EFFECTIVENESS OF SCIENCE PROCESS APPROACH ON REMEDIAL SCIENCE STUDENTS' PERFORMANCE IN JIGAWA STATE

BY

ABDULLAHI GUMEL SANI
B.SC. ED (CHEMISTRY)
MED/EDUC/37473/02-03

A THESIS SUBMITTED TO THE POST GRADUATE SCHOOL AHMADU BELLO UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER DEGREE IN SCIENCE EDUCATION

DEPARTMENT OF EDUCATION
AHMADU BELLO UNIVERSITY
ZARIA

FEBRUARY, 2007

DECLARATION

I declare that the work in this thesis entitled "Effectiveness of Science Process Approach on Remedial Science Students' Performance in Jigawa State" has been performed by me in the Department of Education under the supervision of Dr. J.S. Mari. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at any university.

ABDULLAHI GUMEL SANI
………………………………… …………………………….. ……………………………..
NAME OF STUDENT SIGNATURE DATE

CERTIFICATION

This research project entitled "Effectiveness of Science Process Approach on Remedial Science Students Performance in Jigawa State" by ABDULLAHI GUMEL SANI meets the regulations governing the award of the degree of Master of Science Education of Ahmadu Bello University Zaria and is approved for its contribution to knowledge and literary presentation.

Dr. J. S. Mari
…………………………………………… Date………………………………..
Chairman Supervisory Committee.

Dr (Alh.) Usman Isa
…………………………………………… Date………………………………..
Member Supervisory Committee.

Dr. Sadiq Mohammed
…………………………………………… Date………………………………..
Head, Department of Education.

Prof. S. A. Nkom
…………………………………………… Date………………………………..
Dean, Postgraduate School.

DEDICATION

This thesis is dedicated to my parents Malam Musa and Hajiya Hauwa who sacrificed their meagre resources for my education. It also goes to my wife and children for their love and concern.

ACKNOWLEDGEMENT

First and uppermost I would like to express my profound gratitude to God the Almighty through whose Mercies I was able to undertake this study. I also thank the authorities of College of Education Gumel for granting me the opportunity to further my education and of course all those who have in one way or the other been instrumental towards the successful completion of this work. I specially wish to express my sincere gratitude and appreciation to my Major Supervisor in person of Dr. J. S. Mari for the co-operation, scholarly advice and constructive critisms that I received from him.

I am also gratitude to my second Supervisor Dr. (Alh.) Usman Isah whose assistance to me was also instrumental to the successful completion of this study. I must also not forget to extend my appreciation to all the lecturers in the Department of Education (Science Section) for their fatherly and scholarly advice throughout the period of study. My thanks also goes to Dr. Mamman Musa from Mathematics education Section for his invaluable, sound and professional advice which also contributed to the successful completion of this study.

I am grateful to all those who offered services, suggestions, moral and financial support to me while undertaking this research work. They are so numerous in this category to be mentioned here. I want to specially mention the names of Dr. (Mrs) O. O. Busari of University of Lagos, Dr. (Mrs) A. A. Nwosu of University of Nigeria Nsukka and Mallam Saidu Danladi of College of Education, Gumel in this respect for their moral and material support.

Finally I am grateful to my wife Sa'adatu Ibrahim and children Kabiru, Bukhari, Zainab, Musa and Habibu for their patience and good prayers offered for me throughout the period of study.

ABSTRACT

This study was undertaken to determine the effectiveness of Science Process Approach on Remedial Science Students' Performance in Jigawa State. The major objective of the study was to determine whether or not exposure to process approach promotes the acquisition of science skills and performance in chemistry among remedial students in Jigawa State. The study sample consisted of 78 students drown from two tertiary institutions using a purposeful sampling technique. A Pretest-Posttest marched group experimental design was used. College of Education Gumel comprising of forty (40) students was randomly assigned as experimental group while College of Agric Hadejia comprising of 38 students was assigned as the control group. A Pre-test using Teacher Made Test (TMT) was administered to the two groups to determine equivalence of the two groups before treatment, while TOCA & TOSPS was administered as posttest to the two groups after treatment to ascertain the effect of the treatment. The data obtained were analyzed and the hypotheses stated were tested using t-test statistic at 0.05 level of significance. Major findings of the study revealed that:

- Process approach does not seem to be more effective than lecture method in enhancing academic performance in science.
- There was no significant difference in the level of acquisition of science process skills between boys and girls taught Chemistry using the process approach.

Some of the conclusions drown from the findings are:

- Students do not learn Chemistry concept better when they are taught either using process approach or lecture method.
- Boys learn Chemistry concepts better than girls when they are taught using process-based method.
- Process approach is gender-friendly in enhancing process skills acquisition.

In light of the findings from this study, the following recommendations was offered:

* The study revealed that process approach does not seem to be more effective than lecture method in enhancing performance of students in chemistry. As lecture method has been reported by many researches as unsuitable in teaching chemistry, it was recommended that chemistry teachers should strive hard to come-up with alternative method of teaching that will be more effective in improving students' academic performance than the two methods used in this study.

TABLE OF CONTENTS

CHAPTER TWO

CHAPTER THREE

LIST OF TABLES

LIST OF APPENDICES

ABBREVIATIONS USED

In the course of this study, some words have been abbreviated because of their frequent use and terms have been used in special ways. The abbreviated words and specially defined terms are listed below.

ABBREVIATIONS

A P U	-	Association of Performance Unit
A P S P	-	African Primary Science Programme
B P S P	-	Bendel Primary Science Programme
C H E M	-	Chemical Education Material
C E S A C	-	Comparative Education study and Adaptation Centre
D A T	-	Differential Aptitude Test
E S S	-	Elementary Science Project
N S S S P	-	Nigerian Secondary School Science Project
N I S P	-	Nigerian Integrated Science Project
P S S C	-	Physical Science Study Committee
S A P A	-	Science-A process Approach
S T A N	-	Science Teachers Association of Nigerian
S S C E	-	Senior School Certificate Examination
S C I S	-	Science Curriculum Improvement Study
TOCA	-	Test of Chemistry Achievement
TOSPS	-	Test of Science Process Skills

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Problem

Science education is an indispensable tool for national development because of the important position it occupies in the development and growth of all nation. Odunusi (2001) observed that the economic and political strength of a nation is always assessed in terms of her achievement in Science and technology. This may be the reason why emphasis is placed on the provision of science education at all level of education in Nigeria.

The emphasis placed on science and technology along side with the important role it plays towards national development makes it pertinent and practically necessary for science to be taught in an organised and well structured pattern, involving activities for both teachers and students. This will undoubtedly make learning more interesting and meaningful.

In contrary, before the mid 1950s science teaching was geared towards memorisation and regurgitation of scientific knowledge. Akinmade (1996) observed that most elementary science teachers spend most of their time in class teaching for memory and comprehension as opposed to teaching for the development of productive thinking skills. This attitude of teacher centred teaching method continued until the time when the then Soviet Union launched its first satellite (the Sputnik) into space in 1957. This event necessitated a call for a reform in both curriculum content and method of teaching across the globe.

Several curriculum Materials were developed and implemented to reflect this need. This include among others, the Physical Science Study Committee (PSSC), Science - A process Approach (SAPA) and Chemical Education Material (CHEM) developed in United State and Britain. In these programmes, emphasis was shifted from the acquisition of academic knowledge in science through memorisation of fact, to quantitative and applied aspect of science.

In Nigeria, curriculum changes were stimulated by individuals, professional bodies and Institutions who called for changes in Nigeria educational system to reflect peculiar circumstances and what the nation required of an individual to make him useful to his community. Such Institutions and professional bodies according to Danladi (2003) include the Science Teachers Association of Nigeria (STAN) who developed the Nigeria Integrated Science Project. The Comparative Education Study and Adaptation Centre (CESAC) now NERDC who developed the Nigeria Secondary School Science Project (NSSP), and the Primary Education Improvement Programme of the then Northern Nigeria Government in collaboration with Ahmadu Bello University Zaria.

Emphasis in these curriculum materials was placed on learning science through the process of science. This could be achieved through activity based teaching method which emphasize the acquisition of science skills at the expense of science concept. This is in line with Awodi in Mari (1994) who opined that teachers can-not teach Science effectively without employing the process of science, neither can students learn science effectively without employing the process of science.

Many research findings on the teaching of science in Nigeria, have revealed that science is poorly taught. For instance Weaver (1964) believed that only topics indicated in the syllabus are studied and Ali (1986) is reported to have said that “the present method of teaching science do not encourage the development and sustenance of process skills among science students". To Akuezuilo (1986) teaching is devoid of meaningful learning but oriented towards memorisation and recall of facts. Also Ekpo (1992) observed that the slow pace at which science develops in Nigeria is a consequence of lack of qualified science teachers and poor teaching of science, at all levels in the Country.

The recognition of the superiority of activity-based instructional methods over the other methods has resulted in the recommendation of the process approach, to science teaching as a method of instruction in science class (Akpan 1992). Many innovative science courses developed for Nigerian Schools in the past 10 - 15 years according to Adeniyi (1987) including the Nigeria Integrated Science Project (NISP) put emphasis on teaching and learning by inquiry and adds that "the process approach is meant to foster inquiry and manipulative skills in students and discourage rote learning.

The process approach according to Akinmade (1996) is a strategy for teaching and learning science which, gained prominence during the late 1950's and early 1960's. The strategy is based on the notion that children undergo very active process during their growth and development and science is a participatory subject and not spectator art. He continue to urge that science teaching and learning can not be done by reading and listening alone, rather, pupils should be involved in meaningful activities during which, they have ample opportunity to use the functional intellectual skills called the Science Processes, to solve problem. These processes according to Akinmade (1996) includes observation classification, finding pattern and relationships etc. The believe is that when children use science processes to solve problems like scientist, they experience science rather than just learn about science. They engaged in the development of principles and generalization rather than marely learning by rote. Research has also pointed out that when children learn science using the process of science and activity approaches, they improve their ability to apply Intellectual Skill to solve problem (Breedenman 1982), improve their language development (Rowe 1973, Wellman 1978) and they became more creative, master science content better and develop positive attitude towards science and scientists (Shymansky 1978).

Inspite of the recognition of the process approach, to science teaching, result of some studies indicated that students continued to perform poorly (Akale 1986), Adeyegbe (1993) and Musa (2000).

These category of students who could not obtain good result in their final year examination get absorbed into various institutions of higher learning to undertake remedial programmes.

Remedial studies as defined by Mohammed (2002) is a special training programme organised for secondary school graduates so as to assist them correct their examination deficiency problem. It is a one year intensive training programme design for such group of students ("Remedial students) to help them meet up with the university entry requirement. The Primary idea behind the creation of remedial section in the institutions for higher learning is to assist students who failed in their secondary school final year certificate examination, remedy their deficiency through the provision of extra resources and coaching.

According to Madu (1998) remedial programme is an alternative but accelerated avenue for quality manpower supply for intakes to the University without lowering the standard. Supposedly he added, remedial education provides corrective teaching to remedy deficits in basic skills or literacy and numeracy within the school content. Madu (1998) also identified three additional objectives of remedial studies programme as follows:

* to offer opportunities of University education for children who would otherwise not have had access to it.
* To enhance educational development of the state as well as the students.
* To have a much wider variety of practical work, its integration with factual and theoretical basis of science.

Despite the intensive training provided for the remedial students, there has been a consistent decrease in the performance of these students. Mohammed (2002) reported that less than 35% of remedial students who sat for Senior Secondary School Certificate Examination (SSCE) after remedial studies obtained the minimum University entry requirements in Jigawa State. This may partly be attributed to the method of teaching and learning chemistry in the remedial programme.

However, literature indicates that process development activities are not usually carried out in the remedial science class. Mohammed (2002) observed that many science teachers resist innovation to the extent that when new and novel approach (like the process approach) is introduced, they resist it. The process approach as observed by Mari (1994) is in line with piagetian task as it offers a variety of activities and experience that involve use of concrete object. This hastens students' ability to conserve volume, mass and area, order events and predict changes.

According to Piaget classification, children in remedial programme have entered formal operational stage. At this stage, children are no longer tied to tangible problems. They think about the possible as well as the hypothetical, they think about abstract problems systematically and generalize about result. The child at this stage/period begins to consider all possible explanation to a problem. The process approach because of its uniqueness and distinguishing feature of providing variety of stimulating experiences may be found useful in enhancing process skills acquisition and achievement in science. Teachers should therefore strive hard to employ the use of this novel approach in science teaching especially at remedial studies programme in particular and at all levels in general. This research work is based on the Piagetian theory of cognitive development. Piaget in his theory of cognitive development classified intellectual ability of the child into four (4) categories which includes:

* sensory motor stage (0 - 2)
* Pre-operational stage (2 - 7 years)
* Concrete operational stage (7 - 11 years)
* formal operational Stage (11 - 16 years)

Piaget believed that cognitive development is a function of activity. Activity to him means, internal manipulation of objects. He advocates active learner and learner experience with experimental method and instruction involving teaching of principles and abstraction, by having the learners reconstruct them in carefully designed educational settings involving experiment and problems. At remedial studies programme, learners' intellectual ability is developed and hence formal operational stage supposedly attained. This open up a better chance for the child to manipulate experiment and develop critical thinking skill.

The process approach is in line with Piagetian theory of cognitive development especially when the child attaines the final stage of cognitive development. "The formal operational stage" which deals with abstraction and conceptual thinking, generalization of facts etc. Osisioma and Nzewi (1994) noted that at the period of formal operation, the child's thought process becomes quite systematic and reasonably well integrated. The child thinks formally, logically and in abstraction. He is able to understand and transfer understanding from one situation to another. He shows a particular orientation of problem-solving.

Osisioma & Nzewi (1994) further stressed that much of what is taught in science appear to require formal reasoning that is, reasoning based on abstraction that transcends concrete experience. Poor performance in science can therefore be attributed to lack of appropriate formal operational thought in the students (Osisioma and Nzewi 1994). However, German (1994) posited that students who are functioning at higher level of cognitive development will perform science process skills more proficiently than students at lower cognitive level.

The way learners perceive difficulty in science is in line with their intellectual development. Some researchers reported significant relationship between students reasoning skill and performance. Osisioma and Nzewi (1994) added that formal reasoning ability is closely related to science achievement and the acquisition of science process skills. Baird and Borich (1987) reported investigation showing that a moderate degree of overlap exist between Integrated Science Process Skills and Formal operational thought. Akinmade (1992) noted that formal reasoning ability and achievement in science are not independent of one another. It is in line with the above, the researcher felt that at remedial studies programme, science process oriented approach could be helpful in enhancing students understanding and achievement in science. There is therefore the need to carry out study in this area to see what the result would be.

1.2 Statement of the Problem

Results of several researches conducted over the years have indicated that of all the various factors responsible for the poor performance of students in sciences (chemistry inclusive) poor method of teaching predominates, Ivowi (1991), Ajewole (1991), Ekpo (1992), Danladi (2003). However, Ajewole (1991) suggests the need to adopt a new method that deviate in the style of teaching from the traditional approach to active learning technique. Thus, the problem of this study is to try the process approach with a view to determining whether it can improve learning, as it offers a wide variety of opportunity for pupils to interact with concrete objects during which they can use the functional intellectual skills called the science process skills to solve problem.

However, research in the area of Science A Process Approach (SAPA) and achievement has been used and shown to improve skills acquisition and knowledge content of Junior Secondary Students (JSS) and Senior Secondary Students (SSS) as observed in Mari (1994), Danladi (2003). This study is therefore designed to test the process approach at remedial studies level and see if it is effective in enhancing students' achievement in chemistry.

More specifically this study will investigate what will be the effect of the process approach on academic achievement of remedial students. The study is also designed to find out if gender is also a factor in the understanding of chemistry concept when process approach is used.

1.3 Purpose of the Study

The study is geared towards achieving the following objectives.

(1) To determine the effectiveness of science process on academic performance of Remedial Students.

(2) To establish if exposure to process approach improves the learning of science among remedial students.

(3) To provide equal opportunities for both boys and girls through the implementation of process oriented approach with a view to eliminating gender stereotyping in science learning.

(4) To determine whether exposure to process approach promotes the acquisition of science skills.

(5) To determine if exposure to process approach and achievement in science is gender dependent or not.

