A COMPARATIVE STUDY OF THE EFFECTIVENESS OF CONCEPT-MAPPING AND GUIDED DISCOVERY TEACHING STRATEGIES ON SECONDARY SCHOOL STUDENTS' UNDERSTANDING OF SELECTED CHEMISTRY CONCEPTS

BY

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DECLARATION

I hereby declare that this thesis has been written by me. It is a true record of my research work and it has not been presented in any previous application for a higher degree or published in a book. In the course of writing this thesis, references were made to various sources of information. These were fully acknowledged by means of references.



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CERTIFICATION

This thesis titled "A COMPARATIVE STUDY OF THE EFFECTIVENESS OF CONCEPT-MAPPING AND GUIDED DISCOVERY TEACHING STRATEGIES ON SECONDARY SCHOOL STUDENTS UNDERSTANDING OF SELECTED CHEMISTRY CONCEPTS" by VICTORIA IFEOMA EZENWA, meets the regulations governing the award of the degree of Doctor of Philosophy (Ph.D) of Ahmadu Bello University, Zaria, and it is approved for its contributions to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to Almighty God for his grace that saw me successfuly through this study.

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Uppermost in my list of acknowledgement is my God, the Lord Almighty, whose goodness and grace saw me successfully through this study. My supervisor Prof. J.O. Otuka deserves more gratitude than I can ever express here. Indeed, to have studied and worked under such a distinguished and renowed science educator is a rare privilege for which I am deeply appreciative. My sincere thanks go to Prof. P.K. Oyebanji, Dr. A.A. Shuaibu, Dr. C.O. Abah, Dr. S. Awodi, Prof. S. Thomas, members of my supervisory committee for their constructive criticism and valuable advice. I also wish to acknowledge with thanks the assistance of Mr. H.A. Babagbale, former Acting Director of Computer Centre, Federal University of Technology, Minna and Dr. E.O. Asiribo, the Biometrician of Institute for Agricultural Research, Ahmadu Bello University Zaria, in analysing some of the research data. I am highly indebted to my family, M.I. Ezenwa, Uzo Ezenwa, Chinyere Ezenwa, Ifeoma Ezenwa, Ike Ezenwa and Ogo Ezenwa for their fervent prayers. My thanks also go to my very, very close friends, Mrs. Bola Lagoke and Mrs. Sayo Gbadegesi who tolerated my unannounced visits, interruption of their family activities and even got their husbands involved in my programme. I am also grateful to the principals and students of the schools I used for the study for their co-operation.

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ABSTRACT

Studies have shown that in the study of Chemistry, students perceived bonding, chemical reaction and particulate nature of matter to be difficult. This is reflected in poor performance in tests involving these concepts. It seems that the Federal Ministry of Education, recommended instructional strategy, guided discovery is not yielding the desired result. Considering the importance of Chemistry to man and his environment, there is the need to inquire into ways of ensuring that students make meaning of what they learn in chemistry.

Science educators now advocate for instructional strategies like concept mapping that enable students construct meaning of what they learn. In this study the effectiveness of concept mapping strategy in bringing about understanding of chemistry concepts is compared with that of guided discovery. The effects of the study instructional strategies on some variables (gender, home factors, reasoning ability, reading comprehension and attitude) were investigated.

The study sample consisted of 246 (SSI) chemistry students drawn from 3 randomly selected secondary schools in Niger State of Nigeria. The students were assigned into two groups - concept-mapping and guided discovery. The concept-mapping group was taught using concept mapping strategy and

the guided discovery group taught using guided discovery strategy. Both groups were pre- and post tested. Eight hypotheses were tested. The major instruments for the study were Chemistry Attitude Questionnaire, Home Factor Questionnaire, Chemistry Concept Achievement Test, Reasoning Ability Test and Reading Comprehension Test. The data obtained were analysed and tested at a significant level of 0.05. Findings of this study are:

i. that the concept mapping group performed significantly better and retained more of the selected chemistry concepts than the guided discovery group,

ii. there was no significant difference in the performance of boys and girls taught using concept mapping and guided discovery strategies. However there was a significant interaction effect between gender and instructional strategy attributable to concept mapping strategy,

iii. there was no significant relationship between any of the home factors and performance in chemistry.

iv. that concept mapping strategy improved reasoning ability, reading comprehension and students attitude to chemistry,

v. that reading comprehension and reasoning ability contributed to students performance when concept mapping strategy was used.

Based on these findings, recommendations were made for teacher education and the curriculum.

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DEFINITION OF TERMS

CONCEPTS:

Are perceived regularities in events or objects designated by some label. It could also be described as mental constructs we have of words. For example, An Atom.

CONCEPTION:

Is the process of mental construction of the world which facilitates understanding.

PRECONCEPTIONS:

These are meanings/notions or conceptions students have formed about the physical world before instruction which they bring to class. These pre-conceptions could or could not be in line with scientific way of thinking. Preconceptions have been labelled:

"incorrect conceptions" (Driver and Easley, 1978).

"prior conceptual framework" (Osborne and Gilbert, 1980).

or "misconceptions" (Helm, 1980; Nachtigall, 1986).

Recently, all these terms have been replaced by "pre-scientific conceptions".

COGNITION:

It is a mental process by which knowledge is generated.

CONCEPT MAP:

It is a map intended to represent meaningful

relationships between concepts in the form of propositions.

CONCEPT MAPPING STRATEGY:

It is an instructional strategy for ordering and linking perceived regularities in events/objects/concepts in such a way that meaning is achieved.

CONCEPT FRAMEWORK:

Is a pattern of mental representation of information.

RETENTION:

Ability of memory to store information.

PROPOSITION:

Is the meaningful relationships between concepts indicated by connecting lines and linking words. Two or more concepts linked together by words create a proposition.

MEANINGFUL LEARNING:

Learning that results when new knowledge is applied to other situations to arrive at a correct solution.

CHEMICAL REACTION:

It involves a change in the chemical identity of matter, resulting from the re-arrangement of atoms present in the original kind of matter to give new combinations present in the final kind of matter.

UNDERSTANDING:

The process of understanding is characterized by seeing relations between observed event and existing knowledge.

The ability to perform correctly most of the intellectual task is taken as evidence that a student understands a concept.

COMMUNICATION:

Is a process used to give meaning to signal received.

REASONING ABILITY:

Ability to generate logical relationship among evidences or concepts. It is determined by a student's total score in the non-verbal reasoning ability test.

PERFORMANCE:

Has to do with how well an individual is able to demonstrate desired ability (in an educational concept).

CHAPTER 1

THE PROBLEM AND ITS DEFINITION

1.1 Introduction

In the early fifties, educators were concerned with getting knowledge into the heads of their students and educational researchers were concerned with finding better ways of 'imparting' or transmitting this knowledge to students. The students were told what they needed to know. They were seen as empty-headed and played an intellectually passive role. The teachers did not regard students pre-existing ideas as important. Teachers' view rarely focused on the issue of 'how students learn' (Scott, Dyson and Gater, 1988). The teacher, for instance, might ask "why do things fall" but may not attach meaning to students argument about the 'role of air'. Science was therefore presented as a catalogue of 'facts'. Evaluation of learning emphasised summative assessments on whether knowledge had been transmitted or not.

At the time educators were getting concerned about the 'transmission mode' of teaching, Sputnik of 1957 acted as a catalyst for the reformation of instruction in the United States (U.S.). This later spread worldwide. During this (Golden Age of) curriculum development (1960's - early 1970's), the rationale for science teaching shifted to the

discovery approach. The instructional change brought about during the Golden Age, undoubtedly increased scope of science in schools.

In pursuance of this new teaching method in Nigeria, the Federal Ministry of Education (FME) adopted the use of the guided discovery strategy. This strategy is strongly recommended in the National Science Curricula for Senior Secondary Schools. The strategy is activity oriented and involves discussion, experimentation and practical demonstration. The students are guided by the materials and teachers to discover science concepts. Pre-service and In-service training programmes were mounted for science teachers to acquaint them with the new strategy. The attributes of the guided discovery as stated by Welch et al (1987) are:

i. accurate observation alone provided a secure base from which knowledge could be derived.
ii. science concepts would be learnt by becoming good observers.
iii. concept formation could flow from unbiased observation alone.

The difficulty of the strategy was on this basis under-estimated. However Novak (1987) stated that scientific concepts are imaginative constructs of the human mind and cannot simply be induced from mere observation. Also the necessity of a prior 'conceptual framework' before one could

'discover' anything at all was not accounted for. Although students became more 'active' in the sense that they were spending more time in the laboratory carrying out observations, they were not considered to be active in the sense of actively constructing knowledge, (Cleminson, 1990).

Moreover, it would be difficult to identify significant changes in learning that resulted from guided discovery teaching strategy, despite the huge amount of money expended on curriculum (Babikian, 1971; Bajah, 1986; Lott, 1983; Pankratius, 1990; Obi, 1992; Watt, 1988). Within a few years, the novelty of the new strategy waned, teachers perceived a gap between the noble aims of curriculum and the realities of their implementation at the classroom level. It is now recognized that the major efforts made to improve secondary school science education has fallen short of expectation (Stakes and Easley, 1978; Finocchario, 1980; Okebukola & Jegede, 1989; STAN, 1992).

Novak (1987) suggested that a fundamental reason for the failure of the curriculum development of the 70's was a failure to distinguish between a teaching approach and a learning approach. According to Novak, learning is not mere accumulation of knowledge but an active process in which the learner is engaged in constructing (not discovering) or generating concept to account for novel phenomena.

There is therefore obvious disparity between what science educators would like to see happening in the

classroom and what is actually happening (Bozimo, 1982; Driver and Oldham, 1985; Von Glaserfeld, 1983; Jegede, 1982; 1990; Jegede and Okebukola, 1988; 1989; Ogunniyi, 1988; and Okebukola, 1990). The result is a wide spread call for ways of reforming science education. Some other problems that influenced and prompted the reform movement in science education were:

a. An increase in students' aversion towards key science concepts leading to growth of literature on the following topic difficulties:
   i. Stoichiometry: (Abayomi, 1985; Bello, 1988; Camacho and Good, 1986; Enoch ad Gabel, 1984; Frank and Herron, 1987; Frazer and Sleet, 1984; Greenbowe, 1983; Pearson, 1989; Schmidt, 1984; Tingle and Good, 1990).
   ii. Chemical equations and the concept of mole (Bajah, 1979; Bruce, 1983; Dawson, 1978; Duncan and Johnstone, 1973; Eniayegu, 1990; Eseonu, 1982; Ingle an Shayer, 1971; Johnstone, 1971; Koleoso, 1985 and Schmidt, 1984).
   iii. Co-efficients and subscripts of chemical equations (Bello, 1988; Duncan and Johnstone, 1973; Lazonby et al, 1982).
   iv. Mass ratio and molar ratio (Artherton, 1974; Frazer and Sleet, 1984).

b. High failure rate of science students in the senior

secondary (chemistry) certificate examination (SSCE) which has been attributed to poor understanding and application of chemical concepts. (Abdullahi, 1982; Abimbola, 1983; Ajewole, 1991; Bajah, 1986; Ekpo, 1985; Olaniyi, 1985; (STAN, 1992 See Table 1).

Table 1: Performance of students in SSCE Chemistry (1982-90)
Percentage in Grades 1-6

Year	Chemistry
1982	17.5
1983	12.3
1984	25.5
1985	19.8
1986	39.2
1987	22.6
1988	20.7
1989	10.8
1990	4.1

Source: (STAN/WAEC "1992")

c. Societys' needs and goals have changed. Not only has scientific knowledge increased over two decades, but society experiences problem today such as: acid rain, nuclear energy, etc. that were unimagined before.

d. New family structures have emerged; less than 10% of mothers are currently full time house wives, therefore the time parents and children spend with one another at home has decreased (Hurd, 1990).

e. Sufficient attention is not given to the dimension of students view brought to the class that may influence their understanding of science concepts (Abimbola, 1990; Clark and Peterson, 1986; Gunstone, 1984;

Okebukola, 1990; Shulman, 1980; Wittrock, 1985).

f. Students' prior knowledge has not been considered by researchers on teaching, not even by those who have studied students thinking as mediators of effective learning (Carpenter and Peterson, 1988; Cleminson, 1990; Linn, 1986; Onwu, 1985; Shulman, 1986).

g. The discovery curricula developed during the 'Golden Age' of science education, seem to be ineffective in enhancing students attitude and performance (Cleminson, 1990; Jedege, 1990; Novak, 1981; Osborne and Freberg, 1985; Watts, 1988; Odubunmi, 1983; Pankratius, 1990).

The effect of all these is that science educators in the 80s' and 90s' now advocate for changes in instructional practices. In the search for ways of making science more meaningful and productive, many science educators now advocate an emerging "science for science teaching" based on the preconceptions students acquire before formal study of science. Some researchers have explored new teaching strategies that take cognizance of students preconceptions (Johnstone, 1987; Novak, 1987; Novak and Gowin, 1985; Osborne and Freyberg, 1985). These students preconception and prior conceptual framework are at the core of "alternative conceptual movement". In search for alternative methods of instruction in science teaching, many studies now focus on ways of knowing, learning and teaching with emphasis on students constructing meaning from what

they learn. Amongst the numerous studies are the research works and reports (Clarke, (1988); Novak, (1988,1989); Okebukola and Jegede, 1990).

All these efforts aimed at improving science instruction focused on "alternative conceptions" and are embodied in the constructivist planning of learning. The constructivists view of learning has become a leading idea in science and education. Basically, it views learning as a process in which the learner constructs knowledge from pre-existing ideas. Learning takes place not only through taking in new information but also involves organization and restructuring of the concepts that the learner already has. As such it is a process in which the learner is actively engaged in constructing meaning (Driver and Bell, 1986).

Many new teaching strategies are embodied in the constructivist framework. They include such strategies as: analogies, metaphors, problem solving and concept mapping. Of all the new instructional strategies, within the constructivist framework, concept-mapping seem to be gaining ground. A whole issue of Journal of Research in Science Teaching (JRST) focused only on concept-mapping (JRST, 27(10) Dec. 20 1990).

Concept is the key to human learning and meaning making. A concept is defined as a regularity in events or objects designated by some labels. "Bonding" for example is the label used for the process that involves chemical

rearragement of atoms. Concept mapping therefore is an instructional strategy for organizing concepts in a hierarchical manner and linking the related concepts in such a way that the students make meaning of what they learn.

The steps in concept-mapping activities are:

1. Identify and list the key words/terms/concepts.
2. Rank the listed concepts from the most abstract and inclusive to the most concrete and specific.
3. Cluster the concepts according to two criteria; concepts that function at a similar level of abstraction, and concepts that interrelate closely.
4. Link related concepts with lines and label each line in propositional form (Ault, 1985). When a student completes the above steps for a given concept/topic, the concepts become meaningful to him. He can then communicate the underlying ideas very clearly to his peers or the teacher because he has understood the concept.

Concept mapping teaching strategy involves:

i. elicitation of students prior knowledge

ii. exchange of ideas
   - discussion
   - practical demonstration/experimentation
   - concept mapping activities

iii. drawing of concept map

According to Novak (1985), concept mapping strategy

helps students learn how to learn meaningfully and helps teachers as well become more effective in their teaching. Concept mapping strategy is relatively new in Nigeria, and not much research has been carried out on it. Most of the researches on concept mapping were done overseas by the initiators of the strategy (Novak, 1985; 1988; 1990; Novak and Gowin, 1984; Novak, Gowin and Johansen, 1983; Ault, 1985 and Watt, 1988). The researches were on earth science concepts (Ault, 1985), on physics concepts, (Watt, 1988; Pankratius, 1990) and on biological concepts (Carter and Kahle, 1987; Cliburn, 1987). Their study samples were either primary school children or fresh undergraduates. In Nigeria, Jegede and Okebukola (1990); Okebukola (1990) and Okebukola and Jegede (1989) studied the utilization of concept mapping instructional strategy in biology. They are all in agreement that the strategy could bring about meaningful learning. Therefore a seemingly fruitful method of bringing about understanding of science concepts could be through the use of concept mapping. Mapping exercise demands that a student should have a good knowledge of the attributes of the concept before locating it in the appropriate place on the map. It also enables the students to appreciate the inter-relationships among the concepts and sub-concepts. This procedure requires the students to think in multiple directions and switch back and forth between different levels of abstraction.

Perhaps, if chemistry students are instructed using concept mapping strategy, meaningful learning might prevail and performance might improve. There is no doubt that a new instructional strategy that lays emphasis on prior knowledge of students might improve students understanding of science concepts. Consequently, the purpose of this research is to compare the effectiveness of the concept mapping and guided discovery strategies in bringing about understanding of basic chemistry concepts using Senior Secondary One students in Minna, Niger State. If students are to have a taste of satisfaction in chemistry, it is proper to seek teaching strategies or ways of making chemistry more exciting, stimulating and challenging experience to them.

Apart from seeking effective instructional strategy, science educators are faced with the problem of attracting girls into science. A considerable amount of research has focused on gender differences and school learning. In science education, there is the concern that girls are not achieving as much as they should (Erickson and Erickson, 1984; Kelly, 1978; Welch, 1985). The differences seem to be most pronounced in the physical sciences.

Some researchers have advanced some reasons for the differences. Tracy (1990) postulated that sex related differences in science achievement might be related to three areas: social (sex-role model and orientations); educational (parent, teacher, peer expectation, class extra curricula

activities) and personal (spatial ability) factor. Haggerty (1987) is of the opinion that the more active participation of boys in science class may be an important factor responsible for the variation. Jegede and Inyang (1989) have observed a significant superior achievement of boys over girls in school science. A conflicting report was given by (Comber and Reeves, 1973; 1984; Jacobson and Doran, 1985; and Otuka, 1986) who found no significant differences in the science achievement of girls and boys. The research on gender difference with respect to performance is still not conclusive. Part of this study, therefore, is to determine if any of the research teaching strategies will enhance the performance of girls in science.

No matter the gender, the home is the first laboratory of any child. The home environment therefore has one of the most lasting influences in the development of a child's cognitive ability and effective characteristic (Bloom, 1981; 1984; Marjoribanks, 1979; Walberg, 1984; Ware and Garber, 1976). The way the family is organized and the status of the parents are important in learning. Parental involvement in a child's education has been identified as a key factor influencing a child's desire to learn (Ware and Garber, 1972).

Ware and Garber, (1972) contended that availability of materials in the home seem to be the most important variable predicting school achievement. Walberg (1983) reported that

family socio-economic status was predictive of academic learning. There is no doubt that home environment and activities influence children's learning. At home, a child interacts with mother, father, siblings, other members of the family, toys, peer group and develops intellectually as a result of the wealth of experiences gathered through these interactions. A conflicting report was given by Onyeabe (1972) that the family is negatively associated with achievement in his study with Nigerian secondary school students. Boocook (1972) found that father occupation seems to be strongly associated with the style of interaction between members of the family. Bolarin (1977) reported that the patterns of child behaviour established at home could have a direct carry over to the school. Part of this study is to determine if any home factor variable influences students' understanding of chemistry concepts.

There is evidence that experience in school helps children of all socio-economic levels in language comprehension and reasoning development (Thelan, 1976; Catha, 1977). Kellog (1971) and Renner (1973) found that experience gained by first graders when involved in the science curriculum unit "material object" improved their score on reading and reasoning tests. Part of the present study is to determine if any of the teaching strategies would improve students performance on reading comprehension and reasoning ability.

Attitudes play a major role in students' learning (Gardner, 1975; Levin and Fowler, 1984). Attitude is viewed as representing the underlying dispositional and motivational urge for learning (Hassan, 1985). The attitude an individual has influences science learning and use of scientific information to a considerable degree. Part of this study is to determine if the use of concept mapping and/or guided discovery strategy would result in students developing a favourable attitude to chemistry.

The discussion so far shows that the decision to study the effect of the two instructional strategies on these variables (gender, home factor, attitude, reading comprehension and reasoning) seems desirable.

It is the objective of this study to:

i. compare the effect of concept-mapping and guided discovery strategies on students understanding of some selected chemistry concepts.
ii. determine whether concept-mapping or guided discovery strategies would improve students' retention of chemistry concepts.
iii. find out if there will be differential performance of boys and girls using concept-mapping or guided discovery strategies.
iv. find out if any home factor variable would influence students performance in chemistry.
v. determine whether concept-mapping and/or guided

discovery strategies will improve performance of students in reading comprehension.

vi. find out if the use of concept-mapping and/or guided discovery strategies will improve students reasoning ability.

vii. find out if there is a positive change in students attitude to chemistry learning when concept-mapping and guided discovery strategies are used.

viii. determine the independent and combined contribution by the variables (reading, reasoning and attitude) on students' performance when concept-mapping and guided discovery strategies are used.

1.2 Statement of the Problem

Some of the problems of science education in this country have been: students poor performance, low enrolment and poor performance of girls and the failing of our educational efforts. For years, science educators have advocated for discovery instruction. In Nigeria, guided discovery was adopted. This is because it is believed that science should not be taught to a child but that he should be guided to discover it through such processes as observing, measuring, classifying and so forth. Yet over the years, students outcome in discovery instruction has been disappointing (Welch et al, 1981; Pizzini et al, 1991; Watt,

1981; Babikian, 1971, STAN, 1992).

Many reasons have been adduced. Some researchers are of the opinion that the society is changing and discovery method is no more adequate (Watt, 1988). Others suggested that the process of communication and prior knowledge which are the basis of learning are underestimated. Perhaps, the strategy is either not appropriate for the teaching of senior secondary chemistry or the teachers do not implement the approach appropriately.

Recently, many efforts were made to improve science instruction by looking at various ways students construct knowledge (Novak, 1989; Scott and Dyson, 1989; Urevbu, 1988; Von Glaserfeld, 1989; Osborne and Wittrock, 1983). This is a relatively new method of instruction that owes its existence to Ausubel and Piaget. Ausubel (1968) put forward the view that "the most important factor influencing learning is what the learner already knows; ascertain this and teach him accordingly". An interpretation could be that science educators must elicit the existing preconceptions of the physical world that students bring to class and use them to modify, these students concepts so that they become more like the accepted "scientific conceptions of the world" (Driver and Bell, 1986; Osborne and Freyberg, 1985).

One of the instructional strategies that is gaining ground in science education is concept mapping. There is

evidence that concept mapping could promote understanding of science concepts (Novak, 1983; Okebukola and Jegede, 1989; Okebukola, 1990).

Specifically, the study will attempt to answer the following questions.

i. Would there be any significant difference in performance between groups taught using the concept-mapping strategy and groups taught using the strategy (guided discovery) recommended by the National Science Curricula for Senior Secondary School.

ii. Would the teaching of chemistry concepts using concept-mapping strategy enhance students retention more than the guided discovery strategy?

iii. Would the use of concept-mapping strategy and guided discovery strategy result in differential performance of boys and girls in chemistry?

iv. Would home factor(s) influence students performance in chemistry?

v. Would any of the two strategies (concept mapping and guided discovery) enhance students reading comprehension?

vi. Would the use of concept-mapping strategy be more effective in improving reasoning ability than the guided discovery?

vii. Would the use of any of the two teaching strategies

promote students positive attitude to chemistry learning?

viii. Would there be significant contribution by any or all of the variables (reading, reasoning, attitude) on students performance in chemistry when concept-mapping or guided discovery strategy is used?

1.3 Study Hypotheses

The following hypotheses formulated in the null form were tested in this study.

H(O) 1: There is no significant difference in performance between groups taught using concept mapping and guided discovery strategies.

H(O) 2: There is no significant difference in the level of knowledge retention of selected chemistry concepts between groups taught using concept-mapping and guided discovery strategies.

H(O) 3: There is no significant difference between the performance of boys and girls taught using concept mapping and guided discovery strategies.

H(O) 4: There is no significant relationship between students' home factor (variables) measured by:

i. Parental status

ii. Parental involvement

iii. Students' study routine and performance in

chemistry.

H(O) 5: There is no significant difference between the reading comprehension score of students taught using concept-mapping and guided discovery strategies.

H(O) 6: There is no significant difference between the reasoning ability performance of students taught using concept-mapping and guided discovery strategies.

H(O) 7: There is no significant difference in the attitude to chemistry learning between groups taught using concept-mapping and guided discovery strategies.

H(O) 8: There is no significant contribution by any or all of the variables (reading, reasoning, attitude) to the students' performance in chemistry.

1.4 Significance of the Study

The findings of the study could be useful in the following ways:

i. It could be used to clarify, support or substantiate the existing learning theories expressed by psychologists like Piaget, Bruner and Ausubel.

ii. It could contribute to the improvement of science

instruction at the secondary school level.

iii. It could foster new approaches in curriculum and text development.

iv. It could add to existing knowledge and perhaps open a gateway for further research.

v. It could help in actively involving the participation of students.

The world in general is becoming more and more scientifically and technologically oriented. Chemistry like Physics is a pre-requisite for almost all engineering and other technological courses.

It is therefore anticipated that the findings of this study would be found valuable by students and various bodies engaged in scientific and technological policy formulation, implementation and development in the country like:

i. Teachers:

Teachers responsible for the teaching of chemistry to secondary school students might utilize the findings in the science classroom by:

a. helping students to have conceptions shift in favour of scientifically valid concepts.

b. taking into consideration, students prior knowledge.

c. developing inexpensive modules that would enhance teaching and assessing understanding of concepts.

ii. Universities and Colleges

Institutions of higher learning where chemistry

teachers are trained would need to be aware of the utility value of the strategy to teaching and learning. This would enable them to produce more effective teachers who would help students construct knowledge on their own.

iii. National Education Organization

Bodies like Science Teachers Association of Nigeria (STAN, Science Association of Nigeria (SAN), National Education Research and Development Centre (NERDC) that carry out research, discuss and disseminate research findings, might wish to consider the results of the research with a view to using the strategy to promote science instruction in schools.

iv. Students

It is hoped that the result of the study would encourage students to be actively involved in the construction of knowledge and to take charge of their own learning. Active participation of students might help them to develop self confidence and positive attitude to science. It might attract more girls to science.

v. Curriculum Developers

Curriculum developers who decide on syllabuses and recommend effective methods of instruction might wish to consider the results of the study with a view to recommending it as a teaching strategy in the schools.

