THE EFFICACY OF A CONCEPTUAL CHANGE STRATEGY IN REMEDIATING IDENTIFIED STUDENTS' MISCONCEPTIONS IN BIOLOGY.

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 duly acknowledged.

..... 16/07/98

SAMBA, REGINA MARITA ONABID DATE

CERTIFICATION

The undersigned certify that the thesis entitled *"THE EFFICACY OF A CONCEPTUAL CHANGE STRATEGY IN REMEDIATING IDENTIFIED STUDENTS' MISCONCEPTIONS IN BIOLOGY"* by SAMBA REGINA MARITA ONABID, 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 contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my husband Professor J.N. Samba and our kids Ngwi, Nde and Adang-O-Shie;

and

to all those who toil night and day to see to the improvement of the quality of Science Education, in Africa and the world at large.

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ABSTRACT

The study was carried out to determine the efficacy of a conceptual change instructional strategy in remediating identified misconceptions about photosynthesis and respiration. The effect of this strategy on some variables (retention, attitude and gender) were investigated. Consequently the study was carried out in two parts.

(1) identification of misconceptions

(2) teaching to effect conceptual shift

The target population was SS1 students of selected schools of Benue State. For the identification of misconceptions, 340 students were drawn from eleven (11) schools in Benue State, seven co-educational two single sex boys and two girls school. During the teaching treatment two schools which were selected based on their equivalence in the knowledge of the experimental concepts were used. One school served as the control and the other experimental. Altogether, there were seventy three students (21 girls and 52 boys). The control group was taught using the traditional instructional method while the experimental group was taught using the conceptual change instructional strategy. The conceptual change instructional strategy was developed, based on Posner et al (1982) model.

Both groups were pre and post-tested. The major measurement instruments for the study were

(a) Misconception test on photosynthesis and respiration

(b) Biology concept achievement test

(c) (i) Biology attitude questionnaire (ii) Attitude towards conceptual change approach.

The instructional instruments were;

(1) Conceptual change instructional strategy and

(2) Traditional instructional approach.

The data collected were analysed using t-test, Mann Whitney U-test and Pearson's product moment correlation and tested at a significant level of 0.05. There were altogether nine hypotheses and one question to be tackled.

The findingsof the study were as follows

(I) The experimental group performed significantly better and retained more of the biology concepts than the control group.

(ii) There was no statistically significant difference between the performance of boys and girls taught using both conceptual change instructional strategy and traditional instructional method.

(iii) A statistically significant correlation ($P<0.05$) was found to exist between attitude to biology and performance in the control group - whereas there was no significant correlation for same tests in the experimental group.

(iv) The conceptual change instructional strategy significantly improved students attitude to Biology over their counterparts exposed to traditional instructional method.

(v) Boys and girls differed significantly in their attitude towards the conceptual change instructional strategy.

(v) There was a statistically significant correlation between retention and performance for both groups.

(vi) Students in SS1 habour a wide range of misconceptions on photosynthesis and respiration, some of which can be easily remediated using the conceptual change instructional strategy.

Based on these results recommendations which could give a clearer view of, and support for the efficacy of the conceptual change instructional strategy were made.

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LIST OF ABBREVIATIONS AND SYMBOLS

1. A.A.A.A - American Association for the Advancement of Science
2. B.S.U. - Benue State University
3. CCM - Conceptual Change Model
4. FISS - First International Science Study
5. GIST - Girls Into Science and Technology
6. JSS - Junior Secondary School
7. NAEP - National Assessment of Educational Progress
8. NERDC - National Eduction Research Development Center
9. NSTA -National Science Teacher Association
10. P - Probability
11. SAN - Science Association of Nigeria
12. SSS - Senior Secondary School
13. STAN - Science Teacher Association of Nigeria
14. WAEC - West African Examination council

DEFINITION OF TERMS

Certain terms have several meanings depending upon the context within which they are used, while others might be entirely new to a reader. Below are the operational definitions of some important terms in this study.

Conceptions: These are personally constructed explanatory knowledge, judged by the individual to be intelligible, plausible, and fruitful, as they help the individuals to make sense about how the world or things around operate.

Scientifically Validated Conceptions: These are conceptions which must have evolved through the scientific community to be right.

Misconceptions: An individuals preexisting conception, which constitutes a reliable aspect of his/her theoretical knowledge, but judged by experts in the field to be at odds with the scientifically or commonly accepted scientific idea.

Learning: It is considered to have taken place when a scientifically validated conception has been successfully accommodated in the individuals repertoire following a shift form the misconception. Learning is seen in terms of conceptual development or change.

Cognition: It is a mental process or operation of the intellect by which knowledge is generated. It involves discovering of new and recognition of old information.

Cognitive conflict: It is a state in an individual cognition whereby he or she is caught up in explanatory inconsistencies: his/her preexisting conception fails to explain the current situation, thereby resulting in a difference between preconceptions and scientific conceptions.

Conceptual Change: Knowledge restructure that involves extension, differentiation or a complete shift from preconception (misconception in this case) to a scientifically validated conception.

Conceptual change Model: A model developed on Piagetian epistemology, which described learning as a process in which a person changes his/her conceptions by capturing new conceptions or exchanging existing conceptions for new ones. Piagetian epistemology is a constructivist and relativistic view of knowledge in which the person's present constructioin of experiences form the basis for the handling on new information and projction about future events.

Traditional Method: A method of learning that involves lecture and demonstration.

Attitude: Is a persons, feelings, thought and predisposition to behave or respond in some particular manner.

Retention: Ability of memory to store information

Performance: Is concerned with how well an individual is able to demonstrate a desired ability.

Conceptual Change Strategy: An instructional strategy in which the teacher acts as a facilitator, providing thought provoking questions, experiments and guiding discussions which will lead students thinking towards constructing scientifically valid ideas. The students through the teaching becomes more able to recognise, evaluate and decides whether to reconstruct existng ideas and beliefs relevant to the topic in question.

CHAPTER ONE

THE PROBLEM

1.0 Introduction

The critical role that students' pre-instructional knowledge play in any intellectual activity cannot be disputed. So, too, are the findings that there is considerabled diversity in students' current knowledge, that the diversity frequently contradicts accepted veiws. However, while there has been a wealth of published research identifying misconceptions, realtively little has appeared detailing how miscon ceptions might best be changed.

The essential thrust of this study is to identify misconceptions and explore the efficacy of a conceptual change instructional strategy in remediating them. This thrust needs justification and explaination. This chapter therefore, encompasses the problem and its definition. It begins with the back ground of the study, highlighting the reasons for the study, and gives a clear cut statement of the problem. Among other things, research questions are raised and objective stated, consequent upon which the hypotheses were formulated.

1.2. Background of the Study

The past decades have seen series of curriculum innovations aimed at upgrading the teaching and learning of science. The intention of course has been that of shifting the focus from traditional method of instruction that emphasize memorization of facts and procedures to inquiry-oriented method that facilitate the development of conceptual understanding (Stoffletts & Stoddart. 1994). The teaching strategies devised were mostly, activity based. The objective was to improve science content understanding of students (Alonge and Auguisobo, 1983; Mba and Abdullahi, 1985; Ndukwe, (1985). Consequently, huge amounts of money was invested by the Federal Government of Nigeria on training teachers. Yet, no significant changes were recorded following these activity based strategies, as evidenced by the poor performance of students in science course in public examinations (Jegede, 1982; Okebukola, 1990; Ezenwa, 1993).

The instructional method suggested by the Biology core curriculum designer was the guided discovery approach. According to Jegede (1982) and Bozimo (1985), only minimal changes have been noticed in the learners since the introduction of guided discovery in Nigeria. Watt (1988) observed that students outcome of discovery instructions has been

disappointing despite its existence for several years. There is therefore, obvious disparity between what science educators would like to see happening and what is really happening as remarked, for example, by several scholars (Jegede, 1982; 1990; Ogunniyi, 1986 and Okebukola, 1990). Thus the search for explanations of students poor performance in school science subjects continues to be one of the most crucial and central focus in most researches.

Novak (1990) stated that a fundamental reason for the failure of the curriculum approach of the 70s had to do with the neglect of how humans construct and use meaning to guide their actions. Ausubel (1968) asserted that "the most important factor influencing learning is what the learner already knows, ascertain this and teach him accordingly." Novak (1977) utilizing Ausubel's work argued that the relevant prior conceptual knowledge is the most important factor in learning science content as well as using that knowledge to solve problems.

According to Ausubel's (1968) subsumption model of learning, prior knowledge is used for interpreting the new information to be learned. He therefore, proposed the idea that meaningful learning takes place only when a general subsuming concept is already available in the learners cognitive structure. And that such idiosyncratic concepts are usually derived from the currently held concept in the society. This point is further emphasized by Piaget (1977) who adopted a genetic epistemology which emphasized that individuals construct their own knowledge as a result of their interaction with specific phenomena. Conceptions formed during this process constitute a person's personal explanatory knowledge of the phenomena in question. It is such concepts that usually form the basis upon which new knowledge is anchored. Learners therefore make meaning by bringing their present conceptions to bear on new situations.

However, several studies have shown that learners personally constructed knowledge may be quite different from currently accepted scientific views. The theories are variously labelled by different researchers as alterative conception, preconceptions, misconceptions, minitheories, spontaneous knowledge, and children's science (Driver and Erickson, 1983; Osborne and Wittrock 1983; Stewart and Kirt; 1990; Garnett et al 1990 and Bloom, 1990). Such studies have revealed that children's understanding are often inadequate or erroneous (Garnett et al, 1990). The problem now remains how to shift these erroneous beliefs to scientifically valid ones.