1.4 Research Questions

Based on the problem stated, the following research questions are formulated to guide the conduct of the study:

1. Is there any difference in the academic achievement of students exposed to process approach and those taught using the lecture method?
2. Do boys and girls differ in their academic achievement in chemistry when exposed to Science Process based approach?
3. Is there any difference in the academic achievement of boys taught Chemistry using the process approach and those taught using the lecture method?
4. Is there any difference in the academic achievement of girls taught chemistry using the process approach instructional strategy and those taught using lecture method?

5. Is there any difference in the level of acquisition of science skill between boys and girls when taught Chemistry using the process approach?

1.5 Hypotheses

1. There is no significant difference between academic achievement of students taught Chemistry Using the Process approach and those taught using lecture method.
2. There is no significant difference between academic achievement of boys and girls when exposed to process approach.
3. There is no significant difference between academic achievement of boys taught chemistry using process approach and those taught using lecture method.
4. There is no significant difference between academic achievement of girls taught chemistry using process approach and those taught using lecture method.
5. There is no significant difference in the level of acquisition of Science skills of boys and girls exposed to process approach.

1.6 Significance of the Study

The idea behind an academic research of this nature is to add to the existing knowledge. This is so because problems are identified, solutions provided hence improvement is often expected. In Science-A process Approach, the ability to read is not so essential as it is in many traditional curricula. Success does not depend on reading skills, but on the ability to use the process of science. The implication of this lie in the provision of equal opportunity to children from low socio-economic background and those children from high socio-economic strata. The result of this research work is therefore expected to provide an insight to the practicing teachers on the suitability, applicability and effectiveness of the process approach.

Moreover, teaching method have been shown to be gender related. Some studies shows that some gender learn better than others Jegede (1989), Mari (1991) Ajagun (1998). This research tried the two genders and if it is geared towards one gender, this will inform educators to take adequate step to overcome the gender difference.

Educators have also been trying to find a good means of teaching science through the process of science. This research work therefore provides a model lesson plan suitable for use in teaching certain concepts in Chemistry in our Senior and even Tertiary levels of education. Furthermore, it is hoped that result of this study will make an enamours contribution to the existing literature in the area of science teaching method.

1.7 Scope and Delimitation of the Study

The scope of this study covers all the 5 tertiary institutions in Jigawa State. The study is however delimited to Jigawa State College of Education Gumel and Jigawa State Polytechnic Kazaure. The selection of these tertiary Institutions is done on the basis of the fact that they are the only Tertiary Institutions in the State that undertake Remedial Studies Programme. Findings of this research is however generalizable to all the institutions in Jigawa State.

CHAPTER TWO

2.0 REVIEW OF RELATED LITERATURE

2.1 Introduction

In this chapter, an attempt was made to examine literature related to the topic of research. More specifically the areas reviewed are:

* Nature and Meaning of Science.
* Science Teaching Method.
* Science - A Process Approach.
* The Process Skills to sciencing.
* Academic Achievement in Science Education.
* Gender-related differences in the learning of science.
* Gender related differences and Process Skills acquisition.
* Other Related Findings on the Process Approach.
* Implication of the literature reviewed on the present study

2.2 Nature and Meaning of Science

Views about the structure and meaning of Science vary as the number of those who define it (Musa 2000). Some view it as method. While others perceived it in relation to outcomes of science investigation its process and products. Abdullahi (1982) viewed the configurational nature of science as comprising of concepts, laws and theories metamorphosing into a wonderfully

Structured body of knowledge called science. Reasoning along this line of thought, Mani in Mari (1994) identified additional aspects of the nature of Science to include:

* A method or process of acquiring knowledge which involves the use of process skills like measuring, hypothesizing, classifying etc.
* Part of Man's culture whose product and activities has social relevance to mankind.
* Human activity carried out by scientist which require certain attitudes and beliefs as objectivity, curiousity skepticism, open mindedness etc.
* A social institution and an important agent of social change. The political, economic and technological development of a community is however believed to be transformed through the acquisition and proper utilization of Scientific knowledge.

According to Akpan (1992), scientific knowledge is purely an expansion of common sense, and the growth of it can meaningfully be explored by systematically studying the growth of accumulated scientific fact. It is highly cumulative enterprise whose success depends on the steady extension or widening of the scope and precision of each successive scientific facts which are unchanging truths found some where in nature and upon which all scientific knowledge is based.

Inspite of the fact that scientists believe that science knowledge is activity-oriented, it is tentative and most of the time uncertain it is also continuously being influenced by numerous social and cultural factors (Richardson & Boyles in Akpan 1992). Akpan (1992) view scientific knowledge as uncertain and tentative way of imagining or reconstructing certain aspects of reality based on accumulation of facts, laws and theories.

Ogunfuyi (1980) opined that science should be recognised and taught as a major human activity which explores the realm of human experience, map it methodically but also imaginatively, and by disciplined speculation, create a coherent system of knowledge. Furthermore, Ogunfuyi identified two philosophical position upon which scientific knowledge is based. These are empiricism and rationalism. Empiricism recognises experience as the only source of knowledge with emphasis placed on sensory experience, although some allowance is made too for knowledge derived from intellectual reflection regarding relations among a number of experiences. Hume in Mari (1994) identified impression and ideas as the basic components of perception of the mind. He recognised impression to be the direct sensation received by the senses as the basis of all knowledge. The Images of these senses which remain after an impression has occurred, Hume regards as simple ideas.

The sensory impression of an object according to Ogunfuyi (1980) is decomposable in to a set of sensory qualities all become associated in the mind because they occur closely together in time or in space as interaction with object goes on. The sensory qualities of an object may include colour, smell, size etc. Hence Ogunfuyi identified some characteristic features associated with empiricism to include:

* Sensationalism - the hypothesis that all knowledge is derived from/through sensory experience.
* Reductionalism - the thesis that all complex ideas are build up out of basic stock of simple ideas and that they are in turn reducible to these basic elements.

* Associationism - the thesis that ideas (or mental element) are connected through the action of association by continuity in experience.
* Mechanism - the belief that the mind is like a machine built out of simple elements with no mysterious components simple additive rules serving to characterise the properties of complex associative configurations by sole use of the properties of the underlying simple ideas.

Science is like a game which changes with time. So what may be scientific today may become unscientific tomorrow (Akpan 1992). Reflecting on the consensus view of science, Akpan explains that scientific knowledge is achieved through consensus among the practicing scientist of the time. This means that before any new scientific fact becomes acceptable to the scientific community it has to negotiate a number of huddles in order to enhance public verifiability according to the consensus of trained scientist.

Moreover, scientific activities according to Abdullahi (1982) differ according to the kind and nature of problem confronting the scientist concerned. However, the following steps identified by Abdullahi (1982) are believed to constitute scientific methods:

* The recognition of problem.
* Collection of relevant information.
* The formulation of working hypothesis.
* The making of deduction from the hypothesis.
* Testing by actual experimentation of deduction.
* Depending on the outcome or result of the experiment - the working hypothesis is maintained, modified or rejected.

Scientific investigation must involve all of the above operations although the order of operation may vary depending on the nature of the problem under investigation (Abdullahi 1982, Eniayeju 1994).

2.3 Science Teaching Method

The development of sound basis of scientific and reflective thinking as demanded by the New National Policy on Education (1998) could only be achieved when science is properly and adequately taught. This calls for the provision of opportunity for the child to manipulate and explore his environment through interaction with materials and equipments (hand-on activities) thereby behaving like scientist (Gumel 1995). He should have a great deal of knowledge, problem solving skills, desirable attitudes, appreciation for the contribution of others and broad interests. Eniayeju (1994) observed that science instruction contributes to critical thinking. A Science lesson of an investigative - experimental type demand sensory motor involvement. When science is taught through discovery, activities are structured so that the child learns science concepts and principle and also how to use his mind.

During the past few decades, science teaching was geared towards memorisation of scientific facts. Danladi (2003) observed that teachers at this time employed teacher centred method of instruction which disallowed students active participation in the lesson. However, towards the end of 1950's emphasis was shifted from the traditional ‘chalk and talk’ method to learning science by doing. Nigeria is not left out of this growing culture. Abdullahi (1982) observed that the history of modern science teaching in Nigeria is very recent. He however maintained that unlike most Western countries where science teaching grew from the Universities to high school in Nigeria, science teaching had its root in the primary school.

Modern science teaching emphasise hand-on activities approach as well as students' active participation. Psychologists believed that students participation in science lesson is required for learning to take place. Active participation of students in science lesson according to Akinmade (1992) is also important as it tends to decrease discipline and students management problems. Activity-based science programme which provide students the opportunity to interact with objects and materials is often recommended to teachers on the ground that they improve attitude (Akinmade 1992). This is so because the learning activities force the child to formulate hypothesis, control variables; make operational definitions and carry out the various scientific skills and processes.

Highlighting on the importance of getting students involved during science lesson, Bersenherz in Akinmade (1992) proposed the use of multi-media approaches to science teaching, introduction of novel situation and discrepant events which the teacher can profitably use to motivate students to learn science. These methods he added have been used successfully to arouse curiosity and sustain students' interest in physics, chemistry, biology and integrated science classrooms. Science teaching in a nutshell is expected to be students centred or activity oriented with an overall aim of making science courses alike to students.

Meanwhile, for science teaching to be effective and productive, science teacher need to acquire some basic skills necessary to help students understand and learn science easily as well as making the science lesson interesting and meaningful. Trowbridge in Akpan (1992) identified five skills related to science teaching which include:

* Communication Skill
* Organisational Skill
* Creative Skill
* Manipulative Skill and
* Questioning Skill

Communication skill according Abdullahi (1982) is necessary for an effective teaching of science. The inability of the science teacher to communicate effectively to his students makes the students confused and loose important information. It is imperative to note that both verbal and nonverbal communication skills are very essential on the part of the teacher. This is because learning science requires ability to read, understand scientific materials as well as the ability to communicate science concepts. Akpan (1992) suggests that teachers should develop this skill in students through paraphrasing, perception checks, description of feelings etc.

Organisational skill is very important to both, teacher and students. Akpan (1992) observed that the nature of science calls for teachers efficiency in this regard by organising his students to learn through activities in the laboratory. The way teacher conducts instruction generally reflects his level of organisational skill. An organised teacher produces qualitative students that are well groomed in even other skills.

Possession of creative skill by the teacher is an important asset to his profession (Ango and Sila 1986). Being creative according to Akpan (1992) is one of the six elements in the psychological development of a person and should be one of the objective of teaching. He continued to argue that a teacher must be creative before he can inspire creativity in his students.

Questioning skill as observed by Abdullahi (1982) forms part of guided inquiry in science teaching. A good question of inquiry mode, makes children reason or explain such things as cause and effect.

Students' ability to accurately Interact with instruments with a great deal of precision requires the necessary skill of manipulation. Manipulative skill in science according to Akpan (1992) brings to mind laboratory experimentation, handling of scientific instruments actually "doing" things and having a feel of the action, interacting with scientific objects etc. Moreover, the psychomotor domain, constitute the manipulative skill because it involves using parts of the body (physical and mental) in handling and use of objects or materials, systems or phenomena.

A successful science teacher is therefore one who acquires the necessary teaching skills which serves as a pre-requisite to their subsequent development in students.

2.4 **Science - A Process Approach**

Since the mid-fifties, revolutionary changes have been taking place in the teaching of science. Team of scientists and teachers have attempted to bring about far reaching improvement in Science education at all levels; including the elementary school level. The Commission on Science education of the American Association for the advancement of Science with financial support from the National Science Foundation, embarked upon the preparation of Science programme for the Elementary School, Kindergarten through grade 6. Materials were first written during the summer of 1963 and in each of the subsequent summers through 1967. This effort gave birth to a new curriculum called Science – A Process Approach (SAPA). This curriculum considered the process approach as its main instructional strategy for teaching and learning of science.

In Nigerian context, after 1969 (the year in which the first National Curriculum Conference was organised) there were increased conscious effort to modernise science content and instruction (Akpan 1992) to reflect this pedagogical triumph. Such attempt according to Akpan (1992) have been made through programmes like the Nigerian Integrated Science Project (NISP) by the Science Teachers Association of Nigeria (STAN), the Bendel Primary Science Project (BPSP) and the Nigeria Secondary School Science Project (NSSSP), which was a project of the Comperative Education Study and Adaptation Centre (CESAC) now NERDC. These projects have been designed to be child-centred with an overall aim of making science interesting to the child (Akpan 1992).

In Science - A Process Approach, the ability to read is not so essential as it is in many traditional curricula. Thus, inquiry into science can begin as early as Kindergarten. Success does not depend on reading skills, but on the ability to use the process of science. The implication of this according to Ameh (2001) lie in the provision of equal opportunity to children from low socio economic backgrounds, (many of whom may have reading problem) and those children from higher socio economic strata.

There are however several basic assumptions underlying the SAPA programme. Ahmed (2004) identified some of these basic assumptions as follows:

* The first assumption is that science can be taught to young children in a faithful manner. For the SAPA programme, the primary implication of this is that Children should learn, not so much the facts which are the outcome of scientific investigation, but as the process

used by Scientists. There are eight basic processes and five integrated processes taught in the programme.

* The second assumption is that Science is best learnt by doing.
* The third assumption is that the lesson must take into account the empherical findings of developmental psychology.

SAPA used the insight of the psychologist Robert Gagne as a guide in the programme design. Each lesson in SAPA specified the particular behavioural objective of that lesson. Each lesson also specifies the competency measure for that lesson. This represents a very scientific way of teaching science and a unique contribution to the teaching of science.

The strategy is based on the notion that children undergo very active processes during their growth and development and that science is a participatory subject and not a spectator art (Akinmade 1996). Hence science teaching cannot be done by reading and listening alone. Pupils should be involved in meaningful activities during which they have ample opportunity to use the functional Intellectual skills called the Science Process to solve problems. These science processes according to Wuyep (1996) are the foundation for scientific inquiry and the generalized intellectual skills selected to learn the concepts and broad principles used in making valid inductive inference.

Breedman in Akinmade (1997) found out that process approach improves students' ability to apply intellectual skills to solve problems. It also helps the learner to become more creative, master science content better, develop positive attitude towards science and the scientist. Eniayeju (1994) observes that children who study science through applying science process to solve problem, do learn and remember as many or more facts than those who study science by mere traditional methods. Further support for the adaptation of the process approach in science teaching was given by Awodi in Shaibu and Mari (1997) that science teachers can not teach science effectively without employing the process of science and neither can students learn effectively without the use of the process of science which is ensured by the process approach.

In an attempt to meet the instructional demand of the new 6-3-3-4 system of education in Nigeria, Danladi (2003) observed that a greater concern was given on how to organise science lesson in line with the demand of the process approach. This could be the reason why science teaching presently emphasizes the 3H's (Head, Heart and Hand) and no more the out dated 3R's (Reading, Writing and Arithematic) (Akpan 1992).

In Science - A process Approach, content is used to develop processes and both students and teachers are actively involved in categorising and synthesizing information from the object (Mari 1994). However, research on strategies and methodologies for teaching science in elementary schools has produced clearer evidence that students in process approach programmes learn more than do students in traditional textbook-based programs (Breedman 1983). Report by Karen (1998) also indicates that the process approach programmes of the sixties and seventies, Elementary Science Study (ESS), Science Curriculum Improvement Study (SCIS) and Science-A process Approach (SAPA) were more effective in raising students' performance and attitude than the traditional reading based programmes. Eniajeju (1994) identified seven additional skills attainable from the process approach which include creativity, counting number relationship, questioning, manipulating, controlling variables, organisational and acquisitive skill.

2.5 The Process Skills in Sciencing.

Scientists engage in procedure, of investigation to gain knowledge of natural phenomena.. These tactics and strategies, the skills scientists use in their pursuit of understanding are called science processes (Karen 1998). There is however general believe among science educators that the development of science process form part of attainment of the general objectives of education. This is because the acquisition of science processes play a vital roles in scientific activities (Akinmade 1992). They are often seen as the foundation of scientific inquiry since they can be generalized and are required for learning the facts, concepts and principles necessary for making valid inferences. Gagne (1968) a reknown psychologist believed that a pre-requisite knowledge of concepts and principles can be obtained only if the student has certain underlying capabilities, such as the science processes which are needed to practice and understand science.