1.5 Basic Assumptions

Some assumptions made in this study were:

a. That prior knowledge, determines what further type of learning would take place.

b. That the students in the sampled schools are representative of the student body in the State (Niger State) where the research was conducted.

c. That the students in responding to the questionnaires would give precise and honest information.

d. That students prior ideas about the research concepts have not been altered in any way.

1.6 Delimitations

The subjects for this study were drawn from three secondary schools in Minna. In selecting chemistry concepts for the study, emphasis was placed on topics related to 'structure and energy' because:

i. they are of major importance in chemistry

ii. they are widely used by the society.

iii. they are often misunderstood/misconceived by students.

iv. they are rated as highly difficult by students.

v. the national curriculum content for senior secondary school chemistry is organized around the major concept of "periodicity, structure and energy".

vi. most other concepts can be subsumed into them.

vii. most ordinary level chemistry text books used in Nigeria, treated the selected topics at their initial chapters, thus emphasizing their importance as building blocks.

CHAPTER 2

REVIEW OF RELATED LITERATURE

2.1 Introduction

In the early 70's 'discovery' instructional strategy was adopted. What had existed prior to that time, was what Freire (1985) called "banking" view of learning. Barnes (1976) described it as the "transmission" view. By these views, students minds were seen as empty storage bins into which knowledge could be piled indiscriminately. The teacher provided all the necessary facts of science to the students. The teacher asked and answered questions without much opportunity for the students' to discover things for themselves. The students' passively listened to the information transmitted. As science knowledge increased, the transmission mode of instruction was found to be deficient in meeting the goals of science. Also it encouraged memorization of information with the result that retention and application of ideas were difficult.

In order to avoid the situation where our students become conformists and lack an inventive and committed attitude towards science a change in teaching method was advocated.

It was at this point that 'discovery' method was adopted. Sputnik of 1957 catalysed the shift from 'transmission' or 'banking' view to "discovery" method. It

was assumed that science concepts would be learned by just being good observers. In Nigeria, the 'guided discovery' strategy was adopted and recommended for instruction in the secondary schools. The guided discovery strategy is activity oriented. It involves discussion, experimentation and practical demonstration. The students' guided by the materials and teachers engaged in investigations involving science processes structured to discover some concepts. Willis (1961) asserted that if students are guided to discover concepts themselves, they may be better prepared to make wider application of the materials learned.

There was burst of interest on the introduction of this strategy. A huge amount of money was spent in training teachers in the use of the new teaching strategy. Despite the huge amount invested in training teachers, it would be difficult to identify significant changes that resulted from the use of guided discovery instructional strategy in Nigeria and discovery method overseas.

A large number of influential reports have claimed the existence of serious short-comings in secondary school science education and have proposed major reforms. Bozimo (1985) and Jegede (1982) reported that only minimal changes have been noticed in the learners, since the introduction of guided discovery in Nigeria. Watt (1990) stated that for years science educators have advocated discovery based instruction,yet students' outcome of discovery instruction

have been disappointing. Investigations revealed that during the last two decades, there appears to have been an increase in the catalogue of topics perceived by student to be difficult (Adegbeye, 1986: Duncan and Johnstone, 1973; Lazonby et al, 1982 and Pearson and Hughes, 1986; Jegede and Okebukola, 1990). Students aversion to certain key concepts in science is on the increase. In chemistry; concept of mole, chemical combination, chemical equation and thermodynamics (Bajah, 1979; Bello, 1990; Adeyegbe, 1986; Atherton, 1974; Duncan and Johnstone, 1973; Dawson, 1978; Eniayeju, 1990; Eseonu,1982; Ingle and Shayer,1971; Johnstone et al, 1971), were seen to be difficult. Failure rate in science continues to increase. Also girls are not achieving as well as boys in the sciences. Moreover the noticeably low performance of students in Senior Secondary Chemistry generally (WAEC Chief Examiners report,1988, 1989, 1990, 1991) makes it a matter of necessity to think about what can be done to improve the situation.

If educational efforts are, indeed failing, the pre-suppositions on which these efforts have been founded must be questioned. It seems reasonable to suggest that we begin by inspecting other areas of instruction (Von Glaserfeld, 1987). There must be something about the guided discovery which affected the outcome for the past 20 years. Some reasons have been advanced for the poor outcome of guided

discovery strategy. Schmid and Telarog (1990) cited two principal reasons:

i. the strategy is not actually being implemented to the extent claimed.

ii. lack of materials and difficulty in understanding the strategy.

Novak (1990) stated that a fundamental reason for the failure of the curriculum approach of the 1970s had to do with the neglect of how humans construct and use meaning to guide their actions. Cleminson (1990) asserted that in guided discovery prior conceptual framework before one can discover anything at all was not accounted for.

The world is growing scientifically and technologically. Science educators cannot afford to fold their hands. The importance and practical applicability of chemistry concepts in the everyday life of adults become increasingly apparent. Yet, the failure rate on examinations grow (Duyour, 1981; STAN/WAEC, 1992). So far, efforts to rectify the situation have aimed at creating a better curriculum whereas little has been done with respect to the learning process that underlie science instruction.

It is now recognized that the major efforts to improve science education has fallen short of expectation. Science educators now advocate for changes in instructional practices that would take cognizance of students pre-conception. It is observed that some instructional

strategies proposed to improve science instruction are those using the constructivist view. The premise behind the constructivist view is that knowledge is actively constructed by the learner on the ground of constructs already available to him. In other words, knowledge is not passively built but actively built up by the learner from existing knowledge framework to make meaning. All meaning making begins with objects or events observed. New knowledge is constructed when we perceive new regularity or relationship between what we know and the new regularity we observe in event. Concepts and principles are the major elements usually dealt with in science teaching.

The new epistemology (constructivism) is attracting a great preponderance of adherents (Watts, 1990; Pope, 1985, Driver and Oldham, 1985; Von Glaserfeld, 1983; Gilbert, 1983; Okebukola, 1990). It looks therefore that a revolution in the Kuhnian terms has occurred and constructivism is the new paradigm (Jegede, 1990). The constructivist view has become prominent and is fast gaining ground. The tendency of many science educators to adopt the constructivistic view expresses its efficacy (Ault, 1985; Jegede and Okebukola, 1989; Pope and Gilbert, 1983; Okebukola, 1990). Of all the new instructional strategies within the constructivist framework, there is evidence that concept mapping strategy might enhance students understanding of science concepts and bring about meaningful learning (Novak, 1987; Jegede and

Okebukola, 1990). Concept mapping strategy has been shown to move students from their pre scientific conceptions to science conceptions (Driver and Erickson, 1983; Novak, 1987; Okebukola, 1990). Concept mapping strategy stresses the role that concepts play in guiding the production of new knowledge and meaningful learning. Concept mapping derived from Ausubel (1968) theory stresses meaningful learning and appear to improve science learning.

As students make concept maps, they identify and organize concepts into a hierarchical network depicting relationships among the concepts. Concepts in a map relate to each other by connecting lines that define relationships between concepts. For instance, "Acids have ionizable protons"; 'Photosynthesis produces oxygen'. The acquisition of such relationships is the key element in meaningful learning. When students engage in concept mapping they might increase their understanding of subject matter as they search for personal meaning of the concepts.

This research is therefore undertaken to investigate the effectiveness of concept mapping strategy in bringing about meaningful learning of science concepts. Specifically, the effectiveness of concept mapping strategy was compared with the Federal Ministry of Education (National Curriculum) strategy for secondary school science. Therefore, whatever, view of learning adopted by the teacher/system, be it guided discovery or concept mapping

should have practical implications for what goes on in the classroom.

Some variables known to have some influence on instruction have been included in the study. They are: gender, reading comprehension, home factors, reasoning ability and attitude. The literature review for this study has been discussed under these headings:

- Guided discovery instruction
- Constructivistic perspective
- Concept mapping
- Understanding concepts
- Gender differences and science learning
- Home factors and science learning
- Reading comprehension and science concepts
- Reasoning and science concepts
- Students attitude towards science
- Summary

2.2 Guided Discovery Instruction

Discovery approach is an outcome of the reform movement spurred by Sputnik towards improving instruction in science education. Many science educators in the 70's advocated for this method.They believed that science should not be taught to a child but that he should be left to discover it. Abdullahi (1982) defined discovery in terms of

exploration in the laboratory in which students perform such processes as observation, measurement, classification, and so forth and finally draw conclusion from gathered information.

From the standpoint of instruction, two types of discovery strategies are recognized, namely, guided discovery and unguided discovery. Guided discovery and unguided discovery approaches involve 'finding out'. The two types of discovery strategies require students to engage in activities in an attempt to discover or find out things for themselves. Both approaches may lead students to a discovery.

In the unguided discovery strategy, which is also known as 'pure discovery' individuals act as a mature scientists, formulate problems, design experiments in the process of finding out. In guided discovery strategy, the teacher guides the students to discover some science concepts by using leading questions and engaging students in activities that will make them draw conclusion from their observations. The guided discovery strategy is activity oriented and involves experimentation. This guided discovery strategy is recommended for use in our schools by the National Curriculum for Senior Secondary School Science. This strategy is recommended to ensure that learners are guided through activities to find out things for themselves.

Guided discovery could be structured to be inducive or

deductive in nature. Verification experiments which characterize laboratory exercises in our schools employ the deductive process. When laboratory experiments are designed for students to verify "law of conservation of matter" or "law of definite proportion", guided discovery is used in the form of deductive method. Guided discovery in the deductive form is used in our schools. With this, the general principle is given and students are guided through some experimental activities to discover solution to a specific problem. Literature in the past decade has shown that it is becoming increasingly evident that our educational efforts are failing (Novak, 1987; Watts, 1988). Guided discovery strategy seem not to yield the desired result. There has been little or no significant change in science learning resulting from the use of the strategy. The result of studies carried out on guided discovery revealed that its support is not significantly conclusive.

2.2.1 Related Literature on Guided Discovery Instruction

The Literature examining guided discovery strategy is very sparse. The findings of few reported studies have shown that guided discovery may be effective but it is not actually implemented to the extent claimed. While in Nigeria, guided discovery strategy is recommended for schools, studies overseas used mainly discovery approach. It

is observed that the general outcome of all these strategies has been disappointing. Surprisingly, in research work, the outcome is not so disappointing.

In Nigeria, Ajewole (1990) carried out a study to determine the effects of guided discovery and expository instructional methods on transfer of learning. He used 240 students in six selected secondary schools in Oyo State. He found that the guided discovery group performed better with respect to the transfer of knowledge in biological concepts than the expository group students. He attributed the significant performance of the guided discovery group to the opportunity given to students to employ the processes of science. A follow up study by Ajewole (1991) on the effects of guided discovery and expository instructional methods on the attitude of students to biology gave similar results favouring guided discovery approach. Ajewole used 240 Form IV biology students and 40 item scientific attitude questionnaire to gather data. Analyses of the result showed that the guided discovery group evinced a significantly more favourable attitude to biology than the expository group. He concluded that science learning using the guided discovery method might enable the learners to evince more favourable attitude to science learning than the expository method.

Similarly, Michael and Eugene (1981) in their study found that the guided discovery approach was significantly better in improving achievement of students. Davis (1979)

examined the effects of two science instructional approach on students achievement. He used guided discovery and expository instructional approaches. The result of the study revealed that the guided discovery method of instruction improved students achievement and enhanced positive attitude to science.

These findings were inconsistent with that of Babikian (1971) who found that expository and laboratory methods were significantly more effective than the guided discovery approach for science teaching with respect to recognition and application of concepts. Elsewhere, Schlenker(1971) reported that children who studied under the discovery method developed a significantly greater understanding of science, scientists and retention of science concepts than those children who used the traditional method. Wise and Okey (1983) in their analysis of instructional strategies found an increase in cognitive outcome when the discovery strategy was used. Also the result of meta-analysis by Anderson (1983) pointed to positive result from discovery teaching. A conflicting view was given by Butt and Jones (1966) who studied the effect of discovery training in producing problem solving behaviour in sixth grade children. The study concluded that though students could benefit from direct instruction in problem solving behaviour, the ascertion that meaningful concept development results from discovery training could not be supported.

Although guided discovery strategy is specified in the National Curriculum for secondary schools, it appears that research results on guided discovery instruction is inconsistent. It would be difficult also to identify significant changes that resulted from the strategy (STAN, 1992). What is recognized now is that students achievement in science have been on the decline. Evidence abound in literature showing that there has been increase on topical difficult concepts (Pearson and Hughe, 1986; Jegede and Okebukola, 1989; Okebukola, 1990). If no intervention is forthcoming, the time may be in sight when most of the topics in science syllabuses will be considered difficult by most students. This will make the goal of winning more students over to science difficult to attain. It will also affect the number of future engineers and doctors. Are we ready to take that chance in a country that is crying for inadequate number of doctors and engineers?

The question is "why is it that guided discovery still makes some impart in research work but not in the general performance of students". Some research reports have attempted to suggest reasons for the poor outcome of the general "Golden Age" curriculum approach worldwide.

Welch et al (1987) identified 6 reasons for the poor outcome of discovery instruction:

i. Poor preparation of science instruction

ii. Science teachers view the approach as difficult to

manage.

iii. Science teachers believe that the instructional approach is successful only for above average ability students.

iv. Science teachers sees the purpose of their courses as academic preparation of students for the next level of education.

v. Lack of discovery activities in commonly published science books.

vi. Discrepancy between importance science educators placed on discovery and its use.

Schmidt and Telang (1990) contended that discovery approach may be effective but cited three reasons that might have affected its outcome.

i. The approach is not actually being implemented to the extent claimed.

ii. Lack of materials and difficulty in understanding the approach.

iii. The approach is found difficult by teachers and therefore is motivationally deficient.

Hudson (1988) observed that science activities were initially discovery in nature but degenerated to what he termed "pseudo" discovery because of class management. Consistent with Hudsons' view, Mani (1983) asserted that the choice of teaching method open to science teachers in Nigeria is seemly restricted by social conditions such as

over crowded classes, non-availability of books and insufficient time.In Finocchiarios' (1980) view, one obstacle that stood in the way of improving science education through the discovery approach was the 'obsolete epistemology' that was behind discovery oriented science. According to him, experiments were shown to be ways to 'prove' or 'falsify' hypothesis rather than a method to construct new meaning.

Watt (1988) stated that discovery learning is now 'unfashionable' because the goals of science education have changed since the 60's.

Novak (1981) put forward the view that a fundamental reason for the failure of the "Golden Age" curriculum reform of the 1970's was a failure to distinguish between a teaching and a learning approach.

Consistent with Watt's argument, Abimbola (1983) argued that many of the curriculum projects of the 70's had no foundation in the philosophy of science. He observed that there was little relationships between the conception of discovery held by science educators and those held by philosophers of science.

In spite of the attractiveness of the guided discovery strategy, there is no evidence to substantiate its potency. The general picture today is that our science education lags behind (Bajah, 1986). Science educators, the world over are faced with the problem of finding ways of improving science instruction. In search for an effective method of

instruction, researchers developed other methods like mastery learning, individualized instruction etc. (Osa, 1980 and Brooks, 1982). None of these methods stood the test of time. For instance, Douglas, (1979) found individual instruction effective but admitted that it was difficult and costly to implement.

There is now emerging new consensus among science educators that learners construct knowledge from already existing conceptions. They do not simply mirror what they are told or just discover by mere observation. This emerging construction of knowledge from prior experience is the core of the constructivistic framework. There is evidence that the application of constructivist framework would lead to meaningful learning.

2.3 Constructivism

Current philosophies of science recognize the role of personal construction of meaning in the development of scientific information (Feyaraband, 1980). Constructivism is the new science philosophy dealing with active construction of knowledge by individuals from their prior knowledge. This prior knowledge may or may not be in line with scientific way of thinking. The theory of constructivism rest on the principle that knowledge is not passively received but is actively built up by the learner from existing knowledge.

The tenets of constructivism can be summarized thus (Cleminson, 1990):

i. Knowledge of the physical world develops from birth. Concept and theories are personally constructed. Their status is temporary in so far as additional experience or instruction may modify such conceptions.

ii. These personally constructed views about the physical world affect individuals observation of that world.

iii. Learning new scientific concepts involve more than the utilization of established methods of scientific processes. It requires a creative act of imagination.

iv. Learning new scientific concepts is problematic and never easy. Abandoning cherished knowledge, even as a result of exposure to science teaching, is difficult and may be done only superficially.

v. We all have conceptions about our physical world. These conceptions may or may not correspond to those of formal science. As such they necessarily have subjective meaning for us.

The constructivist view of learning has become a leading idea in science and education in general since the last decade (Duit, 1987). It is based on the idea that the conception the learner already holds, considerably influences the learning process. It focuses on the meaning individuals construct from their experience through learning rather than on behaviour of individuals.

Constructivist view is not new in education, the idea that humans construct their own meaning from prior experience goes back as far as the Greek and Roman times.It has some psychological foundation. The constructivist view is similar to what Piaget (1953) described as the equilibrium of learning. It consists of the process of assimilation and accommodation i.e. adding a new knowledge to an old existing one and attaining a state of equilibrium. To Piaget learning is an active construction process and is possible only on the basis of already acquired knowledge. Gagne (1970) also realized the importance of relating the unfamiliar to the familiar in order to attain meaningful learning when he stated ..... "that any piece of knowledge can be acquired by individuals who possess certain pre-requisite knowledge".

Ausubel spelt out the relevance of prior knowledge in learning. He stated ..... "If I had to reduce all of educational psychology to just one principle, I would say this:..... The most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly". There have been many empirical research reports on constructivism (Driver and Bell, 1985; Drive and Erickson, 1983; Duit, 1987; Novak, 1987; Novak, Gowin and Johansen, 1983; Pope and Gilbert, 1983; Scott and Dyson, 1987; Wittrock, 1974; Wheatley, 1989; Von Glaserfeld, 1987; 1989).

Novak (1990) contended that learning in the constructivist perspective is a process of actively constructing knowledge by the learner on the grounds of already existing conceptions. Osborne and Wittrock, (1983) and Von Glaserfeld (1989) combined all ideas about constructivism to produce a model they called 'Generative learning model'. This model shows how learners construct or generate meaning from old experiences by incorporating new construct into the old. The model is summarized thus:

i. The learner's memory store interacts with the sensory input from environment. He actively selects some input and ignores others.

ii. The learner generates a link between that input and those parts of his memory store relevant to the situation. (At times the learner may make a link between the meaning store not implied by the teacher).

iii. The learner retrieves information from memory store which he uses to construct meaning from the sensed experience.

iv. The learner tests the constructed meaning against the sensed experience.

v. The learner may incorporate the construction into memory. At this stage, the learner may readily accommodate the construction alongside other ideas. Sometimes, a considerable restructuring of ideas or reinterpretation of experiences may be required to

successfully incorporate the new construction.

vi. Finally, the new status is placed on the new construction. At times, the new construct and the previous ideas are held simultaneously. With time, the status of one may decrease while the other may increase.

This model shows the process of human construction of meaning from prior ideas. The implication is that for effective instruction, the teacher must be aware of the ideas students bring to class.

The constructivist framework has been examined in science curriculum development. Hand and Treagust (1989) examined the teaching strategy of conceptual conflict in curriculum development. The curriculum involved the topic "Acids and Bases" taught to tenth grade students of average age of 15- 16 years. In the study, students knowledge about the topic was determined to ascertain the area of students misconceptions. Interviews were conducted to ascertain students knowledge. Through the interviews, misconceptions about acids and bases were identified and used as the basis of the teaching strategy. Students were later tested at the completion of the topic. It was observed that there was a greater degree of meaningful learning using the constructivist approach. The result of the study showed that curriculum development strategy using ideas of constructivism allows for greater student understanding of

concepts.

2.3.1 Constructivist/Traditional/Guided Discovery View of Learning

Learning in the constructivist perspective is not viewed as an accumulation of knowledge by a largely passive learner but as an active process in which the learner is engaged in constructing (not accepting or discovering) concepts. With the constructivist view, the first stage of learning involve the interaction between individual and his environment. Such interaction provides him with a wealth of sensory input which lead him to form meaning. Such meaning are usually from a self centred point of view and invariably different from accepted science view, but for the child are sensible and meaningful.

Individuals at times have two meanings for same idea. One that is for use in science lesson and the other they find plausible for every day living. The two view points may seem quite unrelated and the student may make no attempt to reduce the contradictions between the two stand points. Often these views may not be known to the teacher. Science therefore remains 'unreal' to the student (Osborne and Freyberg, 1985). These intuitive knowledge students possess can adversely affect their ability to learn from science instruction.

During instruction this student may come across new concepts that conflicts his ideas about the world.

According to Champagne, Gunstone and Klopfer (1983), it is this conflict between students intuitive ideas and formal ideals presented in science lesson that makes science lesson difficult. Osborne and Cosgrove (1983) gave example with children arriving science lesson believing that the bubbles in boiling water are air. In science classes they learn that water is made up of oxygen and hydrogen. They deduce that on boiling, water changes into hydrogen and oxygen. Thus showing that the direction of children's learning may be entirely different from that anticipated by the teacher. Hence the emphasis of constructivistic view on the role concept and prior ideas play in human construction of meaning. It recognises that we understand things in terms of what we already know. Only then does learning make meaning. Meaningful learning within the constructivitic view is seen as the fundamental process underlying useful knowledge acquisition and construction.

Learning process in the traditional approach involves transmission of information from teacher to largely passive listeners who accept information unquestioned. What makes learning difficult with the traditional method is the memorization and the passive way of accepting information.

Constructivist view of learning differs also from the guided discovery learning in that the guided discovery approach follows the empiricist philosophy that focus on experiments, designed for proof or falsification of

hypothesis. It ignores the role of prior knowledge and construction of meaning in learning.

Numerous studies have shown that the traditional and even guided discovery methods do not meet science education goals in the 80's (Bajah, 1986; Watts, 1986). There is evidence that the teaching approaches based on constructivism may lead to meaningful and productive learning in science (Novak, 1987; Okebukola, 1990).

2.3.2 Constructivism (General Implications

A. For the Teacher

i. The role of the teacher is that of a diagnostician, prescriber of appropriate learning activities and facilitator of learning.

ii. Gunstone, Northfield (1986) and Du[illegible] (1987) warned that the constructivist idea can only work in school if teachers are familiar with them and are convinced of their value.

iii. Teachers should attach much importance to the ideas students bring to the classroom.

iv. Various techniques should be used by teachers to uncover students prior idea on subject.

B. For the Learner

i. The students assume the role of meaning makers.

ii. The learner constructs his own meaning through

experience with the physical environment.

iii. The learners have the final responsibility for their learning.

iv. The teachers and students are viewed as active meaning makers (Cobb, 1988). Their interaction is seen as a process of negotiating meaning rather than imposed fixed procedure (Bishop, 1985).

C. For Assessment

The constructivist view, recognises that ideas tend to develop with time. Assessment technique gives credit for progress made. This does not suggest that there is no room for formal testing and examination.

2.3.3 Constructivist Teaching Model

There are five stages in the constructivist teaching model (Driver and Bell, 1985; Scott and Dyson, 1985). They are: Orientation, Elicitation of ideas; Restructuring of ideas; Application of ideas; and Review. The model commences with the first phase, Orientation.

A. Orientation

This phase sets the scene for the study by raising students interest in what is to follow. Motivation to learn is aroused through pictures, cardboard drawings, discussion, demonstration and so forth.

B. Elicitation

In this stage students idea about concept or topic is elicited, through small group discussion, concept mapping etc.

C. Restructuring

The exchange of ideas in the elicitation phase may provoke students to reconsider their thinking. In this stage teachers provide learning experiences which interacts with students knowledge.

D. Application

If newly constructed ideas by students are to be meaningful, these ideas should be applied to other situations.

E. Review

This is the final stage or conclusion of teaching. The consequences of teaching science using a constructivist model is to give children opportunity to express their ideas. In the light of the advantages of learning within the constructivist framework, the present study hopes to adopt the teaching model of Driver and Bell (1985) with slight modification.

It should however be noted, that construction is a general theory focusing on individual construction of knowledge from prior ideas. Within the constructivist frame work, numerous teaching strategies abound like concept mapping, analogy, metaphor, problem solving and so forth. Of

all these strategies, concept mapping strategy seem to be gaining ground. There is evidence in the literature that it may lead to meaningful learning (Ault, 1985; Novak, 1987; Okebukola, 1990; Pankratius, 1990).

2.4 Concepts

Recent epistemology of science focused on the role concepts and conceptual framework play in the understanding of science. Concepts are the source of human understanding. Psychologists do not agree on any one definition of the term concept. They all however, agree that thinking is a mental activity involving the use of symbols. The most important process in the thinking is conceptualization, the forming of concepts. Perception is the first stage of conceptualization. In perceiving, for instance, an individual is aware of an object or event that is present in his senses. In recalling what he has perceived, he uses symbols for words to represent the object or event. In forming concepts, one goes through a long process of thinking and classification. Concepts are formed when characteristics common to certain objects are categorized.

Many educators have put forward various definitions of concepts. Klausmeier (1972) and Davis (1973) stated that concepts can be defined structurally, systematically, operationally or axiomatically.

i. Structurally, in terms of properties or attributes

ii. Systematically, in terms of synonymns or antonyms

iii. Operationally,in terms of the procedures used to distinguish the concept from other concepts or

ix. Axiomatically, in terms of numerical or logical relationships.

Staats (1961) defined concepts as a verbal habit formed on the basis of a class of stimulus objects having identical elements. Bourne (1966) states that a concept exists whenever two or more distinguishable objects or events have been grouped or classified together on basis of some common feature.