The conflict paradigm therefore constitutes a real challenge to science educators. (Pines and West 1986). Mature learning in this conflict paradigm involves transfer of ones commitments from one set of beliefs to another. It demands the questioning of reality, abandoning irrelevant ideas that have been established over a long period and becoming committed to a new set of ideas

that are completely incongruent with the old ones. It is therefore, not surprising to find resilience in the original set of commitments and a reluctance on the part of the student to abandon all of those beliefs that are still held by peers, that are validated each day by experience and that have served so well in the past in making sense of the world. The teacher therefore, faces an inordinately difficult task in getting students to take on the new sets of beliefs about the way the world works, that is being propounded (Rowell et al, 1990).

This conflict situation where the spontaneous knowledge clashes with the formal knowledge, results in a situation where students learn the formal content while habouring their misconceptions. The end result is rote learning where knowledge from the two sources remain separated, with the new knowledge being compartmentalized.

However, the learning of science entails that knowledge from both sources become so intertwined that they lose their separated identities. Ways must therefore be sought to bring intertwining of the knowledge from both sources which will consequently lead to meaningful learning. Moreover, traditional teaching has little influence in displacing such theories (Jose et al 1990). Yet prior knowledge is of paramount importance in the teaching learning situation if meaningful learning is to take place. This has been revealed by current studies of how students learn science, as framed within the constructivist view of teaching and learning.

Central to the constructivist perspective is the premise that a learner constructs meaning from new information and events as a result of an interaction between that individuals prior knowledge and experience and his or her current observation. From this perspective, the existence of misconceptions will adversely affect an individual's subsequent learning. Furthermore when incorrect conceptions become established, they are not only resistant to change, but influence and interact with the learning of related concepts, resulting in learning outcomes that may not be meaningful. Thus, the capacity to recognize that children do actively construct their knowledge and beliefs may lead a teacher to consider the possible interpretations that the learner might make of science classroom events.

Researchers have found that students posses many misconceptions. For example Doran, 1972), investigated elementary students misconceptions of some selected science concepts and found out that student picked distractors which are misconceptions. Brumby (1979, 1982), investigated students problems in learning concepts of natural selection and life respectively. Johnstone and Mahmoud (1980), studied students problems with water potential and came out with several misconceptions. Kargo et al. (1980) investigated students conception of inherited

characteristics and recorded many misconceptions. Students have also been found to have misconceptions about key concepts such as respiration, photosynthesis, growth, transport, genetics and evolution (Longden, 1982; Okeke and Wood-Robinson, 1980; Abimbola, 1984; Okebukola, 1990).

There seems therefore to be a wealth of published research identifying students misconceptions. Findings such as those of Driver and Easlely 1978; Driver and Erickson, 1983; McDermoh, 1984; Gunstone and Watts, 1985; Ivowi 1985; Soyibo, 1983; Abimbola 1984, 1988 have revealed that misconceptions occur in many subject areas. As a consequence, many models have also been put forth to remediate such misconceptions. Among such, Pines and West (1986) suggested the use of conceptual development approach, conceptual resolution and conceptual exchange in remediating various misconceptions. The idea of each approach is conceived within the constructivist view of learning. It has also been acknowledged that several other factors other than the instructional strategy, affect the students understanding of concepts which might lead to misconceptions.

Evidence abound in literature, revealing the major role attitude plays in teaching and learning (Gardner, 1975; Levin and Fowler, 1984; Odunusi, 1984, Odubunmi and Balogun, 1985; Abdullahi, 1983; Mukherjee, 1978; Ajewole 1991; Shuaibu and Ameh,(1982). Positive attitudes towards the subject will enhance meaningful learning and better concept formation, while negative attitude will deter proper concept formation. It is therefore pertinent to look for ways of encouraging positive attitude in students towards the learning of biology.

There is evidence in literature also, revealing gender related differences in various studies. Some of such studies have revealed small but consistent differences between the performance of males and females in science achievement task (Mullis and Jenkins, 1988; Orisaseyi, 1977; Otuka, 1986; Hassan, 1985). Whereas, conflicting results have been obtained from some researches too. (Welch, 1985; Tobin, 1988). Some researchers have attributed the gender related differences to cognitive abilities, psychological factors and physical abilities.

Part of this study was to find out whether the teaching strategy employed might have gender related differences.

1.2 **Statement of the Problem**

Though, evidence abound in literature revealing numerous misconceptions and the causes, very little has appeared detailing how these misconceptions might best be changed. Moreover,

results from Glough et.al.(1985) suggested that these misconceptions are viable and relatively resistant to change. The question therefore still remains;- How can students be encouraged to give up these misconceptions?

Pines and West (1986), Nachtigal (1984), Posner et al. (1982), Stofflett and Stoddart (1994), Anderson et al. (1990), Hewson and Hewson, (1991), Songer and Mintze (1994), among others have suggested some conceptual change models. However, most known studies related to conceptual change model are found in Earth and physical sciences. Such studies have demonstrated that it is possible to effect conceptual changes in students using specially designed instructions. This therefore necessitated the use of biology concepts as focus for studies with this approach.

According to Abimbola (1988), biology concepts such as digestion, respiration and excretion which are not easy to place under a system of laws and theories, should be the focus of further researches. Moreso, the related process of respiration and photosynthesis are of circular significance and play central roles in a biologist's understanding of many aspects of living systems.

The bulk of research work on photosynthesis and respiration has been largely those of identification of misconceptions and their causes (Soyibo, 1988; Abimbola, 1984) One of the most recent works with conceptual change model in biology was that of Stofflett and Stoddart (1994) who attempted to examine the relationship between content instruction and development of elementary teachers understanding of conceptual change pedagogy, using water cycle.

The present study, did not only identify students misconception about photosynthesis and respiration, but also developed a strategy aimed at remediating these misconception. The strategy was based on the conceptual change models. Even though several conceptual change models have been developed (Scott and Dyson et al 1985). Nachtigall, 1984; Posner et at. 1982), the Posner et al (1982) conceptual change model is most preferred for this study. This is because the few studies which have been carried out in biology using the conceptual change approach have used this model (Stofflett and Stoddart, 1994; Anderson et al-1990). Also the researcher found this model to be more logical and comprehensive than the other models.

The intention of this work therefore is to identify, and to attempt to remediate students misconceptionsabout photosynthesis and respiration. This could be achieved by restructuring students' understanding about specific concepts using the conceptual change model.

To this effect therefore, the study examined the efficacy of conceptual change strategy in remediating students identified misconceptions about photosynthesis and respiration. It also investigated the effect of this strategy on students' understanding of these topics when compared with these exposed to the traditional instruction.

The effects of the conceptual change strategy on students retention, and attitude, were also determined in addition to finding out whether there was any gender related difference.

1.3 **Research Questions**

The study sought answers to the following questions:

(i) What prior knowledge of SSS1 students about photosynthesis and respiration are misconceptions?

(ii) Is there any difference in the retention of misconceptions between students taught using the conceptual change instructional strategy and those taught using the traditional instructional method?

(iii) Does conceptual change instructional strategy enhance retention of scientifically acceptable conceptions about photosynthesis and respiration more than the traditional instructional method?

(iv) Is any of the strategies more effective in improving students attitude towards learning biology more than the other?

(v) What are the effects of gender, on the students' understanding of the conception of photosynthesis and respiration following instruction?

(vi) Does the use of conceptual change strategy and traditional method, result in differences in performance between boys and girls in an achievement test based on photosynthesis and respiration?

vii) Is there any significant difference in the performance between groups taught using the conceptual change strategy and the traditional method?

viii) What are the effects of attitude on the students' understanding of the concepts of photosynthesis and respiration?

1.4 Objectives of the Study

The objectives of the study are:-

(I) to identify common misconceptions held by SS1 students about photosynthesis and respiration.

(ii) to use the conceptual change model of instruction to remediate misconceptions held by SS1 students about photosynthesis and respiration.

(iii) to assess the impact of conceptual change strategy on students retention level of the concepts of photosynthesis and respiration.

(iv) to determine the effect of the conceptual change method and traditional approach on SS1 students' attitude towards the learning of biology.

(v) to determine whether there would be any differential effect on the performance of boys and girls using the conceptual change instructional strategy.

(vi) to find out if there was any difference in performance between students taught using the conceptual change instructional strategy and the traditional method.

(vii) to plan lessons and evaluate their utility in incorporating conceptual change model strategy in teaching respiration and photosynthesis.

1.5 The study Hypotheses

$H(0)_1$ There is no significant difference in the performance of students taught using the conceptual change instructional strategy and the traditional instruction method.

$H(0)_2$ There is no significant difference between the performance of boys and girls taught using the conceptual change instructional strategy and traditional instruction method.

$H(0)_3$ There is no significant difference between the mean scores of students in the biology concept achievement test (BCAT) before and after respective instruction.

$H(0)_4$ There is no significant difference in the level of retention of concepts between groups taught using conceptual change strategy and traditional method.

$H(0)_5$ There no significant difference in the level of retention of concepts between boys and girls in the control and experimental groups.

$H(0)_6$ There is no significant difference between the attitude of students taught using the conceptual change strategy and traditional method.