Hence process skills are acquired capabilities which can be learned through experience and applied for the understanding of nature and problem-solving. They are categorised into basic and integrated process skill (Shaw 1983). The basic science processes include, observation, measuring inferring, predicting, classifying, collecting and recording data. The Integrated Science Processes or process skill is comprise of interpreting data, controlling variables, defining operationally, formulating hypothesis and experimenting. Observation is considered to be the fundamental skill by virtue of its position at the foundation of the skills needed to discover the broad knowledge required for inquiry. Shaibu and Mari (1997) share a similar view that the acquisition of science skills ought to be a major goal of education moreso that the search for scientific knowledge is process-oriented.

Some of the major features of the processes of science as identified by Finley (1983) include:

* Each process is generalizable (transferable) across content domains and contribute to rational thinking in everyday affair.
* Each process is an identifiable behaviour of scientist that can be learned by student.
* Each process is specific intellectual skill used by all scientist and applicable to understand any phenomena.

The processes are hierarchically organised with the ability to use each upper level process dependent on the ability to use the simpler underlying process (Nduke 1986). These science process skills have been identified as having the enduring quality of enabling the individual acquire and process information and solve problems even when the information base changes (Bybee et al 1989). This view apparently supports Wuyep's (1996) notion that concepts and contents of science will undoubtedly change, but the mental skills of the scientists or the students which are very vital in science and technology, do not.

The significance of the science process skill, maintained Nwosu (1994) has led to the expansion of the goal of science education to include an understanding and development of these process skills in the pupils. School therefore ought to emphasis the development of skills in all areas of curriculum, although the types and levels of skills acquisition will depend on learners' stage of development.

Possession of such skill according to Ekpo (1986) is apparent if pupils can take action to find appropriate information and techniques from the previous experience and bring them to bear on new problems and situations.

2:5:1 **Process: Observing**

This is the first stage in scientific inquiry. It is made on particular event and general principle are developed from a number of specific and consistent cases (Abdullahi 1982.) It is considered to be the fundamental skill by virtue of its position at the foundation of the hierarchy of skills needed to discover knowledge required to conduct inquiry. Eniajeju (1994) described it as the skill of looking and seeing which may be made directly or indirectly. Thus active use of the senses during the process of observation according to Ogunleye (1996) enables one to determine the quantity and quality of things and events. Observations are influenced by past experiences often involving instruments (microscopes, telescopes, etc) and requiring careful recording and description (Karen 1998).

However, Noris in Akpan (1992) identified three broad proficiencies that are logically necessary for achieving observational competence to include:

- Making observation well
- reporting observation well
- assessing report of observation.

The more precise an observation is according to Mari (1994) the more valid are the inferences based on it.

2.5.2 **Process: Measuring**

Measuring involves assigning numbers to objects or events that may be arranged in a continuum according to set of values and expression of observation in quantitative terms adds precision and permits more accurate descriptions (Karen 1998).

According to Eniajeju (1994) measuring employs the use of counting skills to man-made units of length, area, volume, weight and time. The units are initially those developed and applied by the pupil themselves. It is a process which involves the use of an instrument to determine the quantitative value associated with the properties of an object or event (Akinmade 1992, Ogunleye 1996).

Mari (1994) identified seven (7) sub-processes involved during the process of measuring. These are:

* Ordering object by inspection in terms of magnitude of selected common properties such as linear dimension area or volume.
* Comparing quantities such as length, area, volume and weight to arbitrary unit.
* taking measurement using standard units.
* taking measurement of quantities which depend upon more than one variable.
* converting from one system of unit to another.
* using and devising indirect means to measure quantities.

To be proficient in the use of the process of measurement according Akinmade (1992) student should be able to measure time, rate of change of a property of an object, represent an object by scale diagram, draw an accurate map and be aware of the limitations of the various measuring devices in use. In addition, student should be able to determine the area and value of one, two or three dimensional objects.

2.5.3 **Process: Classifying**

Classifying object according to Mari (1994) involves sorting and arranging objects according to their similarities and differences. During this process things or events are organised, categorised and grouped, based on observed or measured property to form an easily recognised pattern. Akinmade (1992) identifies six (6) characteristics of a child who attain certain level of competence in using the process of classifying. Thus the child is able to:

* Categorize object or system of objects using a given property.
* Determine with reason an appropriate property and categorise objects or systems of objects according to that property.
* Classify object or systems of objects according to two or more given simultaneous properties.
* Select and justify two or more appropriate simultaneous properties and group objects or systems of objects on the basis of those properties.
* Identify the properties on which a given set of objects has been grouped; and
* Regroup a given set of objects or systems of objects using a rational procedure.

Eniayeju (1994) sees classification as a process and skill of sorting, grouping and ordering objects by both their quality and quantity. The desired goal in this scientific process is for children to develop sensible reasons as a bases of their grouping, sorting and ordering.

2.5.4 **Process: Inferring**

Inferring as perceived by Ogunleye (1996) is a skill of basing judgement on observed and measured event. Wolfinger in Smith and Welliver (1990) sees it as an interpretation of one's direct observation, past experiences are generally used as a basis for interpretation. According to Eniayeju (1994) inference implies the cause and effect relationship which may be based on preliminary or sketch data or very well founded data from experiment.

Abah in Mari (1994) pointed out that inference is strongly made on the bases of inductive and deductive logic. Deductive inference involves reasoning from general premises to specific instance, while inductive inference involves deriving general preposition from the evidence of specific cases. The following sub processes are involved in the process of inferring as identified by Mari (1994) are:

* distinguishing pertinent observations upon which given inferences are based and are extraneous.
* drawing an inference from a set of related observations.
* stating cause and effect relationships from observations of related events.
* identifying and extending inferences to include discrepant event.
* modifying and extending inferences to include discrepant event.
* developing plans to test the validity of inferences.
* using inferences from one set of observations to suggest further observation.

2.5.5 Process: Predicting

Making prediction according to Akinmade (1992) involves figuring what future observation will be on the basis of available previous information. Identifying some proficiencies associated to a person who achieves competence in using the process prediction, Akinmade (1992) suggests that such a person should be able to:

* find out and explain trends in a given set of data;
* device appropriate procedures for checking the correctness of the prediction made;
* present plausible arguments and evidence to justify his prediction;
* appreciate the importance of multiple observations in making predictions, and
* exercise restraint in making predictions in the absence of reliable and valid multiple observations.

Wolfinger in smith and Welliver (1990) sees the skill of predicting as the process of determining or anticipating future events based on past observations and experience. To Eniayeju (1994), predicting is a scientific process which arises from a well founded bases of hypothesis, theory or even law. With regularly consistent data in hand, one can predict. According to Ogunleye (1996) and Mari (1994) predicting involves forecasting or extrapolating on the basis of past observation.

2.5.6 **Process: Communicating**

This is the process skill of transmitting acquired information from one person or group to another which may result in change in behaviour. A scientific experience in observation, data collection, discovery etc. according to Eniayeju (1994) need to be communicated to other people. This will give growth to knowledge, and it could be in written words, diagrams, graphs or models. However, the following sub processes are involved during the process of communicating (Mari 1994):

* describing observation verbally.
* describing conditions under which observations are made.
* recording observation in a systematic way.
* stating questions and hypothesis concisely.
* using table and graphs to communicate data.
* planning for communication of procedures and result as an essential part of an experiment.
* reporting experimental procedures in a form so that other persons can replicate the experiment.
* using mathematical analysis to describe interpretation of data.

2.5.7 **Process: Interpreting Data**

According to Wolfinger in Smith and Welliver (1990) interpreting is a process of using various forms of data to determine the validity of a hypothesis; to organise information derived from an experiment, and/or revise interpretation of data based on new information. When using the process of interpreting, students are required to determine the pattern or put meaning into it or as well as take meaning out of their experience. They are also expected to provide a justification for the meaning put into their experience, and to generalize to other situations on the basis of sufficient evidence (Akinmade 1992).

Mari (1994) viewed interpreting data as involving identifying changes in size, shape, position and judgement of validity and usefulness of data. However, Akinmade (1992) identified what a student should be able to do to demonstrate competence in the use of the skill as follows:

* make sound generalization from a set of data.

* identify cause and effect relationship
* provide reasonable justification for any generalization made.
* draw as many plausible inferences as are permitted by a given data set.
* test an inference by collecting more data and
* recognise which data lend support to an inference.

This skill answers the question, "what does a collection of data tells you?" It is much more than the collection and classification of data to provide possible generalization with which one may predict (Eniayeju 1994).

2.5.8 **Process: Raising Questions and Formulating Hypothesis**

Questions are raised as a result of observation. Hence observation provokes question in an attempt to provide answer to the problem under consideration. Awodi in Mari (1994) sees hypothesis as a thoughtful educative "guess" as to what solution to a given problem might be. According to Mari (2004) hypothesis is an educative "guess" of answers to a question which is tentative until a real research is conducted.

2.5.9 **Process: Making Operational Definitions**

Here, pupils have the freedom to develop their own scientific vocabulary. Such words and terms describe their operation rather than conform to the standard of discipline of science. According to Ogunleye (1996) making operational definition ensures precision by providing situational definitions of concepts so as to focus attention on the phenomena being observed. Operational definitions according to Mari (1994) are important means of facilitating communication about the phenomena investigated as well as the materials and procedures of investigation. They are however made as precisely as possible and where feasible, mathematical relationship could be used as a way of enhancing precision.

2.5.10 **Process: Experimenting**

This is the testing of hypothesis to confirm our guess or disprove it. Initially it might be in the form of trial and error. According to Eniayeju (1994) experimenting involve chasing after answers along a path that appears fruitful. Designing experiment involves planning a series of data gathering operations which will eventually provide the bases for testing hypothesis or answering a research question. It may however involve the use of some of the other processes such as observing, comparing, interpreting, use of numbers and control of variables. It may also involve designing an investigation to find out the effect of independent variable on the dependent variable (Mari 1994, Ogunleye 1996).

The achievement of competence in the use of this process skill according to Akinmade (1992) implies that student is able to:

* choose, clarify and state the primary variable being investigated in a way that could be tested.
* confine the number of variable to a manageable number.
* competently control variable.
* differentiate between independent and dependent variable.
* select or design data gathering procedures that are appropriate to the investigation.

* use the processes of observing, classifying, comparing and measuring to gather relevant data.
* ensure the reliability and validity of data-gathering procedures employed.
* record and organise data using tables, graphics representations and models.
* use the processes of inferring and predicting to interpret the data collected.
* find a rational answer to the research question posed.
* raise new relevant question; and
* design new experiments to find rational answers or the new research question raised.

2.5.11 **Process: Controlling Variables**

This is the process of identifying the influential variable in a system, holding some constant and varying others to see how the system behaves (Eniayeju 1992). Thus the experiment will discover the real role of a variable or factor in a system.

2.5.12 **Process: Formation of Mental Models**

This is the ability to create a mental, physical or verbal representation of idea, object or event and use model to describe interrelationships of ideas, object or event (Smith and Welliver 1990). A mental model according Eniayeju (1994) is a tool for prediction. A model once formed, is continuously refined and modified in the light of new experience, evidence and discovery which may challenge some aspects of the initial model.

Models according to Mari (1994) make the abstract more concrete, enable the students to study interrelationships of objects and concepts or help them to make prediction. The following sub-processes are involved in the formulating of models (Mari 1994).

* differentiating between models and reality.
* explaining phenomena by using models devised by others.
* constructing a physical representation, a drawing or mental image to explain observed phenomena.
* extending physical or mental model to include related phenomena.

2.6 Academic Achievement in Science Education

Achievement is relatively defined in different ways by different authors depending on the issue at hand. Generally, achievement means accomplishment or proficiency of performance in a given skill or body of knowledge. Academic achievement according to Amuset (1994) is the knowledge attained or skill developed in the school subject, usually designated by test score or by means assigned by teacher. Bomide and Gyuse (1992) accept as evidence, if cognitive achievement such varied performances as recalling scientific information, demonstrating ability to comprehend, apply, analyse, synthesize and evaluate any given scientific information.

Achievement could be classified into either achiever or under-achiever. Under achievement is viewed as performance that is below an acceptable level (Okebukula & Jegede 1986). Under achievement according to Eke (1986:52) is a level of achievement below expected intelligent quotient (10) of an individual. He continues to maintain that a student may be under-achiever even though he/she is performing as well as overachiever, whose average mental ability not withstanding has put up a relatively good show. Academic under-achievement therefore to Eke (1986) means the shortfall below expected level of attainment as predicted by the students known or measured intellectual ability and actual performance. However, Okebukula and Jegede (1986) subdivided achievement in to three categories:

* High achiever (top 75%)
* Medium achiever (middle 55%)
* Low achiever (bottom 25%)

Achievement in this research work is used in the context of performance with regards to the knowledge attained, not the proficiency of the knowledge or the skill attained by the student.

Contrastingly to all these views, academic performance according to Musa (2000) refers achievement as the quality of result produced by students as reflected in the quality of their examination scores.

2.7 Gender Related Differences in the Learning of science

Psychologists' concept of learning is some what different from what other scholars understand by the same term. Psychologists interpret learning as 'covering far more than the acquisition of factual information or even the mastering of skills as well as the means to aid further study, and understanding'. They instead, portray learning as including the entire socialisation process of the individual, the acquisition of behaviour patterns and the styles or particular means individuals tackle issues or solve problems of every day life. (Nwoso, 2001).

Mukharjee (1980) defines learning as "a change in behaviour which is relatively permanent in nature and results from activity, training or observation. Gagne (1968) went further to explain on learning by defining it as "a process which enables living organism to modify their behaviours fairly rapidly in a more or less permanent way so that the same modification does not occur again and again in each new situation.

The influence of gender on the learning ability and interest of students can never be over emphasised. Result of several researches conducted over the years revealed that there is relatively significant difference in students' choice of subject and their performance across science and non-science subjects. Shemesh (1990) reported that there is low participation of girls in high school courses in science and technology, as well as the low numbers of women who hold a professional careers in science or technology. However, data collected by Shemesh (1996) also revealed that while boys are more oriented towards the so-called "hard" subject/sciences (chemistry, physics etc), girls prefer the "soft" subjects such as human physiology, plant life, zoology, biology etc. However, Ezekannagha and Ifeaker (2001) observed that the achievement of women in chemistry in both public examination and teacher made test has not been encouraging. Reasons advanced for females' poor enrolment and learning outcome in chemistry include fear of science (Ezekannagha & Ifeaker 2001).

On the gender difference in the teaching and learning of sciences, Treagust (1980) reported that male and female students did not achieve equal competence in science and mathematics. Okeke (1980) found no significant difference in the performance of boys compared with girls. A small gender-related difference in science achievement among 13 year old or early adolescent was found by Hartal et al (1981). Shuaibu and Ameh (1982) on their findings reported that boys performed better in science than their female counterparts. In a related research, Tamir in Abah (1985) conducted studies which showed boys were interested in physical sciences while girls preferred biological sciences. Also Oriafor (1986) found that female students' performances on the average was poorer in all domains examined.

Feingold (1988) examined the relationship between gender and eight scale of cognitive ability using Differential Aptitude Test (DAT) normative data of 1938, 1944, 1962, 1972, and 1980. For the most recent year, 1989, he found girls scored higher on spelling, language, and clerical speed, while boys scored higher on mechanical reasoning and space relation.

Jegede and Inyang (1989) have observed a significant superior achievement of boys over girls in Integrated Science at the Junior Secondary Level. These differences in achievement between boys and girls according to Jegede (1990) may be due to the varying tasks performed by boys and girls in their early years and therefore are insignificant. He went further to explained that severe limitations on young females in the performance of science process skills at the schools may have an effect on the ease with which they learnt science and consequently the reluctance of the majority of female to actively engage in science and related courses.

Shemesh (1990) conducted a research on gender-related differences in reasoning skills and learning interest of senior high school students and discovered that adolescent boys develop patterns of formal reasoning before their girls counterparts. The result also indicated that boys tend to prefer science and technology subjects, while girls tend to prefer language, social studies and humanities. The boys' choice of science and technology subject was reported to have a direct correlation with age and development of formal reasoning, while girls' choice of language, social studies and humanities has an indirect/inverse relationship with age and a direct relationship with the development of formal reasoning ability.

Young and Frasher (1994) reported that gender differences in science achievement occurs as a result of a number of social factors both at home and at school, and that gender differences appear to be greater in some schools than in others, although statistically significant gender differences in chemistry achievement were also found among year-12 chemistry students favouring boys. There were statistically significant sex differences in Physics achievement among students from all age groups, however, both male and female students appeared to achieve higher physics scores to more advantaged home background (Young & Frasher 1994).