Pella (972) defined concepts as a summary of the essential charateristics of a group of ideas. Shalvonson (1974) defined concept as an assemblage of identifiable elements and the relationship between them. According to Stone (1979) " A concept is an abstraction from objects, situations or events of the attributes these phenomena have in common".

It could be seen that the term 'concept' is used in many ways. Some definitions focus on common attributes of objects or events which make them belong to the same category. Concept is shown to occur at different levels of generality, one subsuming the other and thus be represented by hierarchical relationships (Novak, 1984; Novak and Gowin, 1984). Most notable in the science education

literature is the use of the concept map. For our study,'concept' is defined as a perceived regularity in events or objects designated by a label. Most of the labels we use are words or at times sign.

Concepts are acquired early in life. Macnamara (1982) has shown that children sometimes perceive regularities in objects before they learn the label for the concept. By the age 30 months, most normal children have acquired several hundred concepts. These early concept meaning are constructed by children before any formal schooling. For instance, a baby learns that his family cat is similar to neighbours cat by seeing, touching both animals and hearing them purr. When the baby encounters another cat, he perceive the similarities and classifies the strange animal with the familiar one. The baby has thus formed a concept of "cat". Conceptualization reduces an infinite number of objects, events or symbols to a smaller and more easily manipulated number of categories. Certain attributes have been identified as being common to concepts.

2.4.1 Attributes Of Concepts

Kausmeier (1972); Davis (1973) and Bourne (1970) formulated a conception of concepts in terms of the defining attributes and values which are identified as being common to many concepts from various disciplines.

These defining attributes are useful in specifying what concepts are and also in identifying the great variability among concepts, (Flavell, 1970). The major attributes of 'concepts' are learnability, usability, validity, generality, power and structure. A brief description of each attribute is as follows.

i. Learnability

Learnability of a concept varies from concept to concept in the sense that some concepts are more readily learned by individuals who share similar experiences and language than others. Also the level to which a particular concepts as a mental construct is learned by an individual varies and increases with learning. The level of mastery of any concept also varies among individuals of roughly equival maturational and experiential levels.

ii. Usability

Concepts vary in usability because some concepts may be used more than others in understanding and in solving problems. Concepts as mental construct of the individual become more usable as they are attained at higher level. Bruner, Goodnow and Austin (1956); Novak (1989) indicated that attaining a classificatory/ mapping concept helps the individual by:

i. reducing the complexity of the concept

ii. identifying the objects of the world around him

iii. reducing the necessity of constant learning

iv. providing direction for activity and

v. ordering and relating classes of events/objects.

As the individual matures he begins to use the acquired concepts e effectively in the ways listed above.

iii. Validity

A concept is valid to the extent that experts agreeon its definition. An individuals concept increases in validity when his concept learning come closer to that of the experts. Markle and Tiemann (1969) assess the validity of an individual, classificatory concepts by ascertaining the extent to which he makes errors or over-generalization, under-generalization, and misconceptions.

iv. Generality

The generality of a concept refers to position on hierarchical system of concepts in the subject. Concepts are arranged in hierarchical manner. The higher the concept within the system, the more general it is in terms of the number of sub-classes or subordinate concepts it includes.

v. Power

The attribute of power refers to the extent to which a particular concept facilitates or contributes to the understanding of other concepts. Ausubel (1966) dealt with the power of concepts through the construct of advance organizers.

vi. Organizers

According to Novak (1987) a concept organization that will lead to meaningful learning is one that starts from the most important inclusive concept or events to the least important. That is, the introductory material to a lesson should include concepts at a higher level of generality than those in the lesson so that the concepts presented in the new material could be related to those in the advance organizers.

vii. Structure

Any concept defined in terms of attributes has a structure which is related to the defining attributes. With concept maps the various related units are linked up to form a structure. However, understanding a concept requires recognition and naming of the defining attributes (Bruner, Oliver, Greenfield et al (1966); Wiviott, 1970 and Nelson, 1971).

2.4.2 Understanding Concepts

Understanding has been defined and interpreted in various ways. What does understanding mean? The dictionary meaning of understanding is -- to apprehend, comprehend, conceive or to know. To understand according to Novak (1976) means to connect the new information we perceive, with the old that we know to make meaning. Goodstein (1989) defined

understanding as a bridge between subject matter structure and mental structure in a way that allows the advance from static use of knowledge to flexible, dynamic and strategic mental operation. Nachtigall (1989) defined understanding in terms of the process of understanding itself. He defined understanding as the process of tapping existing individual knowledge and applying it meaningfully to other situations to arrive at a correct solution. It is reported about late Prof. R. Feynman, who received the 1965 Nobel prize for his contributions to the creation of the theory of quantum electrodynamics, that to him understanding meant to reformulate physics so that it could be presented to young students. During a lecture seminar, his colleague was reported to have asked him to explain, so that he, the colleague could understand, the spin - 1/2 particles. Feynman answered, 'I will prepare a freshman lecture on it'. A few days later he came to the colleague and said "You know, I couldn't do it. I couldn't reduce it to the freshman level. That means that we really don't understand it" (Goodstein, 1989). It seems that the term 'understanding' is best explained than defined. It has so far been explained in terms of process, a bridge and the ability to present or communicate to lower level students. To explain what is meant by understanding in this study, we must distinguish between memorization or rote learning and understanding.

In case of 'memorization' or 'rote learning' informations are just stored away in the memory. There are no connections established with what we already possess as our 'mental property' and the new phenomena.

In other words the new phenomena (NP) according to Nachtigall (1989) are still not incorporated into the existing memorystock or stockpile experience (SE). These informations are still strange and unfamiliar to the existing mental environment. One can learn by rote learning but this is highly limited to recall of informations and any deviation from the pattern in the mental structure cannot be understood because according to the psychologist Gagne, the mental structure has been functionally fixed. Therefore higher mental activities or problems beyond the level of just 'know how' cannot be handled by a student who has learnt concept by memorization. For instance, one can recall that Avagradro's number is 6.02×10^{23}. There is no understanding for this kind of knowledge. The constant is just memorized. It can only be said to be understood when this constant could be effectively applied to problem or new situation. The same is true for mastering certain kinds of procedure. For instance, to operate a video recorder, we just have to remember which buttons must be pushed in which succession. This, Nachtigall (1989) referred to as procedural knowledge. Both kinds of knowledge just need memorization. It does not require understanding; students

may even pass examinations requiring only recall and be able to carry out routine operations but still cannot apply knowledge effectively.

The process of understanding is characterized by seeing relations between elements of the SE and NP. The proof of understanding, however, can be obtained from seeing results. The essence of the results is that we can come with others to agreement that we share same concept. Let us consider a classroom situation in an attempt to explain the meaning of understanding. During a chemistry class on the continuation of the topic thermodynamics, for example, the following teacher-student interaction was observed.

Teacher: Gibbs Free Energy is related to enthalpy and entropy by the equation G = H - TS. Then the change in free energy is given by:

DG = DH - TDS.

Do you understand?

Students: Yes, of course; DG = DH - TDS

The question is "Did the students really understand". Relating the term 'understanding' to the thermodynamics question above. If the following questions are now given to these set of students that have affirmed their understanding of thermodynamics,

i. Show how DG, DH and DS are related.

ii. Given the values of H, S, find DG?

iii. Given the values of DH, DS, and T. Find the equilibrium

constant, K.

It could be seen that by recalling the formula, DG = DH - TDS, students can answer question (i) without any understanding of the formula. Question (ii) requires the students to know what DS and DH stand for before they could attempt finding DG.

It therefore requires not only a recall of the formula but an understanding of the various terms. Now to answer question (iii) the students should not only know that DG = DH -TDS but also know that at equilibrium $DG^{\circ} = 0$ and when $DG^{\circ} = 0$, there exists a relationship between DG and K. This last question therefore requires not only knowledge of the terms, application to related tasks but also recognizing relationship between known formula and the new task. Question (iii) could therefore be tackled appropriately only by students who have understood the topic and this will be reflected in the students performance in the test. Therefore a student that has understood the concept of thermodynamics will correctly answer questions (i), (ii) and (iii) but students that learn by just applying rules and memorizing will attempt only (i) and get confused with question (iii) since the question related DG to K and not DH and TDS which she/he has memorized. Understanding is being able to conveniently switch ones thought back and forth without being functionally fixed to a direction. It also has to do with recognizing relationship between known idea and

new observation or event. To understand, the new incoming information or task, one perceives is connected with the old information that we already possess to make meaning.

The 'old' mental structure, in turn is not the same anymore due to the incorporation of the new. It is strengthened, modified and changed. This new mental structure becomes a more powerful tool for operational thought process. The process of understanding is therefore characterized by seeing relations between elements of our existing prior experience (SE) and new phenomena (NP). Understanding is represented thus:

[SE]----------->[NP]

Understanding

Understanding Process

Source: Nachtigall (1989)

Proceeding ofEurophysics study conference.

It follows that understanding is only possible when there is a connection, relationship and integration of new knowledge (NP) with elements of existing experience (SE). SE has been described as a mental map or blue print that enables the learner to find pathwa of understanding. Numerous research reports show that in our science classes, learning by understanding is neglected in spite of the fact that science teachers are aware of its importance. In Nigeria, it seems that the lack of understanding of concepts is the biggest obstacles on the way to better

science teach . (Arons, 1981; Okebukola, 1990; Cleminson, 1990; Novak 1988). Many difficulties and misconceptions that students have in science have been attributed to poor understanding of science concepts.

In chemistry, research report have shown that students avert fundamental concepts. The use of correct chemical formulae and chemical equations is a common occurrence in the classroom (Burce 1983, Adeyegbe, 1989). Also, students inherent difficulties in solving stoichiometic problems are associated with their inability to write correct chemical formula and equation (Lazonby, 1982; Schmidt, 1984). There is the need to find effective teaching strategies that will increase students understanding of chemistry concepts by structuring the multitude of fundamental isolated phenomena in a more lucid way.

The society is changing and the goals of science education is not conformatory anymore hence knowledge by rote or procedural learning is not adequate. The individual and our society need more than rote learning and application of rules if Nigeria is to develop scientifically. To understand a concept, that concept we perceive to be difficult should be taught in such a way that it connects, relates and integrates with the memory stock. This will make meaning to the individual. This type of understanding leads to meaningful learning and science becomes real to the students. To have understood a concept, means to have

attained the concept and is reflected in the application of new knowledge to other situations. The result is high achievement outcome even in standardized tests. However, understanding is a life long process. It is never complete. It is an interactive process where one moves gradually from less understanding to more understanding. The starting point being the individual existing memory stock.

2.4.3 Concept-Mapping/Strategy

Concept-mapping is based on the constructivist epistemology. Concept maps are diagrams in which concepts are organized into a hierarchical network depicting relationships among the concepts. It is based on the premise that concepts do not exist in isolation but depend on each other for meaning. Concepts in a map relate to each other by connecting lines that define propositions or specific relationships between concepts. For instance 'photosynthesis produces oxygen'. The acquisition of such relation is the key element in meaningful learning.

In its simplest form, a concept map would be just two concepts connected by a linking word, to form a proposition. For example, 'sky is blue' would represent a simple concept map forming a valid proposition about the concept 'sky' and 'blue'. Most concept meanings are learned through the composite of propositions in which the concept to be

acquired is embedded. Thus 'acid turn litmus red', 'acid give off protons' and so on, lead to increasing meaning and precision of meaning for the concept 'Acid'.

Mapping exercises require the student to think in multiple directions and to switch back and forth between different levels of abstractions. This procedure demands that a student should have a good knowledge of the nature and attributes of the concept before locating it in the appropriate place on the map. In doing that, students appreciate the inter-relationships among the concepts.

It has been shown that students use different methods to draw concept maps. Some first develop small 'submaps' containing 6 - 10 concepts and then integrate them into a larger final map. Other students begin by ranking the concepts and gradually adding more subordinate concepts as they proceed (Ault, 1985). Either method leads to well organized hierarchically structured concept map. Novak and Gowin (1983) reported that without exception students they worked with reported that concept mapping 'really made them think' and helped them see relationships they never saw before. Novak found a great willingness in boys to redo concept maps. Concept mapping is the act or process of organizing concepts in a hierarchical manner to show relationships among concepts. There has been increasing literature on concept mapping since Novak and Gowin (1983; 1984; 1986) publication of "learning how to learn".

Novak, Gowin and Johansen (1983) explored the use of concept mapping and vee mapping with seventh and eight grade science students. They found that:

i. in general, students of any ability could be successful in concept mapping.

ii. the experimental classes (concept mapping group) demonstrated superiority in problem solving performance on novel problems after less than 6 months of instruction with concept mapping strategy.

Frazer and Edward(1985) conducted a one-short intervention treatment to determine the effect of concept mapping on students achievement in traditional classroom tests.They found evidence that suggested that the students who scored highest on an end of unit test had high level of concept mapping. Bosquet (1982) conducted a study of three versions of concept mapping among 117 students in a college natural - resources management course. Result of the study revealed that Concept mapping skills predicted subsequent achievement on a post-test.

Pankratius (1990) investigated the effect of the degree of concept mapping on achievement. He used six intact high school physics classes. Four classes received six-weeks of concept mapping instruction prior to the unit under study. Two of these four classes were the low-level treatment group and were required to submit concept maps during the instruction. The other two classes were the high level

treatment groups and were required to submit concept maps at the beginning and at the conclusion of the unit under study. One class from each treatment group took the pretest prior to instruction. An analysis of the post test results revealed no pretest sensitization. A one-way analysis of covariance indicated a significant mean effect for the treatment level. He concluded that mapping-concepts prior to, during and subsequent to instruction led to greater achievement.

Lehman, Carter and Kahle (1985) conducted a rigorous study involving ten secondary school biology classes. The study compared concept-mapping and Gowins vee-mapping to outlining. Their results suggested a tendency toward an effect of the experimental (concept mapping and vee-mapping) method.

The findings of Stewart, Rowell (1979), Lehman, Carter and Kahel (1985) in biology; Ault (1985) in earth science concepts revealed that concept mapping may bring about meaningful learning. Cliburn (1987) found that students using concept maps during a 3 week unit on the skeletal systems showed significantly higher performance on a retention posttest. Moreira (1977) used concept maps with university students in physics classes. He used concept mapping for experimental classes and lecture method for control classes. He found that the experimental classes performed significantly better than the control group.

Basconans and Novak (1985) found that the mean sores on problem solving tests in high school physics were two to three standard deviations higher for students using concept mapping.

Pankratius and Keith (1985) compared effect of concept mapping and lecture method on ninth grade understanding of general science. He found 10% higher mean scores for the concept mapping group over an 18 week period.

In Nigeria, three studies were reported on the use of *concept mapping strategy on biological concepts*. The result of the studies showed evidence that concept mapping strategy could lead to meaningful learning and reduction in anxiety towards science.

Jegede, Alaiyemola and Okebukola (1987) determined the potency of concept mapping in teaching nutrition in cell. They found that students taught using the concept mapping strategy performed significantly better than those taught using the traditional method.In a related study,Okebukola (1990) worked on the effect of concept mappingon students anxiety towards science. He administered the Fraser, Nash and Fisher (1983) Science Anxiety Scale to the concept mapping group. He found highly significant difference in mean anxiety scores ($P < 0.001$) favouring the concept mapping students. Analyzing the data with respect to gender, he found that males made greater achievement gains than females and also showed greater reduction in anxiety score.

Okebukola (1990) examined the potency of concept mapping technique in attaining meaningful learning of concepts in genetics and ecology. He used 138 predegre biology students to try the efficacy of the concept-mapping strategy. The results showed that the 63 students in the experimental group who employed the concept mapping technique performed significantly better on test of meaningful learning in genetics ($P < 0.001$) and ecology than the control group (expository) counterpart.

This findings of substantial set of studies on concept-mapping within the past decade have converged in suggesting that the strategy is potent in bringing about meaningful learning (Stewart et al, 1979; Novak, Gowin and Johansen, 1983, Ault, 1985, Okebola, 1987; Okebukola and Jegede, 1987). The research studies compared mainly concept mapping and expository methods.

This study considered concept mapping strategy, based on the constructivistic epistemology in the light of the above reasons and also motivational difficulty, students have in grasping meaning of fundamental concepts in science.

2.4.4 Introducing Students To Concept-Mapping

Concept maps are intended to represent meaningful *relationships between concepts in the form of preposition.* As with any act of teaching, there is no one best way to

introduce mapping of concepts but there are specific steps to be followed.

The steps in concept mapping as elucidated by Ault (1985) are:

i. Select an item for mapping
ii. Choose and underline key words/ideas/concepts
iii. Rank and list concepts from most abstract to most specific
iv. Cluster the concepts according to two criteria: concepts that function at a similar level of abstraction and concepts that interrelate closely.
v. Link related concepts with lines and label each line in prepositional form.

A correct completed map represents a meaningful understanding of the relationship between important set of concepts. For this study, concept mapping will be introduced to students as follows:

i. Introduction to the idea of concept by defining objects, events etc.
ii. Introduction of the word concept.
iii. Introduction of linking words like ... can be, are, have, contain, determine, made of, as in, are in etc.
iv. Students to give examples by constructing some short sentences of their own using 2 or more concepts and a linking word.
v. Listing of concepts from discussion or text.

vi. Ranking the concepts according to levels of abstraction.

vii. Circling the concepts (objects or events) and linking with appropriate word(s).

2.4.5 Usefulness Of Concept Map

A concept map is a schematic devise for representing a set of concept meaning embedded in a framework of proposition. It has been found useful in various ways.

i. Concept maps work to make clear to both students and teachers, the smaller number of key ideas they must focus on for any specific learning task.

ii. Concept maps represent a summary of what has been learnt.

iii. Concept maps provide a kind of visual road map showing the different pathways to connect meaning of concepts.

iv. Concept map is a useful tool for negotiating meaning between students and teachers. Negotiating meaning or sharing meaning in this context is because students bring their own ideas to the class.

v. Concept map has been found to be a powerful evaluation tool for observing the meaning a student holds for the concepts embedded in the map (Novak, 1990).

vi. Concept maps reveal students cognitive organization of knowledge (Bowen, 1990).

vii. Concept maps are used to point out misconceptions (Hand and Treagust, 1990; Driver and Erickson, 1983; Novak, 1987; Okebukola, 1990; Pope and Gilbert, 1983).

viii. Concept maps helps students take charge of their own meaning making (Novak, 1985).

ix. Concept map appears to have capability for helping learners cope with demands of difficult concepts (Cliburn, 1987; Okebukola, 1990).

x. Concept map has been shown to help students in learning the topics "ratio and proportions (Cardemone, 1975) and genetics" (Budgden, 1987; Okebukola, 1990).

xi. Concept maps have been shown to increase comprehension (Taylor and Beach, 1984).

For the teacher

xii. Concept maps have been used as an evaluation tool (Novak, 1983).

xiii. Concept mapping strategy has been shown to force teachers to take students prior knowledge into consideration (Novak, 1987).

xiv. Concept maps serves as a source of instructional feedback on the level of students understanding of concept.

xv. Concept maps can be used byteachers to plan and organize their lessons (Novak, 1987).

xvi. Concept maps have been used to develop curriculum (Cliburn, 1986) for lecture preparation and laboratory

report (Ault, 1985).

For the learning process

xvii. Concept mapping may open up new perspective in learning.

xviii. Result from concept mapping activities point in the direction that students who learn meaningfully acquire, retain and use knowledge better than those who learn by rote (Okebukola, 1990).

2.5 Students' Attitude Towards Science

Measuring students science achievement is not the only way to evaluate students and instruction. Attitude plays a major role in students learning (Gardner, 1975; Mukherjee, 1978; Levin and Fowler, 1984; Alao, 1985; Ajewole, 1991).

Various definitions have been proferred for attitude. Moore and Sutman (1970) defined attitude as an opinion or position taken with respect to a psychological object in the field of science.Gagne (1977) defined attitude as an internal state that influence the personal actions of an individual. Combs (1971) considers attitude as a regulator of all behaviour. Ones behaviour at any time, according to Combs are not causes but consequences of what is going on within the individual. Mukherjee (1978) asserts that attitudes are organized through experiences and impart a direct influence upon the individual. Brown et al (1964)

views attitude as representing the underlying dispositional and motivational urge for the learner. Attitudes, interests, appreciations are all terms used to describe what educators call the "affective domain". It is a continum from positive to negative. A person may like or dislike something or possess varying degree of neutrality. It is this predisposition to respond positively or negatively that characterizes a person's attitude.

For the present study, the term attitude is used to refer to one's feeling, thought and predisposition to behave or respond in some particular manner. Attitudes are best expressed when individuals make statement about their feelings or opinion (Mukherjee, 1978). Students reaction to a subject is influenced by his attitude to it. According to Alao (1985) learners attitude to a subject is influenced by both internal and external factors. Some of these internal and external conditions must be satisfied before attitudes are changed. The internal conditions he noted, are the individual skills and certain amount of relevant information which the learner must possess about the concept to which the new attitude will be directed. The external conditions are mainly the human models appeal to which the object attitude is applicable. Attitude is an important outcome of science teaching (Haledyna et al, 1982; Bajah, 1986). For one, the attitude which an individual has influences to a considerable extent his learning of science and his use of

scientific information (Ajewole, 1991). Secondly, the possession of favourable attitude towards science is an important characteristic of a scientifically literate person, (Balogun, 1985).

The study of students attitude to learning and instruction is important. Shuaibu (1984) holds the view that attitude study is necessary for a teacher who expects to understand why his efforts are sometimes so well rewarded and sometimes so seemingly hopeless. Gardner (1969) likewise explained that attitude research is important because important decisions which students make are strongly bound with their attitudes, such as career choice. It is therefore not surprising that many studies in Nigeria and elsewhere have not only focused on the attitude of students and teachers toward science but also on the relationship of those attitude with performance. Studies by Orisaseyi (1977) and Jegede (1984) concentrated on attitudes towards physics. Babatunde (1982), Soyinbo (1982), Ajewole (1991) investigated students attitude towards Biology. On the whole attitudes were reported to be positive, though correlation of attitude to performance was low. Alao (1985) showed that the attitude to any of the basic sciences, is positively correlated to performance. Among American high school students, attitude was found to have a direct effect on science achievement (Schibeci and Riley, 1986). It is not surprising that individuals who are majoring in science and

who are themselves scientists have a good attitude towards science (Hirschorn, 1974; Baker, 1983; Alao, 1985).

An international study by Kelly (1978) found that attitude was significantly related to achievement in science even when ability was taken into account. McMillian and May (1979) and Baker (1985) found that science achievement as reflected by grades did not influence attitude to science. They interpreted this to mean that students receiving poor grades could have a more positive attitude than those with good grade.

Method of instruction could affect performance of students and attitude (Piburn and Baker, 1991). Studies by (Anderson, 1970; Dickson, 1979; Story and Brown, 1979) have shown that students attitude toward science seem to improve through the use of some instructional procedures and models. This lends support to Nwagwu's (1976) assertion that attitude must be learned and may be modified later by instruction. Disingerand Mayer (1974) investigated the influence of some teachers background characteristic and some instructional variables on changes in attitude toward science. They reported that no single set of teacher and class characteristics could be found to associate with changes in students attitude but rather instructional variables seem to be more related to att[illegible]de. The number of instructional strategies that can be employed in teaching are as many as there are students and teachers but the

instructional strategies of interest in this study are guided discovery and concept-mapping.

Ajewole (1991) investigated the effects of guided discovery and expository instructional methods on the attitude of students to Biology. The study sample consisted of 240 Form (IV) Biology students randomly drawn from six secondary schools in Oyo State of Nigeria. The students were assigned into two groups - the experimental and control. The experimental group was taught using guided discovery method and the control group was taught using the expository method. The major instrument was the 40 item Scientific Attitude Questionnaire using five point scale. Analysis of the data showed that the experimental group (guided discovery) evinced a significantly more favourable attitude to biology than the control group. The study also revealed that there was no significant difference in the attitude of male and female students exposed to the two teaching methods. The above result is consistent with the findings of Johnson (976), Brown and Story (1979), Ajewole (1987) and Balogun (1981) which showed that students taught using discovery method showed a more positive attitude toward science than those exposed to the expository method.

A conflicting result was reported by Fraser (1978) that instructional methods and gender do not affect students attitude. However, Babikian (1971) found that expository and laboratory methods for teaching concepts were significantly

more effective than the discovery method for teaching science concepts to students with respect to recognition of concepts and application of concepts to numerical problems. Some other research reports by Novick and Dauduani (1976), and Hassan (1985) revealed no change in attitude. Gabel and Rubba (1979) and Tolman (1979) reported a positive significant change in students attitude due to their enrolment in some new courses. The change in attitude might be perhaps due to the method of instruction rather than change of course.

There seem to be little or no reported study on the influence of concept mapping strategy on attitude. One reason for this,could be that concept mapping strategy is a recent innovation in the area of science instruction. Research has shown that some students variable like gender seem to be associated with attitude towards science. Most research studies show that male students hold more positive attitude towards science than do female students (Ormerod, 1975; Steinkamp, 1982; and Ormerod, 1975). A few other studies revealed that there is no significant change in attitude with respect to gender.

Fleming and Malone (1983) found that males had more positive attitude than females in the elementary school but females had more positive attitude than males in the middle school. In the high school, they reported, that the trend reversed and males again held more positive attitude towards

science. They attributed the pattern shift to teaching emphasis in which increased effort to promote cognitive learning leads to decreased attention to attitude. Abiola (1971) attributed the positive male attitude to science at secondary school level to parental expectation. He asserted that in some parts of Nigeria, parents expect boys to achieve a higher level of education than the girls.

However, according to Whitefield (1979), boys favourable attitude to science is displayed early during primary school years. In later high school, when science becomes optional the difference in attitude between boys and girls become less marked.A contradicting result was given by Steinkamp and Maehr (1983) after studying attitude and achievement with respect to gender. They reported that for girls, the correlation between attitude and achievement is slightly stronger at the high school than the junior school. A different result was reported by Fraser (1978) who found that gender differences did not significantly affect students attitude. Several students attitude surveys and scales have been developed. In spite of careful development of these attitude components, it is not clear if they measure what they purport to measure. Also none has been developed to measure attitude to specific instructional strategy in chemistry. Moreover, available research on students attitude towards science does not provide satisfactory answer to questions related to

instructional methods affecting performance and attitude.