$H(0)_7$ There is no significant relationship between the student's performance in the attitude questionnaire and BCAT after instructions.

$H(0)_8$ There is no significant difference between the attitude of boys and girls to the teaching of biology using conceptual change instructional strategy.

$H(0)_9$ There is no significant relationship between retention and performance in the BCAT following respective instructions.

1.6 Significance of the Study

The acquisition of knowledge in biology is useful in many field and is often part of the requirements of most Universities and Polytechnics in many countries for courses such as agriculture, food technology and processing, medicine, physiology, forestry, oceanography, pharmacy and maritime studies, to mention but a few. Thus, among others the importance of biology as a bedrock of most science based careers cannot be overemphasized.

Therefore, if Nigeria must make the desired break-through often characterized by science and technology oriented nations, then the government as well as the teachers must think of suitable measures for remediating some of the common misconceptions inhibiting the understanding of science concepts by students.

It is expected that as a result of this study, science educators would help students to (i) learn to organize facts, see relationship or patterns in nature (ii) learn to use these organized facts to explain their observation, as well as disqualify their own logical inconsistencies and (iii) relate such to real life situation and developmental needs.

Conceptual change strategy, has had many advocates in the literature (Hewson and Hewson, 1991; Stofflett and Stoddart, 1994), but there are relatively few reports of its implementation and evaluation. It is hoped therefore that this study would provide a teaching strategy that teachers would adopt and adapt, since it was used to teach a large class with very little, resources. Teachers might be able to identify common misconceptions students hold about scientific concepts and consequently teach to effect a shift to the scientifically validated conceptions. Hence, they may choose to modify aspects of their usual teaching strategies by incorporating changes suggested by this model, for example:-

i. Letting students provide their own tentative answers to their own questions.

ii. Considering and valuing all answers and suggestions from the students.

iii. Providing problems which have several possible answers for students to work on and also

iv. Encouraging students to make their ideas explicit in writing or in discussion. This process would help teachers understand students conception, and possibly help them to resolve such misconceptions.

It is hoped that students taught using this approach would be more involved in the lesson and develop more confidence in themselves. Since the model encourage the interplay of thought and action, the students might become more alert and develop the ability of creative and reflective thinking. The students are trained to develop a questioning attitude to their studies while discouraging the unquestioning acceptance of vaguely understood principles and theories. The rate of retention of scientific concepts might increase too and possibly students could develop a more positive attitude towards their science courses.

It is hoped that the findings of this study will serve as a useful platform for restructuring the curriculum. In the event of a successful shift from misconceptions to scientifically accepted ideas by students, the model can become popularized and included or enlisted as one of the recommended approaches for teaching science. Textbooks could also be produced using new approaches based on this model.

It is hoped that the result of this study would be valuable to institutions that are training teachers and various associations interested in instructional innovations. Associations and research bodies such as Science Association of Nigeria (SAN), National Education Research and Development Centre (NERDC) and Science Teachers' Association of Nigeria (STAN) that carry out researches, organize conferences, seminars and workshop, might find the results useful and incorporate it in their science instruction innovation programmes.

It is also hoped that result of this study would be found valuable to organizations and other academic bodies, both National and International that are interested in popularizing scientific literacy. More particularly as people taught with the conceptual change model could

(i) acquire knowledge and inquiry skills which make it easier to interpret science related information encountered daily.

ii) end up being objective, open-minded and re philosophy or idea that flective in their thoughts.

. The results of this research could prompt WAEC and other examination bodies to review its questioning strategy so as to include more problem solving task and reflective questions in their examinations.

Finally, it is also hoped that the result from this research would serve as a spring board for

further research work, while at the same time contributing its own quota to already existing knowledge.

1.7 Assumptions

The following assumptions were made for the purpose of this study.

a. Though prior knowledge is important in the acquisition of new knowledge, some of the prior knowledge of students used for the study were erroneous and contrary to the scientifically accepted ideas.
b. Students would give precise and honest answers to the questionnaire and the different tests that would be administered to them.
c. The students in the sampled schools are representative of the student body in the State (Benue State) where the research was conducted.

1.8 Delimitation of the Study

This study is delimited as highlighted below.

1.8.1 Concepts taught

The concepts of photosynthesis and respiration were chosen because these processes are central to the biologist understanding of many aspects of living system. The study took into consideration that these concepts have several other related sub-concepts. However, this study is concerned with the following aspects of the students' understanding of the concepts:-

- definition of photosynthesis
- definition of respiration
- definition and sources of food for plants and animals
- sources of energy for plant and animals
- relationship between photosynthesis and cellular respiration
- application of knowledge of photosynthesis and respiration.

1.8.2. Conceptual change instructional strategy

In developing this teaching strategy, the conceptual change model proposed by Posner et. al. was used. The model was chosen because learning here is seen in terms of conceptual development or change rather than a piecemeal accretion of new information. Moreso, that considerable importance is accorded to learners existing conception.

1.8.3. Subjects and location

Subjects used for the identification of misconceptions were SSI students drawn from eleven schools, randomly selected from the three educational zones in Benue State. Subjects for the experimental treatment were drawn from two schools in Makurdi metropolis.

1.9 Summary

The importance of pre-instructional conceptions in any learning situation cannot be overemphasized. Yet studies have revealed the prevailance of erroneous conceptions in students' conceptual framework. For any meaningful learning to occur these misconceptions must be identified and replaced with the scientifically accepted conceptions. The conceptual change instructional strategy seem to provide a means of achieving this. The desire to provide a precise but academically worthwhile research made it necessary to set a limit to the number of variable that were included in the research. Hence only attitude, retention, and gender variables were included as variables.

CHAPTER TWO

REVIEW OF LITERATURE

2.1 Introduction

Most science Educators, would at least pay lip-service to the idea that they teach science to enable learners make sense of the environment in which they live, and also to enable them to become confident citizens in the scientific and technological world. In practice however, one wonders and might ask whether the actual lessons' activities do enable learners to grasp the scientifically validated conceptions enough to help them make sense of things around them.

As a matter of fact, teaching invariably aims at achieving some objectives. Such objectives typically manifest into instructional products of outcomes. Often the nature and intensity of outcomes, the behavioural changes in the learner and the concept attainment ability are a function of the specific instructional approach. Consequently, correct teaching methods require as much attention as content in science. This perhaps explains the series of curriculum instructional innovations that science education has witnessed during the past few decades.

Prior to 1950's teaching of science was characterised mainly by passive transmission of ideas to the learners. Friere (1985), called it the banking view of learning. Pope and Keen (1985), described it as "cultural transmission" approach. Teachers of this persuasion saw the primary task of education as transmission of information, rules or values which formed the "truth" of ones cultural heritage. Barnes (1976) similarly, described this approach as the transmission view. Such methods emphasised the students role as the passive receiver of information. The learners mind was seen as a "tabular raza" in which knowledge could be dumped indiscriminately.

However, with the launching of Sputnik in 1957, there was a tremendous shift from the transmission culture to that which emphasised the students' active participation in learning. Young (1974) recommended the activity method for preparing secondary school science teachers. While Odunusi (1978) was of the opinion that developing higher cognitive abilities especially productivity and creative thinking requires individual work on accumulated problems. At that time science teaching placed emphasis on students active participation in the process of discovery. This was in contrast the traditional instructional procedures which were characterised by telling, passive listening and occasional notes taking.

The newer approaches known as the investigative teaching methods included such strategies as discovery method, expository approach, instructional package strategy among others. The

emphasis was placed upon the active person reaching out to make sense of events by engaging in the construction and interpretation of individual experiences. I encouraged student to develop an active approach to learning. The psychological theories of Piaget, Brunner and Ausubel learnt support to this movement. The innovations were aimed principally at improving teaching and learning.

In Nigeria, the guided discovery approach was embraced although the pedagogy still leaves much to be desired. Ezenwa (1993) remarked that, it would be difficult to identify significant changes that resulted from the guided discovery instructional strategy in Nigeria and overseas. Bozimo (1985) and Jegede (1982) reported that only minimal changes have been noticed in the learner since the introduction of the strategy in Nigeria. Watt (1990) states that for years science educators have been advocating discovery instruction, yet students' outcome using the strategy has been disappointing.

There is therefore a concern among science teachers that perhaps the majority of science students neither understand nor see much point in the conceptually based science they are taught at school (Driver and Bell, 1986). Some are able to learn the taught ideas for examination purposes (though student's performance continue to fall) but have difficulty applying them in every day situations. Other less motivated and perhaps more honest students give up taking the lessons seriously. This is evident in the very poor performance of science students in their Senior Secondary School examination (Soyibo, 1991).

A possible explanation for this drawback could be that learning experiences derived from these method could be limited. Limited in the sense that even though the learners could be active physically during experimentation, there were really no link between the activity and the learners personal concern. Postman and Weignartner (1971) made the point very forcibly, when they suggested that, unless learners perceive a problem to be a problem, and what is to be learn to be worth learning, they will not become active, disciplined and committed in their studies. According to Pope and Gilbert (1983) students must find this body of knowledge true and should be able to incorporate it within their views of the world.

It will therefore seem reasonable to suggest that as teachers, the interest should be to encourage students to develop their own criteria regarding the quality and relevance of ideas and minimize our roles as arbiters of what is acceptable. Rogers (1969) referred to this type of learning as learner based, adding that it is self initiating, has a quality of personal involvement and is evaluated by the learner. This process he said could only be achieved where status is given to

the students' view and an atmosphere of mutual trust established.

