel, R.L. and Frisbie, D.A. (1986). *Essentials for Educational Measurement*. Englewood Cliffs, NJ: Prentice-Hall

Eniayeju, D. (2001).Competencies required of Science Education Teachers. A Paper Presented at the *24th Annual Conference of the Science Teachers Association of Nigeria.*

Ergin, İ. (2006). An Example for the Effect of 5Es Model on the Academic Success, Attitude and Recognition Level of Students in Physics Education: "Projectile Motion in Two Dimensions", Ankara: Gazi University Institute of Education Sciences (Doctoral Thesis).

Ergin, I, Kanli, U and Unsal, Y. (2008). An Example for the Effect of the 5Es Model on the Academic Success and Attitude Levels of Students': "Inclined Projectile Motion." *Journal of Turkish Science Education,* 5(3), 26-32.

Ergin, G., Ünsal, Y. and Tan M. (2006). "5E Modeli'Nin Öğrencilerin Akademik Başarısına Ve Tutum Düzeylerine Etkisi": Yatay Atış Hareketi. Örneği. *Ahi Evran Üniversitesi Eğitim Fakültesi Dergis*i. 7(2),1-15.

Erickson, H.L. (2007). *Concept-Based Curriculum and Instruction for the Thinking Classroom.* Thousand Oaks. CA Corwin press. North America.

Ersoy, Y. (2006). Reflections from the Mirror of TIMSS-R-I: A General Profile of Science Teachers in Turkey. *Turkish University Science Education Journal (TUSED),* 3(1):6-8. Avaliable Online:Http://Www.Tused.Org/Internet/Tused/Tufedmain1.Html

Ellis, K. (1993). Teacher Questioning Behavior and Student Learning: What Research Says to Teachers. Paper Presented At the 1993 Convention of the Western States Communication Association (64th, Albuquerque, NM, Feb, 12-16, 1993).

Eisenkraft, A. (2003). Expanding the 5Es Model. *Journal of Science Teacher*, 70(6), 56-59.

Etiubon, R. U. (2007). Teacher Qualification and Experience as Determinants of Quality Chemistry Education in Nigeria. *Journal of Education and Practices*. 5(24),112-114.

Eke, O.M. (2008). The Effects of Parental Economic Status and Pupil Sex On School Achievement in English Language. *Journal of Vocational and Technical Education in Nigeria*. 3(3), 27-28.

Ezeliora, B. (1999). A Comparative Analysis of the Effect of Improvised and Standard Models and Graphics on Students' Achievement and Interest in Chemistry. *Journal of the Science Teachers Association of Nigeria* 3(4),1-5.

Ezeliora, B. (2004). Motivating Secondary School Science Teachers to Face the Challenges of the Third Millennium. *Journal of Science Teachers Association of Nigerian.* 39 (1&2), 82-88.

Ezeliora, B. (2004). Teaching Economic Relevance of Chemistry. A Case Study of Soap Making Project Exhibition. *A Hand Book for Chemistry Teachers by Science Teachers Association of Nigeria.* (152-155)2008.

Federal Republic of Nigeria (2013). National Policy on Education. Abuja: FME.

Felicia, O. and Peter, W. (2013). Enhancing Students' Achievement in Chemistry through the Piagetian Model: The Learning Cycle. *International Journal for Cross-Disciplinary Subjects in Education (IJCDSE)*, 4(4), 23-25.

Fisher, R. (2003). *Teaching Thinking:* Philosophical Enquiry in the Classroom. (2nd Edition). London:Continuum.

Fisher, R. (2005). *Questions for Thinking in English,* Oxford: Nash Pollock.

Francisco, J, Nicoll, G. and Trautmann, M. (1998). Integrating Multiple Teaching Methods into a General Chemistry Classroom. *Journal of Chemical Education*. (75), 201- 213.

Frankel. J. R. and Wallen, N. E. (2000). *How to Design and Evaluate Research in Education.* MccrawHill, Newyork.

Freiburg, H. J. and Driscoll, A. (2000). *Universal Teaching Strategies.* (3rd Edition). Boston, USA Allyn and Bacon.

Frust, E. J. (1958). *Constructing Evaluation Instrument*. New York, Longman Green Company.

Gabel, D. (1999). Improving Teaching and Leaning through Chemistry Education Research: A Look to the Future. *Journal of Chemical Education.* 7(6),548-554.

Gall, J. T. (1984). Research on Questions and Discussion. *Educational Leadership, 42*(3), 505-560.

Gatlin L.S. (1992). The Effect of Pedagogy Informed by Constructivism: A Comparison of Student Achievement across Constructivist and Traditional Classroom Environments. Unpublished Doctoral Dissertation, University of New Orleans, LA: United State.

Gandu, A. A. (2006). A Comparative Analysis of Teacher Cognitive Question Styles on Academic Performance of Senior Secondary School Biology Students. An Unpublished PGDE Research Program. Ahmadu Bello University, Zaria.

Hand, B., Treagust, D. F. and Vance, K. (1997). Student Perceptions of Social Constructivist Classroom. *Journal of Science Education,* 8(1), 561-575.

Harris, C. W. (1974). Problems of Objective Based Measurement. In: Harris, C. W., Alkin, M. C. and Popham, W. J. (eds.). *Problems in Criterion Referenced Measurement.* Los Angeles: Center for the Study of Evaluation, University of California.

Heath, R. W. (1964). Curriculum, Cognition and Education Measurement. *Educational and Psychological Measurement,* 24(2), 239-253.

Hosseini, J. (1993). Application of Bloom's Taxonomy and Piaget Model of Cognitive Process to Teaching of Management Information Systems Concepts. Journal of Science Education. 3(5) Retrieved February 07, 2013 from Web: http://gise.org/JISE/vol1-5/APPLICAT.html

Ibe, E. (2004). Effects of Guided Inquiry, Demonstration and Conventional Methods of Teaching Science on Acquisition of Science Process Skills among Senior Secondary

School Students. An Unpublished M.Ed. Thesis, Department of Science Education, University of Nigeria, Nsukka

Ibrahim, T.S. (2015). Impact of 5Es learning cycle on academic performance, Retention and Attitude of Biology Students with Varied Abilities, North-West Zone, Nigeria. Unpublished Ph.D. Thesis. Ahmadu Bello University Zaria

Ibitoye, L.N. (1998). The Effects of a Mastery Learning Strategy on Achievement, *Journal of Research in Science Teaching*, 16(6), 33-37.

Iloputaife, E.C. (2001). Effects of Analogy and Conceptual Change Instructional Model on Physics Achievement among Secondary School Students. Unpublished Ph.D. Thesis, University of Nigeria, Nsukka.

Instructional Development, Center for Teaching Excellence Questioning, Levels and Type of Question. Retrieved 02/08/2014. http://www.oiv.uiuc.edu/did/docs/quest1..

International Center for Leadership in Education, Inc. (2001-2006). Instructional Strategies: How to Teach for Rigor and Relevance: Teacher Handbook.

Isa, Y. B. (2012). Effects of a Constructivist Instructional Strategy on the Academic Achievement, Retention and Attitude to Physics among Secondary School Students of Different Ability Levels in Kano, Nigeria. Unpublished Ph.D. Thesis. Ahmadu Bello University Zaria

Iliya, B. S. (2011). Teachers' Cognitive Questioning Styles and their Effects on Academic Performance of Junior Secondary School Students in Integrated Science in Giwa Inspectorate Division. Unpublished M.Ed. Thesis. Ahmadu Bello University Zaria.

Ivowi, U.M.O. (1997). Redesigning School Curricular in Nigeria, *WCCI Region Seminar*, NERDC Conference Center, Lagos, Nigeria.

Jegede, S. A. (2003). The Effect of the Component Task Analysis Model of Instruction on Students' Performance in Chemistry. An Unpublished Ph.D. Thesis, University Of Ado Ekiti, Nigeria.

Jayapraba, G. (2013). Matacognitive Awareness in Science Classroom of Higher Secondary Students. Kanmani, Moi University *International Journal on New Trends in Education and their Implications* 4(3), 49 - 56

Joe, A. I. (1983). An Exploratory Study of Nigerian Students' Cognitive Preferences in Biology. *Journal of the Science Teachers' Association of Nigeria*. 22(1). 104-112.

Joyce, R., Weil, M., and Calhoun, E. (2000). *Models of Teaching* (6^{th} Edition). Needham Heights, MA.

Jyoti, P.B. (2014). Factors Affecting Cognitive Style in Biology: *India Journal of Science and Mathematics Education in S.E. Asia*. 25(1), 41-55.

Katsina State Ministry of Education. (2014). Annual Bulletin Published by the Ministry.

Kamau, D.M. (2012). A Study of the Factors Responsible for Poor Performance in Chemistry Among Secondary School Students in Maagwa District, Kenya. Unpublished M.Ed Thesis Kenyatta University, Kenya.

Kelley, T., Ebel, R. and Linacre, J.M (2002). Research Measurement Transactions. Center for the Study of Evaluation, University of California.

Kurt, H.and Somchai, B.M. (2004). A Comparison of Students' Achievement and Attitudes Between Constructivist and Traditional Classroom Environments in Thailand Vocational Electronics Programs. *Journal of Vocational Educational Research*, 29(2), 1-3.

Kurumeh, M. S., Omenka, J. E. and Mohammed, A S. (2013). Re-branding mathematics : An Approach to Enhancing Students' Performance in Mathematics in Anambra State, Nigeria. *Greener Journal of Education Research.* 3(1):39-45.

Kilaruz, Y. (2005). The Effects of 5e Learning Cycle Model Based On Constructivist Theory on Tenth Grade Students' Understanding Of Acid-Base Concepts. Unpublished M.Ed Thesis Middle East Technical University.

Lawson, A.E. (2002). *Science Teaching and Development of Thinking*. Wadswoth/Thomson Learning.

Lee, C. A. (2003). A Learning Cycle Inquiry into Plant Nutrition. *American Journal of Biology Teaching*, 65(2):136–144.

Liu, T., Peng, H., Wu, W., and Lin, M. (2009). The effects of Mobile Natural-Science Learning Based on the 5Es Learning Cycle: A Case Study. *Educational Technology and Society, 12*(4), 344-358.

Lord, T. R., (1999). "A Comparison Between Traditional and Constructivist Teaching in Environmental Science". *The Journal of Environmental Education,* 30(3), 22–28.

Lorsbach, A. W., (2006). "The Learning Cycle as a Tool for Planning Science Instruction". Http://Www.Coe.İlstu.Edu/Scienceed/Lorsbach/257lrcy.Htm. (11/05/2013)

Llewellyn, D. (2005). *Teaching high school science through inquiry*. Thousand Oaks, CA: Corwin Press.