Olarewaju (2004) reported a significant difference between boys' and girls' achievement in the knowledge of biology concepts. Boys in this report were found to achieve better than girls.

Dahiru (2004) also conducted a research on the relationship between gender and the selection of science subject in Katsina Local Government Area. His result revealed that there is no significant relationship between gender and selection of science subject in the area under consideration.

Adegive (2000) attributes differences in the learning ability of boys and girls to socialization process because girls are denied out-of-school and pre-school experience in problem solving especially those involving visual activity behaviours that inhibit the development of math and science capability in girls. Low ability in girls' performance could be enhanced when they are adequately exposed to science-related activities. This research therefore intends

2.8 Gender-Related Differences and Process Skills Acquisition

For science teaching and learning to be interesting and meaningful, the development of science skills in children becomes a necessary and an integral part of school science curriculum.

Nwosu and Okeke (1995) observed that any meaningful learning of science by students in Nigerian schools must include the acquisition of the science process skills and the science curricula were modified to reflect this emphasis. When these process skills are acquired, intellectual ability of the students is widened and this could be used for life in the understanding of nature and problem solving. This is true and as rightly observed by Gardner (1980) that "Give a man a fish and he eats for a day, teach a man to fish and he eats for a life time". The process skills are the tools for learning and problem solving. They should not only be acquired at all levels of our school, but should also be acquired to a reasonable extent (Nwosu and Okeke 1995), even though literature on the acquisition of these important process skills in relation to gender is deficient (Nwosu 2001).

Johnson and Murphy (1986) reporting data collected from the Assessment of Performance Unit (APU) in the United Kingdom (UK) who indicated that girls show superior performance in observational skill at all ages tested (11, 13 and 15 years). The report suggests that girls out-performed boys with respect to questions that require objects or features to be compared and contrasted, but that the reverse trend is seen with respect to questions where scientific explanation of observation are required. Girls were however found to outperformed boys in relation to reporting observations of color changes in Chemistry context (Ben-Zvi. et al in Lock 1992). On manipulation skill, Scottish data (Robertson 1987) suggests girls show significantly superior performance to boys.

Data collected from low achievers aged 15-16 years in Scottish schools on the skill of measuring (Robertson, 1987) indicated that no gender related differences were found for using lenses or stop clock but that girls were better at focusing of microscope than boys.

Report on the skill of interpreting data (Johnson and Murphy 1986) indicated that at age 11, there are no gender-related differences in performance on interpretation but that at age 13, boys' slight superiority is evident, but by age 15 these differences reach statistical significance which they said may be related to the greater proportion of coordinate graphs used with these ages.

Research conducted by Lock (1992) on gender and practical skill performance on science indicated that there is no gender difference in observation, reporting, or planning skill, and there was no differential performance in the use of scientific language. The report also indicated that boys performed better in interpretation than girls.

However, report by Mari (1994), Shaibu and Mari (1997) revealed that there was significant difference between the male and female subjects in their ability to solve problem requiring their understanding of the process skill as pre-requisites but the female subjects were significantly better in their understanding of science process skills than their male counterparts.

A study conducted by Ameh (1980) to determine the influence of sex upon the acquisition of science process skills revealed that boys were better at using numbers, measuring and experimenting than girls, while girls performed better in the process of observing and inferring. However, the overall mean score of girls in both Integrated and Basic science process was found to be higher than that of the boys. Similar result was obtained by Shuaibu and Ameh (1982). Nwosu (2001) in her study revealed that exposure to science process skill based learning involving activities for both girls and boys (experiment group) yield a more effective learning irrespective of gender and ability level. Report by Danladi (2003) also revealed no significant difference in achievement between girls and boys on task involving process skill acquisition. There is thus, the need to use activity-based learning in schools to help learners especially girls who are denied these opportunities at home to acquire the process skills. Nwosu (2001) suggests that gender stereotyping has to be discouraged in the homes, school and societies to enable girls participate freely in skills-based activities.

2.9 Other Related Findings on the Process Approach.

The development of a sound scientific, reflective and problem solving capabilities in children as demanded by the Federal Ministry of Education Policy document (New National Policy on Education 1998) have been the concern of many science curriculum innovators in Nigeria. This could be achieved when children are exposed to the process of scientific inquiry. The process approach because of its unique and distinguishing feature of developing in children, a set of science process skills will be helpful in this respect. Moreso that there are indications in literature showing students are performing poorly in tasks involving the use of basic and integrated science processes (Ronning and Mc Curdy 1982, Lassa and Akpan 1988). This trend may be partly attributed to many factors some of which include students characteristics, teachers and the curriculum content.

Report by Karen (1998) indicates that science experience not only enhance operational abilities of Kindergarten and First Grade students, but also facilitates the transition from one level of cognitive development to the next in older students. Osisioma and Nzewi (1994) observed that the difficulty in science is believed to be associated with students' intellectual development.

In their study, Osisioma and Nzewi (1994) discovered that formal thinkers were found to perform better in concrete and formal concepts than concrete thinkers.

In a joint study conducted by Padilla, Okey and Dillashaw (1983), to determine the relationship between science process skills and formal reasoning ability among 500 grade 7 - 12 students in Atlanta, Geogia in the United State of America, a formal operational and integrated process skill achievement instrument were administered. Result from these two instruments indicated a strong relationship between achievement on the two measurements (r = 0.73). However, Baird and Borich (1987) observed a moderate degree of overlap existing between integrated science process skills and formal operational thought. Tobin and Capie in Akinmade (1992) found a significant inter-correlations between formal reasoning ability and process skill achievement (r = 0.6 & r = 0.71). Akinmade (1998) too noted that formal reasoning and science process skill acquisition and achievement are not independent on one another. Osisioma and Nzewi (1994) similarly found that formal reasoning and achievement are closely related. They noted that students with low level of ability would be expected to have difficulty in understanding science concepts and this could lead to poor performance.

The kind of science curriculum students are exposed to plays an important role in the development of integrated skill (Akinmade 1992). Nwosu (1994) observed a low level of acquisition of both aggregate and individual process skills among SS1 biology students, and that students performed better in basic process skills than higher skills. Similarly, Nwosu and Okeke (1995) reports that teacher sensitization of students' acquisition of science process skills enhanced the acquisition of the higher/integrative process skills like interpreting data. Shaw (1983) investigating the effect of process oriented science curriculum upon problem-solving ability reported that a relationship does exist between students' being involved in the SAPA II curriculum and their ability to apply problem-solving skill to content not covered in the programme. The result also leave open the possibility that the use of these problem-solving skills may transfer to other academic areas or to non-academic areas and make a person a better problem solver throughout life.

The selection of process-oriented curriculum and training of teachers are necessary but not sufficient condition for the process skill development and achievement in children. Students must also be optimally involved in the process-oriented activities if much development must take place. The view expressed by Akinmade (1992) that scientists learn how to use science processes by engaging in them in their daily activities is crucial. Hence, students should learn the process skill by doing them in and out of school. Yoloye in Akinmade (1992) summarized evaluation studies carried out in the African Primary Science Programme (APSP) and compared it with that of children who experienced the APSP in Kenya and results showed better performance in problem-solving tasks by students who went through the traditional content-oriented science curricula activities.

A study conducted by Tobin (1986) showed that students' achievements on the higher process skills was significantly related to higher students' engagement in collecting and planning tasks. This is supported by Strawite (1989) that students using self-instructional materials significantly out-performed students taught process skills by a teacher. Nwosu (1994) also maintained that science process skills development requires direct involvement in scientific activities and procedures in the laboratories and in the field.

Socio-economic status (background) of students also contribute to the student in science achievement. According to Onocha and Okpala (1985) occupational, educational and material possessions are regarded as gross indicator of the socio-economic status of a family and their findings revealed that the family environment is a useful indicator of performance of pupils in science. Zuzovsky and Tamir (1989) in their study found out that home variable of parental education, number of siblings and number of books in the home accounted for more of variance in science achievement than the school variable of implementation and instruction. They noted that in law socio-economic school-home variable accounted for 75% science achievement. Contrary to this study, the objective evaluation of science-a process-approach by American Association for the advancement of science, shows that performance of children in classes from low socio-economic families was not different from the performance of more privileged children (Ameh 2001). Reason attributed to this according to Danladi (2003) was children directly involved in the process of science reading ability does not determine their success in the programme regardless of aptitude and background. In a contradictory report, Koren (1998) reported that science process skills are part of and central to other disciplines. Research indicates that the integration of science with reading and mathematics has produced positive effect on learning (Koren 1998). Reading and activity-oriented science emphasize the same intellectual skills and are both concerned with thinking processes. When a teacher helps students develop science process skills, reading processes are simultaneously being developed (Machlin and Oliver, 1993 and Simon and Zimmerman, (1980). When students have used the process skills of observing, identifying, and classifying, they are better able to discriminate between vowels and consonants and to learn the sounds represented by letters, and syllables (Murray and Pikulskl in Koren 1998).

Science and mathematics are integrally related. Mathematics to a great extend is the language of science. The development of skills in logical mathematical reasoning and problem-solving is a goal of both science and mathematics' instruction (Koren 1998). Cambel in Koren (1998) reports that involving students in "hand-on" activities, where they count and manipulate objects, provides experience that contributes to their under standing of numbers. In addition, science experiences contribute to the development of other operations basic to the study of mathematics. Some of these operations are: conservation of substances and length, one-to-one correspondence, ordering, seriating and classifying.

However, Mechling and Oliver (1993) observed that students' ability to learn and acquire science process skills enable them apply mathematics to real world problems. At the elementary level, the teacher can provide "hands-on" science activities that facilitate the learning of abstract Arithmetic concepts such as number sequencing, regrouping, and fractions. Attitude was found to be an important correlate of science process acquisition and achievement. Baker (1985) reported in his findings that there is a higher correlation of achievement causing attitude than for the reverse, achievement is more related to interest than it is to attitude.

Gyuse and Akinmade (1986) stated that students characteristics play a major role in the shaping of attitude to science, that significant relationship exist between the child's attitude and his achievement. Wareing (1990) in a related study, states that although a one-to-one correspondence between attitude and behaviour is yet to be definitely proved, the ability of attitudinal characteristic influencing behavioural out-comes, can be categorically denied. This shows that there does not appear to be a cross-age causal relationship between attitude and students' behaviour or characteristics. However, Danladi (2003) in his research findings on the relationship between attitude and achievement in science processes indicated a fairly significant relationship between the two measures. Houtz (1995) in his research discovered that there were no significant differences between attitude towards science as a school subject for males and females regardless of the instructional strategy. This contradicts the findings of Simpson and Oliver (1985). Baker (1985) specially found that middle school females had significantly higher attitudes than males.

Ogunleye (1996) conducted a research to investigate the effect of guided expository, laboratory and discovery methods on level of acquisition of process skills among some physics students using 600 secondary school students and teachers. The guided expository laboratory method was found to be superior than the other methods in enhancing process skills acquisition. The result also indicated that ability, factor, sex and school group composition interacted significantly with the type of laboratory method used.

2.10 **Implication of literature reviewed on the present study**

The literature reviewed indicated that science is poorly taught in most of the Nigerian schools. This implies that the present study should strictly adhere to the modern form of science teaching in which students will actively be involved as stipulated in the SAPA Curriculum Model.

Most of the literature reviewed also revealed a low level of process skill acquisition among students in secondary schools. However applying traditional lecture method along side with process-oriented approach will help in identifying which among these two methods greatly enhanced process skill acquisition among children. However, the literature also indicated a strong gender indifference among students taught using teaching methods which do not emphasize students' active participation. This implies that the use of process-oriented approach could help in determining whether the approach is capable of eliminating gender related differences among students or not.

Most of the researches conducted on the process approach as revealed by the literature reviewed was based on primary/secondary school students. This implies that it is also pertinent to conduct a research to cover the tertiary institution students as intended in this study to see whether the result will be the same or different.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

This study is aimed at investigating the effectiveness of process approach on students' academic achievement in chemistry among remedial students. Therefore, in this chapter, the following specific areas were discussed:

* Research design
* Population
* Sample and Sampling Procedure
* Instrumentation
* Pilot Study
* Item Analysis
* Procedure for Data Analysis

3.2 Research Design

The Pretest-Posttest matched group experimental design was used for the purpose of this study. This according to Akuezuilo (1993) involves two groups in which one group was assigned as experimental, and the other the control group. A teacher-made test (TMT) was administered to the two groups as Pre-test before treatment to determine equivalence in their ability (refer to Appendix I for the pre-test result). The test consists of 30 objective items drawn from general aspect of chemistry. The items in the test were constructed and administered by the researcher in order to determine the equivalence of the experimental and control groups.

After treatment, a Post-test was administered to both the experimental and control groups. The test of chemistry Achievement (TOCA) consisting of 30 objective items and a Test of

Science Process Skills (TOSPS) consisting of 25 objective items were used for the post-test. TOCA was administered to both the Experimental and Control groups, while TOSPS was administered to the experimental group only. The design is presented as follows:

$$R_1 \longrightarrow O_1 \longrightarrow X_1 \longrightarrow O_2 \longrightarrow O_3$$

$$R_2 \longrightarrow O_1 \longrightarrow X_2 \longrightarrow O_2$$

where

R_1	=	Experimental groups - which was exposed to process approach.
R_2	=	Control group - which was exposed to lecture method
X_1	=	Process approach instructional strategy
X_2	=	Lecture method of teaching
O_1	=	Pre-test using TMT
O_2	=	Post-test using TOCA
O_3	=	Post-test using TOSPSS

3.3 Population

The population of this study comprised of 95 remedial chemistry students in the Jigawa State tertiary Institutions. The average age of these students is 20 years. There are 4 Institutions in the State that offers remedial studies programme and they are all Co-educational. The Schools and the number of students are provided in Table 3.1.

Table 3.1: Population of the Study.

S/No.	Name of Institution	Location	Gender		Total
			Male	Female	
1.	College of Engineering	Kazaure	16	1	17
2	College of Education	Gumel	23	17	40
3	College of Business	Dutse	-	-	-
4	College of Agric.	Hadejia	29	9	38
	Total		68	27	95

3.4 Study Sample and Sampling Procedure

A purposeful sampling technique was used for the purpose of the study. This is necessary because out of the four schools listed, college of business studies Dutse does not offer remedial programme in science, the other school (Collage of Engineering Kazaure) has only one female student. Thus, the researcher was left with no choice other than to use the remaining two schools i.e Collage of Education Gumel and College of Agric Hadejia as sample of the study. The two schools and the number of students in each school are provided in table 3.2

Table 3.2 Sample of the Study

S/No.	Name of institution	Location	Gender		Total
			Male	Female	
1	College of Education	Gumel	23	17	40
2.	College of Agric	Hadejia	29	09	38
	Total		52	26	78

However, in determining which school serves as experimental and control group, a simple random sampling technique was used. Thus, Collage of Education Gumel was randomly assigned experimental while Collage of Agric Hadejia was assigned control group.

3.5 Instrumentation

Two Instruments were used for the purpose of this study. They are the Test of Chemistry Achievement (TOCA) and the Test of Science Process Skills (TOSPS)

3.5.1 Test of Chemistry Achievement (TOCA)

One of the Instruments used for this study was the TOCA. This instrument comprises of 30 multiple choice items. The first 15 items in the instrument were adopted from Danladi (2003), items 17, 18, 24, 25 and 29 were adopted from Onumara (1996). Items 22, 23 and 30 on the other hand were adopted from a collection of West African Examination Council (WAEC) past question paper.

Items 19, 20, 21, 26 and 27 were constructed by the researcher. For example item 19 reads as follows:

A pungent smell of a gas perceived which produced dense white fumes with conc HCl when $NaOH_{aq}$ is added to a certain salt solution and warmed indicate the presence of

a. Zn^{2+}

b. Pb^{2+}

c. Ca^{2+}

d. NH_4^{+}

One mark was allocated for each question answered correctly, making a total of 30 marks. All items in this instrument were constructed using the multiple choice format.

3.5.2 Test of Science Process Skills (TOSPS)

This test (TOSPS) was designed to measure Science Process Skill Acquisition among science students. The test consists of 25 multiple choice items designed to measure five skills. The five skills are observation, measurement, inference, interpretation and hypothesis. Five questions were set for each skill making a total of 25 items in the instrument. Each item answered correctly attracts one mark. Thus the total number of marks for this instrument is 25.