However, the bulk of teachers and teaching strategies have hardly paid any attention to the learners ideas or view points. And if our educational systems is to create any impact, then teaching strategies have to be resisted. Even when instructional procedures demand students activities, the teachers often reverted to traditional didactic way of teaching. Tasker (1981), found out that in science lessons, among other things learners' knowledge structures, against which learning experiences were considered, were frequently not the structure the teacher assumed. It is therefore not surprising that science teaching has not been as effective as we might have thought.

In Nigeria emphasis is still being placed on Inquiry/Discovery learning by curriculum developers and science educators. By this, learners are expected to explore phenomena and objects and to discover the concepts and principles through practical experiences. But following recent discoveries, there is no doubt that the description of communication of what has been discovered are carried out by learners on basis of what they already know. In this, connection, Ausubel's recommendation that "the most important single factor influencing learning is what the learner already knows, ascertain this and teach him accordingly". (Ausubel, 1968) should be very operational. Researches in cognitive science have revealed the importance of these ideas that learner bring to class (Ausubel, 1968, Driver and Easley, 1978 Osborne and Wittrock, 1983; Shuell, 1987). Meaningful learning according to Ausubel (1968) takes place when the new materials to be learnt is carefully linked to learners' preconceptions. In this sense, inquiry/discovery and traditional approaches which do not probe into the learners preconception do not seem to have any remediating effect on poor achievement in science that is prevalent presently.

Furthermore, there has been considerable work revealing that some of the preconceptions learners hold are erroneous and different from the scientifically validated ideas (Gilbert et al 1982; Driver and Easley, 1978; Driver and Erickson, 1983; Champagne et al. 1982). Since, the learners' view would appear to have an (a significant) inordinate, influence on their learning, what is required therefore is a change in approach in science teaching/learning. One possible way of overcoming misconceptions and allow for meaningful learning is to teach to disequilibrate the learners with regards to their previous beliefs or views. Ausubel (1968), suggested that activities teachers' should be geared towards providing an environment for the learner to explore the plausibility of his preconception vis a vis the scientific conception as represented by the subject matter. Teaching needs to take into account the learner's perceptions and viewpoints and where

appropriate, attempts should be made to modify or build on such, but certainly not to ignore learners ideas. Champagne et al. 1985; Osborne et al. 1979) have argued that for teaching - learning to be effective, it is important for the teacher to come to an understanding of the learners framework.

If such an approach is to be developed and if it is to be synthesized with and supported by appropriate research, then it is important that there should be a sound conceptual base (Brown, 1977). What is required is a theory or model of learning which places full recognition on the importance of what learners bring with them to any learning experience, in any setting; and how the erroneous ideas within their framework can be remedied.

Unfortunately however, very little research has been done on this crucial problem, despite the fact that the unlearning of erroneous preconceptions might well prove to be the most determinative single factor in the acquisition and retention of subject matter knowledge. Anyone who has attempted to teach science to children or to adults for that matter is painfully aware of the potent role of preconceptions in inhibiting the learning and retention of scientific concepts and principles.

Yet preconceptions are always operative in any meaningful learning and thus any science educator would wish to have only the kind of preconception that facilitates intended learning in the learners (Ausubel et al, 1978)"Conceptual framework" or "repertoire". There is therefore, an urgent need for unlearning of naive preconceptions.

Recent work on cognitive psychology and constructivism has led to a model which is particularly pertinent. The conceptual change model (Posner et al, 1982 Hewson, 1982) has been shown to be relevant in this direction. This model is advocated in preference to the traditional transmission model of teaching. It is in the domain of humanistic constructivism. A view of learning that acknowledges that children construct their own knowledge through personal interaction with natural phenomena and through social interaction with adults and peers (Needman, 1987). Over the past 12 years many studies have been carried out in this field and it has continued to gain popularity. The tendency of many science educators to adopt the constructivist view, show its efficiency (Ault, 1985) Jegede and Okebukola, 1989; Pope and Gilbert 1983; Okebukola, 1990; Hewson and Hewson, 1991; Otuka. 1991; Dysktra, 1991; Andresn et al 1990; Schmidth, 1991).

Of all the instructional strategies within the constructivist domain the conceptual change model strategy, seem to be synonymous with providing the environment for conceptual change

or shift as it stresses the role of cognitive conflict in disequilibrating learners with regards to their preconceptions. It is expected that as students engage in a conceptual change lesson, they become aware of their ideas about scientific conceptions, recognise the inability of such, to explain scientific conceptions, which leads them to a state of disequilibrium. At this stage, they question their own beliefs, create new ones and test their validity.

The focus of this research, therefore is to test the effectiveness of this model in remedying commonly held misconception about photosynthesis and respiration. These concepts apart from the fact that they are central in the understanding of a biologist's understanding of several biological systems, are often perceived as difficult by teachers while students also perform poorly in it.

Some variables other than teaching strategy that affect the teaching - learning process have also been included. They include gender, retention, and attitude.

Consequently, the review of literature will include the following areas:-

- Conceptions and misconceptions
- Traditional instruction and science teaching.
- Constructivism
- Conceptual change approach and science teaching
- Gender related differences and science learning
- Attitude and science learning
- Retention and scientific conceptualization
- Summary

2.2 Conceptions and Misconceptions

2.2.1 Conceptions

These are personal explanatory knowledge about how the world or things around operate.

From a radical constructivist perspective, conceptions are fundamental beliefs about how the world works which individuals form in response to experiences and in concert with others. (Glasersfield, 1984; Dykstra, 1991).

According to Piaget (1977) conceptions are formed by the individual through the process of equilibration. Gunstone (1991) described conceptions as personal constructions.

The above definitions show clearly that conceptions are individual constructs. This is in line with certain assertions related to the constructivist views of learning. These assertions which are

considered valid here are as follows.

1. Each of us individually constructs our own meaning for experiences.
2. Therefore understanding is individual, as individual constructions are different.
3. Much of the construction we undertake as we generate our own understanding involves linking new ideas and experiences with what we already know and belief.

Hewson (1981, 1982). Posner et al. (1982); have described learning as a process in which a person changes his or her conceptions by capturing new conceptions or exchanging existing conceptions. For new conceptions if we take this as a basis for meaningful learning, the question arises, thus - if a conception is a belief or conviction about how the world works, then what makes such a belief possible and what is required to allow one to apply that belief to the world, or give it up in exchange for another conception?

Hewson (1981) has suggested that a key factor in the learning process is the status that new and existing conceptions have for the learner. According to him, certain conditions must be met for a conception to be acceptable. These conditions are intelligibility, plausibility and fruitfulness. The extent to which the conceptions meets these conditions is termed the status of a persons conception. The more conditions that a conception meet, the higher is its status. Learning a new conception invariably implies that its status rises higher than that of the already existing conception in the learners conception ecology.

The notion of status is central to the process of conceptual change as outlined by a model of conceptual change (Posner et al. 1982; Hewson, 1981; 1982). In particular the model predicts that conceptual changes do not occur without concomitant changes in status. This suggest that making the status of students conceptions explicit should be a part of a teacher's plans for conceptual change.

Hewson's (1981) conditions of conceptual change dissatisfaction with existing conception; new conception being intelligible and plausible and fruitful has influenced several researchers in this domain.

Hewson and Thorley (1989) reviewed the ways in which the CCM has been used in the literature and found that the prediction of status change has been widely-assumed to be the case in different instructional approaches.

Hennessey (1991) studied the explicit introduction of status ideas in a class of 20 sixth grade students working on a unit in force and notion and recorded good results.

Hewson and Hennessey (1991) in a study with a 12 year old sixth grade student discovered

that students when taught the technical terms of the CCM model could determined the status of her conception of force.

However, Gunstone (1991) in his theoretical issues and classroom studies related to constructivism and metacognition, found that both dissatisfaction and fruitfulness are particularly difficult to achieve in any managed and predictable form.

From the foregoing, it suffices to say that the conceptions both existing and new are of considerable importance in achieving meaningful learning. Also a realization that existing conceptions have an important role in science learning (Ausubel, 1960; Gagne, 1962; Novak, 1977), and that learners were not passive during learning (Brunner, 1957), many studies have investigated students conceptions of specific science topics. Many of such researches have however revealed that some of these existing conceptions are contrary to the scientifically validated ideas.

2.2.2 Misconceptions

Misconceptions are wrong notions of facts learners have on certain scientific concepts. Current constructivist research on cognition is providing insight into how a learners prior knowledge influences the acquisition of new knowledge and problem solving performance. Based on this, considerable research has focused on exploring such ideas that learners hold about a variety of scientific phenomena.

These studies have revealed that children's understanding are often erroneous or inadequate. Numerous researches have given diversed terminologies to describe these understanding. These include preconception (Driver and Easley, 1978); children's science (Gilbert et al. 1982); misconceptions (Driver and Easley, 1978; Rowell et al, 1990; Gunstone 1984; Soyibo 1983; Abimbola 1988; Okeke and Wood Robinson; 1980; Ivowi, 1984); alternative frameworks (Driver and Erickson 1983), students description and explanatory systems (Champagne et al. 1985) and preconceptions (Good, 1991).