Lundy, M. M. (2008). *The Nature of Questioning Moves used by Exemplary Teachers During Reading Instruction* (Doctoral dissertation). Retrieved from Proquest.

Maab, M. and Artique, M. (2013). Implementation of Inquiry based learning in day to day teaching: A Synthesis, *ZDM Mathematics Education.* 45, 779-795.

Maduewesi, B.U, Aboho, D. A and Okwuedei, C. A. (2010). *A Practical Guide to Curriculum Development.* Onitsha, Nigeria: West and Solomon Publishing Coy Ltd.

Madu, B.C and Amaechi C.C.(2012). Effect of Five-Step Learning Cycle Model on Students' Understanding of Concepts Related To Elasticity. *Journal of Education and Practice. 3(9).*

Mari, J. S. (2001). The Effects of Process Skills Instruction on Formal Reasoning Ability Among Senior Secondary School Students in Kaduna State. Unpublished PhD Dissertation. Department of Education. Ahmadu Bello University, Zaria.

Mailumo, P.H, Agogo, P.O. and Kpagh, J.E. (2009). Education in Fundamental Chemistry. Makurdi: *Journal of Publishers (Nig.) Ltd.*

Makanong, A. (2000). The Effects of Constructivist Approaches on Ninth Grade Algebra Achievement in Thailand Secondary School Students. Unpublished Doctoral Dissertation. University of Minnesota, Minneapolis.

Marais, F. and Combrinck, S. (2009). An Approach to Dealing with the Difficulties Undergraduate Chemistry Students Experience with Stoichiometry. *South African Journal of Chemistry*. 62, 88-96.

Martins, O.O. and Oyebanji, P.K. (2000). The Effects of Inquiry and Lecture Methods on the Cognitive Achievement of Integrated Science Students. *Journal of the Science Teachers' Association of Nigeria,* 35(1&2), 31-35.

Mitrevski, B. and Zajkov, O. (2012). Physics Lab, Critical Thinking and Gender Differences. Institute of Physics, Faculty of Natural Sciences and Mathematics, Gaz Baba bb. 1000, Skopje, Republic of Macedonia. *Macedonia Physics Teacher,* (48), 13-18.

Miller, M.D., Linn, R.L. and Gronlund, N.E. (2009). *Measurement and Assessment in Teaching,* 10th Edition. Upper Saddle River, NJ; Prentice Hall.

Morgan, N.and Saxton, J. (1991). *Teaching, Questioning, and Learning*. New York: Routledge.

Mukherjee, A. (2004). Promoting Higher-Order Thinking Skills in MIS/CIS Students Using Class Exercise. *Journal of Information System.* http:// Findacles.Com/Panticles/Mi-qa4041/15-200407/ni-nq437801.

Myhill, D.and Dunkin, F. (2005). Questioning Learning. *Journal of Languages and Education* 19(5), 415-427.

Nadelson, I.S. (2009). Pre-Service Teachers Understanding and Vision of How to Teach Biological Evolution. *Evolution Education and Outreach*, 2(3), 490-504.

National Research Council, (2000). Inquiry and the National Science Education Standards. Washington, DC: National Academy press.

NSTA, (2001). Assessment: www.nsta.org/about/positions/assessment.aspx

NERDC, (2006). *New Senior Secondary Education Curriculum.* National Educational Research Development Council. Press. National Policy on Education Revised, Abuja

Neo, M., and Neo, T. K. (2009). Engaging Students in Multimedia-Mediated Constructivist Learning–Students' Perceptions. *Educational Technology and Society*, 12(2), 254–266.

Nuhoglu H, and Yalcin N (2006). The Effectiveness of the Learning Cycle Models to Increase Students Achievement in the Physics Laboratory. *Journal Turkish Science Education* 3(2), 28–30.

Njelita, C.B (2007). "Enhancing Science Process Skills Acquisition in Volumetric Analysis Using Co-operative Learning Strategy", *Journal of Chemistry panel workshop* 3(7), 32 – 34).

Njoku, Z. C. (2005). Level of Chemistry Practical Science Skills Acquired by Senior Secondary School (SSII) Students. Nigeria *Journal of Professionals Teachers*, 2(2).

Nwosu, A. A. (2004). Teachers' Awareness of Creativity Related Behaviors Science Classroom. *Journal Science Teacher Association of Nigeria*. 39(1,2), 22-26.

Obeka, S. S. (2010). Effects of Inquiry and Demonstration Methods in Students Achievement and Retention in Some Environmental Concepts of Geography. *Journal of Studies Science and Mathematics Education*. 1(1),52-58.

O'Brien, T. (2010). Brain-Powered Science. Teaching and Learning with Discrepant Events. Arlington, VA: NSTA Press.

Ogenyi, S. D. (2014). Impact of Science Process Approach on Cognitive Questioning Preference, Academic Achievement and Retention Spans among Chemistry Students. Unpublished PhD Dissertation, Ahmadu Bello University, Zaria, Nigeria.

Ogunboyede, M.O. (2003). Sex Differences and Students Achievement at the Primary School Level. *The Nigerian Academic Forums.* 5(1), 154-155.

Ogunyemi, E.O. and Bettie, J.C. (1974). An Investigation of Cognitive Preferences in Mathematics among High and Low Mathematics Achievers in Two Nigerian Secondary. *African Journal of Educational*. 1(1), 97-105, Ogunyemi, E.O. and Eboda, P.M. (1974). Cognitive Preference among High and Low Physics Achievements in two Nigerian Secondary Schools. *African Journal of Educational Research.* 1(1), 170-109.

Okafor, P.N. (2003). Innovations in scientific and technological literacy for sustainable development in Africa. *43rd STAN/CASTIME African Conference Proceedings.* Lagos: Heinemann Books (IIg.) Plc.

Okebukola, P. A. (2002). Beyond the Stereotype to New Trajectories in Science Teaching. Ibadan: *Science Teachers Association of Nigeria.*

Okeke, E.A.C. (2007). Making Science Education Accessible to all. *23rd Inaugural LectureSeries, University of Nigeria, Nsukka.*

Okeke B. and Ezekannegba C. N. (2000). Chemistry Education In The Science of Formality for Sustainable Development 43rd Annual *Science Teachers Association of Nigeria* (SAN) Conference Proceedings Pp.270-273

Okoli, J.N. (2006). Effects of Investigative Laboratory Approach and Expository Methods on Acquisition of Science Process Skills by Biology Students of Different Levels of Scientific Literacy. *Journal of STAN*. 41(1&2), 79- 88.

Omoifo, C. (2002). Students' Perceptions and Patterns of Transition in Science Learning in Two non-Western Countries. In Annual Meeting of the *National Association of Research in Science Teaching (NARST).*

Olatoye, R.A., Aderogba, A.A. and Aanu, E.M. (2011). Effects of Cooperative and Individualized Teaching Methods on Senior Secondary School Students Achievements in Organic Chemistry. *The Pacific Journal of Science and Technology*, 12(2), 310-319.

Oliver, R. (2007). Exploring an Inquiry-Based Learning Approach with First-Year Students in a Large Undergraduate Class, *Innovations in Education and Teaching International,* 44, 3-15.

Olorukooba, S. B. (2001). The Relative Effects of Cooperative Instructional Strategy an Traditional Methods on the Performance of Senior Secondary School Chemistry Students. An Unpublished Phd Dissertations A.B.U Zaria.

Osborne, R. and Wittrock, M.C. (1983). *Learning in Science.* The Implications of Children's Science. Auckland, Heinemann.

Otor, E.E. (2011). Effects of Concept Mapping Strategy on Students' Attitude and Achievement in Difficult Chemistry Concepts. A Ph.D. Thesis Submitted to the Postgraduate School, Benue State University Makurdi, Nigeria

Pandey, R.C. (2008). Academic Achievement as Related to Achievement Motivation andParental Background. *Indian Psychology Revision.* 70 (4),213-216.

Parkinson, J. (2004). *Improving Secondary Science Teaching.* London: Routledge Falmer.

Patrick, S. and Ezenwa, V.I. (2000). Gender Consideration of the Effects of Visual Aids and Tactile Stimuli in the Teaching of English in Selected Secondary Schools in Bosso LGA of Niger State. *Journal of Science, Technology and Mathematics Education, 171-179.*

Perkins, D. N. (2010). Are Cognitive Skills Context Bound? *Educational Researcher,* 19(1),16 25.

Peterson, D. S., and Taylor, B. M. (2012). Using Higher Order Questioning To Accelerate Students' Growth In Reading. *The Reading Teache*r, *65*(5), 295.

Piaget, J. (1960). *Six Psychological Studies.* The Psychology of Intelligence. Vintage: New York

Piaget, J. (1970). *Structuralism* (Chaninah Maschler, Trans.). New York: Harper and Row.

Pizzini, E. L., Abel, S. K. and Shepardson, D. S. (1988). *Rethinking Thinking in Science Classroom.* The Science Teacher, 55(9):22-25..

Popham, W.J. (1981). *Modern Educational Measurement*. Englewood Cliffs, NJ: prentice hall.

Prince, M., and Felder, R. M. (2007). The Many Faces of Inductive Teaching and Learning. *Journal of College Science Teaching, 36, 14-20.*

Pulat, S. (2009). Impact of 5E Learning Cycle on Sixth Grade Students' Mathematics. Achievement and Attitude towards Mathematics. M.Sc. Thesis of Middle East Technical University.

Rathore, H. C. S. and Singh A. P. (1987). Cognitive Preferences and Academic Achievement of Tenth Grade Biology Students. *Indian Educational Review,* 22(4), 29-37.

Richards, J. C. (1996). *Reflective Teaching in Second Language Classrooms*. New York: Cambridge University Press.

Salman, M. F. Olawoye, F.A. and Yahaya, L.A. (2011). Education reforms in Nigeria: Implications for Girl-Child Participation in *Science, Technology and Mathematics (STM). Education Research Journal* 1(1), 1-8.

Samba, R. M. O. and Eriba J.O (2012). Background Information on Teaching Difficult Science Concepts. In Samba, R.M.O and Eriba J.O. (Eds). Innovative Approaches in Teaching Difficult Science Concepts , Makurdi, Nigeria: Destiny Ventures.

Salau, M.O. (2003). Constraint Against Life Coping Skills in the Implementation of the National Policy on Education at the Secondary School Level and Strategies for Redress. *Journal of CON*, 10(2):465-470.

Saigo, B.W. (1994). A Study to Compare Traditional and Constructivism based Instruction of a High School Biology Unit on Biosystematics. Unpublished Doctoral Dissertation: University of IOWA, IOWA City.