Hence,the present study is an attempt to determine instructional strategy that might be effective in positively and significantly changing students attitude towards chemistry. Specifically, the study is interested in determining whether a concept mapping strategy and/or guided discovery strategy could bring about significant and improved change in attitude to chemistry learning.

2.6 Gender Differences And Science Learning

Many studies have focused on gender differences and school learning (Kelly, 1978; Tobin, 1987; Becker, 1989; Versey, 1990; Ajewole, 1991). In science education, there is the concern that girls are not achieving as well as they might (Kelly, 1978; Erickson, 1984; Welch, 1985; Jegede and Okebukola, 1990). The differences were most pronouced in the physical sciences. Also a lack of representation of females in the science and engineering professions is well documented (Olstad, 1981; Dix, 1987; Coe, 1990). The need to attract girls to science profession has led to such projects as GIST (Girls into Science and Technology) and WISE (Women in Science and Engineering) that have examined ways of making science more 'girl friendly'.

Fernama and Sherma (1978) noted that fewer girls take advanced science and mathematics courses and elect careers

in science. Steinkamp (1982) results of qualitative synthesis of data samples taken from studies that examined sex differences in science achievement and attitude toward science revealed a consistent pattern of performance favouring males. He reported that at high school level, males achieve better grade in science courses and perceive the classroom environment to be more supportive than do females (Zerega and Haetel, 1985). Bajah (1979) noted that boys were superior to girls in school achievement. Grayball (1975) found that American boys were better than girls at activities requiring manipulation.

Research by Jegede and Okebukola (1990) revealed that male students made greater achievement gain than females and showed greater reduction in anxiety level when the concept of nutrition in green plants and respiration in cells were tested. Studies by Babikian (1971) revealed that irrespective of the teaching method used boys achieved significantly better than girls.

If gender related differences in science achievement are a reality, as research results have indicated, then there are likely to be differences in students engagement, participation and performance in science activities. Reasons for the sex related differences in science engagement and achievement have been attributed to a wide range of factors including social, personal, interest, study area, teacher, instructional factor and spatial abilities. Since learning

involves internal cognitive process for learner, it is possible that the differences in science achievement might have to do with teacher interaction with students. Studies by Becker (1981) and Hall (1982) revealed that teachers spoke more frequently to boys, asked the boys more higher ordered questions, praised boys for quality work and girls for neatness. Sadker and Sadker (1985) noted that male students received more praise and criticism from the teachers than the females students. Another reason advanced for the sex differences in science learning was given by Tobin and Gallagher (1987b) who observed from their study that teachers asked and expected certain students (mainly the male) to provide appropriate answer. However, Becker (1981) and Versey (1990) noted that the factors which determined whether or not males or females engaged in the same way are complex because of joint influence of the teacher and the students.

Fernema and Sherma (1977) and Sherma (1979) ascribed sex differences in science learning to differences in spatial abilities of males and females. According to them, spatial abilities are related to the development of the right hemisphere of the brain. The males are known to use the right hemisphere more than the left, while the females use the left more but these spatial abilities are usually not observed until adolescence, from the age of 16. In a related study on SAPA process, Shuaibu (1982) noted that

female subjects had statistically superior performance in SAPA process over the male subjects in the test. The girls superiority were evident in the process of observation, inferring and interpretation. He stated that it might have to do with some Nigerian culture where girls are not to be heard but seen.

Ormerod and Duckworth (1975) suggested that the differences in the performance of male and female subjects could be related to interest in content area. Raghubir (1979) found that females were more interested in biology and social science topics. Other reasons for the sex related differences in science achievement according to Tracy may be related to three areas: Social, educational and personal. Social factors included, sex-role model, sex-role orientations and stereotyping. Educational factors included parent, teacher, peer expectation, classroom and extra-curricula activities. Personal factor due to spatial ability. Sherman (1967) suggested that children's sex-typed play behaviour (i.e, the tendency for girls to play with one set of toys, while boys tended to play with another set) may have contributed to the development of sex-type spatial ability. Other studies have found that sex-typed extra curricula activities of boys and girls influenced their career choice in science and their achievement in mathematics and science (Kelly, 1987; Fox, 1981; Skolnic, Langbort and Day, 1982; Kahle, 1983; Jacobson and Doran,

1985). A conflicting report was given by Comber and Keeves (1973), Erickson and Erickson (1984) who found no significant differences in the science achievement of boys and girls.

Ajewole (1990) studied the effects of the guided discovery and expository instructional methods on students transfer of learning. Analysis of the result revealed no significant difference in the transfer of learning between male and female students exposed to guided discovery and expository methods. In a related study on instructional methods and attitude to science with respect to gender, Ajewole (1991) found no significant difference in the attitude of male and female students exposed to the discovery and expository methods.

Most of the literature cited have indicated significant sex differences with respect to achievement. These differences have always consistently favoured male. While this under representation/under achievement of females in science is pervasive, unfortunately, it is still not well understood. The explanations for the observed gender differences in science learning and achievement seem inconclusive. Speculations have centred around differences in spatial ability, differing attitude towards science, differential treatment in science classroom, study or content area and instructional factors.

It is hoped that the result of this study would help to

attract girls to science/chemistry. It could be that a particular teaching strategy to science instruction might perhaps lead to exciting girls interest in science. It is within this context that gender variable for this study was conceived.

2.7 Home Factors And Science Achievement

A reasonable number of studies have been conducted over the years to evaluate the impact made by various factors including age, school and home on students science learning. This is because learning does not occur in a vacuum. Students' performance is affected by factors in the school as well as conditions in the home. The home environment has been identified as having important influence on the development of children's cognitive abilities and effective characteristics (Bloom, 1981; Bloom, 1984; Keeves, 1972; Marijoribank, 1979; Walberg, 1984; and Ware and Garber, 1976). Parental involvement in a child's education is a key factor influencing a child's desire to learn. Teachers therefore find it useful to involve parents in their children learning activities at home. The relationship of performance and students home variables has produced some interesting results, but as with all such results, it has raised more questions than it can answer.

Onocha and Okpala (1985) studied family environment

correlates of science achievement of pupils in primary schools. They found that occupation of parents, material possession, number of children, education of parents when taken together seemed to be effective in predicting the science achievement of primary school children who participated in the study.

Ware and Garber (1972) in their study found that availability of materials in the home seem to be the most important variable for predicting school achievement. He recommended that parents should provide supplementary books for their children to enhance what is taught in schools. Walberg (1983) revealed that family socio-economic status is predictive of academic learning. Awoyemi (1986) examined the status of family as a factor in explaining variations in school achievement. His study revealed that consumption occurring within a household and the size of the family influence educational achievement. According to him, a household within a given income is likely to spend more on food, the more mouths it has to feed. That family must therefore correspondingly spend less on some other materials. He found that there was relationship between students family socio-economic background and their academic performance. A related study by Boocook (1972) found that the most important predictor of achievement in school is family socioeconomic status, SES. According to him the higher the SES of the students family, the higher the

achievement. Research shows the same pattern in America, Europe, Asia and Africa (Dubey, 1972, 1973). According to Dubey, the relationship of SES to achievement is always consistent, no matter the measure of parental occupation, education and income used. A conflicting result was reported by Onyeabe (1977) who found that the family SES is negatively associated with achievement with Nigerian School children. Similarly Fraser (1978) reported that the result of his study indicated no significant difference between SES and School achievement.

In the light of family structure and its influence on science learning and achievement, Blakemore (1981) noted a distinct class structure emerging in Africa. Access to and performance in education was increasingly becoming a reflection of class background. Brown (1982) classified typical Nigerian community into three major categories. The first included the well educated and wealthy business people. According to him, both group strive to give their children good sound education. Though the educated ones are aware of the value of education, the business person is not so sure but since he can afford it, he sends his child to school. The second category is the fairly educated ones who can just manage to make ends meet. They send their children to school for prestige and to show that they can afford it. The third category consists of people with little or no education. They find it difficult to feed

their family properly. This group could withdraw their wards due to fees or even resist efforts to send them to school. The results are consistent with studies by educationists and psychologists such as (Pella,1968; Perl, 1973; Nema, 1978; Ohuche, 1978; Brookover, 1979; Archenhold, 1981; Merem, 1983; and Hassan, 1985).

Abiola (1977) stated that science will only become meaningful to the African child if school science has direct link with home activities. According to him, no matter the method of teaching if the school activities are not familiar to home activities, the child will continue to have a formal distant view of science.

Bookcook's further studies on home factor revealed that father occupation was strongly associated with the style of interaction between members of the family. Middle and upper families tend to give more freedom to their children in decision making. At the same time, they are available for guidance and consultation. Children from lower class families are raised in condition of greater restrictions. Both parents according to him probably work and every one contributes to keep the family alive.

Brown (1973) found from this study that only one variable from a number of student background variables (i.e enrolment in physics course) seemed to be associated positively and significantly with college achievement. In some of the studies, little distinction was made amongst the

various home factors. Results of studies have been inconsistent. Some have reported a positive correlation between home factor and achievement others negative or no correlation. So far the results on home factors and achievement seem inconclusive. The question of what makes student understand has not fully been understood. Also how these factor operate and their overall strength on science learning is far from being fully explained. The present study is an investigation to identifying home factor that affects students' understanding of chemistry.

2.8 Reading Comprehension And Science Concepts

Many concepts, process skills and problems found in science are also part of and central to other disciplines. Reading comprehension and activity oriented science emphasis the same intellectual skills and are both concerned with thinking process. When a teacher helps students to develop science processes, reading processes are simultaneously being developed (Mechling and Oliver, 1983; Simon and Zimmerman, 1980). For instance, when a teacher is working on the concept 'chemical combination' in chemistry, students are learning to isolate and enumerate important characteristic, use appropriate terminology and synonyms.

Reading involves the abilities to decode and decipher intelligently, the graphic symbols of a given language. We

read to add to our range of ideas and become increasingly aware of new developments in arts, sciences, technology and politics. Reading also helps to reshape our way of thinking. However, it is not enough to be able to read but to read well with maximum understanding. Understanding fully what one reads leads to meaningful learning. A text on rapid reading is a test on comprehension. One has to read many passages quickly with maximum understanding to be able to attempt the questions on the passage correctly.Most of what is read is in English. The medium of instruction in the Nigerian secondary schools is English. All science text books that are used for secondary school chemistry in Nigeria are written in English Language.

Many educators have commented on the importance of comprehending the language of instruction (Thelan, 1976; Carter and Simpson, 1978; Harm, 1981;). Sutton (1983) sees language as a tool for the construction of knowledge intimately involved in the process by which concepts are formed. Luna (1986) indicated that language enables the child to form concepts and draw conclusions from accepted assumption. The first step in understanding chemistry concept is to understand the vocabulary and language of the concept. Mgbo-Elue (1985) stressed that English Language should be to enable students imbibe sufficient good English to understand what the science book says as they read it and be able to understand what they are doing, or intend doing

and explain their experiences in simple terms.

Taylor and Brown (1976) stated that without language, there can be little communication, without communication there can be little education. Carr (1970) noted that the failure or the success of the educational enterprise is heavily dependent upon how well students are able to read and comprehend language in their instructional materials, since, much of the knowledge contained in the school curriculum is transmitted through the medium of written and spoken English. Other researchers have also shown that the ability of the students to read with understanding and participate fully during instruction or even read from a textbook may likely affect the understanding of the subject. Quinto (1979) stated that the problem of English Language use and comprehension continue to mitigate against the efforts of science educators in Nigeria. He reported that over 90% of the Nigerian secondary school chemistry students cannot distinguish between the verbs heat and warm, words routinely used in chemistry laboratory classes. Ali (1983) attributed the poor performance in school science to English language comprehension problems. Meshacb (1984) studied the relationship between performance in English language and science subjects in W.A.S.C examination of secondary school students in Niger State. The result of his study revealed that students who performed well in English language had a high probability of performing well in

biology, while performance in chemistry and physics did not depend on performance in English language.

Cassels and Johnstone (1984), studied students understanding of science classroom vocabulary. They found that when they simplified the key words in questions substantially, greater number of students were able to comprehend and answer the question correctly. For example, more students would answer the question 'which of the following is a choking gas?' than could answer 'which of the following is a pungent gas'? Lack of comprehension of English language seem to affect students achievement in science. Though one does not have to hold a degree in English language, but, since language of communication is English, the students are expected to imbibe sufficient good English to enable them understand what they read (Mgbo-Elue, 1985). The following examples from Senior Secondary Certificate Examination (SSCE) in chemistry give a clear indication of how a lack of reading comprehension could affect students performance.

A. Question

State what would be observed if ncentrated HC1 is added to an equilibrium system repres d by the following equation?

$CaC1_2$ (aq) + $H_2C_2O_4$ (aq) CaC_2O_4 (s) + 2HC1(aq)

Answer

Correct answer: The precipitate of CaC_2O_4 formed will dissolve.

Popular wrong answer: The equilibrium position will shift to the left.

This is a clear indication of a lack of reading comprehension which affects performance in chemistry. The question was on observable effect but the wrong answer was based on equilibrium shift which cannot be observed.

B. Question

Arrange the following compounds in their correct order of increasing boiling points.

i. $CH_3CH_2CH_2CH_3$

ii. CH_3COOH

iii. $CH_3C(CH_3)HCH_3$

Answer

Correct Answer: $CH_3C(CH_3)H\ CH_3 < CH_3CH_2CH_2CH_3 < CH_3COOH$

Most Popular Wrong answer:

$CH_3COOH > CH_3CH_2CH_2CH_3 > CH_3C(CH_3)HCH_3$

This shows that the students did understand that the compounds should be arranged but failed to see the

difference between increasing and decreasing order.

C. Question

Give two physical properties of ammonia gas.

Correct Answer: Colourless gas/or choking smell/ or easily soluble in water/ or easily liquefied by compression.

Popular wrong answer: Ammonia turns red litmus blue.

The ability of ammonia gas to turn red litmus blue is a chemical property of the gas and not the physical property asked for. Wellman (1978) provided evidence that science instruction might motivate students who may have reading difficulties. It is against these ground, that the researcher sees the need to determine if any of the two teaching strategies for this study (concept mapping and guided discovery) could enhance reading comprehension and thereby improve performance and meaningful learning in chemistry.

2.9 Reasoning And Science Concepts

Piaget explained that concepts are not born with us but they develop with maturity. He believed that experience and teaching affect the process of concept attainment. Stone (1969) stated that when a child has reached a stage where he is capable of reasoning by hypotheses, then his thinking even makes use of concepts. At the adult stage, he would have formed a complete repertoire of concepts so that when

faced with new situations, he will seek to impose some order on them, drawing on his stock of concepts. Lovell (1968) agreed that reasoning is often involved when concepts are being formed because the selection of the relevant or the rejection of irrelevant must take place. In other words, when we meet with a novel situation, we take in some information which goes through a reasoning process of checking and categorizing in the brain before coming up with a meaningful interpretation of the situation. Same way, meaningful learning is achieved by a sequence of brain operations including hypothesis, trial, check and matching to a category until a perfect or nearfit is obtained. The process of deducing the implications of facts and assumptions (deductive reasoning) and finding the general principle common to set instances (inductive reasoning) make up reasoning. Reasoning is therefore the conscious direction of thought process in orderly sequence to a logical conclusion. Reasoning ability is an important pre-requisite for concept learning. Study by Otuka (1986) found that concept attainment is determined by the reasoning ability of the learner. Onwu (1985) has shown that reasoning is affected by the organisation of content, in a systematic way.

Recent research suggests that success in chemistry learning is dependent upon students proportional reasoning abilities, (Gabel and Sherwood, 1983; Fabel, Sherwood and

Enoch, 1984; Krajcik and Haney, 1987; Tingle and Good, 1990). Stoichiometry, an aspect of the chemistry study area identified as being difficult requires the knowledge of particulate nature of matter, understanding the mole concept and the ability to apply proportional reasoning (Goodstein and Howe, 1978; and Bello, 1990). Also the study of chemical combination, one of the study areas, requires reasoning ability. A possible reason why some chemistry topics are seen as difficult (and this has led to poor performance) could be that the method of instruction does not enhance reasoning. Perhaps there could be an instructional method that could improve reasoning ability and consequently students performance in science.

There is considerable evidence to argue that meaningful learning underlies the constructive integration of thinking and acting leading to human empowerment (Novak and Gowin, 1984; Novak, 1989; 1991). Kurtz and Karplus (1979) showed that it is possible to advance the use of proportional reasoning of many secondary school students by means of a well designed teaching programme. The work of Alex-Johnston (1980) in Chemistry; Robbicase (1987) in science and mathematics support the thesis that working memory efficiency could be enhanced by the quality of instruction.

Glasscons (1989) study was an attempt to determine whether prior knowledge and reasoning ability predicted students achievement. The results of that study showed that

prior knowledge and reasoning ability significantly predicted performance with reasoning ability being the stronger predictor.

The research work by Novak (1990) revealed that concept mapping instructional strategy is a powerful tool to help students learn how to think critically and more creatively. This study attempts to determine if any of the two study instructional strategy might bring about:

i. improved reasoning ability of Nigerian students and
ii. improved performance of students in topical difficult concepts.

2.10 Summary

Though guided discovery teaching strategy is emphasized in the science curriculum, it would be difficult to identify significant changes that resulted from its use. This is reflected in poor performances and increasing literature report on topical difficult concepts. There is evidence that the new emerging constructivist view within the science framework could lead to meaningful learning. Within the limits of available literature, it has been shown that concept-mapping strategy used within the constructivist framework could to a large extent positively influence the understanding of science concepts. Studies on concept-mapping were mainly foreign and centred mainly on the areas

of biology and physics. In Nigeria, only few studies were reported on concept-mapping strategy. These studies were in biology. The implications for the teaching of science using concept-mapping within the constructivist framework have been pointed out in the various literature cited. There was little or no information regarding variables that affected students understanding of science concepts using the concept-mapping strategy. Science educators and psychologists affirm that the variables (gender, comprehension, reasoning, home factor and attitude) do influence learning. Research reports on the effects of the variables on science achievement have been highlighted.

It is against these background that the researcher has seen the need to study the effect of concept mapping and guided discovery instructional strategies on gender, home factors, reading comprehension, reasoning ability and attitude. It is therefore hoped that the findings of this study would open a gateway for further research and provide adequate literature to support the results of findings of this research. This study might also help curriculum developers to take decision on the instructional strategy to use for effective science instruction in our schools.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter incorporates a description of the research design, sampling strategy; selection of teaching topics; pilot study; procedure for data collection; instrumentation and procedure for the analysis of data.

3.2 Research Design

The study was set up to compare the effectiveness of two teaching strategies (concept-mapping and guided discovery) on students understanding of some selected chemistry concepts.

The 'Pretest - Post test Design' was adopted for the purpose of data collection. In the first instance, a pretest was administered to the students. After this, the groups were exposed to the instructional treatments. The concept-mapping group was taughtusing the concept mapping teaching strategy. This teaching strategy involved elicitation of students prior ideas of concepts, discussions, demonstration and concept mapping activities. The concept-mapping activity was withheld from the guided discovery group which received same chemistry instruction using the approach (guided discovery) recommended by the National Science

Curriculum for Senior Secondary Schools.

A post-test on the chemistry concepts was administered at the end of the teaching treatment period to both groups to evaluate the effectiveness of instruction. The pretest and the post-test are the same. The design of the study is represented thus:

R O_1 X_1 O_2

R O_3 X_2 O_4

where R = Random assignment of students

X_1 = Concept-mapping strategy

X_2 = Guided discovery strategy

O_1 O_3 = Pretest measurements (same test)

O_2 O_4 = Post test measurements (same test)

The advantages of this design are that:

i. The pretest scores can be used to statistically control for any differences between the groups at the beginning of the study.

ii. It can be used to give an indication of gain in understanding of the selected chemistry concepts due to the application of treatment.

iii. It can be used to show that a particular treatment/ teaching strategy is superior to the other.

iv. The gain scores may be compared and subjected to a test of significance of the difference between means.

The assumption of this design is that the uncontrollable events act equally on both groups, so gain is as a result of introduced treatment. The variables used for the study are: (i) Gender (boys and girls) (ii) Reading comprehension (iii) Reasoning Ability (iv) Attitude and (v) Home factors.

3.3 Sampling Strategy

A total of 246 Senior Secondary 1 (SS1) chemistry students made up the sample for the study. The students were drawn from 3 randomly selected schools in Minna, Niger State. The selection of the school was done by taking into consideration the gender factor. One of the schools was purely boys school, the second a girls' school and the third a co-educational (mixed gender) school. Each of the three schools had between 3 and 5 SS1 Science classes. However, only 2 classes were selected randomly from each school for the study. In each school, the two classes were randomly assigned to concept-mapping and guided discovery groups. The concept-mapping groups were taught using the concept-mapping strategy while the guided discovery groups were taught same chemistry concepts using guided discovery strategy.

3.4 Selection Of Teaching Topics

The chemistry topics selected for this study were:

- Particulate nature of matter
- Chemical combination
- Acid/Bases and Salts

These chemistry topics were chosen for this study because:

i. they are fundamental to the study of science in general and chemistry in particular.
ii. they revolve around the major concepts of structure, reaction and energy on which the National Chemistry Curriculum for senior secondary schools is organized.
iii. most chemistry concepts are subsumed into the selected chemistry topics.
iv. researchers have indicated that students find these topics difficult and have misconceptions of them in some cases (Abayomi, 1985; Alao, 1985; Bello, 1988; Eseonu, 1982; Eniayeju, 1990; Fraz and Sleet, 1984; Koleoso, 1985).
v. they are part of the National Chemistry Curriculum for SS1 students.

3.5 The Pilot Study

A co-educational school, Ahmadu Bahago Secondary School, Minna was used for the pilot study. The main purpose of the pilot study was to determine:

i. the feasibility of the study through a trial run.

ii. the appropriateness of the instruments.

iii. the timing of the administration of the instruments.

iv. the reliability of the instruments.

3.6 Procedure For Data Collection

The teaching treatment, administration of the questionnaires and test items were personally handled by the researcher. One reason for this is that concept-mapping strategy is relatively new and teachers not familiar with it might easily revert to other methods (Novak, 1988). Moreover, the researcher wanted to maintain uniformity by using the appropriate teaching strategy for each group. Before the start of the study, the researcher went to the schools. She was introduced as a part-time teacher to the students by the different school authorities. The contact period for the concept-mapping and guided discovery groups was 10 weeks. During the first week, the researcher and students familiarised themselves with some Junior Secondary School, JSS, integrated science work, relevant to the selected concepts. Administration of questionnaires and pretests was done in the second week. The next six weeks involved intensive teaching and learning of the chemistry concepts. This was followed by one week of revision and one week of administration of post tests and questionnaires.

At the initial stage of the lessons, the concept-mapping

classes were taken through an induction programme in concept mapping. The intent was to acquaint the students with the procedure for concept mapping. Topics other than those selected for the study were used. The procedure for mapping concepts is as follows:

i. identify and list key words or ideas/concepts.

ii. arrange and rank the listed concepts from the most abstract and inclusive to the most concrete and specific.

iii. link related concepts with lines and label each line in propositional form until a meaningful map is drawn.

The same topics were taught the guided discovery group using the guided discovery approach.

The teaching treatment began with the teaching of the "Particulate nature of matter" for two weeks to both groups by the researcher. The guided discovery class was taught using guided discovery strategy. This instructional strategy is activity oriented and involved practical demonstration and experimentation (see Appendix II). The concept-mapping classes were taught using concept mapping strategy. This strategy involved elicitation of students prior knowledge on topic, discussion, demonstration and mapping activities. Thereafter followed the teaching of chemical bonding for 2 weeks and Acid/Bases and Salts for another two weeks.

A post test was administered at the end of the revision

week to all the students used for the study. This was to evaluate the effectiveness of instruction. In addition to the chemistry concept post test, tests on reading comprehension, reasoning and questionnaires on attitude and home factors were administered. The study sample (246 students) participated fully in the lessons by attending the lessons regularly and participating in all activities.

After 4 weeks from the end of treatment, a post- post test was administered to the students to determine the level of retention of the studied concepts.

The students' score on the test items and responses to questionnaires formed the data for testing the study hypotheses.

3.7 Instrumentation

The following instruments were used for the research:

i. Chemistry Concept Achievement Test, CCAT
ii. Chemistry Attitude Questionnaire, CAQ
iii. Reading Comprehension Test
iv. Non-verbal Reasoning Ability Test
v. Home factor Questionnaire.

3.7.1 The Chemistry Concept Achievement Test (CCAT)

The chemistry concept test consists of 50 multiple choice

items. The test is designed to determine the extent of students' understanding of the following selected chemistry concepts:

i. Particulate nature of matter

ii. Chemical combination

iii. Acid, Bases and Salts.

A multiple choice format was used because it allows for a wide coverage of the content. Also the test could be completed quickly by a large number of students. The main source of the multi-choice items was from a collection of West African Examination Council (WAEC) assessment items available in the field of secondary school chemistry. The selected items were checked against the chemistry content for appropriateness and cognitive level by three seasoned chemistry educators. Item analysis was carried out on these test item instrument. The 50 test items used for the study were selected on the following basis:

i. recommendation of experts

ii. high discrimination indices, $D \geq 0.3$

iii. high facility indices, $40 \leq F \leq 70$.

The selected items reflected the 4 cognitive levels of Bloom's Taxonomy for the cognitive domain (Bloom, 1956). The four levels are:

Level A: Functional information (mainly recall)

Level B: Understanding (ability to use knowledge in a familiar situation in the context it was required)

Level C: Application (the ability to select appropriate knowledge and apply it to a problem situation).

Level D: Higher processes (this includes analysis, and evaluation).