2.2.2.1 Construction of Misconceptions:

From a Piagetian viewpoint, misconceptions and the process of their constructions are those of equilibration. Thus, like explanatory knowledge, the construction of misconception starts with the recognition of a knowledge gap of some kind. Depending on what is already known and on the range and sequence of experience faced, including those contrived by teachers, construction

continues with the creation of potential gap-filling possibilities from which a selection is made and often subsequently modified. The resulting knowledge, which is a misconception, is the best the individual has managed to produce at that point in time. This serves as a starting point for further progress irrespective of whether it is limited or wrong. This of course is because, they are formed in the same pattern or process used in the generation of valid and new knowledge. For the individual, misconceptions are reliable aspects of the individuals theoretical knowledge. It is only the expert who judges it as wrong.

2.2.2.2 Features of Misconceptions:

According to Karmiloff-Smith and Ihedler (1975) misconceptions have the following important features.

1) For individuals misconceptions are knowledge.
2) This knowledge is not different from any other knowledge that they have constructed.
3) In consequence misconceptions are potentially progressive aspect of the thinking process.
4) Misconceptions are successful as they make sense of an aspect of the individual's environment albeit only " up to a point".

2.2.2.3 Studies Related to Misconceptions:

As a consequence of the dampening effect misconceptions have on science learning a great deal of researches in science education have been devoted to the study of student misconceptions. Moreover the alternative conception movement is being considered by many researchers to be the most promising framework for research in science education; with the greatest potential for the development of effective new curricula.

In a study carried out by Champagne and Klopfer (1984), they reported that 80% of University Physics students have misconceptions of nature, while 90% of engineering majors cannot relate their preparation to the real life. Brumby (1979), revealed a number of commonly held misconceptions among University graduates. Kelly and Keadman (1978), examined the understanding of heredity and evolution exhibited by 11-14 years old boys before they encountered these topics in biology. Their study revealed a number of misconceptions. Longden, (1982), and Wooley (1979) revealed students learning difficulties in genetics and the conceptual understanding in the fields of respiration and photosynthesis with advanced level biology students.

Several other studies involving secondary school students showed that biology students

performed poorly because of the numerous misconceptions they had on various biology concepts.

In Nigeria, Soyibo, (1983) listed 17 misconceptions shown by 5 (five) students he tested using 53 open-ended questions and tape recorded interview. Soyibo, (1988) analysed the knowledge and misconceptions shown by 93 form 5 students selected from Lagos and Ogun States and 84 final and first year students in University of Lagos and reported that all the students showed common misconceptions on each concept.

Soyibo and Akintola, (1985) reported that 150 form 4 Lagos students showed many misconceptions on selected biology concepts. The boys showed significantly less misconceptions than the girls. In the same studies, students in the mixed schools showed the least misconceptions followed by the boys and lastly the girls' school students. Abimbola (1984) described and explained the alternative conceptions (misconceptions) held by selected form 4 students on human respiration. Similarly, Adeniyi (1985) analysed the misconceptions held by 232 form 3 students on selected ecology concepts. Okeke and Wood-Ribonson (1980) also revealed several misconceptions held by secondary school students about the concepts of transportation, growth, respiration and reproduction.

Few studies abroad, have addressed students understanding of energy transformation at the cellular level (Amir and Tamir, 1991; Anderson, et al. 1990; Bishop, et al. 1986; Haslan and Treagust, 1987; Seymour and Longden, 1991). Among the most common difficulties identified in those studies are

(I) the use of everyday language to define respiration and food

(ii) fragmentation of knowledge resulting from rote mode of learning and

(iii) a failure to recognise the complementary and reciprocal relationship of photosynthesis and respiration in plants.

Songer and Mintzes (1994) using interviews and concept maps revealed a large number of misconceptions about the relationship of cellular respiration and photosynthesis and about the role of plants and animals in natural ecosystems.

Wandersee (1983) had identified some misconceptions in a cross-age study on plant growth and nutrition. Amongst their discovery the most saddening was the misconception that plants do not respire and the misconception that plants must get their carbon dioxide only from animals and atmosphere.

More recently, Mintzes et al; (1991), Songer, (1993), and Wandersee et al, (1994) have explored the nature and significance of alternative conceptions in natural phenomena and the

nature and use of biological knowledge as employed by novice and experienced individuals, and revealed several misconceptions.

Though seemingly disparate, these evolving research programs represent simply different forays into the same basic problem - that of understanding and conceptual change. It seems that with some elaboration, this is essentially the same problem tackled by Ausubel over 30 years ago and labelled meaningful learning (Ausubel, 1963; Ausubel and Novak and Hanesia, 1978) and more recently embodied in the epistemological position taken by Novak in 1978 in his essay "Human Constructivism" and his review "Learning of Science and the Science of Learning" (1988).

The above studies have revealed the existence of several misconceptions in the learners conceptual framework. Perhaps this may account for the poor performance exhibited by most biology students as revealed by researches carried out by Walker et al 1983; Longden, 1983; Fakunle, 1983; and Okebukola, 1983; Ugwuadu, 1983; Pearson and Hughes, 1986.

If learning has to be meaningful, then ways of remedying these recalcitrant misconceptions must be our main concern. The challenge therefore, is to discover the set of experiences which are similar to that recorded by scientist in the past. To be an effective competitor the new theory must be on an equal mental footing with its "rival". It has to be understood and it has to be believable (Rowell and Dawson, 1988).

For believers in constructivism, understanding cannot be transmitted, it must be build by the individual (Tobin, 1990; Otuka, 1991). Consequently, the inform/verify/practice approach on which the traditional instruction is based, becomes inadequate.

The fact that traditional teaching has little influence in displacing misconceptions has been uncovered by several researchers. More so, changes which do occur are often unanticipated (Osborne and Freyberg, 1985; Aguirre et al, 1990). Rowell (1983;), Rowell and Dawson (1985) have suggested that for optimal progress in overcoming a misconception, students should first construct another potentially relevant, potentially contradictory better explanation based on aspects of their knowledge structure which are familiar to them.

Teaching for conceptual change seems thus far, to be a way out of the numerous misconceptions that have been identified amongst students. Even the inquiry/discovery method of organising the learning environment which does not probe the learners' preconception before scientific inquires are made, does not seem to have remedial effect on poor achievement by learners even though it's recommended by curriculum developers and science educators.

In any case, what is evident today in most science classroom is that the teachers often resort to the traditional didatic way of teaching. A method which has little or no effect on remedying childrens' misconceptions.

2.3 Traditional Instruction and Science Teaching - Its Inadequacies

The traditional instruction strategy is typically the lecture method. However, other methods at times are incorporated into it to make it a bit more meaningful, though teachers often end up invariably lecturing.

This method is teacher centred, and largely characterized by the teacher talking to the class most of the time, while students listen, take down notes and occasionally ask question. Lecturing has had its critic over the years (Bligh,1971; Jackson and Prosse, 1989). Despite its inadequacies, the sad truth is that lecture remains supreme (collier, 1985; Jackson and Prosser, 1989). In this method, the emphasis is on the content or product. This constitutes the knowledge transferred from the lecturer's notes to the students notes. For most students this is the goal, since it provides the key to the examination. In Yagers' (1992) words - concepts are really bits of information mastered for a teacher test, while learning is typically for testing. Students learn how to learn from lecturers.

Where the transfer of information from lecturer to students is the only goal, lecturing accomplishes it as well as other techniques. Therefore if one agrees with Thomas Gradgrind and teach nothing but "facts" we might as well lecture (Dicken, 1961). Though this method can achieve certain social and motivational goals, it is grossly inadequate in science teaching.

Yager, (1993) considered the inadequacies or problems arising from the traditional approach under (5) five subheadings - viz,

(i) Mastery of concepts;

(ii) Emerging process skill

(iii) Student's attitudes

(iv) Student's creative skill; and

(v) Their applications of science concepts emerging from this approach.

For Students' Mastery of Concepts following this tradition, concepts are presented as bits of information which are to be mastered for a teacher test. The concepts are also seen as outcomes

themselves while learning is done principally for testing. This usually results in short retention.

Furthermore, students taught using this strategy often see the science process skills as skills scientists possess. Students see processes as something to practice as a course requirement. This probably results from the fact that the teachers concern for process are not understood by students especially since they rarely affect the course grades. Consequently, students see science processes as abstract, glorified unattainable skills that are unapproachable for them.

Students taught using the traditional approach, often show a decline in interests at particular grade levels and across grade levels. Students curiosity decreases as they see the teacher as a purveyor of information. As such students see science as information to learn.

Students tend to decline in their ability to ask questions. Even when they attempt to ask, the question they do raise are often ignored because students hardly ask unique questions. Students are ineffective in identifying possible causes and possible effects of specific situations. In such a situation, students hardly have original ideas. (Jegede, 1984; Okebukola, 1990; Otuka, 1991).

Traditional teaching has recorded little success in this age of scientific and technological development. Moreover, what makes the learning with this strategy most difficult is the fact that students have to memorize and passively accept information. The role of students personal experiences in their construction of knowledge has been completely neglected. Hence the need to embrace the current philosophies of science which recognize the role of personal construction in the development of scientific knowledge (Kuhn, 1970).

Even the discovery methods that had been much advocated for degenerated into the traditional didactic approach. (Hudson 1988; Anderson et al. 1990) because of class management.

Consistent with Hudson's views Mani (1983), asserted that the choice of teaching method in Nigeria is seemingly restricted by social conditions such as over-crowded classes, non-availability of books and insufficient time. These often cause teachers to teach didactily. Watt (1988) stated that traditional instruction is now unfashionable because the goals of science education have changed since the 60's. Another problem is that the instruction has no foundation in the philosophy in science, and that the strategy failed to distinguish between learning and teaching.