Saxena, A. K. (1986). Attitude towards Physics and Cognitive Preferences Styles among Different Groups of Science Students. Indian Dissertation Abstracts.

Science Curriculum Improvement Study, (1964). Teachers' Handbook Berkeley: Lawrence Hall of Science.

Settlage, J. (2000). Understanding the Learning Cycle: Influences on Abilities to Embrace the Approach by Pre-service Elementary School Teachers. *Science Education,* 84(1), 43-50.

Sponken-smith, R. and Walker, r. (2010). Can Inquiry Based Learning Strengthen The Links Between Teaching And Disciplinary Research? Studies in Higher Education. 35(6), 723-740.

Singh, Y.K., Sharma, T.K. and Upadhya Brijesh (2012). *Educational Technology: Techniques of Tests and Evaluation.* New Delhi: APH Publishing Corporation.

Stiggins, R.J., and Liston, S.(2006). Guidelines on the Use of Instructional Questions as Classroom Assessment. Portland, OR: Northwest Regional Educational Laboratory,

Stiggins, R. (2008). An Introduction to Student Involved Assessment for Learning. (5th Editon). New Jersey: Pearson Education, Inc.

Susan, D. (2001). Cognitive Questioning and Academic Achievement. *Middle School Journal,* (18) 29-33

Tamir, P. (1985). Meta-Analysis of Cognitive Preferences and Learning. *Journal of Research in Science Teaching,* 22(1), 1-17.

Tamir, P. (1988). The Relationship between Cognitive Preferences Students Background and Achievement in Science. *Journal of Research in Science Teaching*, 25(3), 201-216.

Taber, K. S.(2006.).Beyond Constructivism: The Progressive Research Program Into Learning Science. *Studies in Science Education,* 42:125-184.

Tobin, K; and Tippins, D. (1994). Constructivism as a Referent for Teaching and Learning. In K. Tobin (ed), Controvert in Classroom Research, (2nd. Edition) Buckingham. Open University Press.

Tienken, C. H., Goldberg, S., and DiRocco, D. (2010). Questioning the questions. *Education Digest: Essential Readings Condensed for Quick Review, 75(9),* 28-32.

Treagust, D. F., Duit, R. and Fraser, B. J. (1996). Improving Teaching and Learning in Science and Mathematics. Teacher College Press: New York, Columbia University.

Tuckmam, B. W. (1975). *Measuring Educational Outcomes*. Handout Base Huvawick, New York.

Uce, M. (2009). Teaching the Mole Concept Using a Conceptual Change Method at College Level. Education, 129, 683-691.

Udogu, M. E. and Njelita, C. B. (2010). Effect of Constructivist - Based Instructional Model on Students' Conceptual Change and Retention on Some Difficult Concepts in Chemistry. *An International Multi-Disciplinary Journal , Ethiopi.4(2), 219-229.*

Ültay, N.,and Çalik, M. (2016). A Comparison of Different Teaching Designs of 'Acids And Bases' Subject. *Eurasia Journal of Mathematics, Science & Technology Education.*, 12(1), 57-86.

Usman, I.A. (2000). Relationship between Students Performance in Practical Activities and their Academic Achievement in Integrated Science using NISTEP Mode of Teaching, Unpublished Ph.D Thesis Department of Education, A.B.U. Zaria.

Usman, I.A.(2006). Strategies for Condition Practical in Science, Technology and Mathematics. A Lead Paper, Presented at STAN Workshop, at Federal Government Girls' College, Malali, Kaduna.

Usman, I. A. and Memeh (2007). The Relationship between Student's Performances in Practical Activities and their Academic Achievement in Integrated Science using NISTEP Mode of Teaching. Unpublished PhD Thesis, A.B.U Zaria.

Usman, I. A. (2008). The Effect of Class Size on Students' Academic Performance in Integrated Science at Junior Secondary School Level. As Observed by *Journal of Science Teacher and Maths Education.* Federal University of Technology, Minna. Nigeria.1 (1), 144-149

Vogler, K. E. (2005). Improve Your Verbal Questioning. *The Clearing House*, 79(2), 98-103.

Wang, H., and Posey, L. (2011). An Inquiry-Based linear Algebra Class, Online Submission, US-China Education Review, B 4, 489-494.

Walsh, J., and Sattes, B. (2005). *Quality questioning: Research-Based Practice to Engage Every Learner.* Thousand Oaks, CA: Corwin Press.

West African Examination Council (WAEC) (2009, 2014). *Chief examination reports* (2011, and 2012). Katsina State: WAEC.

White, J.H. (1999). Constructivism in a College Biology Classroom: Effects on Content Achievement, Cognitive Growth, and Science Attitude of act-Risk Students. *Unpublished Doctoral Dissertation*, North Carolina State University, Raleigh.

Woolfolk,A.E., Winne,P.H., and Perry,N.E. (2003). *Educational Psychology*. Toronto: Allyn & Bacon,Inc.

Wilen, W. (1991). Questioning Skills for Teachers. What Research Say to the Teacher. 3rd ed. Washington, S. D; *National Education Association* (ED 332-983)

Wilder, M.,and Shuttleworth, P. (2005). Cell inquiry: A 5E Learning Cycle Lesson. *Science Activities: Classroom Projects and Curriculum Ideas*, *41*(4), 37-43.

Wilson, C, D., Taylor, J. A., Kowalski, S. M., and Carlson, J. (2010). The Relative Effects and Equity of Inquiry-Based and Common Place Science Teaching on Students' Knowledge, Reasoning, and Argumentation. *Journal of Research in Science Teaching*, *47*(3), 276-301.

Yadigaroglua,M. and Demircioglub, G. (2012). The Effect Of Activities Based On 5Es Model On Grade 10 Students Understanding Of The Gas Concept. Procedia-Social And Behavioral Science. 47, 634-637.

Zepeda, S.J. (2009). *The Instructional Leader's Guide to Informal Classroom Observations*. Eye on Education, Inc.

Zoller, U. (2001). Interdisciplinary Systemic HOCS Development – The Key for Meaningful Stes- Oriented Chemical Education. *Chemistry Education: Research and Practice in Europe (CERAPIE), 1, 189–200.*

Zohar, A. and Dori, Y. (2003). Higher Order Thinking Skills and Low Achieving Students - Are They mutually exclusive? *Journal of the learning sciences*, 12(2): 145-182.

Zohar. A. (2004). High Order Thinking Skills in Science Classroom: Students learning and Teachers' Profession Development. *Science and teaching Educational Library*. (22).

APPENDICES

APPENDIX A
CHEMISTRY PERFORMANCE TEST (CPT)

TIME ALLOWED: 1HRS

ATTEMPT ALL QUESTIONS

DO NOT START UNTIL YOU ARE TOLD TO DO SO

School Name: ____

Student's Name: ____

Exam Number: ____

Male or Female:___________________

Part 1: Multiple Choice Test Item

1. Potassium and Sodium show similar properties because they

    i. Belong to the same group in the periodic table

    ii. Have equal number of electron in their outer-most shells

    iii. Both exist in the + 1 oxidation state in the compound

    iv. Belong to the same period in the periodic table

    A. All are correct

    B. I and IV are correct

    C. III and IV are correct

    D. I, II, III are correct

2. The presence of sodium chloride in ice will

    A. Decrease or lower the boiling point of the sodium chlorine

    B. Increase the melting point of the sodium chloride

    C. impure sodium chloride

    D. Lower the freezing point of sodium chloride

3. Avogadro number can be defined as the number of

i. molecules in $22.4dm^3$ of a gas at s.t.p

ii. Electrons in 96500 coulombs of electricity

iii. Ratio of elements in a compound.

iv. Molecules in one mole of a compound

A. All are correct

B. I and IV are correct

C. III and IV are correct

D. I, II, III are correct

4. A soda water manufacturer wants his soda 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 a bottle rather than in cans

5. Which of the following statement(s) is/are correct about trend of ionization energies of elements in the periodic table?

i. The noble gases have the highest ionization energies in each period

ii. Ionization energy decreases down Group 1 elements

iii Ionization energy generally increases from left to right across a period

iv. The alkali metals have the lowest ionization energies in each period

A. All are correct

B. I and IV are correct

C. III and IV are correct

D. I, II, III are correct

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

   A. PV=K

   B. V=KT

   C. R & 1/VP

   D. PV=RT

7. In the reaction;

   $$N_2(g) + H_2(g) \underset{\text{Iron}}{\overset{\text{Finely divided}}{\rightleftharpoons}} NH_3(g)$$

   Why was finely divided iron used as catalyst?

   A. to increase the forward reaction

   B. to reduce the energy barrier

   C. to increase the surface area of the reactant

   D. none of the above

8. Which of these 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

9. "Equal volume of all gases at the same temperature and pressure contain the same number of molecule" is an expression of?

   A. Charles' law

   B. Boyle's law

C. Graham’s law

D. Avogadro’s law

10. Which of the following statements is not correct about Group 7 elements?

A. are diatomic

B. are good oxidizing agents

C. are highly electronegative

D. have relatively low ionization energy

11. What is the common name given to group VII elements?

A. Alkaline earth metals

B. Halogens

C. Hydrides

D. Negative ions

12. The Gas law which explains the relationship between volume and temperature is?

A. Boyle’s law

B. Charles’ law

C. Dalton’s law

D. Graham’s law

Part 2: Short Answer Test Items

13. Determine the number of unpaired electrons in the atom of an element whose atomic number is 8?

14. State what will happen when atmospheric pressure equals the saturated vapors pressure?

15. Explain why iodine crystals changes directly into the gaseous state when heated?

16. State Gay-Lussac’s law and illustrate the law with one chemical reaction.

17. How many mole of $AgNO_3$ are there in $500cm^3$ of 0.01M $AgNO_3$ solution.

18. Define a Standard Solution?

19. Calculate the mass of one atom of carbon given that one mole of carbon weights 12.0g.

    [L=6.02×10^{23}]