Items 5 and 21 were adopted from Shaw (1983). Item 22 was adopted from Padilla, Okey and Dilla-Shaw (1983), item 20, was adopted from Janice and Robert (1987), items 11 and 16 were adopted from Smith and Welliver (1990), items 4, 8, 14 and 25 were adopted from Nwosu (1991), items 6 and 12 were adopted from Young and Frasher (1994), item 1 was adopted from Ogunleye (1996) while items 3, 17, 18 and 19 were adopted from Ajagun (1998).

On the other hand however, items 7, 9, 10, 13, 15 23 and 24 were constructed by the researcher, while item 2 was adapted from Shaibu and Mari (1997) with little amendment on the initial item. The initial item reads as follows "Infront of you is a measuring cylinder filled with water. Carefully drop a small piece of stone (provided) into the water in the measuring cylinder. What do you observe? The item is not a multiple choice item. In order to make this item fit into the multiple choice format proposed for this study, this item was restructured and read as follows. "What do you notice when a piece of stone is carefully drop into a certain volume of water in a container? A diagram of two glasses of water one containing a stone inside and the other contains no stone were provided and then the options followed. Adaptation of this item was made with the assistance of the supervisor of this work who is also one of the authors of the initial item adapted.

Below is the summary of the items in the instrument (i.e TOSPS) and the specific skill each item intends to measure.

Item	Skills
1 - 5	Observation
6 - 10	Measuring
11 - 15	Inferring
16 - 20	Interpreting
21 - 25	Hypothesising

All the items used in this test were constructed using the multiple choice format.

3.6 Pilot Study

Pilot study for the two instruments i.e Test of Chemistry Achievement and Test of Science Process Skills (TOCA & TOSPS) was carried out to determine:

(i) The approximate time that will be required by the respondents to complete the test.

(i) The reliability of the instruments

(ii) Difficulty index of the item

Pre-NCE (Science) students of the College of Education Gumel were used for the pilot testing of the instruments. This comprises of 45 boys and 19 girls producing a total of 64 students. The pilot testing was conducted under a very strict condition and no student was allowed to go out with the question paper in order to avoid Linkage of the items in the two instrument which may inturn affect the final post-test result.

3.7 **Item Analysis**

a. Difficulty Index

The difficulty Index of the items in the two instruments (i.e TOCA & TOSPS) were calculated from the result of the pilot study using the split half method. The formula used was

$$DI = \frac{R_u + R_L}{T}$$

where

DI	=	Difficulty Index of the items
R_u	=	No. of students/respondents who get the item correct in the upper group
R_L	=	No. of respondents who get the item correct in the lower group
T	=	Total no. of respondents

This was used by Musa (2000) and advocated for this study

In the Test of Chemistry Achievement all the items were found to have a difficulty index within the range of 0.4 - 0.7 and were all retained and used.

In the Test of Science Process Skills (TOSPS) item 4 with a difficult index of 0.8 and item 16 with difficulty index of 0.2 were dropped and replaced with a more suitable items. Only item with a difficulty index within the range of 0.4 - 0.7 were retained and used. This is in accordance with Musa (2004).

b. Reliability Coefficient

Reliability of a test refers to the reproducibility of scores derived from it for a particular student or group of students (Ajagun 1998). The reliability of TOCA was found to be 0.7 and that of TOSPSS as 0.6 using split half method. The formula used was the Kuder - Richardson measure of internal consistency which is given by

$$r_x = \frac{n}{n-1} \frac{S^2_x - 3p_1q_1}{S^2_x}$$

where

n = number of item in the test

p_1 = Proportion of students who answer an item correct

q_1 = Proportion of students who answer an item wrong

S^2_X = Variance of the test

This was used by Ajagun (1998) and advocated for this study

c. Validity of the Test Items.

The two instruments were submitted to some lecturers in the department of education (science section) ABU Zaria as well as some lecturers in the department of Chemistry and Integrated Science College of Education Gumel for validation. They were all required to determine whether the items in the instruments match the ability of the students, test what they were set to test and whether the language used was clear, unambiguous and correct. In both TOCA and TOSPS, recommendations were made in relation to the language used in some of the items that the language was not very clear and direct, while in TOSPS recommendations were made on the need to include drawings and diagrams for some questions to make the items clear and understanding. All the recommendations were considered and effected. The two instruments were thus screened and found to be valid.

3.8 Treatment

In order to avoid teacher bias, two chemistry lecturers were invited to do the teaching and the laboratory work. The researcher in this respect acted as co-ordinator. However, one week training on how to design and guide process-based teaching was given to the teacher who took care of the experimental group. The training took the form of laboratory activity based on the chemistry concept and the skill chosen. The concept selected for this study was the qualitative test for metallic radicals while the skills include observation, measurement inference etc. Attention was also given to the qualification, working experience and commitments of these teachers. This is necessary in order to avoid teacher factor influencing the result of this study.

However, to teach science using the process approach, the following 4-step procedure was adopted:-

1. Identification of the process skills you want your students to develop and the level of success you want them to attain in the practice of these skills.
2. Statement of behavioural objective specifying the level of skill attainment.
3. The design of activities that would inculcate the desired skills.
4. Provision of adequate materials to the students and guidance on the conduct of the proposed activities

The contact session for both the experimental and control groups was six (6) weeks for 2 hours per lesson. The Process Approach was used for the experimental group while lecture methods were used for the control group.

In the experimental group where Process Approach was used, students were assigned into group of 4. All the necessary apparatus/materials needed for the laboratory activities were provided by the researcher. The teacher during the laboratory activities acted as a guide to the students. He cross-checked and assess the activities of the students throughout the contact session.

In the control group class, the teacher conducted the lesson using the traditional lecture methods. The content taught in this group is similar to that of the experimental group and the lesson plan used was prepared based on the traditional lecture method.

3.9 Administration of the Instrument

Administration of the instrument was conducted by the teachers who did the teaching with the assistance of the researcher. A pre-test was first conducted before treatment was given to the two groups. A teacher-made test was used to pre-test the two groups in order to determine the entry level of the students in both the control and experimental groups . A post test was later administered to the two groups after treatment.

The Test of Chemistry Achievement (TOCA) was used for the post-test in both the experimental and control groups, while the Test of Science Process Skills (TOSPS) was used for the post-test in experimental group only. This is because the test is designed to test science process skills acquisition among the students, and since experimental group was the only group taught using skill- based method, the test was administered to the experimental group only. 40 minutes was allocated for the students to answer the questions in TOSPS, while 45 minute was allocated for TOCA. The answer scripts of the two tests taken were collected, graded and compiled by the researcher. The result of the two tests formed the data for this study.

3.10 **Procedure for Data Analysis**

Data collected in this research work was analysed using t-test statistic.

Hypothesis One

"There is no significant difference between academic achievement of students taught chemistry using the Process and those taught using lecture method.

t-test statistic was used in testing this hypothesis. $P \leq 0.05$ level of significance was set for retaining or rejecting null hypothesis

Hypothesis Two

There is no significant difference between academic achievement of boys and girls when exposed to process approach.

t-test statistic was used to testing this hypothesis. $P \leq 0.05$ level of significance was set for retaining or rejecting null hypothesis

Hypothesis Three

There is no significant difference between academic achievement of boys taught chemistry using the process approach and those taught using lecture method.

t-test statistic was also used in testing this hypothesis. $P \leq 0.05$ level of significance was set for retaining or rejecting null hypothesis

Hypothesis Four

There is no significant difference between academic achievement of girls taught chemistry using the process approach and those taught using lecture method.

t-test was also used in this case at $p \leq 0.05$ level of significance.

Hypothesis Five

There is no significant difference in the acquisition of science skills between boys and girls exposed to the process approach.

t-test statistic was used to test this hypothesis at $P \leq 0.05$ level of significance.

CHAPTER FOUR

4.0 DATA ANALYSIS AND DISCUSSION

4.1 Introduction

In this chapter, Data obtained from the results of the two instruments (i.e TOCA & TOSPS) administered during the post-test were analysed and presented. The analysis essentially involved statistical testing of the hypotheses stated in chapter one.

The level of significance adopted was $P \leq 0.05$ which formed basis for retaining or rejecting each of the Null hypotheses stated. The t-test statistic was particularly used to test all the stated hypotheses. Each of the hypotheses is restated below along with description of the statistical tools used for testing each at $P \leq 0.05$ probability level.

4.2 Presentation of Result

The results obtained are presented in the tables below along with the hypothesis re-stated.

Ho_1: There is no significant difference between academic achievement of students taught chemistry using process approach and those taught using lecture method.

t-test statistics was used to compare the mean score of experimental and control group and the results are presented in table 4.1

Table 4.1 **Comparison of mean scores of the experimental and control group after treatment**

Groups	N	X	Sd	Df	t-value	P	Remark
Experiment	40	17.73	5.87	76	0.51	0.609	not significant
Control	38	18.37	5.16				

significant at $P \leq 0.05$

The t-value 0.51 obtained as shown in Table 4.1 is less than the critical t-value of 1.66 with df 76 at $P \leq 0.05$. The null hypothesis is maintained. This means that there is no statistically significant difference in the academic achievement of students taught chemistry using process approach and those taught using lecture method. This result contradicts the findings of Danladi (2005) who discovered a significant difference in the performance of experimental and control group in favour of the experimental group.

Ho_2: There is no significant difference between academic achievement of boys and girls when exposed to process approach.

The null hypothesis was used to determine whether performance of male and female subject would differ when science process approach is used. Scores of the males and females subjects in the experimental group was analysed using t-test statistic to test this hypothesis and the result is shown in Table 4.2

Table 4.2 **Comparison of the mean scores of males and females in experimental group after treatment.**

Groups	N	X	Sd	df	t-value	P	Remark
Male Experiment	23	19.96	5.03				
				38	3.09	0.004	significant
Female Experiment	17	14.71	5.69				

Significant at $P \leq 0.05$

The result from Table 4.2 indicated that there was a significant difference between academic achievement of boys and girls when taught chemistry using the process approach. This is because the t-value of 3.09 obtained is greater than the critical value of t which is 1.68 with df = 38 at P≤ 0.05. Thus the null hypothesis stated is rejected. The method is therefore found to be more effective to boys than girls. Gender is therefore a factor in the benefit derived from the method. This result disagree with the findings of Danladi (2003) who discovered no statistically significant difference in the performances of boys and girls exposed to process approach.

Ho_3: There is no significant difference between academic achievement of boys taught chemistry using process approach and those taught using lecture method.

This null hypothesis was used to compare the academic achievement of boys taught chemistry using Process approach and those taught using lecture method. The academic achievement of boys (only) was singled out and compared. The t-test statistic was used in the analysis and this is presented in table 4.3

Table 4.3 **Comparison of the mean scores of males in experimental and control groups after treatment.**

Groups	N	X	sd	Df	t-value	P	Remark
Males Experiment	23	19.96	5.03	50	0.06	0.951	not significant
Males Control	29	20.03	4.07				

significant at P≤ 0.05

The result from the Table 4.3 revealed that there is no significant difference in the academic achievement of boys taught chemistry using process approach and those taught using lecture method. The critical t-value was however found to be 1.658 which is greater than the obtained t-vale of 0.06 at $P \leq 0.05$ level of significance. The null hypothesis is therefore maintained

Ho_4: There is no significant difference between academic achievement of girls taught chemistry using process approach and those taught using lecture method.

t-test statistic was used to compare the mean scores of Females in the experimental and control groups. This is presented in the table 4.4.

Table 4.4 **Comparison of the mean scores of girls in experimental and control groups after treatment.**

Groups	N	X	Sd	df	t-value	P	Remark
Females Experiment	17	14.70	5.69				
				24	0.77	0.45	not significant
Females Control	09	13.00	4.77				

significant at $P \leq 0.05$

Analysis of the data as presented in Table 4.4 indicated no significant difference in the academic achievement of girls taught chemistry using process approach and those taught using lecture method. The obtained t-value of 0.77 was found to be less than the critical t-value of 1.711 with df = 24 at $P \leq 0.05$ probability level. The null hypothesis is therefore maintained. This result contradicts the earlier findings by Musa (2000) who reported a significant difference existing between girls, experimental and control, with girls in experimental group performing significantly better than girls in control group.

Ho_5: There is no significant difference in the acquisition of science Skills between boys and girls exposed to process approach

This hypothesis intends to determine if there is any gender related differences in the acquisition of science skills between boys and girls exposed to process approach. t-test statistic was used in comparing the mean scores of the boys and the girls as presented in table 4.5

Table 4.5 **Comparison of the mean scores of boys and girls in experimental group in the Test of Science Process Skills (TOSPS) after treatment.**

Groups	Gender	N	X	Sd	df	t-value	P	Remark
Experimental	Males	23	14.65	4.27				
					36	0.815	0.23	not significance
Experimental	Females	17	20.03	4.07				

significant at $P \leq 0.05$

Table 4.5.1 **Comparison of the means scores of boys and girls in experimental group in observational skill after treatment.**

Groups	Gender	N	X	Sd	df	t-value	P-value	Remark
Experimental	Males	23	2.2174	1.413				
					36	2.09	0.044	significant
Experimental	Females	17	3.1765	1.468				

significant at $P \leq 0.05$

Table 4.5.2 **Comparison of the mean score of boys and girls in experimental group in skill of measurement after treatment after treatment.**

Groups	Gender	N	X	Sd	df	t-value	P-value	Remark
Experimental	Males	27	3.4348	1.037	38	0.44	0.664	Not significant
Experimental	Females	17	3.5882	1.176				

Significant at $P \leq 0.05$

Table 4.5.3 **Comparison of the mean score of boys and girls in experimental group in skill of inference after treatment.**

Groups	Gender	N	X	Sd	df	t-value	P-value	Remark
Experimental	Males	23	3.0435	1.430	38	0.83	0.412	Not significant
Experimental	Females	17	2.6471	1.579				

Significant at $P \leq 0.05$

Table 4.5.4 **Comparison of the mean scores of boys and girls experimental group in the skill of data interpretation after treatment.**

Groups	Gender	N	X	Sd	df	t-value	P-value	Decision
Experimental	Males	23	3.4348	1.308	38	3.83	0.000	significant
Experimental	Females	17	1.7647	1.437				

Significant at $P \leq 0.05$

Table 4.5.5 **Comparison of the mean scores of boys and girls in experimental group in the skill of formulating hypothesis after treatment.**

Groups	Gender	N	X	sd	df	t-value	P-value	Decision
Experimental	Males	23	2.5217	1.310	38	0.39	0.664	Not significant
Experimental	Females	17	2.3539	1.412				

Significant at $P \leq 0.05$

The result shown in Table 4.5 indicated that there is no significant difference in the acquisition of science skills between boys and girls exposed to science process approach instructional strategy. The critical t-value of 1.684 was found to be higher than the obtained t-value of 0.24 with df = 38 at $P \leq 0.05$ significance level. The null hypothesis is therefore maintained. This result contradicts the earlier findings by Mari (1994) who discovered a significant difference in the acquisition of science skills between boys and girls in favour of girls.

4.3 **Discussion of the Results**.

This research work is aimed at determining the effectiveness of the process approach as compared with lecture method of teaching in improving students' performance in chemistry. Five hypotheses were stated and tested based on the scores of the subjects obtained from TOCA and TOSPS.

Analyses of the data obtained were presented in the tables 4.1 to 4.5 in accordance with the stated hypotheses. The findings from the analysis are discussed below:

* The result presented in table 4.1 revealed no significant difference in the performance of the students in experimental and control group. The data obtained also revealed that the control group with a mean score of 18.37 is a little better than the experimental group with a mean score of 17.73. This result disagrees with the findings of Walberg (1991), Akpan (1992) and Danladi (2003) who discovered a significant difference in the performance of the experimental group taught using process approach over the control with the experimental group performing significantly better than the control group. Reason(s) for the result obtained in this study may be attributed to the short period (six weeks) during which the teaching and the laboratory work was conducted as well as the short time of training (one week) given to the teacher who took care of the experimental group. However, should the period of teaching be extended to 8 - 10 weeks, the experimental group may perform significantly better than the control group. The result of this study therefore indicated that the process approach is not better than the lecture method in improving students' performance in chemistry.