There is hardly any evidence in literature to substantiate the effectiveness of this method in remediating misconceptions. Hence the need to embrace the new epistemology.

Based on the way the concepts have been presented to the students, they see no value or

use of their science study to their living. Students see no value in their science study for resolving current societal problems. Students can only recite information studied, but cannot relate the science t any current technology.

The overall picture resulting from this traditional approach is that students come out having several problems. One of the greatest problem is that of misconceptions. Students come out with a large number of misconceptions and worse still the misconceptions that the most successful students have is shocking (Yager, 1993).

The interest in science and further study of science declines across years: while positive attitudes about science, science classes, science teachers and the usefulness of science to living declines the more science is studied. (Hueftle, Rakow and Welch, 19983; NAEP, 1981). 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 strategies.

Studies on method of science instruction in Nigeria show that the traditional methods is predominant (Balogun, 1972). Several studies have revealed the inadequacies of the traditional instruction strategy to meet current science education needs of the 80's (Bajah, 1986; Watts, 1988).

2.4 Constructivism

Constructivism is a theory which stipulates that knowledge cannot exist outside the bodies of cognizing beings.. Knowledge is a cognition of reality (Tobin, 1990). Therefore learners actively construct their own knowledge and beliefs as a result of their interaction with specific objects or phenomena.

Constructivism is now attracting increasing attention as the dominant learning model in educational reforms efforts. Von Glasersfeld (1989) traces constructivism back to Vico, who in 1710 described his concept of human learning. "Epistemic agents can know nothing but the cognitive structures they themselves put together". "To know means" "to know how to make". He substantiates this notion by arguing that one knows a thing only when one can explain it. Such explanations are for others to understand (Yager, 1992).

In line with the above view, Wheatley (1988), stated that, knowledge is not passively

received, but is actively built up by the cognizing subject. For an individual to be able to build up knowledge, demands that he should understand and be knowledgeable. To know according to Otuka (1991) is to understand in a certain way - a manner which can be shared by others. Yet this task of understanding is compounded by the fact that we cannot transmit meaning, but that meaning must be constructed (Von Glasersfeld, 1989). It seems reasonable to conclude from the above that meaning is not conveyed but evolved, while knowledge is a leraners activity. The learner is actively involved in constructing knowledge.

Constructivist theories of learning have encouraged researchers to look for the connections learners make when information is received. Research is beginning to uncover such connections between incoming scientific information and the non- scientific content of the mind (Gunstone, 1990). The learner uses these non- scientific content as a basis upon which incoming ideas will react to generate new knowledge. It is this new idea that the learner is not passive but actively engaged in constructing knowledge, that constitutes the core or central focus in the constructivist approach to science learning - teaching.

Teaching in the constructivist approach therefore, is not a transmission of knowledge. Rather, it involves the organisation of the situations in the classroom and designing of tasks, materials and resources from which students construct their own knowledge. This definitely calls for a different approach to science teaching. An approach in which the teacher becomes the enabler in the classroom, he may interact with learners, raise questions, build in appropriate challenges and experiences and offer new ways of thinking (Otuka, 1991).

However, following results from cognitive science research, the following generalization could be derived concerning childrens idea.

- most persons have naive theories or ideas concerning the natural world, even including the best student in the education system.
- Each students' explanation of the things around them comes from their own experiences (as opposed to what is taught).
- It is extremely difficult to alter a persons own mental constructs (certainly not by merely telling them they are wrong).
- Altering misconceptions occurs best through personal challenges to the concept, thereby creating situation where the erroneous conceptions does not explain and
- Learning is a social activity; even when an individual constructs explanations for him/herself it must be communicated and validated.

These finding gave more support to the constructivist learning model. This model demands newer approaches and suggests such approaches as to

- Allow students thinking to drive a lesson or entire unit.
- Shift activities and content plan to fit student responses, interest and ideas.
- Encourage student initiation of ideas, display of leadership, autonomy in planning and doing.
- Encourage students to expand and follow upon their ideas.
- Allow adequate wait-time for students to think and to propose.
- Encourage group work and encourage students to interact frequently with other students and others outside the particular class.
- Use open-ended and thought provoking questions; encourage the same from students.
- Encourage students reflection, analysis and predictions.
- Seek out existing concepts; using these in teaching as opposed to those from the teachers or textbooks and
- Offer alternative suggestion and encourage them to get suggestions from other students, and use these as challenges to misconceptions.

These constructivist ideas have derived support from Jean Piagets work. His works and ideas support, elaborate and exemplified the constructivist views of leaning. Following this, several empirical researches have been reported (Driver and Bell, 1985; Driver and Erickson, 1983; Duit, 1987; Novak, 1987; Novak, Gowin and Johnson, 1983; Pope and Gilbert, 1983; Scottand and Dyson, 1987,) Osborne and Wittrock (1983) used the above mention ideas to produce a leaning model called the generative leaning model. According to the model, which is consistent with cognitive approaches to leaning research in the brain (Wittrock, 1980), to lean with understanding, a leaner must actively construct meaning from old experiences by incorporating new constructs into the old.

Other models under the constructivist approach to teaching include the CLIS, Wheatley and Nachtigal models. The CLIS model shows five stages (Otuka, 1991; Scott and Dyson 1985) which include

1) Orientation phase during which the teacher arouse interest and sets the scene. This can be done, through practical activities real problem solving, film strips, practical activities or small group discussion.
2) Elicitation of ideas - to enable teachers to become aware of prior ideas.

3) Restructuring phase during which ideas are restructured. This include clarification and exchange, exposure to conflict situation, construction of new ideas and evaluation. The purpose of the phase is to create an awareness of an alternative viewpoint, the scientific one, as to modify, extend or replace with a more scientific view, it will also help in the recognition of alternative idea critical examination of such and finally the testing of the validity of the new idea.
4) Application Phase: The purpose is reinforcement of constructed ideas in familiar and novel situation which could be achieved through personal writing, practical activity, problem solving and project work.
5) Review Phase: this will help to create an awareness of changes of ideas and familiarization with learning process to allow the learners to reflect upon the content to which their ideas have changed.

The Wheatley model has three components: task, cooperative groups and sharing. In this model, the teacher identifies a task that is problematic to the learners, ask the students to work in small groups after which solutions are discussed. The teachers role is that of a facilitator.. Nachigall (1984), opined that the teacher should actively create and make conscious conflicts in the students. The teaching model focuses on the psychological terms of assimilation and accommodation.

A model of conceptual change (CCM) was developed by Posner et al. (1982) and expanded by Hewson (1981, 1982). This model describes learning as a process in which a person changes her or his conception by capturing new conceptions or exchanging existing conception for new conception. A common property of the models is that they are for creation of awareness of problems, management of cognitive dissonance and co-operative work to ensure meaningful learning. Of all the models, the conceptual change model seems to be gaining grounds in effecting shifts in the numerous misconceptions that are pervading science educational system today. There is evidence of its potency in effecting shifts in conception in literature (Hewson, 1980, 1981, Posner, 1983;).

2.4.1 Constructivism and Conceptual Change

Many science educators recommended the application of constructivism to teaching (Cheung and Taylor, 1991; Cleminson, 1990; Roth, 1990; Vosniadou, 1991). Some constructivist educators have advocated the use of conceptual change approaches in science education (Gunstone and Northfield, 1992; Hewson and Hewson, 1988; Neale and Smith, 1989; Roth and

Roscan, 1991; Stofflett, 1991).

The conceptual change pedagogy is grounded in constructivist learning theory. This instructional theory holds that learners must become dissatisfied with their existing conceptions as well as find new concepts intelligible, plausible and fruitful before conceptual restructuring will occur (Posner, Strike, Hewson and Gertzog, 1982). An intelligible concept is understood and internally represented by a learner. For a concept to be plausible, the learner must find it potentially believable and consistent with his or her experiences and world view. To be fruitful the learner must be aware or understand novel practical application of experiences which the new conception suggests, (Strike and Posner, 1985).

2.5 **Conceptual Change Approach and Science Teaching**

Researchers in this tradition view science learning as a complex process in which new information interacts with prior knowledge and beliefs to produce changes in the students' conceptual ecology (Posner et al, 1982; Anderson et al, 1990). Learning is seen as a process in which a person changes his or her conception by capturing new conceptions or exchanging existing conceptions for new conceptions. Schwedes and Schmidt (1991), described conceptual change as a change in the concepts nucleus. They also stated that conceptual change is not an evolutionary process taking place in small steps from one concept to another, rather it means the installation of a totally new cognition. An idea which is supported by Hewson and Hewson, (1991).

In a review of conceptual change model employed by various researchers, Hewson and Thorley (1989) also found that the prediction of status changes has been widely assumed to be the case in different instructional approaches. Hennessey (1991) for example, negotiated the meaning of intelligibility, plausibility and fruitfulness within the discourse of developing physics concepts in an elementary science classroom.

Therefore, if conceptual change is to occur the status of the new conception must rise higher than that of the already existing conception. That is, the learner understands it, accepts it and sees that it is useful. If the new conceptions conflicts with an existing conception, it cannot be accepted until the status of the existing conception is lowered.