20. State two ways in which boiling differs from evaporation

    i. ---

    ii. --

21. Reaction occurs when the colliding reactant particles have?

22. Give two ways by which a solid solute can be made to dissolve more quickly in liquid solvent.

23. Which of the state of matter contains particles that are:

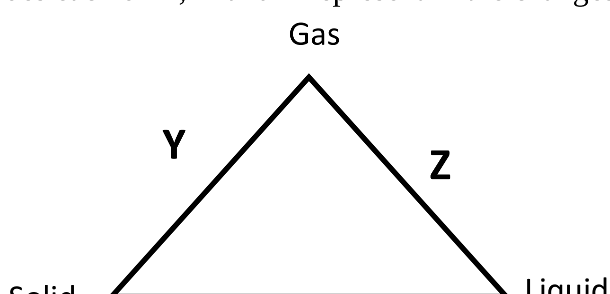
    i. Readily compressed

    ii. Held firmly together by some forces of cohesions

    iii. Involved in rapid random motion

24. Give two differences between a solids and gases.

25. What process does each of X, Y and Z represent in the changes shown below?



26. State Charles' law and draw a sketch to graphically illustrate Charles' law

27. Arrange the three state of matter in order of increasing

    i. Kinetic energy

    ii. Force of cohesion

28. Determine the number of sulphur atoms in 3.20g of SO_2 (g).

    [O=16.0; S=32.0; Avogadro constant = 6.02×10^{23}]

29. How does the collision theory affect the rate of chemical reaction?

30. Consider the following reversible reaction which occur at the temperature of 298k:

    $N_2(g) + 3H_3(g) \longrightarrow 2NH_3(g)$

    Propose two factors that would increase the formation of $NH_3(g)$

APPENDIX B
Answer Sheet

School Name: ____

Student's Name: ____

APPENDIX C
Marking scheme

Part 1: Objective Test Items

1. D
2. A
3. B
4. C
5. A
6. D
7. C
8. A
9. D
10. D
11. B
12. B

(1 mark each = 12 mks)

Part 2: Short Answer Test Items

13. An element with an atomic number of 8 has this electronic configuration

    From the configuration, there are 2 unpaired electrons **(2mks)**

14. Boiling **(1mks)**

15. This happens because iodine crystals are held together by weak forces**. (2mks)**

16. Gay-Lussac's law states that when gases combine, they do so in small whole number which bear simple ratio to one another and to the product formed if gaseous at the same temperature and pressure. **(3mks)**

Example: $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

Mole ratio: 2 1 3

17. 0.005mole **(2mks)**

18. A standard solution is a solution of known concentration. **(1mks)**

19. 2.0×10^{-23}g **(2mks)**

20. i. Evaporation differs from boiling in that it is the separation of a solute from its solution while boiling simply refers to the state when the pressure of a liquid is equal to its external pressure.

    ii. Evaporation is determined by temperature while boiling is determined by temperature. **(2mks)**

21. Energy that is less than effective collision. **(1mks)**

22. i. heating the solute in solvent.

    ii. Improving the surface area of solute or changing is form. **(2mks)**

23. i. Gas

    ii. Solid

    iii. Gas **(3mks)**

24. i. Solids have definite shapes while Gases have no definite shape

    ii. Solids cannot be compressed while gases are easily compressed

    iii. Solids are held together by strong attractive force while gases molecules are held together by weak attractive force. **(3mks)**

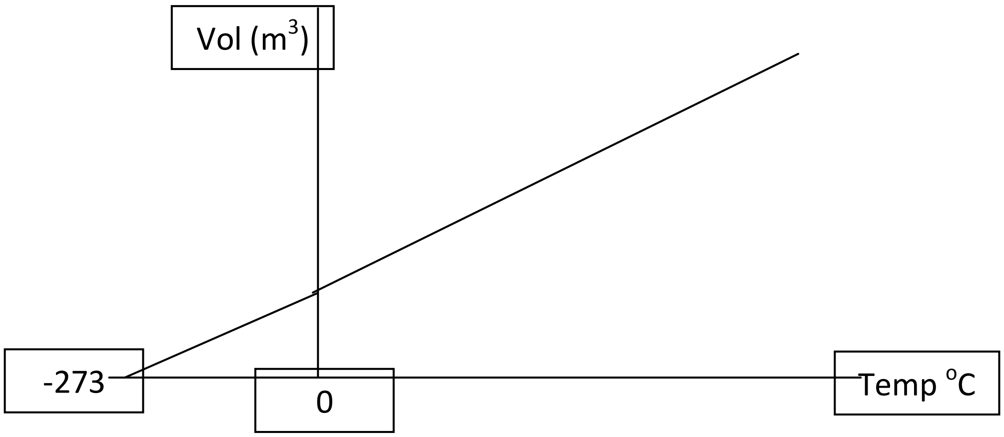
25. i. Liquid to solid X is freezing

    ii. Solid to gas Y is Sublimation

    iii. Gas to liquid Z is Condensation **(3mks)**

26. Charles' law states that the volume of a given mass of gas is directly proportional to its absolute temperature at constant pressure. **(3mks)**

It is graphically represented as;



27. i. solid < liquid < gas

ii. gas> liquid > solid **(2mks)**

28. 3.01×10^{22} atom **(2mks)**

29. The collision theory postulates that the rate of chemical reaction is dependent on the number of collision. The higher the number of collisions per time, the higher the rate of reaction.**(2mks)**

30. i. Lowering the temperature

ii. High pressure

iii. Increase in concentration of nitrogen and hydrogen **(2mks)**

Part 1: 12mks

Part 2: 38mks

Total = 50mks

APPENDIX D

5Es INSTRUCTIONAL MODEL LESSON PLAN

LESSON PLAN ONE

WEEK ONE

Method of Teaching:	5Es LESSON PLAN
Subject:	Chemistry
Group:	Experimental
Class:	SS II
No. Of Students In Class:	83
Topic:	Periodic Table
Title:	Electronegativity, Electron Affinity, Atomic Radius, Atomic Mass, Ionization Energy
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio. Revised Edition.

Instructional Materials:

- Periodic Table of Elements
- Periodic Table Scavenger Hunt worksheet
- Paper and pencils/pens

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

1. Be familiar with the trends in the periodic table.
2. Describe how elements are arranged in the periodic table.
3. Compare elements based on their properties and on their location in the periodic table.

4. Describe the difference between a period and a group.

Previous Knowledge: Students have been taught Electronegativity, Electron Affinity, Atomic Radius, Atomic Mass, Ionization Energy.

Introduction: Introduction of the lesson will take the form of revision of the previous learnt lesson and provision of materials needed for the lesson, organizing students and resources needed for effective learning process. The students' are grouped in to table groups.

Lesson presentation: A total of 83 students make up the experimental group. The researcher will introduce the activities and emphasize the need for each student to participate fully. A Periodic Table Scavenger Hunt worksheet will be provided for each student.

Activity 1: Engagement

The students will learn a song on how to memorize the elements of the periodic table.

- Students make list of five things that are periodic and explain which repeating property causes each one to be periodic.
- Students respond to questions; some possible answers may include the seasons, the months of the year, the television program schedule, and sport seasons, phases of the moon, and the schedule of classes.
- After data has been collected, have students construct a chart/ table in which to arrange what they have written based on similar and differing characteristics.
- Collect charts; choose a few, without naming names, to share with the class. Initiate discussion regarding the process of developing the charts. What are the similarities and differences between the charts? Which characteristics were chosen? Why? Did everyone use the same characteristics? Are they specific/discerning enough? What other characteristics might we use? Objective vs. subjective? Testable?

- Discuss and emphasize the difficulties in achieving consensus of characteristics to be used and arrangement of tables. Do you think consensus was achieved immediately in development of The Periodic table? Discuss the need for standardization of characteristics and arrangement of Periodic table.
- As a reinforcing activity, ask three volunteers to stand at the front of the class. Put two of them together, and ask the third to step off to the side for a moment. Ask the class what similar characteristics the two students share in other words, why would these two be grouped together? List students' responses on the board. Encourage students to look for as many similarities as possible.
- Now separate the two; ask the third student to stand next to one of them. Repeat the exercise. Compare the two lists of characteristics. Discuss with the class the similarities and differences in the lists. Pick out the characteristics which are most specific and may best discern one person from the other. Guide students to responses away from purely the obvious physical characteristics, to those that we might measure. I.e. mass etc.
- Introduce to students notion that there tables are like the periodic table i.e. rows and columns, with similar characteristics being grouped together by these rows and columns.

Probing Questions

How is the periodic table arranged? Why is it arranged that way? How do valence electrons relate to that arrangement? What does the number of valence electrons tell you about an element?

Student responses

Increasing atomic size which actually decreases across a period. This should lead into a discussion about the history of the periodic table.

Activity 2: Exploration

Periodic Table Activity: Students will explore how the periodic table is arranged using review information about groups and periods as well as incorporating information about valence electrons and properties. Every student will have a note card with the name of an element taped to their back. They must determine what their element is by asking other students questions such as “Do I have 7 valence electrons?” They may only ask yes/no questions and may only ask one question per student. The students cannot ask atomic number, symbol, or atomic mass as they guess the element. Discuss as a class the engagement questions. Discuss properties of elements that can be predicted from the periodic table. Ask students what these properties mean and what they describe about the element. The properties include electronegativity, electron affinity, atomic radius, atomic mass, and ionization energy.

Probing questions

Students will be called on to explain how they determined which element they had. What other questions might you have asked to determine your element? What can you learn about an element from its position on the periodic table? What is atomic mass? Where can you find atomic mass? What is the atomic mass of oxygen? What is atomic radius? What factors might affect atomic radius? What do you think ionization energy is? What does it tell us about the element? What do you know about electronegativity? What do you know about electron affinity? How is it related to electronegativity?

Activity 3; Explanation

Brief lecture about the properties of electronegativity, electron affinity, and ionization energy. Following the brief lecture we will ask the students questions about these properties and the elements. Students will work in groups of 2 or 3 and will write down their answers on a sheet of paper then we will call on students to share their answers. We will collect their papers at the end of class to use as formative assessment. Which element do you expect to have the largest atomic mass? Smallest? Why? Have the students describe what they think the trends are in these properties. The students will be given copies of the periodic table and pass around markers. They will use the markers to draw the trends in different colors so that they can use it as a reference later in the course.

Probing Questions

Based on what you know, which element do you expect to have the highest electronegativity? The lowest? Why? (Students will have to explain their answers) Which element do you expect to have the largest atomic radius? Smallest? Why? Which element do you expect to have the highest electron affinity? Lowest? Why? Which element do you expect to have the highest ionization energy? Lowest? Why? Which element do you expect to have the largest atomic mass? Smallest? Why? Have the students describe what they think the trends are in these properties.

Students Responses

Students should be able to use their knowledge about valence electrons and ions to predict that the element with the highest electronegativity will be in the halogen family. Many of them may not be able to pick out the correct element in the family however. Many will likely guess Astatine because it is larger. Similarly, they should be able to predict that the element with the smallest electronegativity will be in the 1st group. But they will likely choose H. Students will most likely mistakenly think that atomic radius increases with atomic mass. So they may guess Radon or one of the heavier elements. Using the same reasoning, they will likely guess that H has the smallest radius. Since electron affinity is similar to electronegativity at this point it is expected that students will be able to predict that F has the highest electron affinity and Fr has the lowest. Students should be able to guess that it is hardest to remove an electron from He. Fr has the lowest ionization energy. Students should know that the largest elements have the biggest mass and vice versa.