- From the result in table 4.2, it was found that there was a significant difference in the performance of boys and girls when taught using the process approach. The boys performed significantly better than the girls. This means process-based instruction is gender friendly in favour of boys than girls. This report agrees with the earlier reports by Treagust (1980) who reported that Male and Female students did not achieve equal competence in Science and Mathematics, Shuaibu and Ameh (1982) also reported that boys preformed better in Science than girls, Tamir in Abah (1985) who reported that boys were more interested in physical sciences while girls preferred biological sciences.

- The difference in the performance of boys and girls as revealed by this result might be attributed to cultural and religious factors, The Female respondents, being from pre-dominantly Islamic area, are restricted from exploring their environment unlike the boys and will thus find it very difficult to participate in hand-on activities.

* The result presented in table 4.3 revealed no significant difference in the performance of the males in experimental and control groups. This means that the treatment has no effect in enhancing performance. Reasons for this finding may also be attributed to the short period of laboratory work (6 weeks) as well as short time training given to the teacher who took care of the experimental group (one week). This result contradicts the findings of Musa (2000) who reported a significant difference in the performance of boys in the experimental and control groups favouring boys experimental.

* The values in table 4.4 indicated that girls in experimental group shows no statistically significant difference in their performance when compared with girls in the control group. However, unlike in the case of mates experimental and control groups where the males control performed a little better than the males experimental as indicated by their mean score, here, the performance of girls experimental is a little better than the performance of girls control. This may suggest that girls benefit better than boys in process-based learning. This result also disagrees with the findings of Musa (2000) where a significant difference was obtained between the performance of Females experimental and Females control.

* Analysis of the data presented in the table 4.5 indicated no. significant difference in the overall performance of boys and girls on the test of science process skills. This finding lend support to earlier report by Danladi (2003) who also observed no significant difference in the performance of boys and girls on task involving science skill acquisition. On the other hand, the

report contradicts the finding of Mari (1994), Shuaibu and Mari (1997) where a significant difference was observed between males and females subjects in their ability to solve problem requiring their understanding of the process skill as a pre-requisite and that the females subject were significant better in their mastery of science process skills than their males counterparts.

* On the individual skill, analysis of the data presented in table 4.5.1 indicated that girls performed significantly better than boys in observational skill. This finding support the earlier finding by Lock (1992) who also reported that girls perform better than boys in observational skill. The performance of the boys experimental and girls experimental on the skill of measurement was also analysed and presented in table 4.5.2. The finding revealed no significant difference in the performance of boys and girls on the process skill of measuring. This report agrees with the findings of Robertson (1987) who also discovered no gender related difference in the acquisition of measuring skill.

The data presented in table 4.5.3 revealed no significant difference in the performance of boys and girls on the process skill of drawing inference from an observed behaviour or characteristic. Table 4.5.5 also revealed no significant difference between boys and girls performance on formulating hypothesis. On the process skill of data interpretation, analysis of the result presented in table 4.5.4 showed that boys excel their girls counterparts. This finding supports the earlier finding by Johnson and Murphy (1986), Lock (1992) who also reported that boys performed better than girls in the skill of data interpretation.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This study deals with determining the effectiveness of science process approach in enhancing students' academic achievement in chemistry. The data obtained was analysed using a t-test statistics. In this chapter, a summary of the result obtained is provided. The chapter also deals with the following specific areas.

* Summary
* Conclusion
* Recommendations of the study
* Suggestion for the study

5.2 Summary of findings

This study is aimed at determining the effectiveness of science process approach in enhancing academic achievement of remedial students in Jigawa State. Two tertiary institutions were randomly selected for the study. Chemistry remedial students from these schools were selected and used for this study. The School are College of Education Gumel and College of Agric Hadejia. One of the schools was randomly assigned the experimental group while the other school formed the control group. The experimental group was taught using the process approach while the control group was taught using the lecture method. The concept selected for the study was qualitative analysis. Five hypotheses were formulated and tested using t-test statistic.

A Pretest-Posttest marched group design was used for the purpose of data collection. A pre-test was first administered using teacher made test (TMT) before treatment was given. After this there was an intensive teaching session of six weeks after which a post tests using the two instruments (i.e TOCA and TOSPS) were administered. Data collected from the post-test scores of the students in the two groups were analysed and used at the 0.05 level of significance.

Result of the data analysed revealed that:

1. Process approach does not seem to be more effective than lecture method in enhancing academic achievement in chemistry.
2. Boys performed significantly better than girls in chemistry when taught using process-based method.
3. There is no significant difference in the acquisition of science skills between boys and girls taught chemistry using the process approach. This means that the process approach is gender friendly in enhancing science skills acquisition.

5.3 **Conclusion**

1. Students do not learn chemistry concept better when they are taught either using Process-based method or lecture method.
2. Boys learn chemistry concepts better than girls when they are taught using process-based method.
3. Boys do not differ in their understanding of chemistry concepts when they are taught using either lecture or process-based method.
4. Girls do not differ in their understanding of chemistry concepts when they are taught using either lecture or process-based method.
5. Process approach is gender - friendly in enhancing science process skills acquisition.

5.4 Recommendations

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

* The result of this study also revealed that boys achieve significantly better than girls. This means that some methods of teaching discriminate among gender. It is therefore recommended that gender stereotyping should be discouraged. On this note, both the home, the school and the society should encourage both boys and girls to participate freely in skill-based activities within and outside the school.

* No matter how effective certain method of teaching is, it may not yield the required result if the implementers of the method (the teachers) are not properly and adequately equipped with the technique known how regarding the use of the method. It is therefore recommended that State Government should encourage teacher training institutions in the state(i.e collage of education) to regularly organise a training workshop for science teachers so as to provide for them the technique known how regarding the proper use of any novel approach to science teaching.

5.5 Limitation of the Study

The following are the limitations of this study

* The schools used for this study were state owned, other tertiary institutions such as Federal, Private owned have not been included. This might affect the scope of generalization made on the findings as it affects the population.

* The one week period of training given to the teacher who took care of the experimental group is rather short. A longer period might be necessary to help the teacher understand and use the approach better. This might also affect students' performance.
* The use of Pre-NCE (science) students of the College of Education Gumel for pilot testing of the instruments (i.e TOCA & TOSPS) became another limitation of this study. A more neutral school should have been used for this purpose.

5.6 Suggestions for Further Study

Based on the findings of this study the following suggestions may be found useful.

* That similar study be conducted else where to see whether it will yield similar or different result with the present study.
* That the composition of schools be changed to include both State and Federal Institutions.
* The result obtained in this study was for chemistry. The method can therefore be tried for other science disciplines like physics and biology.
* That the researcher conducts both the teaching and the laboratory work himself (i.e to take care of the control and experimental groups).

REFERENCES

Abdullahi A. (1980) Science Teaching in Nigeria. Ilorin Attoto Press 32-34.

Adeniyi E. O. (1987) Science as a way of Knowing. The NSSP experience. Journal of Research in Curriculum, 5(2), 67-77.

Adegive, J. C. (2000) Ethnicity, School Location and Attitude of girls towards Science Education. Jos Journal of Education, 5(1), 37-41.

Adeyegbe, S. O. (1993) The Senior school science Curricular and Candidates Performance, and appraisal of the first cycle of operation. Journal of science Teachers Association of Nigeria. 28(1&2), 3-12.

Ahmed M. (2004) Science - A Process Approach. A paper presented at a post-graduate seminar presentation session, Dept of Education, A. B. U., Zaria.

Ajagun G. A. (1998) The development and evaluation of a test of science process skills (TOSPS) for Nigeria Secondary school. Unpublished Ph.D Thesis A. B. U., Zaria.

Akinmade C. T. O. (1992) Developing Basic and Integrated Science Process Skills in Elementary and Secondary School Students. In E. O. Akpan (Ed) Towards creative Science teaching and learning in west African Secondary School (54-64) Cape Coast Catholic Mission Press.

Akinmade C. T. O. (1996) Using the Process Approach to Teach Concept of Energy to Primary School Pupils in W. V. Famwang, T. O. Oyetunde, P. O. Awotunde, S. N. Wuyep and M. L. Ango (Eds) effective Lesson planning and delivery (37-42) LECAPS (Nig) Ltd.

Akpan E. U. U. (1992) Developing Pedagogical skills in Science Education. In O. E. Akpan (Ed) Towards Creative Science Teaching and learning in West African Secondary schools (88-110). Cape Coast, Ghana: Catholic Mission Press.

Akale M. A. G. (1986) Assessment of Students' Achievement in Science, What Implication for Teachers Training. Proceedings of the Annual Conference of the Science Teachers Association of Nigeria. 313-322.

Akuezuilo E. O. (1986) "Science Curriculum and Instruction in Nigerian Secondary Schools". A Need for Re-appraisal. Journal of Science Teachers Association of Nigeria. 24(1 & 2), 261 - 266

Akuezuilo E. O. (1993) Research Methodology and Statistics. Nuel Centi (Nig) Publishing Company.

Amuset F. I. (1994) Cognitive Preference and Achievement of SS1 Chemistry Students in Sabon Gari and Zaria Local Government Areas of Kaduna State. Unpublished Med. Thesis University of Jos.

Ameh C. O. (1980) Effect of Sex Differences Upon the Acquisition of science Process skills in Zaria, Kaduna State/Unpublished M.Ed Thesis Department of Education A. B. U., Zaria.

Ali A. (1986) "Nigeria scientist and Science Teacher Educators Perception of the Process and Product of science". Journal of science Teachers Association of Nigeria. 24(1&2) 134-142.

Ameh C. O. (2001) Post - Graduate Lecture note University of Jos.

Ango M. L. And Sila M. D. (1986) Teaching and Learning of Biology Practical: The Experience of Some Nigeria Secondary Schools. Journal of science Teachers Association of Nigeria. 24 (1&2), 33-47.

Baird W. E. And Borich G. D (1987) Validity Consideration for Research in Integrated science Process skills and formal reasoning Ability. Journal of Research in science Teaching. 71(2) 259-269.

Baker D. R. (1985) Predictive Value of Attitude, Cognitive Ability and Personality to science Achievement in Middle School. Journal of Research in Science teaching. 22 (2), 103-113.

Berge Z. L. (1990) Effect of Group Size, Gender and Ability Group on Learning science Process skills Using microcomputers. Journal of Research in science Teaching. 27(8), 747-759.

Breddeman T. E. D (1983) The effect of activity-based science in elementary schools. In Mary Budd Rowe (Ed), Education in the 1980's science. Washington DC National Education Association 63-75.

Bomide G, and Gyuse E. Y (1992) Instructional Variables in science Cognitive achievement. In U. E. Akpan (Ed) Towards Creative science Teaching and Learning in the West African schools. Cape Coast Ghana.

Bybee et al (1989) "Science Process". Journal of Research in science Teaching. 20(1), 47-54.

Cox D. A. and Berger C. F. (1985) The importance of group size in the use of problem solving skills on a computer. Journal of Education Computing Research. 1(4), 459-468.

Dahiru S. Y. (2004) Relationship of Gender on the Selection of science subject, in Katsina Local Government Area of Katsina State. A paper presented at a post-graduate seminar presentation session. Department of Education, science section, A. B. U., Zaria.

Danladi S. (2003) Effect of Science Process on Students' Achievement in Chemistry. A Study of SSII in Gumel Educational Zone Jigawa State. Unpublished M. Sc. (Ed) thesis University of Jos, Jos Plateau State.

Ekpo J. O. (1986) Assessment of students' Manipulative Skills in the Junior secondary School Integrated Programme. Journal of Science Teachers Association of Nigeria 25(4) 54-59.

Ekpo O. E (1992) Factors Affecting Science Development in Nigeria. In O. E. Akpan (Ed) Towards Creative Science Teaching and Learning in West Africa secondary school (13-23) Cape Coast Ghana Catholic Mission Press.

Eke E. (1986) "causes of Students" under achievement in science.. Journal of Science Teachers Association of Nigeria. 27(2) 45-56.

Eniayeju P. A. (1994) Teaching Science in Primary School; a Practical Demonstration. A Paper Presented at 1994 seminar/Workshop of the Bayero University Staff School, Kano 12-17 Sept.

Federal Republic of Nig. (1998) New National Policy on Education. Abuja NERDC Press.

Gadner W. L. (1980) The Psychology of Teaching Monetary C. A. Brook/Cole.

Gagne R. M. (1986) 'Learning Hierarchies', Education Psychologist. Vol. 6. 1-9.

Gagne R. M. (1968) The Condition of Learning. Haper and Row. New York.

German P. J. (1994) Teaching a Model of Science Process Skills Acquisition. An Interaction with Parents' Education, Preferred Language. Gender, Science Attitude, Cognitive Development, Academic Ability and Biology Knowledge. Journal of Research in science Teaching. 31(7) 749-783.

Gumel S. A (1995) Problems and Prospects of the Use of Secondary School Chemistry Laboratory in Some Selected Schools in Kano State. Unpublished B.Sc.Ed Project F.C.E Kano.

Gyause E. Y and Akinmade C. T. O (1986) A Study of Some of the factors Affecting Science Achievement at the Junior secondary School Level. 27th Annual Conference Proceedings of the Science Teachers Association of Nigeria, 302-308.

Hartal R. (1981) Early Adolescent differences in Learning: Evidence from the National Association of Education Progress. American Education Research Journal 18(3), 329-341.

Hautz L .E (1995) Instructional Strategy Change, the attitude and Achievement of 7th and 8th grade science students. Journal of Research in Science Teaching, 36(6), 629-648.

Ivowi U. M. O (1991) Improving Verbal Communication in schools. Presidential Address at the 32nd Annual Conference of the Science Teachers Association of Nigeria. Yola 1991.

Jegede O. J and Inyang N (1989) Gender differences and Achievement in Integrated science Among Junior Secondary School students. International Review of Education. 36(3), 310-319.

Johnson S. And Murphy P. (1986) Girls and Physics. Reflection on A. P. U survey findings A. P. U Occupational Paper Number 4. London DES.

Janice R. M. And Robert F. T (1987) The Impact of Microcomputer-based Labs on Children's Ability to Interpret Graphs. Journal of Research in Science Technology Teaching. 29(3), 301-313.

Koren O. (1998) What Research says About Science Process Skills. Http://unv.educ/home page/jcannon/ejse/ost lund. Ntml, ink ostlund (Ed) JSE 2(4).

Lassa P. N and Akpan O. E (1998) A Comparison of science students' Performances on SAT, SA and WSPI in Selected Nigerian Secondary School, A Preliminary report. Journal of Education studies. 1(2), 19-29.

Lock R (1992) Gender and Practical Skills Performance in Science. Journal of Research in Science Teaching 29(3), 227-241.

Mari J. S. (1994) The Understanding of science Process and its Relationship to Achievement in Integrated science. Unpublished M.Ed Thesis Department of Education A. B. U., Zaria.

Mahammad S. (2000) An Evaluation of Remedial Science Programme of the Jigawa State College of Education, Problems and Prospects. A Paper Presented at a 3-days Seminar Organized by the School of Science. Jigawa State College of Education, Gumel.

Machlin K. R and Oliver D. L (1983) Handbook 1: Section Teachers Basic skills: Washington DC: National Science Teachers Association.

Musa B. (2000) The Relative effectiveness of Laboratory Teaching Methods for Enhancing academic Performance in Chemistry Among Senior Secondary School Students. Unpublished M.Ed Thesis A. B. U., Zaria.

Musa M. (2004) Post-graduate Lecture note. A. B. U., Zaria.

Mukharjee A. (1980) Educational Psychology. K. P. Basu Coy Press Ltd.

Ndukwe U. (1986) Levels of Process skills in STAN'S Nigerian Integrated Science Project. Journal of Science Teaching Association of Nigeria. 24 (1&2), 78-81.

Nwosu A. A (1991) Effect of teacher sensitization programme on level of acquisition of science process skills among SS biology students. Unpublished Ph.D Thesis University of Nig. Nsukka.

Nwosu A. A (1994) Levels of Acquisition of Science Process skills Among Year One senior Secondary School Students. Journal of Science Teaching Association of Nigeria. 29(142), 47-53.

Nwosu A. A and Okeke E. A. C. (1995) The effect of teacher sensitization of students' acquisition of science process skills. Journal of Science Teachers Association of Nigeria. 30(1 & 20), 39-45.