Table 2 shows the distribution of the test items according to the levels.

Table 2: Number of questions at each Cognitive level

Chemistry Content	Cognitive Level A	B	C	D
Particulate nature of matter	4	4	4	4
Chemical combination	4	5	4	4
Acid, Bases and Salts	4	5	4	4

The reliability coefficient of CCAT (0.86) was determined using the split-half method, stepped up by the Spearman-Brown prophecy formula.

3.7.2 The Chemistry Attitude Questionnaire, (CAQ)

The instrument used to discern students attitude toward chemistry was CAQ adopted from Otuka (1986) with slight modification. The test now includes a section on attitude towards chemistry instructional strategy. The instrument was revalidated by two science educators and an educational psychologist who were intimated with the purpose of the

study. The attitude questionnaire now contains 40 items. 22 of these measured students attitude towards chemistry. The other 18 items measured students attitude towards concept mapping teaching strategy. Some of the attitude statements were positive in nature while others were negative. By including the negative statements, it was intended that the students would read all the statements carefully in order to respond consistently. The instrument is a Likert-type questionnaire using four scales - Strongly Agree (SA); Agree (A); Disagree (D); Strongly Disagree (SD). The 4 options bore simple weights, 4, 3, 2, and 1 respectively for positive items and the reverse for negative items. High scores represented favourable attitude and low scores represented negative attitudes. The reliability test using a split-half reliability technique gave a reliability coefficient of 0.76.

3.7.3 The Reading Comprehension Test

The instrument is a reading comprehension passage on one of the chemistry topics used for the study, along with 10 multiple choice questions based on the passage read. The validity of the test was determined by ~ ing the critical opinion of the instrument from two English language experts from College of Education, Minna and two chemistry lecturers from Federal University of Technology, Minna. The

reliability coefficient (0.79) of the comprehension test items was determined using Kuder-Richardson formula 20, Kr20.

3.7.4 The Non-verbal Reasoning Ability Test

This test consists of 50 items. Each item has 5 options of which only one is correct. It is a non-verbal test with little or no cultural trait. This test has been used for many studies in the psychology section of the Faculty of Education, Ahmadu Bello University, (A.B.U.) Zaria. Such studies include Ibrahim (1980) and Musa (1982). The reliability coefficient of 0.80 was established using Kr 20.

3.7.5 Home Factor Questionnaire

This instrument was constructed by the researcher. It consists of 30 statements designed to obtain information about:

i. students' parental background/status;
ii. parental involvement and encouragement in chemistry study.
iii. students' study routine.

The statements were framed in such a way that in some sections of the questionnaire the students ticked 'Yes' or

'No'. In other sections, space was created for correct responses. The questionnaire was validated by two psychologists. A test-retest method was used to obtain a reliability coefficient of 0.92.

3.8 Procedure For Analysis Of Data

The data for this study were obtained from the scores of test items and questionnaire responses.

3.8.1. Scoring of Responses

Points were awarded for each question or test item a student answered correctly in the following instruments:

i. Chemistry Concept Achievement Test, (CCAT)

   A point each up to a maximum of 50 points.

ii. Chemistry Attitude Questionnaire, (CAQ)

   Responses to each of the Likert type scale questions were scored/weighted as follows:

Strongly Agree (SA)	4
Agree (A)	3
Disagree (D)	2
Strongly Disagree (SD)	1

For the negatively worded items, the reverse order weighting was used in the scoring.

iii. The Reading Comprehension Test

A point each up to a maximum of 10 points.

iv. Non-verbal Reasoning Test

A point each up to a maximum of 50 points

v. Home factor Questionnaire

The home factor inventory was scored as follows:

a. Occupation of parents = Low - Average - High

(1 point) (2points)(3 points)

Educational attainment

From - did not go to primary school (1 point)

| |

to - University graduate ..... (11 points)

b. Parental Involvement

One point for any correct response in the 'Yes/No' statement up to a maximum of 12 points.

c. Study Routine

One point for each correct response up to a maximum of 9 points.

vi. Concept maps drawn by students were scored to a maximum of 50 points as below:

a. Hierarchy: 5 points for each valid level, maximum 20 points

b. Proposition/Cross linkages

Each meaningful valid proposition scores 2 points up to maximum 20 points

c. Examples - specific valid objects scores 2 points, maximum 10 points.

3.8.2 Test of Hypotheses

The data collected from the five instruments were used to test the study hypotheses.

H(0)1: There is no significant difference in the performance on chemistry concepts between groups taught using concept mapping and guided discovery strategies.

To determine whether significant learning occurred during teaching treatment, the following statistics were computed.

i. Mean for each group

ii. Standard deviation

iii. t-Test.

H(0)2: There is no significant difference in the level of chemistry knowledge retention between groups taught using concept-mapping and guided discovery strategies.

The following statistics were computed.

i. Mean of Pretest, Post test and Post-post test

ii. Standard Deviation

iii. t-Test

H(0)3: There is no significant difference between the performance of boys and girls taught using concept mapping and guided discovery strategies.

The following statistics were computed.

i. Means

ii. Standard Deviation

iii. t-Test

iv. Analysis of covariance, ANCOVA.

H(0)4: There is no significant relationship between students home factors and performance in chemistry.

The statistics computed were:

i. Means for parental status, parental involvement and study routine.

ii. Pearson correlation was computed using the responses for home factor and scores from chemistry concept post test.

iii. Regression of concept post test on each of the home factor variables.

H(0)5: There is no significant difference between the reading comprehension score of students' taught using concept-mapping and ided discovery strategies.

To test this hypothesis the following statistics were computed:

i. Mean for both groups

ii. Standard Deviations

iii. t-Test

H(0)6: There is no significant difference between the reasoning ability scores of students taught using concept-mapping and guided discovery strategies.

The following statistics were computed.

i. Means

ii. Standard Deviations

iii. t-Test

H(0)7: There is significant difference in the attitude to chemistry instruction between groups taught using concept mapping and guided discovery strategies.

The following statistics were computed:

i. Mean of pre- and post attitude scores

ii. Standard Deviation

iii. t-Test

iv. Pearson correlation using the scores of responses from the attitude to teaching and the attitude to chemistry.

H(0)8: There is no significant contribution by any or all of the variables (reading, reasoning, attitude) on students performance in chemistry.

The following statistics were used to test the

hypothesis.

i. Means

ii. Standard Deviation

iii. Regression Analysis.

3.9 Summary Of The Chapter

The procedure for both collection and analysis of data for this study has been highlighted in this chapter. A t-Test statistics was used to test hypotheses, 1,2,3,5,6 and 7. Hypotheses 4 and 7 were analysed using Pearsons' correlation statistics. Regression analysis was applied in testing hypothesis 4 and 8. Analysis of covariance, ANCOVA was carried out in testing hypothesis 3. The result of the data analysis is discussed in the next chapter, i.e. Chapter IV.

CHAPTER 4

DATA ANALYSIS AND FINDINGS

4.1 Introduction

The analysis of data collected on the two teaching strategies and the study variables (gender, reasoning ability, reading comprehension, attitude and home factors) is discussed in this chapter.

4.2 Comparing The Effectiveness Of Concept-Mapping And Guided Discovery Strategies

H(0)1: There is no significant difference in performance between groups taught using concept-mapping and guided discovery strategies.

H1: There is significant difference in performance between groups taught using concept-mapping and guided discovery strategies.

Table 3: Means, Standard Deviations and t-Tests of Concept- Mapping (CM) and Guided discovery (GD) Groups on the Pretest and Post test scores of Chemistry Concept Achievement Test (CCAT)

Test	Group	N	Mean ($\bar{x}$)	Standard Deviations (S.D)	t-value	P
Pretest	CM	123	8.39	4.56	0.69ns	0.49
	GD	123	8.05	4.19		
Post test	CM	123	37.94	10.97	3.98**	0.000
	GD	123	32.71	9.76		

ns = Not Significant
** Significant at the .05 probability level.
CM = Concept-mapping
GD = Guided discovery

To determine possible post experimental differences between the two teaching strategies, a t-test was applied on the chemistry concept data (Table 3). The result of this statistical analysis revealed:

i. no significant difference on the pretest scores (P>0.05) of the concept-mapping and guided discovery groups. This means that the students in the both groups were found to be equivalent with respect to their initial (prior) knowledge on the selected chemistry concepts before teaching treatment commenced. This was demonstrated by the results of the t-tests conducted on the pretest scores of CCAT, ($t = 0.69$, $P>0.05$).

ii. that the concept-mapping and guided discovery groups

differed significantly from one another after treatment ($t = 3.98$, $P < 0.001$, See Table 3).

The table revealed that the concept-mapping group taught using concept-mapping strategy ($\bar{x} = 37.94$) performed significantly better than the guided discovery group ($\bar{x} = 32.71$) exposed to the guided discovery strategy in the CCAT (based on the same number of observations, $N = 123$). This showed that the concept-mapping strategy was found to be more effective than the guided discovery strategy for the understanding of chemistry concepts. On this basis, the research hypothesis that there is no significant difference between the two teaching strategies was not supported. The null hypothesis was rejected and its alternative accepted.

4.3 Retention Test

H(O) 2: There is no significant difference in the level of knowledge retention of selected chemistry concepts between students taught using concept-mapping and guided discovery strategies.

H2: There is significant difference in the level of knowledge retention of selected chemistry concepts between students taught using concept-mapping and guided discovery strategies.

Table 4: Means, Standard Deviations and t-Tests of Concept-mapping and Guided discovery Groups Retention of Chemistry Concepts.

Group	Test	N	x	S.D	t-value	P
CM	Post	123	37.94	10.97	4.88**	0.000
	Post-Post	123	44.38	11.56		
GD	Post	123	32.71	9.76	1.56ns	0.121
	Post-Post	123	30.83	11.44		
CM	Post-Post	123	44.38	11.56	10.18**	0.000
GD	Post-Post	123	30.83	11.44		

ns = Not Significant Exp. = Experimental
** P<0.001
CM = Concept-mapping
GD = Guided discovery

To test the retention ability of students taught using two teaching strategies, the mean scores and the standard deviation of the concept-mapping and guided discovery groups were used to calculate t-Test.

The result of the t-Test analysis revealed:

i. a significant difference in performance between the post test and post-post test scores of the concept-mapping group.

ii. no significant difference between the post test and post-post test of the guided discovery group.

iii. a significant difference between the concept-mapping and guided discovery groups post-post tests score.

Since there was a significant difference between the post test and post-post test of the concept-mapping group ($t = 4.88$, $P<0.001$) whereas for the guided discovery group,

there was no difference, ($t = 1.56$, $P>0.05$), it follows that the concept-mapping method enabled the students retain more knowledge on the chemistry concepts than the guided discovery method. This fact was further demonstrated by the results of the t-test comparing the concept-mapping and guided discovery groups post- post test score [$t=10.18$, $P<0.001$], (See Table 4).

The insignificant difference in the level of chemistry concept retention with the guided discovery group does not mean that the students did not retain any knowledge rather the knowledge retained was not significant compared to the knowledge gained immediately after treatment. It could also be that guided discovery strategy helped students just to pass examinations only, leaving them with poor retentive knowledge of what they have learned thereafter.

The significant performance of the concept-mapping group could be due to the fact that the concept mapping strategy enabled the students to have the concepts organized and summarized in a compact diagrammatical form which could easily be remembered at a later time. It could also be that mapping activities helped to make knowledge of the concept clear and meaningful to the student. This knowledge in a clear meaningful organized form could have attributed to the improved retention ability of the concept-mapping group. It could also be that concept links create many routes for remembering. This finding is supported by studies reported

by Novak and Gowin (1983) and Novak (1985) that concept-mapping aids retention of subject matter. On this basis, the null hypothesis was rejected and its alternative upheld.

4.4. Performance According to Gender

H(0)3: There is no significant difference between the performance of boys and girls taught using concept-mapping and guided discovery strategies.

H3: There is significant difference between the performance of boys and girls taught using concept-mapping and guided discovery strategies.

The null hypothesis, H(0)3, seeks to determine whether performance of boys and girls would differ when the two teaching strategies were used. Using the mean differences for the gender categories in the pretest and post test scores a t-Test was carried out. Further analysis was done by computing a 2 x 2 Analysis of Covariance (ANCOVA) using pretest scores as covariates.

Table 5: Means, Standard Deviations, t-Tests of Pretest and Post test scores comparing Concept-mapping and Guided discovery groups by Gender Category

Group	Gender	Pretest N	$\bar{x}$	S.D	t-value	Post test N	x	S.D	T-value
CM	Male	61	8.64	4.70	.58ns	61	38.46	11.71	.52ns
	Female	62	8.17	4.45		62	37.44	10.25	
GD	Male	61	8.02	4.23	.26ns	61	33.82	10.73	1.25ns
	Female	62	8.08	4.18		62	31.62	8.65	

ns = Not significant

CM = Concept-mapping

GD = Guided discovery

The t-Test result revealed that there was no significant difference in the pretest mean scores obtained by boys and girls using the two teaching strategies, (Table 5). Similarly, there was no significant difference in the scores obtained by boys and girls in the post test using the two teaching strategies. This means that the effects of both teaching strategies on performance are independent of gender. The null hypothesis is therefore upheld. The fact that performance of students was not influenced by the gender is further supported by results from the ANCOVA.

Table 6: Analysis of Covariance (ANCOVA)
Showing The Interaction of the
Variables Gender and Teaching Strategies

Source	Sum of Squares(SS)	DF	Mean Squares(MS)	F	P
Covariate (Pretest)	195.92	1	195.92	1.92	
Main Effects Gender	390.63	2	195.32	1.92	0.1497ns
Teaching (Treatment)	1619.93	1	1619.93	15.88	0.0001**
Interaction Gender x Teaching	1053.28	2	526.64	5.16	0.0064**
Error	23769.93	233	102.02		

ns = Not Significant
** Significant at the .01 level

The results of the ANCOVA presented in Table 6 show that the P values of 0.0001 and 0.0064 were significant for the teaching strategy and the interaction of gender and teaching strategy. The significant interaction effect is clearly shown on Table 6 to be as a result of the effect of the teaching strategies used ($F=15.8790$; $P < 0.05$) and not gender ($F=1.92$; $P>0.05$). This result indicates that students performance was not influenced by gender, but by the teaching strategy used. The means for the concept mapping and guided discovery strategies in Table 7 reveal that the significant interaction effect could be attributed to the use of concept mapping teaching strategy (mean concept mapping = 37.775; mean guided discovery = 32.575).

Table 7: Means of Interaction between Gender and Teaching Strategies

Gender	Teaching Strategy	Adjusted Mean
1	-	36.979
2	-	34.314
-	1	37.775
-	2	32.575
1	1	37.449
1	2	36.508
2	1	36.194
2	2	32.433

Key to gender/strategy variables

Gender: 1 = boys
2 = girls

Strategy: 1 = Concept mapping
2 = Guided discovery

Gender	Strategy	
1	1	= male (concept-mappin
1	2	= male (guided discove
2	1	= female (concept-mapping)
2	2	= female (guided discovery)

The boys and girls taught with concept mapping did not differ much in their performance (Table 7 boys mean score= 37.45; girls = 36.19). However, boys and girls in the guided discovery group showed slight difference in performance which was not significant.

From the results on Tables 6 and 7, the hypothesis of non-significant difference in the performance of boys and girls taught with concept mapping and guided discovery strategies is thus upheld.

The finding that there is no significant difference between performance of boys and girls in chemistry concept tests is in agreement with similar finding by Erickson and Erickson (1984) who found no significant difference in science achievement of boys and girls. Similarly, Ajewole (1990) found no significant difference in the transfer of learning between male and female students when guided discovery teaching method was used. Tobin (1989) reported that there was no observed difference in the engagement of boys and girls in science.

From the above findings, one could rightly deduce that:

i. the use of concept mapping in teaching chemistry concepts was useful to both boys and girls. Though the difference was not significant but the mean scores appear to favour the boys.

ii. boys in the guided discovery group benefitted more than the girls when the mean scores were considered, though

the difference was not significant at the .05 level.

4.5 Home Factor And Performance in Chemistry

H(0)4: There is no significant relationship between students home factors measured by the following instruments:

i. Parental background

ii. Parental involvement

iii. Study routine and performance in chemistry

H4: There is significant relationship between students home factors measured by the following instruments:

i. Parental background

ii. Parental involvement

iii. Study routine and performance in chemistry.

The general purpose of this section of the study was to examine relationships between measures of the home factors and students performance in chemistry. Mean scores, standard deviations, correlation and regression were used to determine the relationship(s) if any between measures of the home variables and performance in chemistry.

Table 8: Pearsons Correlation between Students' Home Factors and Performance in Chemistry.

Factors	Number of cases	Means	Standard Deviation	r	P
Background	246	48.52	21.88	0.01	0.86ns
P/Involvement	246	67.21	18.60	0.01	0.89ns
Study Routine	246	63.14	19.26	0.03	0.63ns
Post test	246	35.33	10.67		

ns = Not Significant P/Involvement = Parental Involvement

Results from Table 8, showed that, there is no significant relationship between any of the home variables and students performance in chemistry (P>0.05). This finding contradict results by Dubey (1973) who found that no matter the measure of parental socio-economic status (SES), their relationship to achievement is consistent. A further analysis done by calculating the percentage of children in various socio- economic sets revealed that about 33% of the children from well to do homes did not do well while about 12% of those whose fathers never went to school did very well, scoring above 40% in the test. This further supported the finding that home background of parents did not influence performance. On this basis the null hypothesis is upheld.

Table 9: Correlation Matrix of Home Factor (variables) with Chemistry Post test

	1	2	3	4
1	1.000 (P=0.000)			
2	0.088 (P=.168)	1.000 (P=.000)		
3	-0.054 (P=.402)	0.209 (P=.001)	1.000 (P=.000)	
4	0.011 (P=.861)	-0.009 (P=.889)	-0.031 (P=.633)	1.000 (P=.000)

Key to Variables

1 = Background of parent
2 = Parental involvement in student study
3 = Students study routine
4 = Chemistry concept post test
( ) = Probability values

Table 9 shows the inter-correlation of all three factors with the post test. The table revealed that there is significant association at the .01 level between parental involvement in students study and study routine. This could mean that when parents show concern by getting involved in their children's study, the children themselves probably get motivated and get serious with their study.

Further analysis was done on the home factor weighting and the post test scores to determine the effect of teaching strategies used as they interact with the home factor variables. Regression of the concept-mapping group post test scores on the home variable weighting was carried out and the results are shown on Tables 10 and 11.

Table 10 : Regression effect on Concept-mapping Group

Variables	B	SEB	t-ratio	P
1Background	.0025	0.043	0.58	0.96ns
2Involvement	0.510	0.058	2.62	0.01**
3Study routine	-0.040	0.053	-0.754	0.45ns
4 (Constant)	50.600	4.94	10.24	0.00

ns = Not Significant
** = Significant at .01 level

The result in Table 10, identified the contribution made by each home factor variable to the prediction of performance when concept-mapping is used. The values of t-ratio associated with each variable showed that only parental involvement (variable 2) contributed significantly to the prediction of performance using the Concept-mapping strategy treatment. This result lends support to earlier findings of Ware and Garber (1972) and Keeves (1975) that availability of materials to children seem to be the most important variable predicting school success.

Table 11: Regression Analysis on Concept-mapping Data

Multiple R = 0.263

Multiple R-Square = 0.069

Analysis of Variance

Source	DF	SS	MS	F-ratio	P
Regression	3	1016.37	338.37	2.95	.04
Residual	119	13656.24	114.76		

Results in Table 11, identified the joint contribution of the home variables to predicting performance in chemistry when concept mapping strategy is used. Table 11 revealed that:

i. a combination of the 3 home factors in predicting performance yielded a coefficient of multiple regression (R) of 0.263.

ii. the home variables taken together accounted for 6.9% of the total variance in students performance (R^2) = 0.069

iii. analysis of variance for the multiple regression data producedan F-ratio of 2.95 significant at the 0.05 level.

Table 12: Regression Effects on Guided discovery Sample

Multiple R = 0.087

R-Square = 0.008

Analysis of Variance

Source	SS	DF	MS	F	P
Regression	87.98	3	29.33	0.30	0.82
Residual	11531.48	119	96.90		

ns = Not significant

Table 12 showed that a combination of the 3 home variables yielded a coefficient of multiple regression (R) of 0.087 and a multiple R-square of 0.008. The analysis of variance for the multiple regression data produced an F-ratio of 0.30 which is not significant at the 0.05 level. Thus, the results reveal that the home factors when taken together accounted for 0.8% (less than 1%) of the total variance in the students performance with respect to the guided discovery strategy.

Table 13: Testing the significance of Regression for Guided discovery Group Data

Variable	B	SEB	t-ratio	Sig T
1	0.032	0.039	0.808	0.42
2	0.012	0.053	0.229	0.81
3	0.014	0.049	0.276	0.78
Constant	29.349	4.54	6.465	0.0000

Table 13 revealed that the t-ratio is not significant for each home variable. As can be seen from the table, the t-ratio ranged from .276 to .808. This means that no single home variable is significant at the .05 level. The finding that home factor is not a significant predictor of performance lends support earlier findings by Esyenck and Cookson (1970). However, this findings tends to run contrary to the views expressed by Majoribanks (1979), Bloom (1984), Awoyemi (1986) and Walberg (1984) that SES and parental involvement are predictive of achievement.

Judging from all the evidences above, the following points become clear:

i. there is no significant relationship between any of the home factors and performance in chemistry.

ii. there is significant association between parental involvement in students' study and students' study routine.

iii. that only one variable (parental involvement) out of the 3 home variables made the most significant contribution to the prediction of students performance when concept mapping strategy is used.

iv. that the home factors taken together could not predict performance in chemistry (R^2 = .069;0.008) when guided discovery strategy is used.

Although the main pattern of the findings does not relate any home variable to performance using the guided discovery strategy, however, the three home variables taken together revealed that parental involvement in students' study is a useful predictor of performance, when concept mapping straegy is used.

4.6 Reading Comprehension and Teaching Strategies

H(0)5: There is no significant difference between the reading comprehension score of students taught using concept-mapping and guided discovery strategies.

H5: There is significant difference between the reading comprehension score of students taught using concept-mapping and guided discovery strategies.

To investigate possible post experimental differences in students reading comprehension which could be attributed to the difference between the two teaching strategies, a t-test was applied on the reading comprehension data.

Table 14: Means, Standard Deviations and t-Tests comparing Reading Comprehension scores by Concept-mapping and Guided discovery Groups

Test	Group	N	Mean ($\bar{x}$)	Standard Deviations (S.D)	t-value	P
Pretest	CM	123	24.15	11.01	0.46	0.65ns
	GD	123	24.79	11.25		
Post test	CM	123	54.39	20.93	8.62	0.000**
	GD	123	34.72	16.36		

ns = Not Significant
** Significant at .01 level
CM = Concept-mapping
GD = Guided discovery

The result of the t-Test revealed that there is no significant difference in the pretest reading comprehension scores by the concept-mapping and guided dicscovery groups (t = 0.46; P> .05). However, data for the post test produced t-value of 8.62, significant at the .01 level. The reading comprehension post test scores of the concept-mapping and guided discovery groups were found to differ significantly from one another (Concept-mapping mean score = 54.39; Guided discovery mean score = 34.72). Judging from the mean scores, the result showed that the concept-mapping group exposed to the concept-mapping teaching treatment demonstrated superior performance. This indicated that the concept-mapping teaching strategy enabled the students to read and comprehend chemistry concepts more than the guided discovery strategy. In other words, concept mapping strategy seems to improve students reading comprehension of chemistry concepts.

A text cannot be comprehended unless the great majority of its sentences can be converted to propositions that are familiar or that can be related immediately to elements that are present in the memory. One important process that affects reading comprehension is the process of elaboration. Elabortion aids memory by providing additional routes of information retrieval and construction.

Perhaps the significant effect of concept mapping on reading comprehension could be due to the concept-mapping exercises which create relationships between important sets of concepts and link the related concepts in a readable meaningful manner.

It would appear therefore that concept-mapping as a teaching strategy has a tremendous capacity for helping students comprehend what they read. Concept mapping has been reported to increase comprehension (Taylor and Beach, 1984). On this basis the null hypothesis is rejected, and its alternative upheld.

4.7 Reasoning Comprehension and Teaching Strategies

H(0)6: There is no significant difference between the performance in reasoning ability of students taught using concept-mapping and guided discovery strategies.

H6: There is significant difference between the performance in reasoning ability of students taught using concept-mapping and guided discovery strategies.

Table 15: Means, Standard Deviations and t-Test Comparing students Reasoning Ability Scores on the Pretest and Post test by Concept-mapping and Gudided discovery Groups

Test	Group	N	Means	S.D	t-value	P
Pretest	CM	123	31.40	11.07	0.32	.75ns
	GD	123	31.80	9.38		
Post test	CM	123	62.12	16.25	13.85	.000**
	GD	123	36.98	11.26		

ns Not Significant

** Significant at both the .05 and .01 levels.

CM = Concept-mapping

GD = Guided discovery

To investigate the effect of concept-mapping and guided discovery instructional strategies on the reasoning ability of chemistry students, a t-Test was applied on the pre-reasoning and post-reasoning test scores. The result of the t-Test revealed:

i. a non-significant difference in the pretest performance of reasoning ability between the concept-mapping and guided discovery groups ($t = 0.32$, $P>0.05$).
ii. that there is a significant difference in the performance of the concept-mapping and guided discovery groups in the post-reasoning test ($t = 13.85$; $P<0.001$).
iii. a remarkable difference in the mean score of the concept-mapping and guided discovery groups in the post reasoning ability test (Table 15).

The results show that the concept-mapping group taught using the concept-mapping teaching strategy performed better in the reasoning ability test ($x = 62.12$) than those in the guided discovery group taught using guided discovery teaching strategy ($x = 36.98$).