Activity 4: Elaboration

Teacher show the students a model of the periodic table. Discuss how the trends can be used to predict reactivity and why it is important to understand the trends. Discuss nuclear charge and how that affects the trends. Discuss the effects of electron shielding. With remaining time students will have the option of three different activities to reinforce the vocabulary learned in the lesson. The activities will be at different difficulty levels to provide differentiated instruction. The activities will require students to recognize and understand the vocabulary from the lesson.

Probing Questions

What are the trends that you see in the periodic tables? Explain what your periodic table model.. How do the trends of the different properties compare? Why does atomic radius have a different trend than atomic mass? Why do you think electronegativity and electron affinity have similar trends? The periodic table model shows first electronegative. Do you think it is possible to have 2nd or even 3rd order electronegativity values? Why or why not? How can the trends you just modeled help you predict what will react together or how violently two elements might react? What determines the nuclear charge? How does it affect atomic radius? How does it affect the other trends? Why does Fluorine have a higher electronegativity than iodine? Think about atomic structure.

Students Response

The models should help the students see the trends and recognize how they are similar. They should be able to respond that electronegativity, electron affinity, and ionization energy follow the same general trend. Each group of students can display their models and should be able to articulate the trends for the respective property. We have already discussed the atomic radius trend so students should be able to tell us that the increasing protons as you move right across a period pull the electrons in, decreasing the radius. They should also be able to make the connection that the increase protons also add mass. Students may have some trouble understanding the difference between electronegativity and electron affinity. They will likely not have an accurate guess about why elements can have multiple electronegativity. This will be a good opportunity. to relate this concept to the concept of ions. Students should be able to tell us that elements with high electronegativities will react with low electronegative elements and so on for the other properties. Students should know that the number of protons affects nuclear charge. The higher the nuclear charge, the smaller radius, as in the trends. Students will likely not know what shielding is. We will have to prompt them and to think about electron configuration to figure out what it is.

Activity 5: Evaluation

At the end of the lesson, the students' in their groups will be given a copy of the Periodic Table Scavenger Hunt sheet to complete.

Periodic Table Scavenger Hunt

1. The name of the element whose symbol is U.________________________
2. The name of the heaviest element on the chart.______________________
3. The symbol of the element with an atomic mass of 207.2____________________
4. The symbol for the element gold.__________________________________
5. The element in group 4 period 4.__________________________________
6. The symbol for tin.________________________________
7. The number of periods on the Periodic Table. _________________________________
8. An element whose atomic number is 53.__________________________________
9. An element whose atomic mass is 173.04._______________________________
10. The name of group 14. ____
11. The element before silver._________________________________
12. The name of the element with the symbol Pt.______________________________
13. The lightest weight metalloid.______________________________
14. A metalloid with the atomic mass 12.011_________________________________
15. Group and period of the element Iodine.__________________________________
16. Element with atomic number 81.__________________________________
17. Element in group 4 period 7. _____________________________________
18. Two elements next to each other that have decreasing atomic masses. _____________________
19. How many electrons are in the element hydrogen? ______
20. How many protons are in the element bromine (Br)? _____

Answer To Periodic Table Scavenger Hunt

1. Uranium
2. Hassium
3. Pb (Lead)
4. Au
5. Titanium Ti
6. Sn
7. 7
8. Iodine I
9. Ytterbium Yb
10. Carbon Family
11. Palladium Pd
12. Platinum
13. Hydrogen
14. Carbon
15. Group 17 , period 5
16. Thallium Tl
17. Manganese (Mo)
18. Tellurium Te 127.6

    Iodine I 126.9
19. 1
20. 35

LESSON PLAN TWO

WEEK TWO

Method of Teaching:	5Es LESSON PLAN
Subject:	Chemistry
Group:	Experimental
Class:	SS II
No. Of Students In Class:	83
Topic:	Mole Concepts
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio.Revised Edition.

Instructional Materials:

- Periodic Table chart
- NaCl, $CaC0_3$, water, conical flasks, measuring cylinder, weighing balance, crate of eggs, oranges

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

1. Define mole, molar mass and standard solution.

2. Write a balanced equation of the reaction and show ratio of reactants to products in the balanced equation and the actual number of moles of reactants to products.

3. Explain how moles relate to mass.

Previous Knowledge: Students have already been taught periodic table, elements and atomic mass.

Introduction: Teacher uses dozen of eggs, oranges, to show that the mole can be represented in numbers in terms of measurement. Teacher asks students to count the number of eggs in the crate and the oranges. S/he further asks them whether they can count the sand particles on the ground.

Lesson presentation: A total of 83 students make up the experimental group. The researcher will introduce the activities and emphasize the need for each student to participate fully.

Activity 1: Engagement

Phase 1: Questions relating to learners environment were posed by the teacher. You are going to a party and you have been asked to help out by preparing stick meats for 20 people. The recipe given is as follows: 4kg of meat. 1 litre of warm water and 0.1 litre of oil i. What information does the recipe provide? ii. What is the ratio of substances used in the recipe? iii. Convert the amount of flour used in grams? iv. Convert litre of water and oil to cm^3.

Phase 2: If grains of rice are weighed on a kitchen balance and corresponding masses of grains are given as:

Number of grains of rice	Corresponding mass
200	5.0g
400	10.0g
800	15.0g

Probing Questioning

i. What quantity of grains will weigh 2.5g? ii. What is the ratio of grains of rice to mass? iii. Assuming 200 grains is equivalent to 1 mole of rice, how many moles will 400 grains and 800 grains be? iv. If you were to receive 300hundred per second, how long will it take to accumulate l million naira? Assuming there are 6.03×10^{23} particles inside 300hundred naira. Where 6.02×10^{23} is equal to (a term called mole), how many naira are equal to 1 mole; 2 moles; 3 moles.

Activity 2: Exploration

Students are supplied with substances placed on the bench tables arranged according to your working groups. i. Observe the specimen bottles ii. Identify each one from the labels and copy down the names of the substances on the specimen bottles. iii. Identify the substances in terms of color and smell. iv. Write down the formula of each substance (students had learnt how to write formula in form 1). v. Deduce the number of atoms in each substance. vi. Write down each element and find its position in the periodic table; show the metals and the non-metals. vii. Write down the atomic number and atomic mass of each element.

Applying the knowledge you had in form 1 on particles of an atom, show the number of protons, electrons and neutrons in each element

If He is expressed as 1 mole He, express 2 NaCl, Mg, $Ca(OH)_2$ in moles. Do the same for the substances you listed in (iv) Express NaCl in ionic form and show number of moles of ions for Na and Cl from the ionic formula. Do the same for the substances you listed in IV above. If 1mole of NaCl is calculated by adding together the atomic mass of sodium and chlorine, calculate the mass of 1 mole of Na_2CO_3, NaOH, H_2SO_4, $Ca(OH)_2$.. Now (B) measure $1000cm_3$, $250cm^3$, $500cm^3$ of water using volumetric flask Measure 0.5mole $Ca(OH)_2$, put the substance into a beaker, put some water and stir, pour into $1000cm^3$ volumetric flask and top water to exactly $1000cm^3$, shake. What was the mass of 0.5M $Ca(OH)_2$ that you measured?

How big is 1 mole?

Activity 3: Explanation

The concept: The mole, conversion of mole to mass, mass to mole, and volume, molar solution, standard solution, mole ratio; Avogadro number; the periodic table and equations are discussed among students. Teacher continued to make open suggestions, providing models where necessary. S/he may show sample of summary of the mole concept using the concept map and ask each group to design similar maps on the topics or choose alternative designs of their own.

Activity 4: Elaboration

The activities in the previous stage would be extended if the students identified the relationships in the mole and are able to extend the knowledge gained so far to a general formula which may guide them in further calculations.

V_1 cm^3 of M_1HCl solution reacted with V_2 cm^3 of M_2 KOH solution.

In the titration, V1M1/1000 = moles of HCl reacted with $V_2M_2/1000$ = moles of KOH

Probing Question

What is the ratio of volume to mole of HCl and KOH in the equation? Deduce (i) the formula for the conversion of mass of a substance to mole. (ii) Unit of concentration and hence define the term concentration.

Activity 5: Evaluation

The diagrams which the students drew and the dexterity with which they deduced formula, balanced and interpreted equations helped the students and the teacher to assess the extent students understood the concepts. Misconceptions were clarified by the teacher as s/he closely supervised students in their discussion groups. Students' recorded work (group) were also examined by the teacher and adequately scored.

Probing Questions

How will you prepare a 0.05M solution of H_2SO_4. Define (a) the mole (b) molar mass (c) (d) standard solution. How does the mole relate to mass? How many moles are in 36g of water? What is the benefit of the mole to the chemist? Do a glossary of important words you came across during the lesson. Write a balanced equation of the reaction between potassium hydroxide and tetraoxosulphate VI acid (sulphuric acid); show ratio of reactants to products in the balanced equation and the actual number of moles of reactants to products.

LESSON PLAN THREE

WEEK THREE

Method of Teaching:	5Es LESSON PLAN
Subject:	Chemistry
Group:	Experimental
Class:	SS II
No. Of Students In Class:	83
Topic:	Gas Laws: temperature, pressure, volume and mole of gas
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio.Revised Edition.

Instructional Materials:

- calculators
- temperature probes
- soda cans
- water bin or tub
- hot plates
- beaker tongs
- graduated cylinder, beaker, pipettes
- ice (optional)

Safety Alert:

- goggles
- aprons

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

- Understand the relationship among temperature, pressure, volume and moles of gas.
- Calculate the effects of pressure, temperature, and volume to gases using Gas Law Formulas

Previous Knowledge: The students have already been taught the kinetic theory of gases and the different Gas laws.

Introduction: The teacher introduces the lesson by revising Gas laws with the students and set up the demo section for the lesson. The teacher also engages the students with an event related to the concept that the teacher plans to introduce.

Activity 1: Engagement

Safety Alert: Wear goggles and apronsand Beware of hot and sharp objects.

. Begin the lesson by reviewing Boyle's law and Charles's Law. Discuss pressure, temperature and volume changes with a gas. (Be heating a soda can with about 10 mL of water in it while you are reviewing). The teacher have a student volunteer to dunk the can into a water bin, using tongs and turning it upside down in the process

Possible questions:

What do you observe?

What just happened to the volume of the can? Why?