The challenge therefore is to discover the set of experiences which are most likely to result in the students' constructing a set of understanding which is satisfactory to them and also similar to that recorded by the scientist in the past. Perhaps a key point to effective lesson plan, to effect

shift in conception will be to first identify the category of change to be effected. Dysktra (1991) made this point when he said "if we find that all conceptual change can be understood as being members of categories... and that those categories are associated with general strategies which can be initiated for each member of the category, then we could have a powerful tool for inducing conceptual change.

2.5.1 Categories of Conceptual change

The word change in itself can connote several meanings. It can either mean an extinction of a former state, an increase or decrease in the amount of something or an exchange of one entity by another. However, change in the last category seems more appropriate and to some extent the second instance too can be considered.

The first change extinction can hardly ever be realistic because hardly is there any instance that one view will completely be erased and replaced by another. At best, the students will remember both views and simply say "I changed my mind" or it made more sense. The last two are more useful, Hewson (1981) calls them conceptual capture and conceptual exchange respectively. Based on experience in the kind of change Dysktra (1991) suggested that conceptual change could be classified into:

Differentiation

Class extension and

Reconceptualization

In a similar vein Carey, (1985) described conceptual change in two possible senses. She captioned the change "knowledge restructuring" which she said could either be weak or strong. According to Carey, knowledge restructuring in the weak sense entails an arrangement of the relationship between existing concepts. In weak restructuring concepts are not changed, rather their application are extended, restricted or rearranged. Restructuring in the strong sense means changes in the concepts themselves. In Carey's conclusion, rearrangement without changes in the concept is not conceptual change.

Hewson, (1981) called Carey's strong restructuring conceptual exchange. There seems therefore to be a general concensus that whenever conceptual change is mentioned what is evoked for most people is conceptual exchange (Hewson and Hewson, 1991; Hewson, 1981; Dysktra 1991; Hewson and Hennessey, 1991). It follows logically therefore that, to teach with the intention of effecting a shift of misconceptions, invariably calls for instances of conceptual exchange or conceptual capture. The importance of the above categorization cannot be

underestimated as different categories are associated with different strategies.

2.5.2 How to Initiate and Nurture Conceptual Change

Dysktra, (1991) suggested that a student must become motivated to change by entering a state of disequilibration. The fact that certain conceptions are not changed as a result of normal instruction is due to the failure of that instruction to disequilibrate students. Disequilibration occurs when the students expectations are not met. This causes students to order the new information to make sense out of what has been found; leading to accommodation of the new idea (Purser and Renner, 1983). To achieve this, it is better to think in terms of what supports or undermines beliefs. This therefore draws attention to status consideration that influence learning, a point which has been discussed earlier in this chapter.

To determine the status of the new conception involves the following as described by Hewson and Hewson (1991).

1) Identification of representative of conceptions
2) Identify comments
3) Interpret representations and comments

On the other hand the methods of determining status include:

- non-technical interview
- non-technical classroom discourse
-technical interview
- technical classroom discourse

After disequilibrating the learner, conceptual change has to be nurtured. Nurturing involves not only heightening of students disequilibration but something more. At this stage students must be given a chance to construct their own sensible conclusion, followed by correct explanations or answers.

This calls for a classroom environment in which students are free to suggest tentative ideas and possibly test them without concern for rightness and wrongness of idea (Stofflett, 1994). Such debates might lead to each side attempting to understand the others position well enough to find "holes" in their argument.

The challenge therefore is to find a disequilibrating experience and then to nurture the resulting thinking that leads to ideas comparable to the scientists description of the world.

2.5.3 Theoretical Basis of Conceptual Change Model

Various attempts have been made to elaborate this conceptual change model of learning

(Hewson 1980; 1981; Posner 1993; Posner et al 1982; Strike 1983; Osborne and Wittrock, 1983). Appleton (1989) proposed a possible theoretical basis for guiding practice, combining aspects of several constructivist theories, notably those of Piaget (1978) and Osborne and Wittrock (1983). Researchers persuading the conceptual change model approach have borrowed Piagets notions of assimilation and accommodation to explain the process of conceptual change in learning. However, Hewson (1981) used a different term known as conceptual capture to substitute Piagets assimilation.

A learner comes to class bringing all his/her previous experience which are arranged into Schemata or mini theories (Claxton, 1990). A learning experience commences with some new encounter which the learner interprets and makes sense of in-terms of his or her existing cognitive structure.

In the process of assimilation (Piaget, 1978) the learner will perceive that the existing schemata provide adequate explanation for the experience. If there is some inadequacy, the experience cannot be fully explained leading to disequilibrium. Concerning accommodation, it only occurs if there is dissatisfaction with the existing conditions and if a new conception is intelligible, plausible and fruitful for further research. Accommodation also occurs if the following features of a conceptual ecology are at play.

1) The old idea has anomalies.

2) Appropriate analogies and metaphors are available to describe new ideas that will replace old.

3) The epistemological commitments of the individual permits thinking in the new mode.

4) The metaphysical beliefs and concept must be compatible with new ideas and

5) The relationship of other knowledge that the individual has may be relevant to or competitive with the new idea.

Suffices to say from the foregoing that many learners would therefore need assistance in accessing and interpreting new information, relevant to the experience so that appropriate modification to Schemata and links between them could be made.

2.5.4. Strategies to Promote Conceptual Change

The effectiveness of the conceptual change approach to science has been demonstrated by numerous studies (Champagne, Gunstone and Klopfer, 1985; Hewson and Hewson, 1983; Igwebuike, 1991; Nussbaum and Novick, 1982; Roth and Rosaen, 1991). Russel et al. (1989) studied childrens preconceptions in a variety of science topics with a view of preparing teaching

packages. Other studies have focused on strategies linked to specific topics (Stavy and Berkovitz, 1980; White and Horowitx, 1988; Hewson and Hennssey, 1991; Stofflett and Stoddart, 1994)

Howe et. al. (1989).reported the importance of peer discussion in facilitating conceptual change. Scott, Asoko and Driver (1991), have identified two main groupings of strategies to promote conceptual change. These are:

1) Strategies based on cognitive conflict and the resolution of conflicting perspective.
2) Strategies which build on learners existing ideas and extend them, through for example metaphor, or analogy to a new domain.

2 5 4.1Strategies Based on Cognitive Conflict and Its Resolution.

Prominent here are the discrepant events of Nussbaum and Novick, (1982a &b) and the works of Osborne and Cosgrove (1988).

Nussbaum and Novick (1982) suggested a teaching sequence which draws upon the Piagetian notion of accommodation (Piaget, 1964) and includes four elements.

- initial exposure of students preconceptions through their responses to an exposing event.
- sharpening students awareness of their own and other students frameworks.
- creating conceptual conflict by attempting to explain a discrepant event.
- encouraging and guiding cognitive accommodation and the invention of a new conceptual model consistent with the accepted science view.

Students of ages 11-13 were taught aspects of the structure of gases using this sequence. The results showed that the method successfully created cognitive challenge and motivation for learning but failed to lead to the desired total conceptual change in all students (Nussbaum and Novick 1982). They concluded based on comparison drawn from history of science that a major conceptual change does not occur...through revolution, but by nature is an evolutionary process.

This is contrary to the idea held by Schwedes and Schmidt (1991) who say conceptual change is not a step by step evolutionary process, but a complete installation of a totally new conception.

Another group of researchers based their strategy on conflict between ideas. Stavy and Berkovitz (1980) distinguished between

(1) Conflicts produced between two different cognitive structures related to certain physical reality and the physical reality.

(2) Conflict produced between two different cognitive structures related to the same reality.

They developed a strategy based on the second idea and used it on 9-10 years old children to

explore the conflict between two different representation systems that the child uses to describe temperature. Their findings indicated that training by conflict did improve childrens' understanding of the concept of temperature both in individuals and in classroom training situations. They also noted the success of the strategy in helping to develop childrens understanding of the intensity of temperature.

Osborne and Cosgrove (1985) Champagne et al. (1985) and Rowell and Dawson (1985, 1990) have developed teaching approaches which requires students explicitly to resolve differences between ideas from arrange of different sources. Osborne and Cosgrove (1985) have proposed a generative learning model of teaching. It has four phases (1) Preliminary Phase, Focus Phase, Challenge Phase and Application Phase.

11-14 years old children were taught about current flow in electricity circuits using this model. It was successful in changing pupils views from electricity "being used up" to current being conserved around the electric circuit. However, they raised the problem of stability of new ideas with regard to both time and context and suggested that, where ideas are counter-intuitive and not reinforced by other learning situations then further experiences with the topic will be very valuable.

Champagne, Gunstone and Klopfer (1985) proposed a dialogue-based strategy called ideational confrontation, specifically designed to alter students declaration knowledge within a particular domain. The authors after their studies with 2 age groups of students concluded that the method is successful in promoting change in views. They also made the point that students must be motivated and that the quality of arrangements improved over the course of instruction.

Rowell and Dawson (1988) proposed a strategy in which resolution occurs after new conceptions have been introduced. Their approach draws upon a perspective from the history and philosophy of science and equilibration theory (Piaget, 1977) and is based upon the following premises.

- a theory is only replaced by a better theory and not discarded on the basis of contradictory evidence alone.
- The construction of a better theory need not involve an immediate confrontation with the knowledge that an individual spontaneously considers relevant.
- although cognitive change involves both strategic and metastrategic knowledge (Kuhn, 1983) they need not be constructed together.

2.5.4.2. Strategies Based Upon the Development of Ideas Consistent with the Science Point of Views

Strategies within this domain build on students existing ideas. Subsequent teaching involves the student extending and developing their ideas towards the science viewpoint.