The use of concept mapping strategy might be more effective in improving students critical thought than the guided discovery strategy. The finding that concept-mapping is effective in improving reasoning ability is not surprising. Concept mapping activities involve a lot of flexible and critical thinking before a meaningful map could be drawn. Mapping exercises require the students to think in multiple directions and switch back and forth between different levels of abstraction in the process of ranking and linking concepts to show meaningful relationships. In this study, the students were seen to move a particular concept or subconcept or idea from one section of the concept map to another until an appropriate location reflecting its correct position on the map is identified.

Concept mapping activities also require the students to reasonably and logically develop links among subconcepts and concepts. These could have accounted for the significant performance of the concept mapping group in the reasoning ability test.

This finding supports earlier reports of studies by Novak and Gowin (1988) and Okebukola (1990) that concept mapping effectively improves students' thinking.Similarly, Otuka (1986) revealed that concept attainment is determined by the reasoning ability of the learner. Lovell (1986) also argued that reasoning is often involved when concepts are being formed.

4.8 Attitude to Chemistry and Teaching Strategies

H(0)7: There is no significant difference in the attitude to chemistry between groups taught using concept- mapping and guided discovery strategies.

H7: There is significant difference in the attitude to chemistry between groups taught using concept mapping and guided discovery strategies.

Table 16: Means, Standard Deviations and t-Test Comparing Students Score on Attitude to Chemistry by Concept-mapping and Guided discovery Groups

Test	Group	N	Means	S.D	t-value	P
Pretest	CM	123	51.70	14.98	-0.89	.38ns
	GD	123	53.28	15.65		
Post test	CM	123	77.18	6.81	5.61	.000**
	GD	123	72.23	8.32		

ns = Not Significant

** Significant at the .01 level.

CM = Concept-mapping

GD = Guided discovery

Table 16 shows the means, standard deviations, t-values and probability levels of the pretest and post test by the concept-mapping and guided discovery groups. For both groups, the pretest indicated no statistical significant difference ($t = 0.89$; $P=0.38$). However, the post test result revealed a statistical significant difference between the concept-mapping and guided discovery groups ($t = 5.61$; $p<0.05$). The concept-mapping group taught using concept-mapping strategy with a means score of 77.18 demonstrated a more favourable positive attitude to chemistry than the guided discovery group exposed to the guided discovery strategy ($x = 72.23$). Therefore, the hypothesis that there would be no significant difference between the attitude of students exposed to chemistry concepts using concept-mapping and guided discovery strategies is rejected. The alternative hypothesis is upheld. This means that concept-mapping strategy had a direct influence on students attitude. The more favourable attitude of students to chemistry learning in the concept-mapping group could be attributed to students interest in constructing meaningful relationship between concepts. It could be that the students have noticed that concept mapping activities aided knowledge retention and better performance.

In a related study, Ajewole's (1990) found that students exposed to discovery method showed a more favourable attitude to science than students taught with expository method. Ajewole compared discovery and expository methods while the present study compared guided discovery and concept-mapping strategies.

However, this finding seem to support the notion that learning using concept mapping strategy may likely enable the learner to be more involved in the knowledge seeking process and evince a more positive attitude towards science learning than when guided discovery strategy is used.

Table 17 shows the correlation between the students attitude to chemistry and the teaching strategy.

Table 17: Pearsons' Correlation between Attitude to Chemistry and concept-Mapping Teaching Strategy

Attitude	N	Mean	S.D	r	P
Chemistry	123	74.7189	9.1652	.6195	.000**
Strategy	123	74.6585	9.5392		

** Significant at the .01 level

A correlation of attitude to chemistry and teaching strategy revealed that there was a significant correlation. The value of r = 0.62 obtained was significant at both the 0.05 and .01 levels. Thus, concept mapping teaching strategy appears to positively influence students' attitude to chemistry learning. This indicates that positive attitude to chemistry by student was a direct effect of the concept mapping strategy to which they were exposed.

4.9 Contribution of Reading Comprehension, Reasoning and Attitude to Students Performance

H(0)8: There is no significant contribution by any or all of the three variables (reading comprehension, reasoning and attitude) to students performance in chemistry.

H8: There is significant contribution by any or all of the three variables to students performance in chemistry.

The independent and combined influences of three variables (reading, reasoning and attitude) on the understanding of chemistry concepts by students are of interest to this study.

Analysis was done by regressing the three variables against chemistry concept test. The results of the analysis are represented in Tables 18 and 19 for the concept-mapping and guided discovery groups respectively.

Table 18: Regression of attitude, Reading, Reasoning on Chemistry Concept Post test (Guided Discovery)

Multiple R = 0.25

R-squared = 0.06

F = 1.28, P> .05

Variable	B	SEB	T	Sig T
Reading	.015	.056	.27	.79
Reasoning	0.00317	.080	.04	.97
Attitude	.163	.097	1.69	.09
Constant	13.941	10.205	1.37	.17

Table 18 revealed that neither reading, reasoning nor attitude could be used to predict the performance of students when guided discovery strategy was used. The R value indicated that the three variables accounted for only 6% of the variance.

Table 19: *Regression of Attitude, Reading, Reasoning on Chemistry Concept Post test (Concept-mapping Group)*

Multiple R = 0.46

R = 0.21

F = 5.17

P = 0.0001

Variable	B	SEB	T	Sig T
Reading	.091	.045	2.02	.046
Reasoning	.124	.058	2.14	.035
Attitude	.181	.139	1.30	.195
Constant	7.880	10.681	.74	.46

The regression result (Table 19) revealed that only two variable (Reading and Reasoning) out of three variables accounted for significant difference in the performance of students using concept mapping strategy. The R^2 value indicated that these variables accounted for 21% of the variance. This showed that the combined influence was significant for only concept mapping group. On this basis, the null hypothesis is rejected.

CHAPTER 5

DISCUSSION, CONCLUSION, RECOMMENDATION AND SUMMARY

5.1 Introduction

Concept-map is a diagram constructed to indicate concepts and their inter-relations. Concept-mapping activities require the learner/student to plot concepts and link them in a meaningful organizational network. The most important factor in concept mapping is the construction process. That is the process of creating the map itself not the resulting map. This involves identification, differentiation and integrating concepts into a progressively more meaningful framework. Maps generated by the students give insight into organization of ideas and understanding of the concept. Concept-mapping has been used as an instructional strategy (Ault, 1985; Cliburn, 1987; Lehman, Carter and Kahle, 1985; Novak, Gowin and Johansen, 1983; Okebukola, 1990; Pankratius and Keith, 1987; Sherris and Kahle, 1987, Basconas and Novak, 1985). Concept-mapping strategy is based on the constructivist epistemology. Constructivist epistemology acknowledges the subjectivity of observation. What we see is an interpretation of our experience based on what we know. According to the constructivists ideas students have about a concept, often seem to be different from the generally accepted ideas by

scientists. Constructivist epistemology therefore sees learning as a human construction of meaning from prior experiences. Meaningful learning is the foundation of human construction. In concept-mapping students are made to construct meaning from what they learn based on their prior knowledge. There is enough evidence to show that concept mapping might be an effective teaching strategy which can facilitate students meaningful understanding of concepts (Abimbola, 1985; Ault, 1985; Cliburn, 1987; Okebukola, 1986; 1990).

In this study, concept mapping strategy was compared with the strategy recommended by the National Science Curriculum for Senior Secondary School (guided discovery). The effect of these two teaching strategies on students' understanding of chemistry, as well as their effect on these variables (home factors, reading comprehension, reasoning ability, attitude) was investigated. The present study provided evidence that reasoning ability, reading comprehension and development of positive attitude to chemistry might be enhanced by using concept mapping instructional strategy.

5.2 Discussion

The general purpose of this study is to compare the effectiveness of concept-mapping strategy and the guided

discovery teaching strategy in bringing about meaningful understanding and improved performance on chemistry concepts. Eight hypotheses were tested in this study. Three schools were randomly selected for the study. Students from two Senior Secondary 1 classes in each school were used for the study. In each school, one class was randomly assigned to the concept-mapping group and the other to the guided discovery group. The concept-mapping classes were taught using concept mapping strategy while the guided discovery classes were taught using guided discovery strategy. The same concepts (Particulate nature of matter, Chemical combination, Acids, Bases and Salts) were taught in both classes. Both groups were pre- and post tested. The data collected were used to test the eight hypotheses. The result of testing hypothesis 1 of this study provided evidence that concept mapping strategy could bring about meaningful learning and improved performance in difficult chemistry concepts. This means that it might be more efficient when used for less difficult concepts. It is noteworthy that even though the concept mapping strategy was used for the first time and in a limited period, the students from the concept-mapping group still performed significantly better than the guided discovery group. This is an indication that under normal classroom situations, the approach might prove to be more efficient.

The concept-mapping group taught using the concept

mapping strategy was found to achieve significantly better than their guided discovery group counterpart taught using guided discovery. Mean scores were 37.94 for the concept mapping group and 32.71 for the guided discovery group (t= 3.98; P = 0.001). The result showed that concept mapping instructional strategy facilitated students' understanding of chemistry concepts. The superior performance achieved through concept mapping strategy is in agreement with earlier findings of (Ault, 1985; Okebukola, 1990; Novak, Gowin, Johansen, 1985; Cliburn, 1987; Pankratius and Keith, 1987).

According to Okebukola (1990) students taught using concept mapping performed significantly better on test of meaningful learning in genetics and ecology than the lecture method group. In a related study by Okebukola (1987) and Novak (1987) concept mapping was found to be more effective in improving performance and bringing about meaningful learning than the expository method. Similarly, Ajewole (1990) reported that the guided discovery strategy was found to be more effective than the expository method in science instruction.

However, the present study found that students taught using concept-mapping strategy performed significantly better than those taught using guided discovery method. The above evidence, therefore suggest that concept mapping strategy might be more effective in the teaching and

learning of chemistry than either the guided discovery strategy or the expository method.

This finding lends support to earlier report by Okebukola and Novak (1987) that concept mapping strategy appears to be useful tool for science education. Novak (1985) obtained evidence that concept mapping helped students learn how to learn meaningfully. From the interactions, the researcher had with the students in the classes and the responses students gave to questions, it was obvious that concept mapping helped them monitor and diagnose their understanding.

Typical of the students comments were those given after the last topic.

i. "Concept map has helped me. It makes me understand what I am doing. I draw the map the way I understand the topic and if there are mistakes, it will help me to understand why I am wrong".

ii. "My attitude to chemistry is really positive now compared to when I was asked to join the science class. I have started drawing this diagram for physics topics too".

iii. "This method helped me to recognize what I know and what I did not know".

iv. "The map helps me to have everything clear in my head. This makes me to remember".

The superior performance of the concept-mapping group therefore could be due to the demands of concept mapping which requires students to reflect and think critically before coming up with a meaningful concept map. Construction of a map on any concept involves a lot of mental activities such as:

i. identification of concepts and sub-concepts.

ii. ranking the listed concepts.

iii. arranging the concepts according to levels of abstraction.

iv. progressively differentiating the different levels of ideas/concepts using different prepositions to elaborate and link related concepts (see fig. ii).

All these activities are overtly represented during the evolution of any concept map. These mapping activities make meaning to the student and seem to aid understanding of concepts.

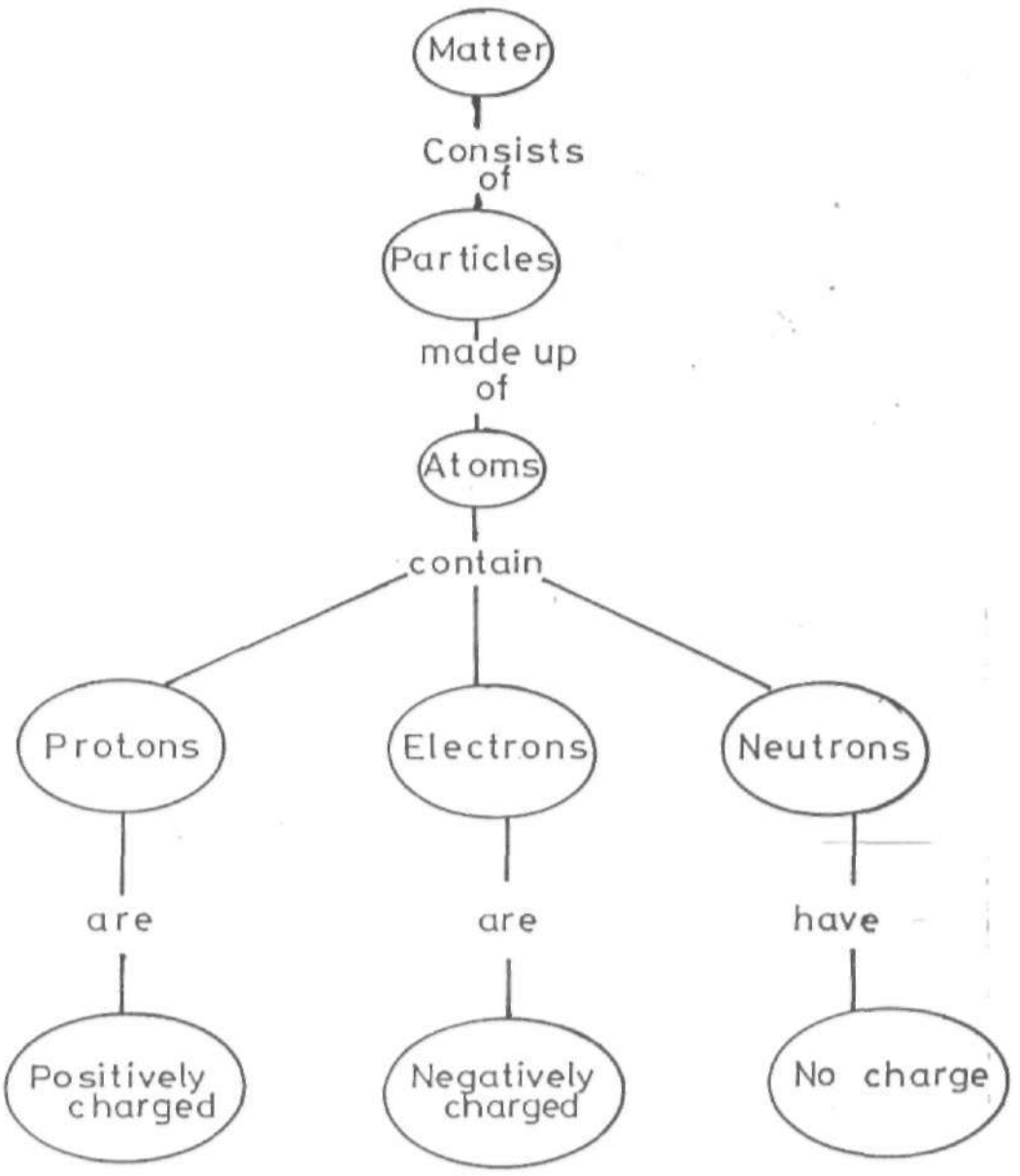


Fig 1. A concept map prepared by a student . The map represents clear relationships between connected concepts.

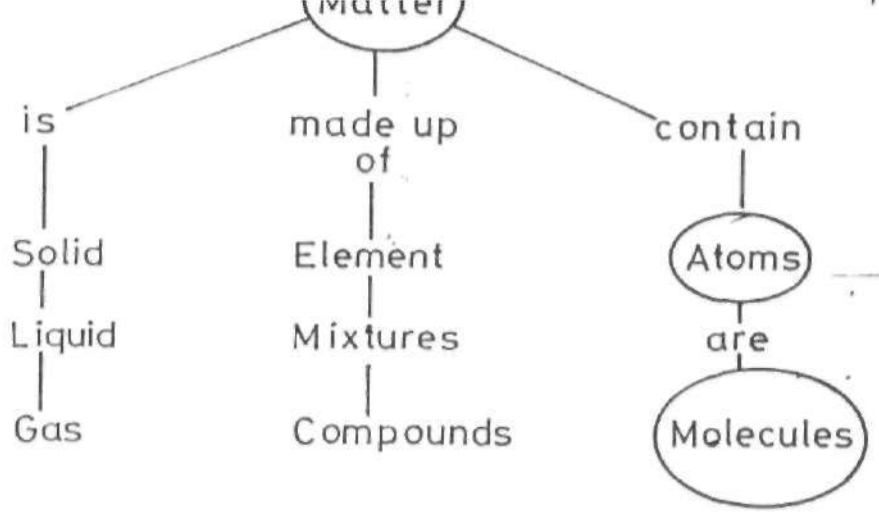


Fig ii. Concept-map constructed by student prior to the lesson on matter.

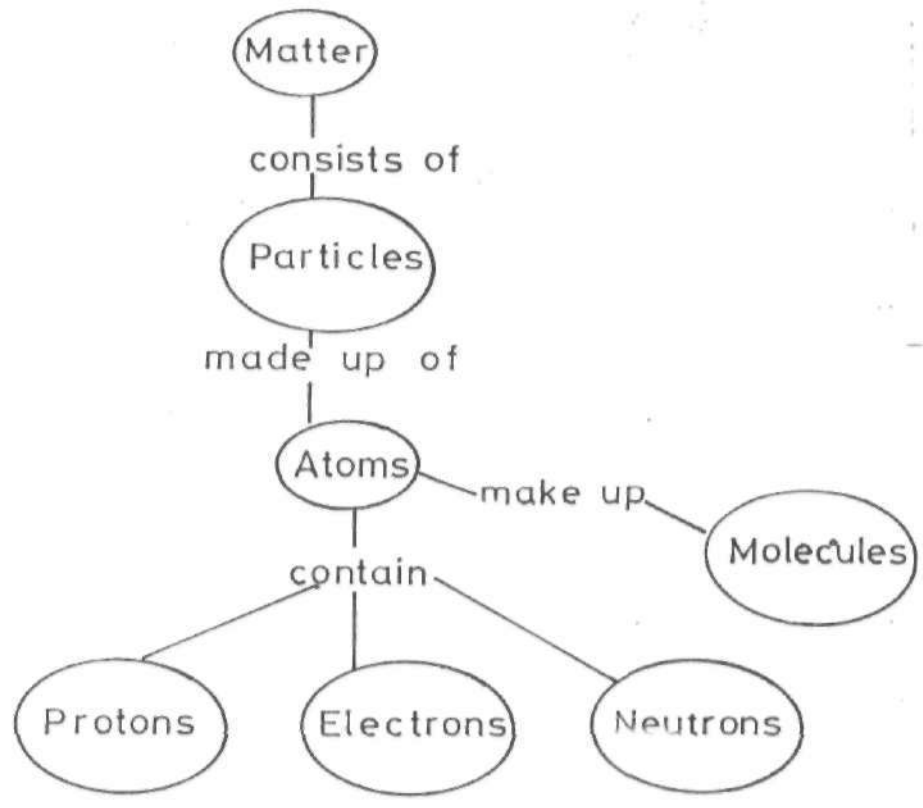


Fig. iii Concept-map constructed by a student after the lesson on matter.

For instance, concepts in the map on Fig. ii related to each other by connecting lines that define specific relationships between the concepts. Matter is connected to atom using the preposition 'made up of atoms'. Similarly, atom is connected to proton using the preposition 'contain' - Atoms contains protons. The acquisition of such relationships is the key element in meaningful learning. Students increase their understanding of concepts as they search for personal meanings of concepts through progressive differentiation and integration of concepts and subconcepts. Without such differentiation of concepts and subconcepts, the students cannot make connections in the map and the concepts will remain isolated and meaningless. The result is that the students will not understanding the concept. The use of concept mapping strategy in this study has also helped in the identification of some misconceptions (See Figs iii and iv). The misconception that matter is solid, liquid, gas is revealed. Also noteworthy is the confusion between atom and molecule concepts. It is observed that the initial map (fig. iii) contained only a few concepts that were pertinent to the major topic.

Other misconceptions identified in the other concepts (Bonding, Acids, Bases and Salts) were:

i. Covalent bond taken to be the same as coordinate bond

ii. Sodium atom combines with chlorine atom to form sodium

chlorine molecule.

iii. Acids are very dangerous and corrosive.

iv. Bases are alkali.

v. Salts refer to sodium chloride.

The findings of this study has shown that concept-mapping strategy seems to be more effective in understanding chemistry concepts and correcting misconceptions than the guided discovery strategy.

The result obtained in testing for the second hypothesis revealed that concept-mapping strategy facilitated students performance in test of concept retention. The concept mapping group outperformed the guided discovery group on test of chemistry concept retention. The mean scores were 44.38 for the concept mapping group and 30.83 for the guided discovery group, ($t=10.18$; $P<0.001$). The significant performance of the concept mapping group could be due to the added advantage of concept mapping excercise.

The result of this study was found to be consistent with Cliburn (1987) who found that students using concept maps during a 3 week uniton skeletal system showed significantly higher performance on a retention test. The finding was however found to be inconsistent with that of Sherris and Kahle (1984) who found no significant difference between groups taught using concept mapping and without concept map on a 6 week retention test scores. The

difference could be due to the latter treatment (without concept mapping) used for their study.

A considerable amount of research has focused on gender differences and school science learning (Welch, 1985;Tobin et al,1989). Conflicting results have been obtained from these researches. Welch (1985) observed that girls were not achieving as well as boys. Tobin (1989) and Erickson and Erickson (1984) reported that there was no observed differences in the performance of boys and girls in science. Findings from this study indicated no significant difference in the performance of boys and girls taught using concept-mapping and guided discovery strategies. The difference in the mean score was also not significant at the 0.05 level. The result of the study indicated however, that the performance of students was influenced by the concept-mapping strategy, rather than gender ($F = 15.88$, $P<.001$).

Examination of the relationships between students' home variables (home background, parental involvement and student study routine) and performance in chemistry revealed that performance was not influenced by any of the home variables. However, further analysis showed that performance could be predicted from parental involvement in child's study, when concept - mapping strategy was used ($t = 2.62$, $P = 0.01$; $F(3,119) = 2.95$; $P = 0.05$). Apart from home factors, other findings from this study have shown that concept mapping seemed to enhance these other study variables - reading

comprehension, reasoning ability and attitude to chemistry (t values of 8.62; 13.85; 5.61; respectively).

Investigations of the independent and combined contributions by these variables on performance of the experimental and control groups revealed that:

i. the combined influence of the three variables was significant only for concept mapping strategy ($F = 5.17$, $P = .001$).

ii. performance could be predicted by only two variables, reading and reasoning ability ($t = 2.02$, $P < .05$; $t = 2.14$, $P < .05$ respectively) when concept mapping strategy was used.

The study has provided evidence that concept mapping strategy, appears to have tremendous capability for enhancing reading comprehension, reasoning ability and development of positive attitude to chemistry. Also concept mapping instructional strategy has been shown in the study to facilitate understanding and retention of science concepts. However, there was no significant difference in the performance of boys and girls taught using concept mapping and guided discovery strategies. These results show a direction through which we could positively help students to attain better understanding of science concepts.

5.2.1 Limitations

The following are limitations to this study:

i. This field of study in science education appears to be relatively new in Nigeria. Therefore most of the references and literature cited in connection with concept-mapping are foreign.

ii. Considering the fact that the students are not familiar with the strategy of teaching with concept-mapping,their interpretations and mapping of chemistry concepts for the study may or may not be the same with that of the researcher.

iii. The content area was specific. The study considered only three chemistry topics.

iv. Studies on instructional strategies based on the understanding of concepts could be conducted over long or short time interval. This study was for a short interval to reduce cost and meet other requirements.

v. Despite all research precautions to remove bias in the various steps of the procedure in this study, some form of interaction among the experimental and control group students are envisaged.

5.3 Conclusion and Recommendations

From the findings of this study, the following

conclusions were drawn:

i. The use of concept-mapping instructional strategy enhanced the quality of instruction and understanding of the study concepts thus leading to improved performance.

ii. Concept mapping strategy improved knowledge retention.

iii. The difference in the performance of boys and girls taught using concept mapping and guided discovery strategies was not significant.

iv. There was no significant relationship between any of the home variables and performance in chemistry. However one variable (parental involvement) contributed to the prediction of performance in chemistry when concept mapping was used.

v. Concept mapping strategy improved reading comprehension of students.

vi. Concept mapping teaching strategy significantly improved reasoning ability of students.

vii. Concept mapping strategy positively improved students attitude to chemistry.

viii Only two variables (reading comprehension and reasoning ability) contributed to performance in chemistry when concept mapping was used.

These findings indicated that better understanding of chemistry would result using concept mapping strategy within the constructivist model. The primary prediction of this

study is that meaningful learning and understanding of concepts will be promoted when students are taught using concept-mapping strategy.

Despite the limitations of this study the overall results appear to have important implications for curriculum developers, science teachers, educators and the teaching and learning of science. It is against this background that the following recommendations are proferred:

i. School curriculum planners should consider the introduction of concept mapping strategy in our schools. It is easy to teach and implement. It requires no additional time or costly materials. The only task required is the effort by both teachers and students to initially learn the mapping strategy.

ii. Workshops, pre- and in-service training should be organized by institutions and professional bodies like STAN to familiarize Science teachers and educators with the concept mapping strategy.

iii. A schedule for learning about the use of concept mapping strategy for instructional purposes should be built into the training programme for pre-service science teachers.

iv. Conscious attempts should be made to relate students prior knowledge to classroom learning experiences using concept maps.

v. Inclusion of concept maps in textbooks should be given

a trial for the benefit of learners.

vi. As much as possible students should be encouraged to draw and re-draw concept maps till a meaningful map is drawn. This would enhance better understanding of concept.

vii. Variations in construction of concept maps should be encouraged.

Recommendation for Further Research

Though concept mapping strategy has been shown to improve performance and knowledge retention, it appears that more research would prove helpful in confirming and supporting the effectiveness of the strategy. On this basis, it is recommended that:

i. the effect of concept mapping strategy on various ability levels be carried out.

ii. the strategy be tried out in other disciplines.

iii. the study carried out over a longer period is another promising diretion for future research.