° Students collaborate, collect data, experiment, build and explore

° Teacher facilitates and checks for understanding

Activity 2: Exploration

Student groups design an experiment to find the final temperature (the temperature inside the Can at the crush point). You cannot keep a probe in the can while it crushes. Explain to students that they are going to have to come up with a procedure that details how they find initial volume, final volume, and initial temperature. They need to explain all equipment and measurements.

Show the materials on the desk.

Ask questions such as:

How do you measure temperature?

What are you going to use?

Students will have a hard time explaining how to find final volume. Let them figure out that the best method to finding the final volume is by filling the crushed can with water. Then, putting the water in a graduated cylinder to read the final volume. In the laboratory notebook, students should create a pre-lab consisting of: title, objective, materials, and procedures. In their procedures, make sure that students include how the temperature probes were used to measure the initial temperature of the can. Students need to also explain what will be graphed (temperature and volume).

Students must submit the written pre-lab to the instructor prior to performing the lab.

Safety Alert: goggles, aprons, beware hot and sharp objects.

Once the groups' procedure is approved, students begin the experimentation. The kids get excited, especially on the first dunk.

° Students explain what was learned while exploring

° Teacher monitors for correct understanding.

Activity 3: Explanation

Discuss with the student groups what happened and why. Students should make the connection that as the can was heated the water turned to a vapor and expanded inside the can (also a change in pressure). When the can was dunked, the temperature change caused the gases inside to condense and the change in pressure caused the can to collapse.Ask them to use the data to calculate the final temperature inside the can using Charles's law.

Using a graph book, ask them to transfer the data to their experimental book.

The graph should be a straight line graph because of the relationship being directly proportional between temperature and volume. If it is not, discuss what went wrong.

Students graph and analyze the data. Students should formulate conclusions and incorporate these sections into the science laboratory notebook.

- Students apply new understanding to real world situations
- Students expand knowledge to related concepts

Activity 4: Elaboration

Challenge students to design an experiment that gets the can to crush the best.

Let students manipulate the design. Such as, creating an ice bath to dunk the cans in, sealing most of the can before they dunk it, changing the volume of the water inside the can, changing the amount of time the can is heated. Let them test original ideas as long as they are safe.

Ask students to compare and contrast the experiments and to summarize what could be done to improve the investigation. Have them use specific examples from the experiment.

- Teacher assesses throughout

- Students reflect throughout

Activity 5: Evaluation

Observe groups as they perform the experiment. Assist with questions and address misconceptions. Ask guided questions to keep students engaged. Evaluate students on the quality and accuracy of the written lab report, graphs and calculations. Ask students to write the mathematical presentation of Boyle's law, Charles's law etc. Ask students explain how volume, temperature and pressure relate in the of Boyle's law.

LESSON PLAN FOUR

WEEK FOUR

Method of Teaching:	5Es LESSON PLAN
Subject:	Chemistry
Group:	Experimental
Class:	SS II
No. Of Students in Class:	83
Topic:	Rate of Chemical reaction
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio. Revised Edition.

Instructional Materials:

- Rusted iron
- Calcium tablets
- Test tubes
- Hydrogen peroxide
- Yeast
- Zinc
- Hydrochloric acid
- Hot water bath

Safety Alert:

- goggles
- aprons

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

- explain what is mean by the rate of a reaction
- State the factors the effect the rate of chemical reaction.

Previous Knowledge: The students have already been taught the Chemical reactions using a burning candle and a jar to illustration.

Introduction: The teacher introduces the lesson by revising chemical reaction with the students and set up the demo section for the lesson. The teacher also engages the students with an event related to the concept that the teacher plans to introduce and explains briefly to the students the collision theory, that they must be a collision between reactant particles for a chemical reaction to occur and for this to happen, the colliding particles must possess a certain minimum amount of energy called the activation energy. Every reaction has its own energy of activation depending on the factors affecting the rate of reaction. A reaction with activation energy will take place spontaneously at room temperature. A reaction with a high activation energy will only take place if energy is supplied, usually in form of heat, light or electrical energy. The addition of a catalyst lowers the activation energy of a reaction.

Activity 1: Engagement

The teacher begins the lesson by taking a calcium tablets, drops one in cold water and one in warm water. Ask the students to observe. Which one dissolves quicker? Which show that a given reaction can occur at different rates if the conditions of the reaction are different. From the above demonstration, calcium tables dissolves slowly in cold water and rapidly in warm water. After which, the teacher divides the students into three groups.

The first group is given HCl of different concentration, 4 test tubes in a test tube rack and four pieces of zinc.

The second group is given; 3 beakers, hot water bath, ice cubes, 3 medium test tubes, 1.0M HCl(aq) and 3 small pieces of zinc of about equal size. And the third group will be hydrogen peroxide, test tube and yeast.

Activity 2: Exploration

Students participate in activities to explore the concept. This exploration provides students with a common set of experiences from which they can initiate the development of their understanding.

To the first group: Get 4 clean small test tubes and set them in a test tube rack. Pour 5ml of 0.1M HCl(aq) into the first test tube, 5ml of 1.0M HCl(aq) into the second, 5ml of 3.0M HCl(aq) into the third and 5ml of 6.0M HCl(aq) into the fourth. Obtain four small pieces of zinc of about equal size. Drop one piece of zinc into each test tube.

Have students record their results and make hypothesis.

To the second group: Put 100ml of tap water into each of 3 beakers. Put one on a hot water bath, put two ice cubes in another and leave the third at room temperature. Obtain three medium test tubes and pour 5ml of 1.0M HCl(aq) into each. Put one test tube into each beaker. Obtain three small pieces of zinc of about equal size. Drop one piece of zinc into each test tube.

Have students record their results and make hypothesis.

To the third group: 1. Pour 5ml of .3% hydrogen peroxide into a clean test tube. Add little amount of yeast, watch the reactions carefully for the hydrogen peroxide to decompose into hydrogen and oxygen gas. Record results.

Activity 3: Explanation

The teacher clarifies the concept and defines relevant vocabulary as needed. Students interpret data, construct inferences, make predictions, and build explanations.

Teacher explains that the speed or rate of chemical reactions differ greatly. Some reactions are fast and others are slow. For a reaction to occur there must be a collision the reactant particle. This is referred to as Collision theory. There are different factors that affect the rate of chemical reaction. Some of which are Concentration, Temperature and catalyst. From the Exploration process, **Group one** are to determine the effect of Concentration on the rate of a reaction, **Group two**; the effect of temperature of the rate of reaction and **Group three** the effect of a catalyst on the rate of reaction.

Teacher explains to the students that an increase of decrease in the concentration of the reactants will result in a corresponding increase or decrease in the effective collision of the reactants and hence in the reaction rate. Increase in temperation can lead to an increase in reaction rate. Adding of a catalyst will fasten the reaction rate as in group three.

Activity 4: Elaboration

Students elaborate and build on their understanding of the concept by applying it to new situations and problems. Teacher asks the students to connect the relationship between their observations and teacher's explanation.

Activity 5: Evaluation

Students' complete activities that will help them as well as a teacher evaluate their understanding of the concept with a short 5mins quiz. Teacher asks students to explain how each of the factors studied affects rate of reaction.

LESSON PLAN FIVE

WEEK FIVE

Method of Teaching:	5Es LESSON PLAN
Subject:	Chemistry
Group:	Experimental
Class:	SS II
No. Of Students in Class:	83
Topic:	State of Matter and Change of State
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio.Revised Edition.

Instructional Materials:

- Beakers
- Ice blocks
- Ice cream cone
- Hot plate
- Bottle
- Pea nuts
- Hand hair dryer

Safety Alert:

- goggles

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

- Differentiate between the three states of matter
- Explain the change of state the takes place between the three states off matter.

Previous Knowledge: The students have already been taught the molecules, atoms, matter, what is matter and kinetic theory of matter.

Introduction: the teacher introduces the lesson by revising what is matter and how matter can be generally classified by their physical properties and the state of matter. The teacher ask the students to look around the classroom and identify some of the matter that they see since matter is anything that has mass and occupies space and it is part of our everyday live because Air is matter; it takes up space and has mass. The teacher then asks the students to classify the object into solid, liquid and gas.

Activity 1: Engagement

To engage the students, we will be performing a melting ice experiment and balloon activity. The teacher divides the students into groups, shares the ice block and beakers, ice cream cone and Balloons to the groups. Ask the students to melt the blocks by putting them into the beakers and putting it on the old plate, and then ask students to also observe what happens to the ice cream cone over a period of time when keep in the refrigerator and when kept close to the hot plate and they should blow air into the balloon.. Let students record their observations of what happens to the ice block in the beaker and the ice cream cone according to their own understand.

Activity 2: Exploration

Ask the students whether they know what happens when a substance gets hot or cold. Ask them if they ever had an ice cream cone on a hot day. Ask them what they think is happening in both of these circumstances. Ask groups to perform the experiments as teacher

Provide learners with common, concrete, tactile experiences with skills and concepts. Observe and listen to students. Ask probing questions. Act as a consultant, walk round to supervise.

Probing Questions:

- What happens when matter goes from a solid to a liquid or vice versa?
- Is it still matter when it changes phases?
- What characteristics do you notice when it is a liquid?
- What characteristics do you notice when it is a solid?

By this students explore their own understanding from their little experiment. Ask students to blow up their balloon without tying it. They will squeeze the balloon to keep it closed.

- Ask students "Does it feel like something is inside the balloon when you blow it up?"
- "What do you think makes up the inside of the balloon?"
- Have students release a little bit of the air in their face so they feel the air coming out
- "Do you feel anything when you release the air from the balloon?"
- "What do you think the air represents?"

Quickly discussion on how the air in the balloon represents the gas phase of matter.

Activity 3: Explanation

The teacher clarifies the concept and defines relevant vocabulary as needed. The teacher allows the students generate their own definitions for each phase of matter, allow them to generate the different properties that make up each phase, and allow them to generate their own examples for each phase. During this section I will be informally assessing them based on their prior knowledge and what they have picked up so far.

• Solid- A state of matter that has a definite shape and takes up a definite amount of space.

• Liquid- A state of matter that takes up a definite amount of space but has no definite shape

• Gas- A state of matter that does not take up a definite amount of space and has no definite shape

• "What does a liquid look like?" "How do you know it is a liquid?" What examples of liquids can you come up with?"

The teacher generates questions like this for all three phases and further explaining to the students the forces of cohesion the exist between the molecules, atoms and ions of a solid, liquid and gas by demonstrating to the class how the particles or molecules move in matter using a 2 liter bottle, peanuts (representing particles or molecules) and hair hand dryer. The teacher does this with two or three students to assist. Take the peanuts and put them into the 2liter bottle.