Nwosu A. A (2001) Gender and acquisition of Science Process Skills among Secondary School Students. Implication for Science Teaching. In O. O. Busari (Ed) 42nd proceeding of Science Teachers Association of Nigeria. (PP. 206 - 209) Ibadan: Heineman Educational Books.

Odunusi T. O. (2001) Women in Science Technology and Mathematic Education: An Alternative Strategy. In O. O. Bursari (Ed), 42nd annual conference proceedings of Science Teachers Association of Nigeria (14 - 21) Ibadan: Heineman Education Books.

Okgunfuyi (1980) This thing called science: some historical characteristics and current perspective of its nature. Journal of Science Teachers Association of Nigeria. 20(1), 151 - 100.

Ogunleye A. D. (1996) Level of acquisition of process skills among some Physics students and implication for science. Journal of the Science Teachers Association of Nigeria. 31, (1&2): 39 - 46.

Okebukola P. A. and Jegede J. O. (1986) "The under - achieving students in science option on the etiology of ailment". Journal of Science Teachers Association of Nigeria. 22(1) 26 - 30.

Onocha C. and Okpala P. (1985) Family, environmental correlate of science achievement of pupils in primary school. Journal of Science Teachers Association of Nigeria. 23, (1&3), 154 - 155.

Onumara O. J. (1996) Quantitative/Qualitative analysis. First principle for SS students/Secrets of Chemistry Practical IUPAC. Nomencleture. Fab Anies (Nig) Limited Shukira House Jos.

Okeke E. A. C (1992) "Women in Non-traditional Occupation School Can Make the Difference. A Paper Presented at the Training Workshop on Competence Building and career Development for Women", Nsukka 21-23 Sept.

Oriafor C. N (1986) "Cognitive styles: A study of Comparative Educational study and Adaptation Centre (CESAC) Curriculum Material and its Graduates". Unpublished M.Ed thesis A. B. U., Zaria.

Olarewaju R. R (2004) Gender-related Differences in Learning of Biology Concepts Among the Senior Secondary School Students. A Research Seminar Paper Presented at the Department of Education (Science Section) A. B. U., Zaria.

Osisioma U. I and Nzewi U. (1994) Relationship Between Formal Reasoning ability, Acquisition of Science Process Skills and Science achievement. Journal of Research in Science. 29(1&2), 41-45.

Padilla M. J, Okey J. R and Dillashaw F. G (1983) The Relationship Between science Process Skill and Formal Thinking Ability. Journal of Research in Science Teaching, 20(3), 239-246.

Perterson P. L (1981) Ability to Treatment Infection Effect in studies of Small-group Learning. University of Washington Madison. Paper Presented at the annual Meeting of the American Educational Research Association, Los Angeles C. A.

Robertson I. J (1987) Boys and Girls and Practical Science. International Journal of science Education. 9(5), 505-518.

Rowe M. B (1973) Teaching Science as Continuous Inquiry New York: McGraw Hill Book Company, 14-15.

Shaibu A. A. M and Mari J. S (1997) Gender-Related Differences in the Understanding of science Process Skills, Among Junior Secondary School students in some Nigerian schools. Journal of Science Teachers Association of Nigeria. 32,(1&2): 21 - 27.

Shaw T. J (1983) The Effect of Process-oriented science Curriculum Upon Problem solving Ability. In Mary Bud. R (Ed), Science Education. 67(5), 615-623.

Shuaibu M. J and Ameh C. O (1982) "Sex difference in the Performance of Science Process skills" Education Forum 5(2), 157-163.

Shemesh M. (1990) "Gender Related Differences in Reasoning Skills and Learning Interest of Senior High School Students. Journal of Research in Science Teaching. 27(1), 27-34.

Shymisky J. S (1978) activity Centered Science. Science and Children. 15(6), 38-39.

Simon M. S and Zimmerman J. M (1980) Science and Writing science and Children 38(3), 7-9.

Smith K. A and Welliver P. N (1990) The Development of a Science Process Assessment for Forth Grade students. Journal of Research in Science Teaching. 27(8), 727-738.

Strawltz B. M (1989) The Effects of Teaching on science skills achievement. Journal of Research in Science Teaching. 26(8), 661-554.

Tamir P (1985) "The Relationship Between Cognitive Preference students' Background and Achievement in Science". Journal of Research in Science Teaching. 25(3), 201-216.

Tobin K. (1980) Students Tasks Involvement and Achievement in Process Oriented Science Activities. Science Education. 65(1), 61-72.

Wareing C. (1990) A Survey of antecedents of Attitudes Towards Science. Journal of Research in Science Teaching. 27(4), 371-385.

Wellman R. T (1978) Science: A Basic for Language and Reading Development. In Mary Budd Rowe (Ed). What Research Says to the Science Teachers, II, Washington DC National Science Teachers Association 1-12.

Weaver E. K (1964) Science Education in Nigeria. Science Education 28(4), 351-361.

Wuyep S. N (1996) Using the Process approach to Teach Biology and Integrated science. In W. V. Famwang, T. O. Oyetunde, P. O. Awotunde, S. N. Wuyep and M. L. Ango (Ed). Effective Lesson Planning and Delivery (47-50) Jos: LECAPS (Nig) Limited.

Yoloye A. (1982) science Education in the Nigerian Primary Schools: A Need for Radical Approach. In the 23rd Annual Conference Proceedings of the Science Teachers Association of Nigeria. Lagos: Gilbert Grace and Gabriel Association 15-16.

Young D. J and Frasher B. J (1994) Gender Differences and Science Achievement: School Effects Makes a Difference. Journal of Research in Science Teaching. 31(8), 857-871.

Zuzovsky R and Tamir P (1989) Home and School Contribution to Science Achievement in Elementary School in Israel. Journal of Research in Science Teaching. 26(2), 705-714.

APPENDIX A

LETTER OF INTRODUCTION

Sir,

The bearer SANI A. GUMEL, MED-EDUC-37473-02/03 is a Post-graduate Student of Ahmadu Bello University, Zaria in the Department of Education (Science Section) currently undertaking a research on the effectiveness of Science Process Approach on students' academic achievement in Chemistry among Remedial students in Jigawa State. You may therefore wish to give him all the necessary assistance he may require.

Thank you.

(…………………………………)	(………………………..)
Student's Supervisor	Head of Section
Dr. J. S. Mari	Dr. S. S. Bichi

APPENDIX B

PROCESS APPROACH INSTRUCTIONAL STRATEGY MODEL LESSON PLAN

SUBJECT: Chemistry

TOPIC: Qualitative analysis of metallic radicals

AVERAGE AGE: 20 years

SEX: Mixed

DURATION: 2 hours

TEACHING AIDS: Salt solutions of different metallic radicals, NaOHaq, NH_4OHaq, $AgNO_3$aq, BaCl, e.t.c

BEHAVIOURAL OBJECTIVE: By the end of the lesson Students should be able to:

(1) acquire certain level of Science Process Skills which may include Observation, Measuring, Inference, data interpretation and hypothesis.

(2) Identify some metallic radicals from salt samples provided.

PREVIOUS KNOWLEDGE: Students have conducted a preliminary test of some metallic radicals.

INTRODUCTION: Introduction of the lesson will take the form of revision of the previously learned lesson and provision of materials required for the lesson, organising students and resources for effective learning, provision of clear instructions on students activities, managing student task and thinking as well as summarising the key concepts and ideas which students are required to remember on the black board.

PRESENTATION: The teacher will present the lesson through the following activities.

Activity I

(1) Sample A is a NaOHaq reagent

(2 Sample B is a NH_4OH aq reagent

(1) Add one $1cm^3$ of sample A to $1cm^3$ of Fe^{2+} solution provided and allow it to stand for 10 minutes.

(2) Add $1cm^3$ of sample B to $1cm^3$ Fe^{2+} and allow it stand for 10 minutes.

(3) Add $1cm^3$ of sample A to $1cm^3$ of Cu^{2+} solution provided and allow it stand for 10 minutes. Use ruler to measure the hight of each precipitate formed.

(4) Add $1cm^3$ of NH_4OH solution to $1cm^3$ of cu^{2+} solution provided and allow it stand for 10 minutes.

(5) Add $1cm^3$ of sample A to $1cm^3$ ofAl^{3+} ions provided and allow to stand for 10 minutes.

(6) Add $1cm^3$ of sample B_1 to $1cm^3$ pg $A1^{3+}$ provided.

(i) State your observation in each case

(ii) Use ruler to measure the height of each precipitate formed.

(iii) If you add $1cm^3$ more of sample B into each of the solutions provided, what will you observe?

(7) Carry it out and record your observations.

(iv) How will you use sample A and B to differentiate a solution that contains Fe^{2+} and Cu^{2+} ions?

ACTIVITY TWO

SECTION A . Carry out the following tests and record your observation

1. Take about $1cm^3$ of $Pb(NO_3)_2$ solution in a test tube and add dill HCl dropping until in excess.

2. Take about $1cm^3$ of NaCI solution in a test tube and add $AgNO_3$ solution dropwise until in excess.

3. Take about $1cm^3$ of NaCl solution in a test tube and add $AgNO_3$ solution dropwise until in excess.

4. Take about $1cm^3$ of Na_2S0_4 solution and add $Bacl_2$ solution dropwise until in excess.

SECTION B. You are provided with four solutions labelled A, B, C and D. They are aqueous solutions of Nacl, NaI, $Pb(NO_3)$, Na_2S0_4 but they are not in this order. E, F. G are aqueous solution HCl, $AgN0_3$, Bacl respectively. Describe how you would based on your observations in Section A use solutions E, F, G as reagents to identify solutions A, B, C and D.

Carry out the test according to the procedure you have outlined.

ACTIVITY THREE

1. A is a solution of lead (II) nitrate

   B is a solution of aluminium sulphate

   C is a solution of copper II chloride

   i. Take $1cm^3$ of solution A and add dil Hcl drop wise until in excess.

   ii. Repeat the activity with solution B and C.

iii. Take $1cm^3$ of solution A and add sodium hydroxide drop wise until in excess.

iv. Repeat activity III with solution B and C.

2. Solution D contains Aluminium sulphate, copper II chloride and lead II nitrate.

   Describe how you will separate the compounds using dil hydrochloric acid and ammonia solution and sodium hydroxide

ACTIVITY IV

A is a solution of NH_4aq

B is a solution of NaOHaq

Use the two solutions to carry out the following activities.

(1) Add $1cm^3$ of solution B to sample 1 and record your observations.

(2) Add $1cm^3$ of solution B to sample 2 and record your observations.

(3) Add $1cm^3$ of solution C to sample 3 and record your observations.

Heat the mixture and allow to cool and then record your observations.

(4) With reasons state the substances that are contained in sample 1, 2 and 3.

CONCLUSION

Process approach is a scientific and well integrated way of teaching science during which students are encourage to develop their intellectual skills known as science process skills in order to explore their environment.

APPENDIX C

LECTURE METHOD LESSON PLAN ONE

SUBJECT: Chemistry

TOPIC: Preliminary test of salt substances (Physical properties)

CLASS: Remedial students

AVERAGE AGE: 20years

NUMBER AIDS: Cupper salt, iron salt, lead salt.

INSTRUCTIONAL OBJECTIVE: By the end of the lesson, student should be able to identify the metallic salt presented through careful observation of their physical properties (i.e colour, smell, crystalline etc.)

PREVIOUS KNOWLEDGE: Student has learned the concept of acid, base and salt.

INTRODUCTION: The teacher introduced the lesson by reviewing briefly the concept of acid, base and salt. The teacher will at this stage of the lesson provide resources for learning, organising pupils and resources for effective learning, provision of class instructions on pupils' activities.

PRESENTATION: The teacher provides salt samples of varying physical properties and asked the students to carefully examine the samples.

Step II

The teacher explains the physical properties of each solid substances provided e.g colour, smell of size of particles.

Step III

The teacher draw an inference from the explanation he provided in step II above as follows:

Observation	Inference
Blue	Indicates the presence of copper II
Yellow substance	Indicates the presence of lead (II) or Ion (III)

Observation	Inference
Substance sublines	Most probably an Ammonium halide.

EVALUATION

The teacher evaluates the lesson by asking questions such as:

1. What is the expected colour of a salt substance containing cupper?
2. Yellow salt substance indicates the presence of ?
3. What is the expected colour of Iron (iii) salt?

CONCLUSION: The teacher concludes the lesson by summarising the main points of the lesson.

APPENDIX D

LECTURE METHODS LESSON PLAN TWO

SUBJECT: Chemistry

TOPIC: Preliminary test of substances (Flame test)

CLASS: Remedial Students

AVERAGE AGE: 20 years

NUMBER IN CLASS 38

DURATION: 2 hours

TEACHING AIDS: Con Hcl, Watch glass, platinum wire, solid substance containing calcium ion, cupper ion, lead ion, sodium ion e.t.c.

BEHAVIOURAL OBJECTIVE: By the end of the lesson students should be able to identify some metallic radicals from a solid substance.

PREVIOUS KNOWLEDGE: Students have learned the preliminary test of substance by examining physical appearance of the substance

PRESENTATION: The teacher presents the lesson by explaining to the students the procedure of the experiment as follows:

Pour some concentrated hydrochloric acid into a watch glass and dip a platinum wire into it. Hold the wire in a hot flame until it is colourless. Repeat this process. Moisten the wire by dipping it into a concentrated hydrochloric acid; dip it into the unknown solid heat strongly.

Step II

The teacher at this stage provides an explanation to the students on the result of the procedure described in step I as follows

* Brick red colour indicates calcium ion
* Bluish green colour indicates copper ion
* Pale blue colour indicates text
* Bright yellow indicate sodium ion.

CONCLUSION: The teacher concludes the lesson by providing more clarification on the procedure of the experiment explained above.

EVALUATION: The teacher evaluates the lesson by asking questions such as:

* What are the materials needed for flame test of metallic radicals? <u>As described in step I</u>
* What is the colour of the flame produced by a solid substance containing copper ion? <u>Bluish green</u>
* A pale blue colour indicates the presence of? <u>lead ion</u>.

APPENDIX E

LECTURE METHOD LESSON PLAN THREE

SUBJECT: Chemistry

TOPIC: Identification of Metallic Redicals

CLASS: Remedial

AVERAGE AGE: 20 years

NUMBER IN CLASS: 38

SEX: Mixed

DURATION: 2 hours

TEACHING AIDS: Sodium hydroxide, Ammonium hydroxide salt sample containing Fe^{2+}, Fe^{3+}, Cu^{+}, Zn^{2+}, Pb^{2+}, NH_4^{+}

BEHAVIOURAL OBJECTIVE: By the end of the lesson, students should be able to identify the presence of the following metallic radicals from unknown sample using sodium hydroxide solution

i.	Fe^{2+}	iv	Zn^{2+}
ii.	Fe^{3+}	v.	Pb^{2+}
iii.	Cu^{+}	vi.	NH_4^{+}

PREVIOUS KNOWLEDGE: The Students have conducted a preliminary test of metallic radicals e.g Cu (II), Lead (II), Iron (II) e.t.c.

INTRODUCTION: The lesson will be introduced by refreshing the memory of the students on the previously learned lesson, i.e preliminary test of metallic radicals.

PRESENTATION: The lesson will be presented via the following steps.

Step I

The teacher explains the various reagents used for identification of metallic radicals, e.g ammonium hydroxide and sodium hydroxide

Step II

The teacher will explain how a solution of the salt containing each of the metallic radicals listed above could be made.

Step III

The teacher at this stage will explain the procedure necessary for carrying out the experiment. Thus the teacher will explain to the students that a metallic radical can be identified from the colour and solubility of the precipitate it forms with sodium or ammonium hydroxide.

Step IV

The teacher will explain the various test to be conducted on each sample and the inference to be drawn as follows:

* If a little sodium hydroxide is added to solution of the substance and a blue precipitate insoluble in excess sodium hydroxide is obtained, this indicates the presence of copper (Cu^{2+}) ion.
* If the precipitate is green but insoluble in excess sodium hydroxide Iron (ii) (Fe^{2+}) ion is present.
* If addition of sodium hydroxide followed by shaking produce a brown precipitate insoluble in excess sodium hydroxide Iron (iii) (Fe^{3+}) ion is present.
* If ammonia gas is given off on heating ammonia salt is present.

SUMMARY: The teacher will summarise the lesson by explaining/reviewing the main points e.g sodium or ammonium hydroxide solutions are mainly used for identification of metallic radicals.