5.4 Summary

The purpose of this study was to determine the effectiveness of concept mapping and guided discovery teaching strategies. Eight hypotheses were tested for the study. The research was experimental in nature. 3 schools

were randomly selected for the study. In each school students from two Senior Secondary 1 classes were randomly selected for the research. One class formed the concept-mapping group while the other class formed the guided discovery group. The concept-mapping classes were taught using concept mapping strategy while the guided dicovery classes were taught same concepts using guided discovery strategy. The concepts selected for the study were:

i. Particulate nature of matter
ii. Chemical Combination and
iii. Acid, Bases and Salts

The contact session for both groups lasted ten weeks. The pretest - post test design was employed for the purpose of data collection. In the first instance, the pretest was administered to the students. The test was a 50-item test. After this, there was an intensive teaching session of six weeks during which the students were exposed to instructional treatments. The concept mapping group was taught using concept mapping strategy while the guided discovery group was taught same concepts using guided discovery strategy. This was followed by a 50-item post test to evaluate the effectiveness of instruction after the treatment. A delayed post test (post-post test) was administered four weeks after the first post test to test the retention of concepts by the students. In addition to the post-post test, two other tests and two questionnaires

were used for the research. An attitude questionnaire was used to assess the attitude of students to chemistry as a subject and to the teaching strategy. A home factor questionnaire was used to determine home factor(s) that affected performance. The other two tests were reading comprehension and reasoning tests. They were used to determine if a particular teaching strategy could improve reading comprehension and reasoning ability respectively. They were all administered before and after instruction.The students' scores before and after exposure to the appropriate teaching strategy were recorded. Data gathered for this research were analysed at the 0.05 level.

The major findings of the study were:

i. Concept mapping strategy was significantly more effective in improving performance in chemistry than guided discovery strategy.

ii. Concept mapping strategy improved students retention of chemistry concepts than guided discovery strategy.

iii. There is no significant difference in the performance of boys and girls using concept mapping strategy and guided discovery strategies.

iv. There is no significant relationship between any of the home factors (home background, parental involvement and study routine) and performance in chemistry.

v. Concept mapping instructional strategy improved students reading comprehension.

vi. Concept mapping strategy improved students reasoning ability.

vii. Concept mapping strategy improved students attitude to chemistry.

viii Two study variables (reasoning and reading comprehension) out of three contributed to students performance in chemistry when concept mapping strategy was used.

Findings from the study have shown that understanding and retention of chemistry concepts could be promoted when students are exposed to the concept-mapping strategy. Similarly, reasoning ability, reading comprehension and attitude to chemistry appear to be improved through the use of concept mapping strategy. However, there was no differential performance by boys and girls using the two teaching strategies. The most important contribution of this research lies in its description and illustration of how concept mapping strategy could lead to students' understanding and retention of chemistry concepts.

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APPENDIX A

CONCEPT MAPPING TEACHING MODEL

PARTICULATE NATURE OF MATTER

Step I: Introduction

A cube of sugar is placed in a beaker of water for students to see that water has allowed a piece of matter (cube of sugar) to dissolve in it.

Step II: Elicitation of Ideas

Ideas about matter is elicited through questioning on the nature of matter. Students draw a concept map on matter based on ideas they have about the nature of matter.

Step III: Exchange of Ideas

Teacher provides learning experiences which interact with students prior knowledge, leading to exchange of ideas. The teacher discusses the fundamental particles of atom and the law of conservation of matter. Students identify major ideas on matter and list them.

Step IV: Application

Students redraw concept map based on the 'new' knowledge gained.

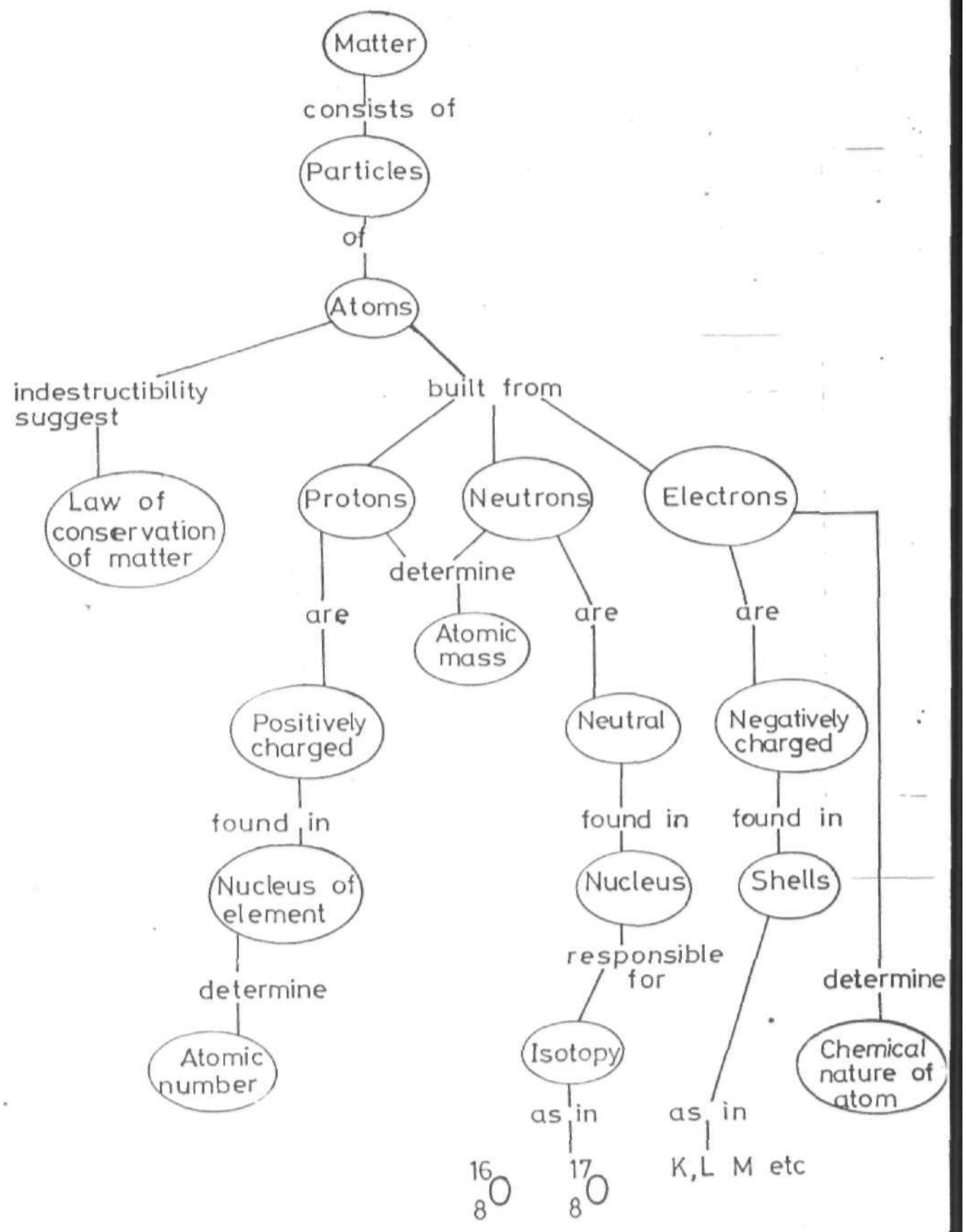
Step V: Review

The class compares initial ideas held (represented in the map drawn at the elicitation stage) with current ideas they have on the concept.

Chemistry text reading: Bajah S. and Godman, A. (1984) pages 23 - 27; Ababio, O.Y. (1980) pages 1-4, 45-48;

PARTICULATE NATURE OF MATTER: MAJOR CONCEPT MAP

DESCRIBING THE PARTICULATE NATURE OF MATTER.



The map depicts the make up of matter.

CHEMICAL COMBINATION

TEACHING MODEL

Step I: Introduction

Teacher lets students compare the properties of two compounds (NaCl and Napthalene/iodine), with respect to appearance, smell, effect of heat and solubility.

Step II: Elicitation of Ideas

Students are asked to explain the differences observed in the properties of the two compounds. They draw concept map of chemical bonding.

Step III: Exchange of Ideas

Teacher provides learning experiences which interact with students prior knowledge. Students test the solubility and conductivity of some given samples. (NaCl, $CaCl_2$, iodine, candle wax and sugar). They conclude on various types of bond present in a given sample. Students are grouped for discussion on bonding and model making of compounds. Teacher discusses the various types of bonding. Students identify and lists concepts and subconcepts.

Step IV: Application

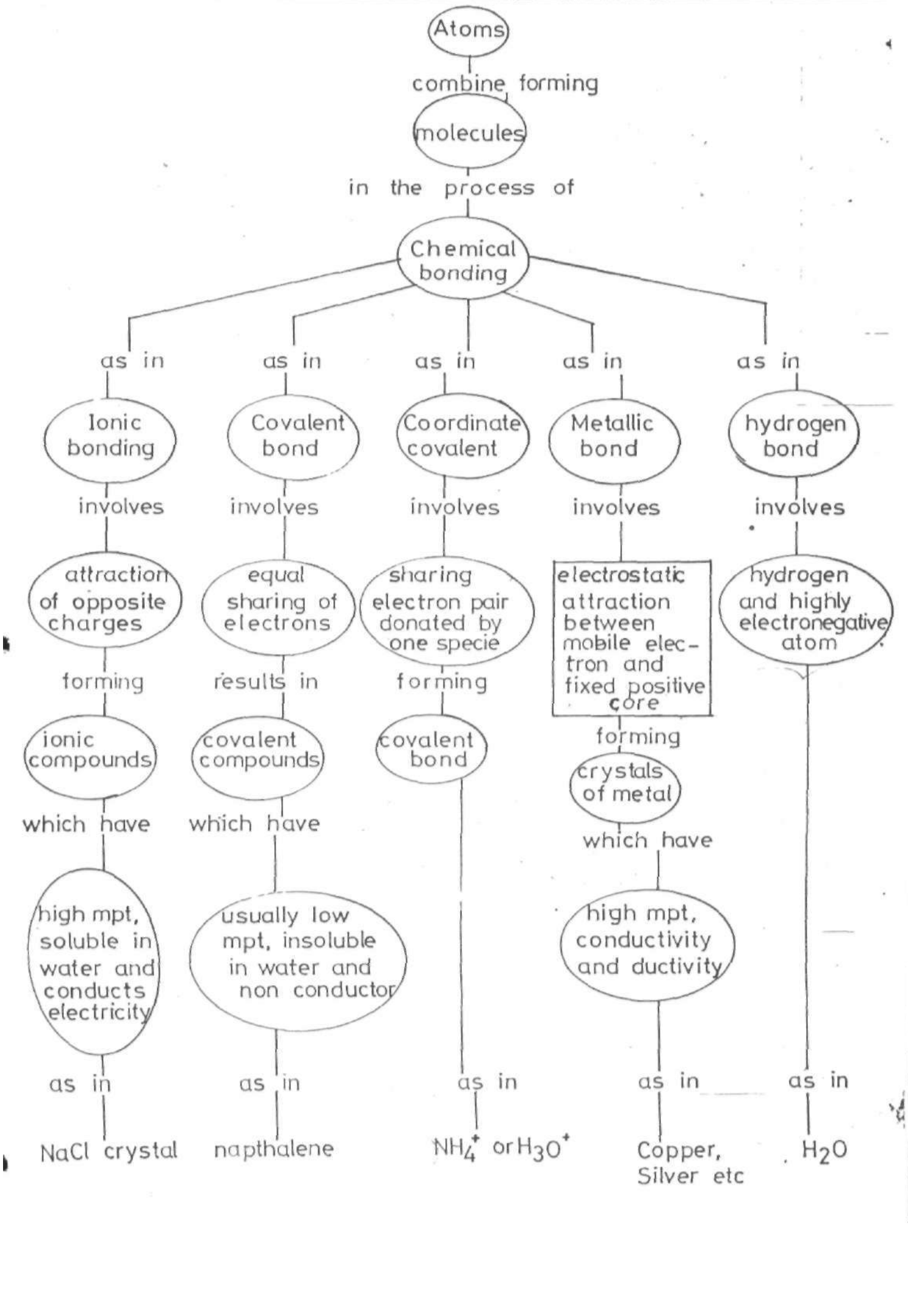
Students redraw concept map based on 'new' knowledge gained. They practise arranging the elements in shells.

Step V: Review

The class compares initial idea held with current ideas.

Readings: Ababio, O.Y. (1992) pg 41 - 53.

MODEL CONCEPT MAP FOR CHEMICAL COMBINATION CONCEPT.



ACID

Step I: Introduction

Students compare the taste of ripe, unripe fruits and discuss their findings.

Step II: Elicitation of Ideas

Ask students questions relating to Acid. From their responses; they draw initial concept map on acid.

Step III: Exchange of Ideas

The teacher provides learning experiences which interact with students prior knowledge on 'acid'. Students identify properties of acid through interaction with materials. Teacher discusses the properties of acid. Students identify and list major ideas on acid. Students discuss in groups.

Step IV: Application

A new concept map of acid is drawn.

Step V: Review

The class compares the two concept maps drawn.

Readings: Ababio, O.Y. (1992) pg 77 - 94; Bajah, S.T. and Godman, A. (1984) pages 94 - 98.

BASES AND SALTS

Step I: Introduction

Students feel a piece of soap and a pellet of NaOH between fingers.

Step II: Elicitation of Ideas

Students are asked questions relating to bases and salts. Based on their idea of the concept of bases and salts they draw concept map.

Step III: Exchange of Ideas

Teacher provides learning experiences which interact with students prior knowledge. Students identify properties of bases and salts. Teacher discusses properties of bases, salts and methods of salt preparation. Students identify key ideas and lists them.

Step IV: Application

Concept map of bases and salts are drawn.

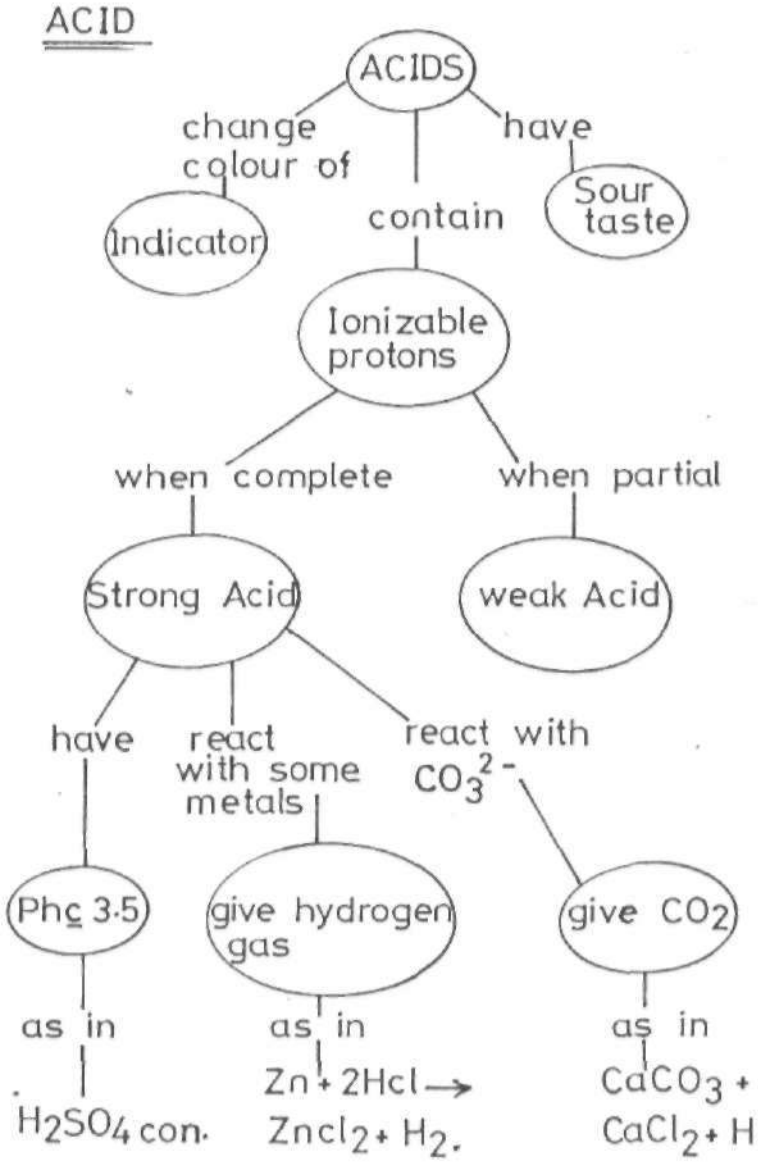
Step V: Review

The class compares the initial and final concept maps.

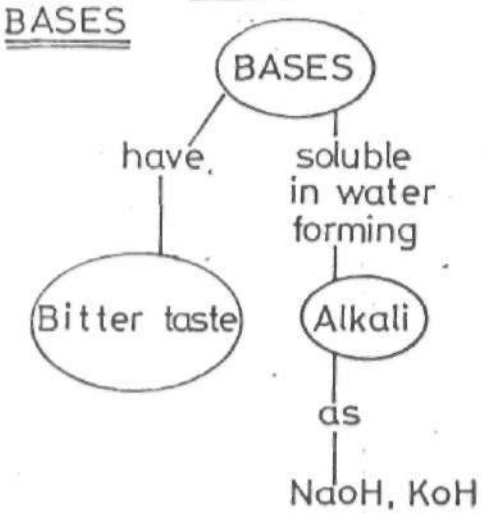
Text Reading: Ababio, O.Y. (1992); Bajah, S.T. and Godman, A. (1984) pg 99 - 102.

MODEL CONCEPT MAP OF ACID BASES

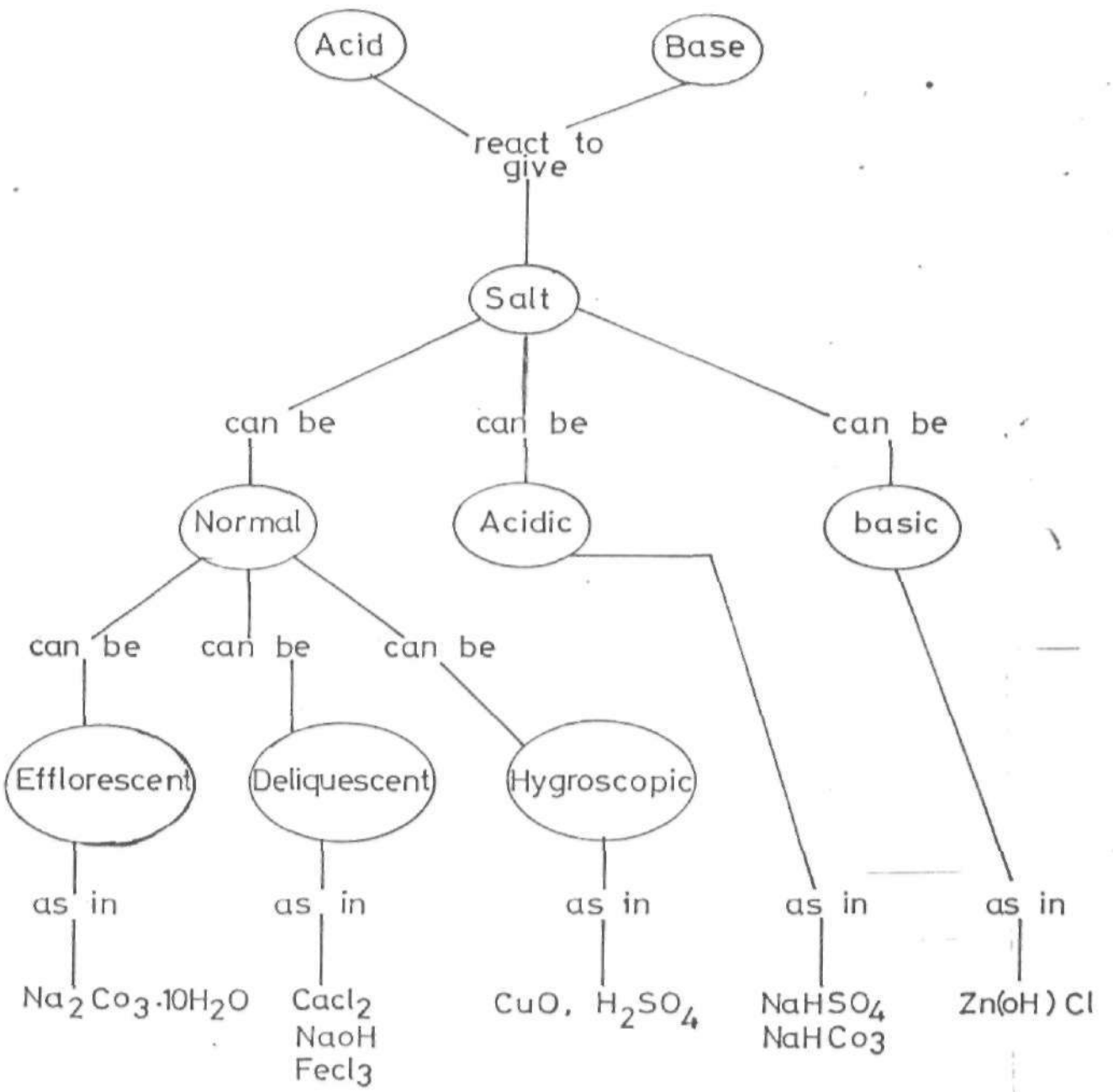
ACID



BASES



SALTS


Acid
Base
react to give
Salt
can be
can be
can be
Normal
Acidic
basic
can be
can be
can be
Effloresent
Deliquescent
Hygroscopic
as in
as in
as in
as in
as in
$Na_2Co_3.10H_2O$
$Cacl_2$
NaoH
$Fecl_3$
CuO, H_2SO_4
$NaHSO_4$
$NaHCo_3$
Zn(oH)Cl

APPENDIX B

GUIDED DISCOVERY TEACHING MODEL

PARTICULATE NATURE OF MATTER

Step I: Introduction

Introduction to the general properties of matter. (Matter is anything that has mass and occupies volume. The simplest kind of matter is known as atom. Atom is made up of minute particles which are difficult to ascertain even with the most powerful microscope. Existence of the make up of matter is supported by certain common observation).

In the activities that follow, you will determine the nature of matter.

Materials: $KMnO_4$, BaCl(aq), Na_2SO_4, Sulphur, conc NH_3, sugar cube, camphor, acetone, conical flask, measuring cylinder, watch glass, beaker, filter paper, funnel.

Step II: Activities/Discussion

Learning about the nature of matter through certain common observations:

* $KMnO_4$ in water
* Volume change of acetone or ether
* Powdered sulphur in water
* Change in weight of camphor

What do you observe? Does your observation give you an idea about the nature of the substances? Explain your observations.

Step III Conclusion (Post lab)

Discussion of results on the nature of matter (colour spread, volume change of acetone and weight change of camphor show that all the solids and liquid are composed of very small particles). Further discussions on law of conservation of matter and make up of atom. Chemistry text reading: Bajah S. and Godman A. (1984) pages 27 - 37. Ababio O. Y. (1980) pages 1-4, 45-48; Ababio, O.Y. (1992) pages 6 - 40.

CHEMICAL COMBINATION

Step I: Introduction

Introduction to arrangement of electrons in shells, description of how atoms combine to form molecules and compounds. (Atoms combine to form molecules or compounds. Properties of compounds formed relate to type of bond present in them. Bonding is an attempt by compounds to attain noble gas (octet) configuration. Different types of chemical combination of atoms lead to different properties. With ionic bonds, electrons are transferred from one atom to another giving ions. The oppositely charged ions attract each other to form ionic compounds. In solution such compounds dissociate to give ions. When atoms combine by equal sharing of electrons a covalent compound is formed. Covalent compounds do not have ions but contain molecules.In the activities you will undertake, you will determine properties of different compounds and suggest the type of bond present.

Step II Activities/Discussion

* Activities to determine solubility, melting point, conductivity of substance.
* From result, discover and explain patterns observed in the properties of compounds.
* Predict the type of bond present in the listed compounds.

Substance	Solubility Water	Warm water	Kero-sene	Conduct-ivity	Mpt	Effect of heat	Type of Bond
1. NaCl							
2. $CaCl_2$							
3. Iodine							
4. Palm oil							
5. Candle wax							
6. Sugar							

* From activities, list the differences between ionic and covalent compounds.
* Draw a sketch of bonding in NaCl and CH_4
* Make models (using broom stick and cornstalk) of electron configuration of sodium.

Step III: Conclusion

Discussion on the properties of ionic and covalent compounds. mention of other types of bond.

Chemistry text reading: Ababio, O.Y. (1992) pg 41-55

ACID

Step I: Introduction

Introduction to the concept of "Acid". (Acids have peculiar taste). They change colour of many dyes. In solution they produce H_3O_+ . Acids can be classified according to strength or basis of source. Acids react with metals, trioxocarbonate (IV) compounds and bases. Basicity of acids based on number of replaceable proton in one molecule of acid).

Step II: Activities/Discussion

Students guided to discover properties of acids through certain activities:

* Tasting ripe/unripe orange, very dilute HCl
* Using indicators on HCl, H_2SO_4, HNO_3, Vinegar, lemon juice
* Action of Acid on metals, noting reactions, colour of gas evolved.
* Action of Acid on trioxocarbonate (IV) compounds.

From your results, list the properties of acids you have discovered.

Step III: Conclusion

Discussion on the results obtained from the properties of acid.

Emphasis on test for CO_2 using lime water.

Reading: Bajah, S. and Godman, A. (1984) pages 94 - 98;

Ababio, O.Y. (1992) pg 77 - 94.

BASES AND SALTS

Step I: Introduction

Introduction to the concept of Bases. Reaction of bases with acids.

Step II: Activities/Discussion

* Testing the properties of bases
* Identifying properties of salts
* Preparation of soluble/insoluble salts.

Step III: Conclusion

Review of the properties of bases; and different forms of salt.

Neutralization reaction and methods of salt preparation and drying.