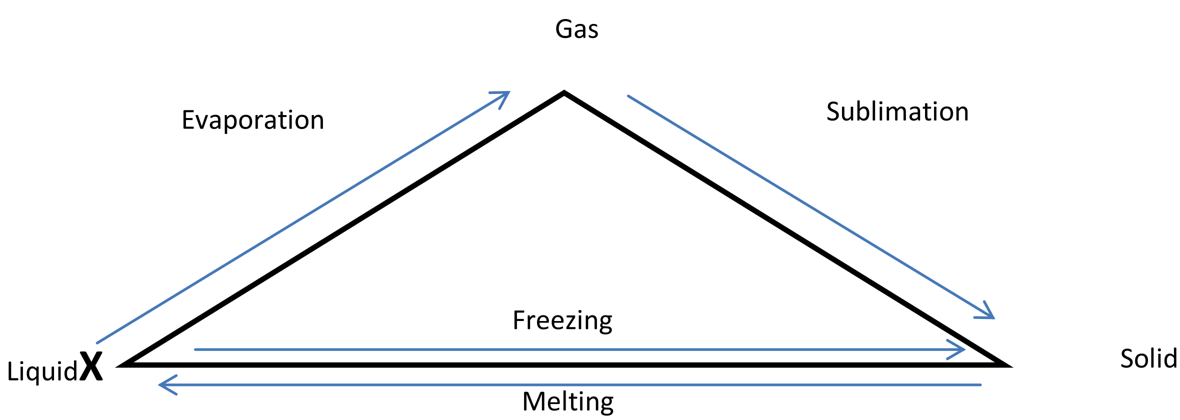
For solid, the peanuts are closed together which shows that the molecules are very closely packed and are held together firmly by force of cohesion. The cohesive forces binding the molecules or particles of a solid are strong enough to restrict their movement so there are held in fix position.

For liquid, turn on the hair dryer on low and blow air into the bottle. There is some movement, which shows that the particles in liquid are slightly further apart than those of solid. The can vibrate, rotate and translate but they are still under the influence of cohesive forces and their movements are restricted.

For gases, turn the hair dryer on high to demonstrate the faster movement of the particles (peanuts in the bottle). This implies that, the cohesive forces in a gas are negligible and the particles are free to move about in all directions at great speed, restricted only by the walls of the container. Gas particles are relatively far apart and may be readily compressed.

Activity 4: Elaboration

Students elaborate and build on their understanding of the concept by applying it to new situations and problems. Teacher use the engagement activity to elaborate on the changes that takes place in the state of matter, as an experimental phase change. Teacher explains the melting ice and ice cream cone experiment. Teacher explains that substance can exist as a solid, liquid or a gas. Change of state is brought about by a change in temperature that is heating or cooling as they have done in the engagement activity of melting the ice block on heat to liquid and the steam that comes out as gas which when cool can also exist as liquid. The figure below summarizes the change of state of matter and shows that a substance can exist as a solid, liquid or a gas.



Activity 5: Evaluation

Students will complete an exit slip about states of matter.

- Give an example of each phase.
- Explain the properties that make up each phase.
- Is it the same substance when it changes phases?
- Differential between evaporation and condensation?

Other evaluations are embedded within the lesson.

APPENDIX E

LECTURE METHOD LESSON PLAN

LESSON PLAN ONE

WEEK ONE

Method of Teaching:	LECTURE METHOD
Subject:	Chemistry
Group:	Control
Class:	SS II
No. Of Students in Class:	81
Topic:	Periodic Table
Title:	Electronegativity, Electron Affinity, Atomic Radius, Atomic Mass, Ionization Energy
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio.Revised Edition.

Instructional Materials:

- Periodic Table chart
- Chalk board
- Text book

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

1. Be familiar with the trends in the periodic table.
2. Describe how elements are arranged in the periodic table.
3. Compare elements based on their properties and on their location in the periodic table.

4. Describe the difference between a period and a group.

Previous Knowledge: Students have been taught Atomic structure and chemical combination.

Introduction: Introduction of the lesson will take the form of revision of the previous learnt.

- **i.** what is an atom and what do u understand by atomic mass and mass number?
- ii. define electron configuration and electronic affinity?

Lesson Presentation: The teacher presents the lesson with the following step.

Step 1:

The teacher begins the lesson by showing the student a large model of the periodic table. And Asking then what it is. Then explain to then a brief history of the periodic table and how Electronic configuration of atoms is the basis of the periodic table.

Step 2:

The teacher explains and shows to then how the periodic table is been arrange.

i. Division of the periodic table into eight vertical columns known as Groups and seven horizontal rows known as Periods. Division of the Groups into numbers from 0 to 7 and the Periods from 1 to 7. Elements in the same group have the same number of electrons in the outermost shell of their atoms and elements in the period have the same number of electrons shells that is elements of period 2 have two electron shells e.t.c.

ii. The teacher further explains the features of the periodic table which shows a diagonal division metals, metalloid and non-metals, using the periodic table model to show the division.

Step 3: the teacher explains the atomic properties of the periodic table such as the atomic radius, ionic radius, ionization energy, electron affinity and electronegativity

Step 4: The teacher explains the atomic properties of the elements of the periodic table; vary across and down the periodic table.

- Atomic radius decreases across the periodic table and increases down the periodic table.
- Ionic radius decreases across the periodic table till group 3, peaks at group 4, and then decreases again while down the periodic table, it increases.
- Ionization energy increases across and decreases down.
- Electronic affinity decreases down and increases across.
- Electronegativity increases down the table and decreases across the table

The teacher familiarizes the students with the elements of each group in the periodic table, their physical properties and chemical properties.

Students' Activity: Students observe listen and answer teacher's questions

Step 5: Evaluation: The teacher asks students the following questions:

1. Define the electron affinity and electronegativity and how it varies down and across the periodic table.
2. Explain how electronic configuration is a basis for the periodic tables.

LESSON PLAN TWO

WEEK TWO

Method of Teaching:	LECTURE METHOD
Subject:	Chemistry
Group:	Control
Class:	SS II
No. of Students in Class:	81
Topic:	Mole Concepts
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio. Revised Edition.

Instructional Materials:

- Periodic Table chart
- Text book
- Chalk board
- NaCl, CaC03, water, conical flasks, measuring cylinder, weighing balance

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

1. Define mole, molar mass and standard solution.
2. Write a balanced equation of the reaction and show ratio of reactants to products in the balanced equation and the actual number of moles of reactants to products.
3. Explain how moles relate to mass.

Previous Knowledge: Students have already been taught periodic table, elements and atomic mass.

Introduction: Introduction of the lesson will take the form of revision of the previous learnt.

Lesson presentation: The teacher presents the lesson with the following step.

Step 1:

Teacher's Activities: Teacher shows students atomic masses of elements in Periodic Table. The Teacher explains that particles of element cannot be counted but can be represented in grams. Each element measured in grams = 1 mole =Av No= 6.023 x1023.

Step 2:

Teacher's Activities: Teacher defines the term mole. S/he demonstrates to the students how to Calculate the molar mass of compounds; then how to measure 1mole of NaCl, CaC03. Teacher asks students to weigh ¼ of same substances given the value in mole and Avogadro number.

Students' activity: Students measure ¼ of 1 mole of NaCl, CaC03 using the weighing balance.

Step 3:

Teacher's Activities: Teacher measures 1000 cm^3, 500 cm^3, 250 cm^3 of solutions of NaCl, $CaC0^3$; then relates mole to volume; the teacher then defines the mole, molar mass; explains the conversion of mole to mass to volume; defines molar solution, standard solution.

Students' activity: Students carry out the same demonstration as directed by the teacher. They ask questions and answer teacher's questions.

Step 4:

Teacher's Activities: Teacher prepares 0.05MHCl, 1MKOH. He/she demonstrates the difference between molar and standard solution. S/he writes on the chalk board the equation for the reaction between HCl and KOH and explains the concept of mole ratio. She gives more examples of how mole ratio is determined in an equation. Concept of concentration is explained and the formula written for the students on the chalk board.

Students' Activity: Students observe listen and answer teacher's questions

Step 5: Evaluation: Teacher assesses students by giving them the following assignment:

(1) Define the following; (i) the mole (ii) molar mass

(2) Distinguish between molar solution and standard solution

(3) Balance the equation of reaction between Sulphuric acid and Potassium Hydroxide.

LESSSON THREE

WEEK THREE

Method of Teaching:	LECTURE METHOD
Subject:	Chemistry
Group:	Control
Class:	SS II
No. Of Students In Class:	81
Topic:	Gas Laws; temperature, pressure, volume and moles of gas
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio.Revised Edition.

Instructional Materials:

- Text book
- Chalk board
- Calculator

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

- Understand the relationship among temperature, pressure, volume and moles of gas.
- Calculate the effects of pressure, temperature, and volume to gases using Gas Law Formulas

Previous Knowledge: The students have already been taught the kinetic theory of gases and the different Gas laws.

Introduction: The teacher presents the lesson with the following step.

Step 1:

Begin the lesson by reviewing Boyle's law and Charles's Law. Discuss pressure, temperature and volume changes with a gas.

Step 2:

The teacher uses kinetic theory to explain boyle law. Teacher explains that a given mass of gas enclosed in a vessel with a movable piston, which is kept stationary by placing a suitable weight on it. At constant temperature, the average velocity of the gas molecules is constant, so the number of collisions they make with per unit area of the wall of the vessel is also constant that is the gas exerts a certain constant pressure p on the walls of the vessel. The links explanation to the definition of Boyle's law.

Step 3:

Teacher explains Charles's law using kinetic theory. Explaining to the students that a given mass of a gas confined in a vessel with a movable piston, if heated the molecules acquire more kinetic energy, move faster and collide more often with the walls of the vessel, thereby increasing the pressure they exert. To remain at constant pressure, the piston moves up so the volume of the gas is increased. At constant pressure, the volume of a given mass of gas is directly proportional to the temperature.

Step 4:

Teacher explains to students the relationship between mole, Avogadro number and molar volume. Using examples, teacher explains to the students how to calculate volume of a gas.

Student activity: Teacher asks students to solve a question on the board together.

Step 5: Evaluation

Teacher evaluates the students by asking question about the lesson just taught;

i. State the mathematical presentation of Boyle's law, Charles's law.
ii. Ask students to explain how volume, temperature and pressure relate in the of Boyle's law.

LESSON PLAN FOUR

WEEK FOUR

Method of Teaching:	LECTURE METHOD
Subject:	Chemistry
Group:	Control
Class:	SS II
No. Of Students in Class:	81
Topic:	Rate of Chemical reaction
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio.Revised Edition.