* a blue Ppt insoluble in excess sodium hydroxide indicate the presence of? $\underline{Cu}^{2+}$ ans.
* a green Ppt formed by salt solution which is insoluble in excess sodium hydroxide indicates the presence of ? $\underline{Fe}^{2+}$ ans.

APPENDIX F

LECTURE METHOD LESSON PLAN FOUR

SUBJECT: Chemistry

TOPIC: Identification of metallic Radicals

CLASS: Remedial

AVERAGE AGE: 20 years

NUMBER IN CLASS: 30

SEX: Mixed

DURATION: 2 hours

TEACHING AIDS: Ammonium hydroxide, sodium hydroxide salt samples containing, Fe^{2+}, Fe^{3+}, Cu^{2+}, Pb^{2+} e.t.c

INSTRUCTIONAL OBJECTIVE: By the end of the lesson students should be able to identify the following metallic radicals using ammonium hydroxide

i. Cu^{2+}

ii. Fe^{2+}

iii. Fe^{3+}

iv. Pb^{2+}

v. Zn^{2+}

INTRODUCTION: The lesson will be introduced by reviewing the last lesson briefly i.e identification of metallic radicals using sodium hydroxide solution.

PRESENTATION:

The teacher will introduce the lesson by explaining the following test, observation and inference.

Test	Observation	Inference
Reaction with ammonium hydroxide Addition of ammonium hydroxide solution to a solution of the substance. In drops and then in excess	Light blue precipitate is formed soluble excess ammonium hydroxide producing a dark blue colour	Copper (Cu^{2+}) ion is present
	Green Precipitate Insoluble in excess ammonium hydroxide	Iron (ii) ion is present
	Brown Precipitate Insoluble in excess ammonium hydroxide.	Iron (III) ion is present
	White precipitate soluble in excess ammonium hydroxide	Zinc (II) Ion is present

CONCLUSION: The lesson will be concluded by pointing out to the students the main points of the lesson e.g

* Ammonium hydroxide is another reagent used for identification of metallic radicals.
* Some salt solutions produce precipitate with ammonium hydroxide in drops. Precipitate dissolves when excess of the reagent is added for some salts.

EVALUATION: The lesson will be evaluated by asking questions such as

* Green precipitate insoluble is excess ammonium hydroxide indicates the presence of? Iron(II) ion
* Light-blue precipitate soluble in excess ammonium hydroxide indicates the presence of? Copper ion.

APPENDIX G

PRE-TEST ITEMS USING TEACHER MADE TEST (TMT)

INSTRUCTIONS Time: 30min.

The test consist of 20 items selected from different chemistry concepts. Each item in the test is followed by four (4) alternative responses lettered A - D. Circle the letter of the option/response you choose for each item.

(i) The number of protons in the nucleus of an atom is referred to as.

a. Atomic number

b. Mass number

c. Oxidation number

d. Avogadro's number

2. Atoms of the same elements having the same atomic number but different Mass number are called.

a. Isomers

b. Isotopes

c. Electrolytes

d. Conductors

3. The sum of the proton and neutron in the nucleus of an atom constitute.

a. The atomic number

b. The atomic Mass

c. The Mass number

d. The nuclear number

4. A solution which allow current to pass through it is called

a. Saturated solution

b. Unsaturated solution

c. Deliquescent

d. Electrolyte.

5. The electrode through which current passes and enters the electrolyte is called.

a. The Cathode

b. The anode

c. The Electrode

d. The Pole

6. Gas Pressure/volume relationship is best explained by

a. Charles's law

b. Boyle's law

c. Dalton's law

d. Avogadro's law

7. A chemical combination which involve transfer of electrons from the donor atom to the acceptor atom is referred to as

a. Coordinate covalence

b. Ordinary covalent combination

c. Electrovalent combination

d. Nuclear reaction

8. Compounds having the same molecular formula but different structural formula are referred to as

   a. Isomers
   b. Isotopes
   c. Insulators
   d. Ions

9. The ability of an atom to accept electron is called.

   a. electropositivity
   b. electronegetivity
   c. electrolysis
   d. electron affinity

10. Substances that can absorb moisture from the atmosphere and dissolve in it are called

   a. Hygroscopic substances
   b. Deliquescent substances
   c. Efflorescent substances
   d. Solutions

11. Substances that can exist in more than one form are referred to as

   a. Isomers
   b. Isotopes
   c. allotropes
   d. Enansiomers

12. Alkanes have the general formula given by

a. CnH_2n+1

b. CnH_2n+2

c. CnH_2n-1

d. CnH_2n-2

13. The process of electron lost is called

a. Reduction

b. Oxidation

c. Isomerisation

d. Delocalisation

14. Whenever a system in equilibrium is disturbed by one of the factors establishing the equilibrium, the equilibrium will shift so as to absorb the effect of the added stress. This statement is in accordance with

a. Hook's Law

b. Boyle's Law

c. Equilibrium Law

d. Lechartelier's principle

15. All of the following can affect equilibrium position except

a. Colour of the reacting substances

b. Concentration of the reacting specie

c. Temperature

d. Pressure

16. Complete the following neutralization reaction

$H_2S0_4 + 2NaoH$ 6 ?? $+ 2H_20$

a. N_aS0_4

b. Na_2S0_4

c. Nacl

d. H_20_2

17. Which of the following represents the electronic configuration of sodium?

a. $1s^22s^22p^2$

b. $1s^22s^22p^63s^2$

c. $1s_22s^22p^63s^1$

d. $1s^22s^22p^3$

18. When two or more compounds combine physically they form a

a. Solution

b. Electrolyte

c. Ions

d. Mixture

19. Which of the following is called laughing gas?

a. Carbon (i) oxide

b. Nitrogen (i) oxide

c. Carbon (iv) oxide

d. Nitrogen (iv) oxide

20. The reaction between acid and base to produce salt and water is called

a. Condensation reaction

b. Oxidation reaction

c. Substitution reaction

d. Neutralization reaction.

APPENDIX H

TEACHER-MADE TEST MARKING SCHEME

1.	A
2.	B
3.	C
4.	D
5.	A
6.	B
7.	C
8.	A
9.	B
10.	A
11.	C
12.	B
13.	B
14.	D
15.	A
16.	B
17.	C
18.	D
19.	B
20.	D

APPENDIX I

ANALYSIS OF PRE-TEST SCORES

EXPERIMENTAL VS CONTROL GROUPS

Groups	N	0	Sd	Df	P	t-value	Decision
Experiment	40	17.73	5.87				
				76	0.501	0.68	not significant
Control	38	18.37	5.16				

not significant at P> 0.05

Analysis of the data obtained from pre-test revealed no significant difference in the performance of the experimental and control groups. The critical t-value of 1.658 was found to be higher than the calculated t-value of 0.68 at $P \leq 0.05$ level of significance.

APPENDIX J

TEST OF CHEMISTRY ACHIEVEMENT (TOCA)

INSTRUCTIONS

each question is followed by four (4) alternative responses lettered A - D. Circle the letter of the response you choose for each question. Use pencil throughout.

a. Name of the Student -------------------------------------- sex ----------------------------

b. School --- Time: 45 min.

1. Sodium hydroxide solution is used in the identification of

   a. Cu^{2+}

   b. Fe^{3+}

   c. Methallic radical

   d. Fb^{2+}

2. A white precipitate soluble in excess NaoH.

   a. Confirms Pb^{2+}

   b. Indicates Pb^{2+}

   c. Confirms Fe^{2+}

   d. Fe^{2+}

3. Which of the following is used in the confirmation of Pb^{2+} ?

   a. K1

   b. $K_2 Cr_20_4$ and K1

   c. $K_3Fe(CN)_6$

d. K1 and $K_3Fe\ (CN)_6$

4. The reddish colour of our blood may probably be due to the presence of

a. Fe^{2+}

b. Fe^{3+}

c. Fe^{3}

d. Pb^{2+}

5. $CuS0_4 + H_4S$ 6 x + H_2S0_4 what 5 x ?

a. Cu

b. Cus

c. Cu^{2+}

d. Cu0

6. The equation in 5 above

a. Indicates Cu^{2+}

b. Confirms Cu^{2+}

c. Shows Cu^{2+}

d. Confirms Pb^{2+}

7. A mud mixed with dried grass and water when left for some days changes to green. This colour(green) changes to reddish brown after being exposed to air or atmospheres (i.e on building walls) This shows

a. The conversion of Fe^{3+} to Fe^{2+}

b. The oxidation of Fe^{2+} + Fe^{3+}

c. Confirmation of Fe^{2+}

d. Identification of Fe^{3}

e. Potassium thiocyanate is used in the

a. Confirmation of Fe^{2+}

b. Identification of Fe^{2+}

c. Confirmation of Fe^{3+}

d. Identification of Fe^{2+}

9. Assuming that a rotten egg contains Hydrogen sulphide. If rotten egg and dil Hcl are added to unknown sample, a black precipitate is formed, this

a. Shows the presence of Cu^{2+}

b. Confirms the presence of Cu^{2+}

c. Shows the presence of Fe^{2+}

d. Confirms the presence of Fe^{2+}

10. Consider the equation pb $(No_3)_2$ +2K1 6 Pb1 + $2KN0_3$ the colour of Pb1 is

a. Green

b. White

c. Brown

d. Yellow

11. When Potassium hexacyanoferrate 111 is added to a substance, a dark blue precipitate is formed. This confirms

a. Cu^{2+}

b. Fe^{2+}

c. Fe^{3+}

d. Pb^{2+}

12. Ethanoic acid is used in the

   a. Confirmatory test for metallic radicals

   b. Identification of metallic radicals

   c. Confirmation of Fe^{2+} only

   d. Confirmation of Pb^{2+} only.

13. All laboratory reagents are dangerous to our health, which of the following is the most dangerous?

   a. NaOH

   b. Ammonium hydroxide

   c. Phenolpthalene

   d. Those containing cyanide

14. A green gelatinous precipitate was observed by the addition of NaOH to unknown solution.

   This precipitate change to reddish brown on exposure to atmosphere. Which of the

   following equations represents this statement?

   a. Fe^{2+} - e 6 fe^{3+}

   b. Fe^{2+} +e 6 fe^{3+}

   c. Fe^{3+} +e 6 fe^{4+}

   d. Fe^{3+} +e 6 fe^{2+}

15. When potassium tetraoxochromate (vi) is added to unknown sample solution, a yellow precipitate is formed.

   a. Indicating Cu^{2+}

   b. Indicating Pb^{2+}

   c. Confirming Cu^{2+}

d. Confirming Pb^{2+}

16. Which of the following cation gives a green gelatinous Ppt with both aqueous sodium hydroxide and ammonium solution?

a. Cu^{2+}

b. Fe^{2+}

c. Zn^{2+}

d. Pb^{2+}

17. If an oxide of certain metal is heated it changes colour. Yellow when hot and white when cold. The most likely metal present is

a. Zn^{2+}

b. Cu^{2+}

c. Zn^{+}

d. Al^{3+}

18. The process by which a precipitate of certain metal chloride ion on exposure to sun light emits electron and changes colour is known as

a. Photosynthesis

b. Electrolysis

c. Photo-electric effect

d. Phototropism

19. A pungent smell of a gas perceived which produced dense white fumes with cone. Hcl when $NaOH_{aq}$ is added to a certain salt solution and warmed indicate the presence of

a. Zn^{2+}

b. Pb^{2+}

c. Ca^{2+}

d. NH_4^+

20. Which of the following is not used as a preliminary test in qualitative analysis?

a. Use of chemical reagent

b. flaming

c. Colour identification

d. Observing physical appearance

21. The most common reagent used for the identification of cation are

a. Barium chloride and silver nitrate solution.

b. Sodium hydroxide and Ammonium solution

c. Aqueous ammonia and aqueous Barium chloride

d. Aqueous sodium hydroxide and aqueous silver nitrate

22. Fe^{2+} aq - e 6 fe^{3+} (aq) The equation above is a typical

a. reduction reaction

b. redox reaction

c. oxidation reaction

d. neutralization reaction

23. What would be the possible change in colour of the ions in the reaction in question 22 above from left to right?

a. green Ppt to reddish Ppt

b. reddish brown Ppt to green

c. Pate-yellow Ppt to dark green Ppt

d. green Ppt to Pate-yellow Ppt

24. Why did the Pate-blue Ppt of Cu^{2+} which was formed when ammonia solution was added in drops dissolved in excess of the alkali to give blue solution?

a. due to the formation of Cu^{2+}

b. due to insoluble ion of copper (ii) hydroxide

c. due to addition of excess ammonia solution

d. due to addition of excess aqueous sodium hydroxide

25. In the equation $Cu(OH)_{2+}$ x $| Cu(NH_3)_4^{2+} + 2OH^-$ x stand for

a. NaoH aq

b. $CuSU_4$ aq

c. 4 NH_3 aq

d. H_2O

26. Addition of reagent to a sample in a qualitative analysis must always be done carefully because

a. The reagents are difficult to purchase

b. The samples are in various quantities

c. Both the reagents and the samples are dangerous

d. Both the reagents and the samples are hazardous

27. The presence of Cu^{2+} is confirmed by

a. addition of ammonium solution is drops

b. addition of sodium hydroxide solution in drops

c. addition of ammonium solution in excess

d. addition of sodium hydroxide solution in excess

28. Students in a qualitative analysis class were given salt sample to test. Careful observation of the sample gives a pale green colour to the eye. This indicates that the salt sample given is

a. hydrated Iron (ii) salt

b. hydrated copper (ii) salt

c. hydrated Iron (ii) salt

d. copper (I) oxide

29. The method employed for the identification of the physical or chemical nature of a substance is best described as

a. volumetric analysis

b. qualitative analysis

c. chemical analysis

d. quantitative analysis

30. Cautions are

a. negatively changed ions formed by gain of electrons

b. positively changed ions formed by gain of electrons

c. positively changed ions formed by lost of electrons

d. negatively changed ions formed by lost of electrons.

APPENDIX K

TEST OF CHEMISTRY ACHIEVEMENT (TOCA)

MARKING SCHEME **1 Mark each**

1. C	11. B	21. B
2. B	12. A	22. C
3. B	13. D	23. A
4. B	14 A	24. B
5. B	15. D	25. C
6. B	16. B	26. D
7. B	17. A	27. C
8. C	18. C	28. A
9. B	19. D	29. B
10. B	20. A	30. C

Total = 30 marks

APPENDIX M

TEST OF SCIENCE PROCESS SKILLS (TOSPS)

MARKING SCHEME

1.	B
2	C
3	B
4	D
5	C
6	C
7	A
8	D
9	B
10	C
11	C
12	B
13	C
14	C
15	B
16	B
17	C
18	C
19	B
20	A
21	C
22	C
23	B
24	B
25	A

APPENDIX N

TEST OF CHEMISTRY ACHIEVEMENT (TOCA)
SCORES FOR EXPERIMENT AND CONTROL GROUPS

EXPERIMENTAL GROUP		CONTROL GROUP	
Males	Females	Males	Females
18	20	22	10
22	09	09	11
10	10	08	16
25	15	23	05
20	11	19	11
20	11	20	18
09	13	23	16
16	21	18	10
11	17	24	20
23	08	20	
16	23	19	
27	16	19	
19	10	21	
24	15	22	
26	19	27	
22	26	20	
20	06	18	
25		24	

19		22
18		20
23		20
26		24
20		16
		22
		20
		18
		25
		17
		25
X = 17.725	t-value = -0.51	X= 18.3684
S.D = 5.870	P = 0.609	S.D = 5.159

APPENDIX O

TEST OF SCIENCE PROCESS (TOSPS) SCORES

FOR THE EXP. AND CONTR. GROUPS

EXPERIMENTAL GROUP		CONTROL GROUP	
Males	Females	Males	Females
11	09	19	09
15	20	10	19
10	18	07	20
17	10	15	11
09	15	12	12
07	17	10	10
18	11	18	09
18	14	16	12
10	15	20	18
12	13	17	
20	11	11	
19	15	13	
18	08	16	
12	16	10	
22	19	08	
15	16	17	
13	03	11	
10		20	

19		15
11		21
16		09
14		11
21		18
		15
		20
		17
		20
		16
		19
$\tilde{X}$ = 14.525	t-value = -0.20	X = 14.342
S.D = 3.929	P = 0.842	S.D = 4.141