Reading: Ababio, O.Y. (1992), pg 77 - 94;

Bajah, S. and Godman, A. (1984) pp 99 - 102.

APPENDIX C

CHEMISTRY CONCEPT ACHIEVEMENT TEST (CCAT)

Instructions: Attempt all questions. Each question is followed by five options. Circle the correct answer.

Time Allowed: 60 minutes.

1. The mass number of an element is 59 and its atomic number is:

   27. The number of neutrons presentin the nucleus is:

   A. 27 B. 32 C. 59 D. 86 E. None of the above

2. The atomic mass of an atom is mostly due to the mass of

   A. Electrons and Protons

   B. Electrons and Neutrons

   C. Protons and Neutrons

   D. Positrons and Neutrons

   E. Positrons and Electrons

3. The simplest unit of water that retains its properties is called:

   A. an atom B. an element C. an hydroxide

   D. a molecule F. none of the above

4. A molar solution of NaOH is prepared by dissolving:

   A. 40g NaOH in $100cm^3$ of water

   B. 40g NaOH in $1000cm^3$ of water

   C. 20g NaOH in $500cm^3$ of solution

   D. 20g NaOH in $1000cm^3$ of solution

   E. 20g NaOH in $80cm^3$ of solution

3	19	24	20	17
R	U	S	T	Y
1	9	12	10	9

5. Which of the following statements is not true of the elements R,U,S,T,Y?

   A. R,U,S, and T are metals

   B. U and Y are isotopes

   C. R is an isotope of hydrogen

   D. T is a noble gas

   E. S will react with oxygen to form SO



6. The above diagram represents an atom of:

   A. Chlorine B. Helium C. Magnesium

   D. Neon E. Potassium

7. An element having atoms which have the same number of protons but different number of neutrons show:

   A. Allotropy B. Isotopy C. Isomerism

   D. Variable valency E. Covalency

8. The number of electrons in the outer shell of the neutral atom is:

   A. 1

   B. 4

   C. 6

   D. 8

   E. none of these

9. Which of the following atoms contains the least number of neutrons?

(A) $^{13}_{7}N$ (B) $^{14}_{6}C$ (C) $^{14}_{7}N$ (D) $^{16}_{8}O$ (E) $^{18}_{8}O$.

10. Which of the following pairs of particles have the same number of electrons as argon? (Ar = 18)

A. L1+ and F-

B. K+ and Cl-

C. Na+ and F-

D. K+ and F-

E. Na+ and Cl-

11. For any atom other than a hydrogen atom,the maximum number of electrons in the inner most shell is:

(A) 1 (B) 2 (C) 8 (D) 10 (E) 18

12. If an element X has two isotopes of mass numbers 18 and 20 respectively, and these are present in the proportions of 1:2, the relative atomic mass of X is:

(A) 19.33 (B) 18.67 (C) 19.00 (D) 18.33

(E) 19.67

13. Which of the following contains the greatest number of atom?

(A) 12g of carbon (B) 6.4g of sulphur

(C) 8g of helium (D) 2.4g of magnesium

(E) 2.3g of sodium

(S = 32, Mg = 24, C = 12, He = 4 Na = 23)

14. The atomic number of an element is the number of

A. protons in the nucleus of its atom

B. neutrons in the nucleus of its atom

C. electrons in the nucleus of its atom

D. electrons and neutrons in the nucleus of its atom

E. protons and neutrons in the nucleus of its atom

15. A neutral atom is coverted into an ion with a positive charge by

A. losing a proton

B. losing an electron

C. losing a neutron

D. sharing electrons

E. sharing protons

16. The atomic number of chlorine is 17. A chloride ion therefore differs from a chlorine atom in that the ion has

A. 16 protons B. 16 electrons

C. 17 neutrons D. 17 protons

E. 18 electrons

17. Potassium and sodium show similar chemical properties because they:

A. belong to the same group in the periodic table

B. have equal number of neutrons

C. both exist in the +1 oxidation state in compounds

D. end with ium

E. go together

18. When the equation

$Al(OH)_3 + HNO_3 \text{ --------> } Al(NO_3)_3 + H_2O$

is balanced, the coefficient of HNO_3 is:

(A) 1 (B) 3 (C) 4 (D) 5 (E) 6

19. The percentage composition of a gas is

C = 80% and H = 20%. Its empirical formula is:

(A) CH (B) CH_2 (C) CH_3 (D) C_2H_2 (E) C_2H_3

(C = 12, H = 1)

20. The percentage of sulphur in $Al_2(SO_4)_3$ is:

(A) 9.36 (B) 14.71 (C) 21.33 (D) 28.01 (E) 28.09

(Al = 27; S = 32; O = 16)

21. Which of these are found in the nucleus of the atom?

A. Electrons and Protons

B. Electrons and Neutrons

C. Protons and Neutrons

D. Photons and Electrons

E. Photons and Neutrons

22. If the atomic number of an element is 10, then the outermost shell will have

(A) 8 electrons (B) 4 electrons (C) 6 electrons

(D) 2 electrons (E) 10 electrons

23. The type of bond between two atoms of an element with atomic number 9 is:

(A) Ionic bond (B) Covalent bond

(C) Co-ordinate covalent bond

(D) Hydrogen bond (E) Metallic bond

24. Which of these properties do you expect to find in ionic compound?

i. High melting point

ii. very soluble in water

iii. low melting point

iv. solution is a good conductor of electricity

(A) I, II, III (B) II, III, IV

(C) I, III, IV (D) I, II, III, IV

(E) I, II, IV

25. Which of the following is a compound?

(A) Oxygen (B) Graphite (C) Sulphur

(D) Chalk (E) Mercury

26. The most probable arrangement of the electrons in the atoms of the element with atomic number 11 is:

(A) 8,2,1 (B) 2,8,1 (C) 2,6,3 (D) 5,6 (E) 2,3,6

27. The element with atomic number 6 is likely to be:

A. covalent with a valency of 4

B. electrovalent with a valency of 2

C. covalent with a valency of 2

D. electrovalent with a valency of 1

E. inert with zero valency

28. Electrovalent compounds are usually

A. solids with low melting points

B. solids with high melting points

C. gases

D. volatile liquids

E. organic compounds

29. Arrange the following chemical bonds in decreasing order of strength (that is, beginning with the strongest bond)

i. Covalent bond

ii. Ionic bond

iii. Hydrogen bond

(A) I, II, III (B) II, III, I (C) II, I, III

(D) I, III, II (E) III, II, I

30. Five elements P, Q, R. S, and T have atomic numbers 4,6,8,19 and 20 respectively. Which of these elements will have a combining power of 2?

(A) P, Q, and T (B) Q, R, and S

(C) P, Q, and R (D) P, R, and S

(E) P, R, and T

31. During chemical reactions the atoms of elements may form ions. A positive ion may be formed as a result of

(A) electron loss (B) electron gain

(C) protonloss (D) electron and proton loss

(E) proton gain

32.

Element	Electron configuration
X	2,1
Y	2,8,7

Which of the following statements is correct with respect to X and Y?

A. X and Y are reducing agents

B. The bond between X and Y will be electrovalent

C. X and Y are in the same period

D. The bond between X and Y will be a coordinate bond

E. The bond between X and Y will be covalent

33. If an element G has electron configuration 2,8,8,2. Its atomic number and group number in the period table will be:

(A) 20 and III (B) 12 and II (C) 20 and II

(D) 16 and IV (E) 20 and I

34. The acid which constitutes a small percentage of gastric juice is:

A. CH_3COOH B. HNO_3 C. H_2SO_4

D. HCl E. None of the above

35. When a farmer sweetens the soil with lime, what does the lime actually do?

A. It makes the soil sweeter

B. It neutralises the soil acid

C. It makes the soil more fertile

D. It kills off the bacteria in the soil

E. It makes the farm product to be sweet

36. The pH of four solutions, W,X,Y,Z are 4,6,8,10 respectively. Therefore

A. none of these solutions is acidic

B. the pH of Y can be made acidic, by adding distilled

water

C. Z is the most acidic

D. W is acidic

E. X is neutral

37. When sulphur dioxide (SO_2) is bubbled into water

A. sulphur trioxide is formed

B. hydrogen sulphate (VI) acid is formed

C. free sulphur is liberated

D. trioxosulphate (IV) acid is formed

E. all of the above

38. An example of an efflorescent compound is:

A. KOH B. $BaCl_2$ C. $CaCl_2$ D. $Na_2CO_3.10H_2O$

E. NaOH

39. A piece of sea shell when dropped into a dilute solution of HCl produces a colourless, odourless gas which turns clear lime-water milky. The sea shell contains

A. Sodium Chloride B. Ammonium Trioxonitrate (V)

C. Calcium Trioxocarbonate (IV)

D. Calcium Chloride E. Magnesium Chloride

40. Exposure of a few pellets of sodium hydroxide (NaOH) to the atmosphere for a few days results in the formation of

a solution. This shows that sodium hydroxide is

A. Efflorescent B. Deliquescent

C. Hydroscopic D. hydrated

E. Concentrated

41. Solid sodium hydroxide on exposure to air absorbs a gas and ultimately gives another alkaline substance with the molecular formula.

A. $NaOH.H_2O$ B. $NaOH.N_2$ C. NaCl

D. $NaHCO_3$ E. $NaNO_3$

42. When a person's stomach secret more acid than normal, the person get ucler. This excess acid tends to corrode the walls of the stomach and form sores. To help such person, the doctors normally prescribe drugs like aluminium hydroxide.

The function ofsuch drug is to:

A. neutralise the acid

B. lubricate the walls of the stomach

C. prevent sores forming in the stomach

D. decompose the acid

E. none of the above

43. An acidic salt is one:

A. formed from an acid

B. formed by the action of a base on an acid

C. formed by the partial replacement of the hydrogen in the acid by a metal ion

D. formed when a blue litmus solution turns red

E. which turns red litmus solution blue

44. Dilute CH_3COOH is a poor conductor of electricity because CH_3COOH

A. is soluble in water

B. is associated in water

C. is completely ionised in water

D. is dissociated in water

E. is only slightly ionised in water

45. When an acid reacts with an alkali to form a salt and water only, the reaction is termed:

(A) Hydration (B) Neutralization

(C) Direct Combination (D) Hydrolysis

(E) Esterification

46. Why are indicators used in acid-base titrations?

A. So as to determine the exact volume of acid needed to neutralise a given volume of base and vice versa.

B. So as to determine the pH of both the acid and the base

C. Because an acid requires an indicator before it can react with a base.

D. Because indicators are acids which first have to be neutralized by the base.

E. All of the above.

47. Zinc oxide reacts with both acids and alkalis to form salts.

Zinc oxide is therefore:

A. an acidic oxide

B. a basic oxide

C. a neutral oxide

D. a peroxide

E. an amphoteric oxide

48. All of the following are properties of acids except:

A. ability to neutralize a base

B. ability to produce hydroxonium ions in aqueous solution

C. sour taste

D. soapy feel

E. ability to liberate carbon (IV) oxide from trioxocarbonate (IV) salts

49. Which of the following solutions is the most acidic? A solution with a pH of:

(A) 6 (B) 4 (C) 3 (D) 9 (E) 11

50. The reaction represented by the equation,

$NaOH(aq) + HCl(aq) \longrightarrow NaCl(aq) + H_2O\ (l)$

A. is by direct combination

B. is a neutralization reaction

C. is reversible

D. is usually catalysed

E. attains equlibrium after a few seconds

KEY TO APPENDIX C

1. b
2. c
3. d
4. b
5. a
6. c
7. b
8. d
9. a
10. b
11. b
12. a
13. c
14. a
15. b
16. e
17. c
18. b
19. c
20. d
21. c
22. a
23. b
24. e
25. d
26. b
27. a
28. b
29. c
30. e
31. a
32. b
33. c
34. d
35. b
36. d
37. d
38. d
39. c
40. b
41. d
42. a
43. c
44. e
45. b
46. a
47. e
48. d
49. c
50. b

APPENDIX D

QUESTIONNAIRE ON HOME FACTORS

Section 1: Home background information

1. Name: _____

2. Gender: Female ( )

Male ( )

3. Age: 10 - 11 ( )

12 - 13 ( )

14 - 15 ( )

16 - 17 ( )

Over 18 years ( )

4. Type of School:

Boys only ( )

Girls only ( )

Co-educational ( )

5. Fathers' occupation: _____

Note: i) father or mother here refers to people you live with.

ii) Do not write worker or civil servant, state whether he is a cleaner, typist, accountant, secretary, lecturer, primary or secondary school teacher

iii) Do not write business man, state whether he is a petty trade, textile dealer, food contractor etc. Please try to be specific.

6. Fathers educational qualification:

Did not go to a primary school	( )
Had some primary education	( )
Finished primary education	( )
Had some secondary education	( )
Finished seondary education	( )
Spent some years in Grade II Teachers College	( )
Holds Grade II Teachers Certificate	( )
Holds N.C.E., OND, HND etc	( )
Holds professional certificate e.g. A.C.C.A	( )
Went to a University for some time	( )
University Graduate	( )

7. What is your mothers occupation?_____

e.g. full-time housewife, teacher, petty trader etc.

8. Educational qualification of mother

Did not go to a primary school	( )
Had some primary education	( )
Finished primary education	( )
Had Some Secondary Education	( )
Finished secondary education	( )
Spent some years in Grade II Teachers College	( )
Holds Grade II Teachers Certificate	( )
Holds N.C.E., OND, HND etc.	( )
Holds professional certificate e.g. A.C.C.A	( )
Went to a University for some time	( )
University Graduate	( )

9. I attended a nursery school Yes ( ) No ( )

SECTION II: Parental Involvement

		Yes	No
10.	My parents/guardian provide me with most of the recommended chemistry textbooks	( )	( )
11.	My parents/guardians often advise me to listen to science programmes in the radio and/or television	( )	( )
12.	My parents/guardian often engage me in other activities like farming, trading, cooking etc, rather than allowing me to study after school hours.	( )	( )
13.	My parents/guardian inspect my chemistry note books.	( )	( )
14.	My parents/guardian bring home some magazines or novel for me to read.	( )	( )
15.	My parents/guardian organize extra lessons for me in chemistry during the holidays.	( )	( )
16.	My parents/guardian do not allow me to watch the television or listen to the radio until I have finished my work.	( )	( )
17.	My parents/guardian would like me to do such courses like medicine, pharmacy, biochemistry or engineering which involve chemistry.	( )	( )
18.	My parents/guardian do not let anyone to disturb me when I am studying.	( )	( )
19.	My parents/guardians are never at home to check whether I study or not.	( )	( )
20.	At times I discuss scientific events with my parents, brothers and sisters.	( )	( )
21.	My parents/guardians do not care whether I do chemistry at school or not so long as I get promoted every year.	( )	( )

Section III: Students' Study routine

22.	I hate spending my free time doing chemistry work.	( )	( )
23.	I cannot study at home because I have to do all the house work when I come home.	( )	( )
24.	I make sure that I do chemistry work at home before going out to play with my friends.	( )	( )
25.	I study with my elder sister/brother or friend at home.	( )	( )
26.	I study chemistry for at least one hour everyday after school.	( )	( )
27.	I do not like to be disturbed when I am studying chemistry at home.	( )	( )
28.	When I am free at home I like listening to music or sleeping.	( )	( )
29.	I play some science games in my spare time.	( )	( )
30.	I lie down when studying chemistry.	( )	( )

APPENDIX E

CHEMISTRY ATTITUDE QUESTIONNAIRE (CAT)

Instruction: Tick only one of the given responses for each question depending on whether you strongly Agree (SA), Agree (A), Disagree (D) or Strongly Disagree (SD)

SECTION I: Attitude Towards Chemistry

	STATEMENTS	RESPONSES			
		SA	A	D	SD
1.	Of all the science subjects, I enjoy chemistry most.				
2.	Chemistry is too abstract, I will drop it at the earliest opportunity.				
3.	I do not care whether I do well or poorly in chemistry test.				
4.	Everyone should have some knowledge of chemistry.				
5.	I would prefer to do experiments than to read about them only.				
6.	Chemistry text books are difficult to read and understand. I do not need to read such books before I survive in life.				
7.	Most of the problems in our society could be solved through chemistry principles.				
8.	I get bored in the chemistry practical classes because the practicals are difficult and one keeps mixing dangerous substances.				
9.	I am studying chemistry because the WAEC regulation states that all science students must offer chemistry.				
10.	Chemists are very useful in the society				

	SA	A	D	SD
11. I would like to be a chemist when I leave school.				
12. A job as a chemist would be uninteresting.				
13. I would like to pursue a chemistry related career after my school certificate examination.				
14. Research incchemistry is totally unrelated to human needs.				
15. I would enjoy visiting a chemical treatment plant.				
16. I would like to belong to a science/ chemistry club.				
17. Chemistry is mainly for very intelligent people.				
18. Money used on chemistry study is wasted.				
19. Listening to a talk about chemistry is interesting.				
20. Knowledge of chemistry helps people to figure out new ways to kill more and more people.				
21. Chemistry lessons are not as interesting as other lessons.				
22. I like to spend my free time studying chemistry.				
SECTION II: Attitude Towards Teaching Approach				
The approach the teacher used in teaching chemistry during the past few weeks has:				
23. made chemistry lesson more lively and interesting.				

		SA	A	D	SD
24.	increased this feeling of making me walk out of the class when the teacher starts to write all those equations.				
25.	enabled me to see that a lot of chemistry/science activities go on in my home.				
26.	made me to dread chemistry lessons				
27.	taken too much time in relation to the benefit derived.				
28.	made me to look forward to chemistry lessons.				
29.	made the lesson boring.				
30.	made chemistry topic more difficult to understand.				
31.	been the worst I have experienced since entering this school.				
32.	made me to understand how to read other subjects.				
33.	given me opportunity to apply knowledge gained in chemistry lesson to my daily activities.				
34.	increased my reasoning ability.				
35.	made me score lower marks than before in my tests.				
36.	made me less confident in the subject				
37.	made me to dislike all science subjects				
38.	made me to see the relationship existing between chemistry and other science subjects which I have not noticed before.				
39.	helped me to be more active in class.				
40.	so much excited me that I would prefer to be taught chemistry with that approach only as from now on.				

APPENDIX F

READING COMPREHENSION TEST

Instruction Read the following passage carefully and answer the questions that follow. There are five options to each question. Select the correct option by circling the letter which corresponds to the choice you have made.

Some students were performing a titration experiment during their practical chemistry period when one of them mistakenly spilt some acid on her cloth and arm. Oblivious of the effect it might have on her, she just brushed off the spill on her cloth and arm. Some minutes later, she started to feel some severe pains on her skin and then alerted the teacher who quickly got information about what happened. He quickly poured clean water around the affected area and referred the student to the health centre.

After the incident, the teacher took some time to explain to the whole class the concepts of acids and bases. He said, that acid is a useful substance but when misused or mishandled could be dangerous as could be seen from the minor incident that had just occurred in the laboratory. He said that water was poured on the affected part of the body in order to reduce the effect of the acid and its concentration but harm has already been done to the skin. He advised that in case of acid spillage, the first thing to do is to pour a lot of water to the affected part. This is because acid

reaction with most substance is usually spontaneous, therefore, a quick action is required. He stressed that only strong acids are corrosive and their corrosive action depends on their concentration. Concentrated H_2SO_4 acid is very corrosive. It attacks skin and paper. Citric acid is not corrosive because it is a weak acid. He defined an acid for them as a substance which in solution produces oxonium ions as shown:

$HCl + H_2O \text{ ----> } H_3O_+ + Cl-$

Acid has many properties he said. It reacts with a base to form salt and water. The process is called neutralization. It is so called because the acid is being made neutral by the base giving salt and water as resultant products. A base in turn is a metallic oxide or hydroxide which neutralizes the acid to form salt and water. Bases in solution produce ions. The hydroxide ion from base combines with oxonium ion from acid to form water.

As the teacher was just rounding up his talk, a student asked him to explain what he meant by the term salt. The teacher went on to explain that salt refers to a chemical compound which results from the replacement of one or more hydrogen ions of a corresponding acid by an equivalent number of metallic ions. The salt therefore has a net charge of zero.

As the teacher was just trying to conclude, one other girl asked him the relevance of all that he had explained. The teacher further explained that first, students should not

play with chemicals in the laboratory. Secondly, they should note that the laboratory activities are very important because chemical reactions in aqueous solutions including the chemistry of life processes, very often depend on concentration of hydrogen ions in the solution. Using stomach ulcer as an example, he explained that stomach ulcer is caused by an excessive secretion of gastric acid which has HCl as the component in the alimentary canal of man. The acidity causes the abrasion of the walls of the alimentary canal of the patient. To soothe the pains caused by such abrasions, doctors advise patients to take antacid which neutralizes the action of HCl secreted by the alimentary canal. Another example was given from the natural phenomena such as in farm lands, where excessive cultivation or poor management of farm lands increases the acidity of the soil. The acid in the soil is treated by the application of basic substance like lime. The result of liming is that most nutrients in the soil are made available to the agricultural crops.

1. What is meant by neutralization process?
   (a) It is a reaction involving acid and base
   (b) It is a process in which acids react with bases to produce only salt.
   (c) It is a process in which bases react with acids to produce neutral salt and water.
   (d) It is a reaction between neutral salt and water.

(e) It is a reaction involving salt and water.

2. The acidity of the soil can be reduced by:

(a) adding more fertilizer

(b) adding a base

(c) frequent cultivation

(d) leaching the soil

(e) adding sodium chloride salt

3. From the passage, bases and acids have a similar property, what is this property they have in common?

(a) They both neutralize the soil

(b) They are both corrosive

(c) They both produce ions.

(d) They both react to form only salt

(e) None of the above.

4. What other word could be used in the place of 'oblivious' in the passage.

(a) Remembering

(b) Cautious

(c) Unaware

(d) Knowing

(e) Observant

5. Doctors usually prescribe antacid for patients with stomach ucler, the antacid is likely to contain mainly:

(a) a base

(b) Salt

.) sugar

(d) antibiotics

(e) analgesic

i. Which of these statements is correct. The teacher explained:

(a) that salts contain replaceable hydrogen ion

(b) that acids react with bases to form only salts

(c) that bases contain hydrogen ions

(d) that salts contain metals and ions.

(e) that the hydroxyl ions from base and hydrogen ion from acid react to from only water.

'. When an acid pours on an individual,the best immediate aid would be:

(a) to take him to a health centre

(b) to pour some base on him so that it will neutralize the effect of the acid

(c) to clean the acid with towel

(d) to pparta large amount of water on the affected

(e) to look for a teacher.

). The acid soil is limed so as to:

(a) make most nutrients in the soil available to the agricultural crop

(b) neutralize the acid in the soil

(c) increase the organic content of the soil.

(d) decrease the base content of the soil

(e) reduce soil erosion

9. What is meant by the statement 'the salt has a net of charge of zero'.

(a) It means that the acid has zero effect on the base

(b) The base has zero effect on the acid

(c) When the salt is charged it becomes zero

(d) The negative and positive charges are equal

(e) The salt is an acid salt.

10. Which is the best title for this passage?

(a) The acid victim

(b) The ucler patient

(c) The teacher

(d) Liming of the soil

(e) Acid reactions in nature

KEY TO APPENDIX F

1. c
2. b
3. c
4. c
5. a
6. e
7. d
8. b
9. d
10. a

APPENDIX G

NON-VERBAL REASONING TEST (AH_4)

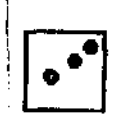
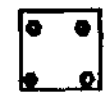
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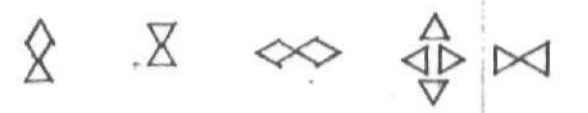
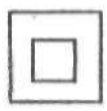
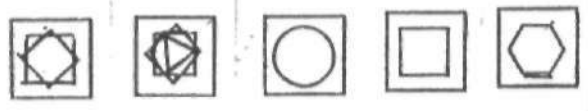
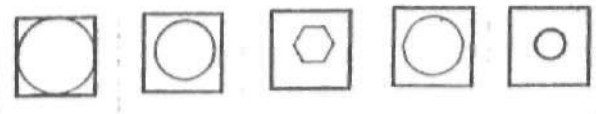
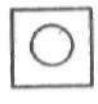
In the test that follows you will find some items which are in the form of pictures, The items are there to test your understanding of some sort of relationship between the item. The right answer is one of the five alternatives marked 1,2,3,4 and 5, given for every question. When you find the correct answer, circle the number in the answer sheet provided. The test generally is not difficult but the questions become a bit difficult gradually. If you find any item difficult, do not waste time on it; proceed to the next one. You have 30 minutes only to complete this test. Now continue with the work.

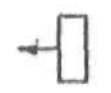
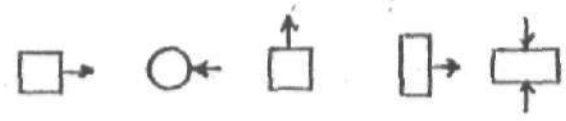
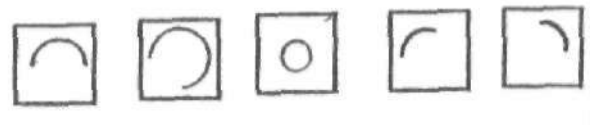
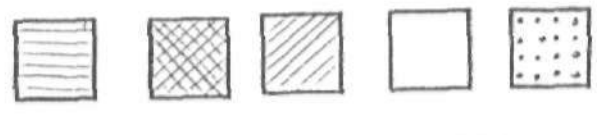
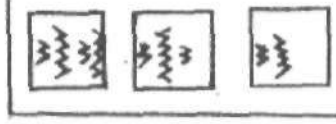
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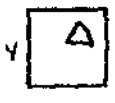
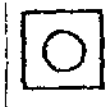
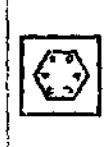
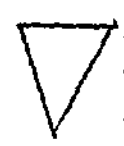
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