Instructional Materials:

- Rusted iron
- Text book
- Chalk board

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

- explain what is mean by the rate of a reaction
- State the factors the effect the rate of chemical reaction.

Previous Knowledge: The students have already been taught the Chemical reactions using a burning candle and a jar to illustration.

Introduction: The teacher introduces the lesson by revising chemical reaction with the students.

Lesson presentation: The teacher presents the lesson with the following step.

Step 1:

Teacher starts the lesson by explaining the meaning of rate of reaction as the number of moles of reactant converted or product formed per unit time. Explain that the speeds of rates of chemical reactions differ greatly. Some reactions are fast while others are slow. The teacher shows the students a rusting iron nail and explains that the rusting of an iron nail in air is a slow process that takes several days.

Step 2:

Teacher explains briefly to the students the collision theory, that they must be a collision between reactant particles for a chemical reaction to occur and for this to happen, the colliding particles must possess a certain minimum amount of energy called the activation energy. Every reaction has its own energy of activation depending on the factors affecting the rate of reaction. A reaction with activation energy will take place spontaneously at room temperature. A reaction with a high activation energy will only take place if energy is supplied, usually in form of heat, light or electrical energy. The addition of a catalyst lowers the activation energy of a reaction.

Step 3:

Teacher explains to the students the factors affecting the rate of reaction. Teacher explains that from the collision theory, the rate of reaction would depend on the frequency of effective collisions between reactant particles. The factors which influence the energy content of the particles, the frequency of collision of the particles, and the activation energy of the reaction will also affect the rate of chemical reactions. List some of the important factors to the students as; concentration of reactant, temperature, presence of catalyst, light etc.

Step 4:

Explain to the students how each of the factors affects the rate of chemical reaction. Teacher explains to the students that an increase of decrease in the concentration of the reactants will result in a corresponding increase or decrease in the effective collision of the reactants and hence in the reaction rate. Increase in temperation can lead to an increase in reaction rate. Adding of a catalyst will fasten the reaction rate.

Step 5: Evaluation

Teacher evaluates the students by asking question about the lesson just taught in form of a 5mins short quiz, to explain how each of the factors studied affects rate of reaction.

LESSON PLAN FIVE

WEEK FIVE

Method of Teaching:	LECTURE METHOD
Subject:	Chemistry
Group:	Control
Class:	SS II
No. Of Students in Class:	81
Topic:	State of Matter and Change of State
Duration:	1hr 30min
Reference:	New School Chemistry, for Senior Secondary School, Ababio.Revised Edition.

Instructional Materials:

- Ice blocks
- Ice cream cone

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

- Differentiate between the three states of matter
- Explain the change of state the takes place between the three states off matter.

Previous Knowledge: The students have already been taught the molecules, atoms, matter, what is matter and kinetic theory of matter.

Introduction: the teacher introduces the lesson by revising what is matter and how matter can be generally classified by their physical properties and the state of matter.

Step 1:

The teacher ask the students to look around the classroom and identify some of the matter that they see since matter is anything that has mass and occupies space and it is part of our everyday live because Air is matter; it takes up space and has mass. The teacher then asks the students to classify the object into solid, liquid and gas. Teacher explains state of matter and gives the fundamental difference between these three states of matter which is the degree of movements of their particles.

Step 2:

Teacher further explains in details how the degree of movement of particles is the fundamental difference between the three states of matter. Teacher explains that for;

Solid: the particles are very closely parked and held firmly together by forces of cohesion. The particles can only vibrate and rotate about their fixed positions but can move from one place to another. As a result solids have definite sharps and volumes and are difficult to compress.

Liquid: the particles of liquid are slightly further apart than those in solid. They can only vibrate, rotate and translate. The particles can slight about randomly, they are still under the influence of the cohesive forces and their movements are restricted. Liquid possesses a fixed volume but has no definite shape or form.

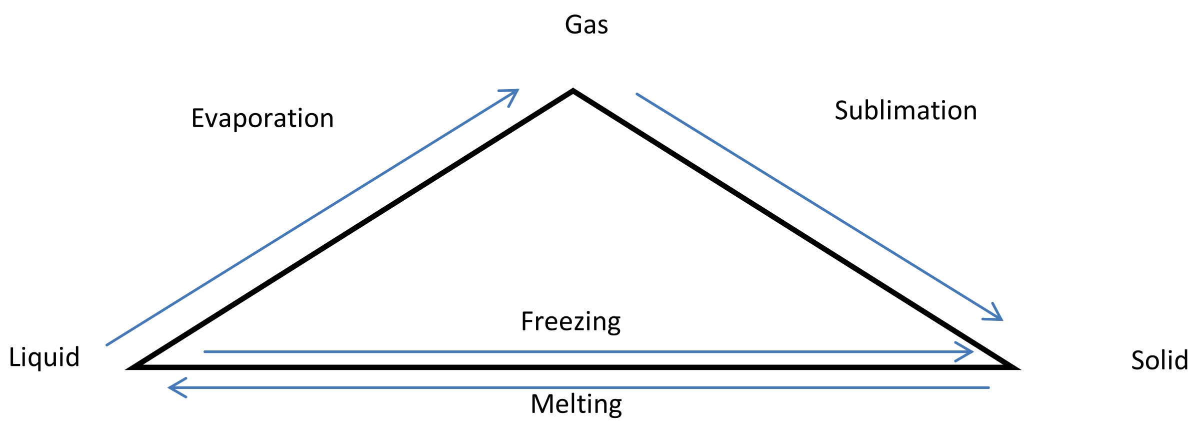
Gases: The cohesive forces in a gas are negligible and the particles are free to move about in all directions at great speed, restricted only to the walls of the container. A gas has no definite shape, it occupies the whole volume of its container, and the particles are relatively apart and may be readily compressed.

Step 3:

Teacher talks about change of states and explains to student that a given substance can exist as a solid, a liquid or a gas. Change of state is brought about by a change in temperature that is heating and cooling. When a substance is heated, its particles acquire more kinetic energy. When cooled, they become less energetic.

Step 4:

Teacher use figure to explain how substance can exist as a solid, a liquid or a gas. From the figure teacher explains Evaporation and condensation, freezing and melting and sublimation.



Step 5: Evaluation

Teacher evaluates the student by asking the following questions:

- Give an example of each phase.
- Explain the properties that make up each phase.
- Differential between evaporation and condensation?

APPENDIX F

Item Analysis for Chemistry Performance Test (CPT): Table for Difficulty and Discrimination Indices

Item	RU	RL	Difficulty Index (P)	P%	Discrimination Index
1	7	6	0.65	65	0.14
2	4	3	0.35	35	0.43
3	8	6	0.70	70	0.29
4	6	6	0.60	60	0.00
5	6	5	0.55	55	0.14
6	6	3	0.45	45	0.14
7	7	5	0.60	60	0.29
8	2	3	0.25	25	-0.14
9	5	4	0.45	45	0.43
10	4	3	0.35	35	0.14
11	7	5	0.60	60	0.29
12	2	3	0.25	25	0.14
13	3	3	0.30	30	0.00
14	6	4	0.50	50	0.57
15	4	3	0.35	35	0.43
16	6	5	0.55	55	0.14
17	3	3	0.30	30	0.00
18	7	5	0.15	15	0.29
19	3	1	0.20	20	0.29
20	2	1	0.15	15	0.14
21	2	0	0.10	10	0.29
22	4	4	0.40	40	0.00
23	4	3	0.35	35	0.71
24	4	2	0.30	30	0.29
25	1	2	0.60	60	-0.29
26	4	4	0.40	40	0.00
27	6	7	0.65	65	-0.14
28	5	4	0.45	45	0.14
29	1	4	0.25	25	0.29
30	8	6	0.70	70	0.57

APPENDIX G

DEPARTMENT OF SCIENCE EDUCATION
AHMADU BELLO UNIVERSITY ZARIA

Vice Chancellor: **Professor Abdullahi Mustapha** *B.Sc(Hons)Pharm(ABU), Ph.D(London) FPSN*
Head of Department: **Dr. Mamman Musa** *B.Ed, M.Ed, Ph.D (ABU, FMAN, FANE, DAC.*

Your Ref:
Our Ref: DSE/R/I/Vol.1 **Date:** 21/05/2015

THE PRINCIPAL
K.C.K (PTTC)
KATSINA

Dear Sir/Madam,

AN INTRODUCTORY LETTER TO ACCESS RESEARCH DATA

This is to introduce the bearer, UMAHABA Ramatu Ematum, with registration number M.Ed/Educ/4454/2011-2012, as one of our Masters in Education students who is conducting a research on the topic: IMPACT OF 5Es LEARNING MODEL ON ACADEMIC ACHIEVEMENT AND COGNITIVE QUESTIONING PREFERENCE OF SECONDARY SCHOOL CHEMISTRY STUDENTS'. KATSINA METROPOLIS, NIGERIA.

Please accept our sincere thanks in advance for your kind action.

Yours faithfully,

Dr. Mamman Musa
Head, Science Education Department

Accepted.
21/5/15
PRINCIPAL
KATSINA COLLEGE KATSINA
SIGN
DATE

APPENDIX H

DEPARTMENT OF SCIENCE EDUCATION
AHMADU BELLO UNIVERSITY ZARIA

Vice Chancellor: **Professor Abdullahi Mustapha** *B.Sc(Hons)Pharm(ABU), Ph.D(London) FPSN*
Head of Department: **Dr. Mamman Musa** *B.Ed, M.Ed, Ph.D (ABU, FMAN, FANE, DAC.*

Your Ref:
Our Ref: DSE/R/I/Vol.1 **Date:** 25-05-2015

THE PRINCIPAL
GOVERNMENT DAY
SECONDARY SCHOOL
KOFAR YANDAKA, KATSINA

Dear Sir/Madam,

AN INTRODUCTORY LETTER TO ACCESS RESEARCH DATA

This is to introduce the bearer, UMAHABA Ramatu Ematum, with registration number M.Ed/Educ/4454/2011-2012, as one of our Masters in Education students who is conducting a research on the topic: IMPACT OF 5Es LEARNING MODEL ON ACADEMIC ACHIEVEMENT AND COGNITIVE QUESTIONING PREFERENCE OF SECONDARY SCHOOL CHEMISTRY STUDENTS'. KATSINA METROPOLIS, NIGERIA.

Please accept our sincere thanks in advance for your kind action.

Yours faithfully,

Dr. Mamman Musa
Head, Science Education Department

PRINCIPAL
G.D.S.S.S. YANDAKA
SIGN
DATE