Clement et al. (1987) developed and tested an analogical teaching strategy, aimed at increasing the range of application and useful intuitions and decreasing detrimental intuitions within the field of mechanics. The strategy assumes that conceptual change can be encouraged by providing opportunities for students to build up qualitative-intuitive understandings of phenomena before mastering qualitative principles.

Experimental use of such strategies to overcome misconceptions about static, frictional forces and Neutons third law of motion have been reported as producing significantly pre-post test gains than for control group. Stavy (1991) suggested that the use of analogical relationship between the known and the unknown can help students learn new information and discard or modify misconceptions.

Neidderrer (1987) used an approach based on the new philosophy of science outlined by Brown (1997). This does not aim at replacing students theory by the scientific theory but to allow them to learn scientific concepts by learning the difference between everyday-life thinking and scientific thinking.

The researches done so far have revealed a number of theoretical issues concerning the strategies.

2.5.5. Theoretical Issues in Conceptual Changes.

Teaching irrespective of whether its conflict based or development of ideas, certain common features cut across all the strategies.

that one which stresses the importance of acknowledging the learners existing ideas and understanding, in any teaching-learning event. This process has been put into operation in various ways viz.

- through elicitation of students ideas in class
- informing and selection of starting points to teaching.
- informing curriculum design.

It could be noted in the teaching strategies that four positions about the role of conflict and its resolution can be identified.

- strategies where conflict must be recognized by the student in the early stages of teaching

if learning is to occur (Nussbaum and Novick, 1992; Stavy and Berkovitzs (1980).

- strategies where an alternative way of looking is introduced and the conflict highlighted later (Rowell and Dawson 1983).
- strategies where conflict may occur but are not seen as essential for promoting learning. Clement et al. (1987) for instance see conflict as a potentially useful motivator for learning.
- strategies which aim to avoid conflict for the student. (Stavy, 1991).

The studies also have revealed that, in the process of construction of a new scientific conceptions students are not going to adopt a new conception unless they can first represent it to themselves. In other words, they must find it intelligible. However, the way new conceptions originate and how they are made intelligible to students depends upon the teaching strategies adapted. At one extreme there are the strategies where students through brainstorming and reflection are encouraged to generate more viable conceptions themselves. They way the teacher then encourages some ideas and discourages others may give differential status to certain ideas and in this indirect way induce students into a scientific perspective.

In some more direct ways of supporting the students, some strategies carefully choose analogies which are well planned to support the construction of new conceptions (Clement, 1987).

The strategy proposed by Rowell and Dawson (1985) explicitly gives time for the construction of a new model though without saying exactly how.

In Niedderer's (1991) strategy, the teacher, drawing on the range of experiences provided for students offers an integrative way of seeing and negotiates its use with students.

In some cases for example in the work of (Twigger et al. 1991) they explicitly introduced representational devices at appropriate points in the students work.

However, it is worthwhile nothing that the construction of conception is sometimes problematic particularly in instances where the construction of a scientific model requires the establishment of a quite extensive series of concepts and inter-relationships. Although they can be constructed in bits, such complex ways of seeing may only make sense as a whole, thus presenting a complex problem for pedagogy.

Another pertinent issue arising is that of evaluation of the scientific conceptions. Scott et al. (1991) suggests that instead of evaluating new conceptions ontologically, students may evaluate them in a utilitarian way. In this case the conception is evaluated in terms of its usefulness in particular contexts.

2.5.6. Demands Placed by Conceptual Change Teaching on Teachers

The teacher is required to be aware of students:

- ideas and understanding relating to the topic under consideration.
- likely conceptual path ways for that topic, and
- be sensitive to students progress in learning
- be able to generate learning tasks to support and encourage that progress in learning.
- be sufficiently confident in his/her own understanding of the subject topic to be able to appreciate and respond to differing points of view.
- be able to organize and manage a classroom which will allow for all of this to happen.

on students

The strategies involve lots of discussion, so this places many demands on the students, including the need to listen to construct meaning for and evaluate the points of views of others. Students, disagree, negotiate and finally come to a concensus.

2.6 Gender Related Differences and Science Learning

Narrow participation of girls in school courses of science and technology as well as the low number of women who hold a professional career in science or technology are well known and documented phenomena (Lockhead et al. 1985; NAEP report, 1981;). This has necessitated the formation of projects such as GIST (Girls into Science and Technology) and WISE (Women in Science and Engineering) that have occupied themselves with ways of making science more attractive to girls.

Many studies have reported small but consistent differences between the performance of males and females on science achievement tests (Comber and Keeves, 1973; Hueftle, Raskow and Welch 1983; Mullis and Jenkins, 1988; NAEP, 1978).

The initial investigations of sex differences in achievement by Keeves (1973) using the FISS data suggested that girls consistently performed less well than did boys in mathematics and science. In addition, Kelly (1978) found that girls have less favourable attitudes toward science than did boys.

It also seems that girls who do choose to learn science prefer subjects that are different from those favoured by boys. In their studies, Entwisthe and Duckworth (1977); Jungwirth (1973) and Tamir (1975) have shown that while boys are more oriented towards the so-called hard sciences (Physics, Chemistry) girls prefer the soft subjects such as human physiology plant life, and zoology.

Perhaps this explains the results of studies by Sherma who noted that fewer girls take advanced science and mathematics and elect science. Maccoby and Jacklin (1974) suggested that sex differences are not evident until ages 12-13 but thereafter boys mathematical skills increase faster than girls. Halpern (1986) claimed that the findings that males out perform females in tests of quantitative or mathematical ability is "rubust", whereas Benbow and Stanley (1980), 1983) on the basis of data from the Johns Hopkins talent quest, characterized sex differences in achievement in mathematics as "sizable", "substantial" "large", "huge", and "remarkable".

In contrast to the above claims, Hyde, at al (1990) noted that the differences between boys and girls in mean scores on mathematical test, typically is small relative to the extent of variability in scores within each sex.

This was confirmed by a measurement unit conducted by Hyde et al. (1990) which revealed not only that differences in mathematical achievement between boys and girls were slight but suggested that boys are advantaged less now than they were in the past. Further sex differences were not uniform across all aspects of mathematics (Pattison and Grieve, 1984).

Similarly, Howe and Doody (1989) observed that sex difference in science favouring boys was documented "so often and so well that it was not an artifact of testing or testing procedures" a conclusion which applies to Nigerian samples (Bajah, 1979; Jegede and Okebukola, 1990).

Linn and Hude (1989) noted that sex differences for science process are not as great as for science knowledge and appear related to learning opportunities both inside and outside of schools. When science knowledge is distinguished from science process, sex differences purportedly occur only on science knowledge (Hueftle, Rakow and Welch, 1983; Zimmerer and Bennett 1987).

Assessment of science in British Columbia have revealed that boys outperform girls on physical science questions and on high-level questions (application, analysis, synthesis) whereas girls do as well as, or better than boys on questions in Biological sciences and on lower-level(knowledge, recall, comprehension) questions (Hobbs et al. 1979; Taylor, 1982). Work reported by Haggerty (1987) and Atkin, 1979 cited in Walding et al, (1994) also implicates a process difference. Akin for instance assessed the performance of students in organic chemistry test at Cornwell University and found that males performed better on questions dealing with novel problem solving but not with questions requiring recall of factual informations.

Jegede and Okebukola (1990) revealed in one of their studies that male students made greater reduction in anxiety level when the concept of nutrition in green plants and respiration in cells were tested. Studies by Ajewole (1990, 1991) revealed that irrespective of the teaching method

used boys achieved significantly better than girls. From the foregoing it can be said that sex differences in science is a reality. This difference in performance has been attributed to a variety of reasons including social, personal interest, study areas, teacher instructional factor and special abilities.

Lawson and Bealer (1984) on trying to elucidate the relation among development learning and acquisition of basic reasoning skills found a significant association between the kind of science courses that students have selected and their level of cognitive development.

Another possible explanation for gender scores may be that tests used favoured one gender or the other because of the extraneous characteristics in the individual items. As Linn and Hyde(1989) have pointed out...gender differences are not homogeneous across test questions.

Sudweeks and Tolman (1993), in a study of Empirical versus subjective procedures for identifying Gender Differences in science test items, concluded that both judgmental and statistical procedures provide useful information and suggested that both be used in test construction.

Young and Fraser (1994), attributed gender differences in science achievement to the school. They concluded that school effects were very powerful in explaining gender related differences.

Since learning involves internal cognitive process for learner, it is possible that 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 order questions and praised them for quality work and girls for neatness. Sadket and Sadker (1985) noted that male students received more praises and criticisms from the teachers than the female students.

Another reason advanced for the sex differences in science learning was advanced by Tobin and Gallagher (1987b). They observed from their study that teacher asked and expected certain students (mainly boys) to provide appropriate answers. 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.

Shemesh (1990) suggested that gender related differences could be attributed to reasoning skill. Many studies (Graybill, 1975; Howe and Shayer, 1981) have shown that girls are surpassed by boys in their level of performing Piagettan-like formal reasoning tasks. Shemesh, (1986), in a survey of student's cognitive development in Israel, found that gender related differences in performance of Piagetian-like tasks were not abundant before the ninth grade (14-15 years).

Others have also attributed gender-related differences to interest in content area (Ormerdod

and Duckworth, 1975; Shemesh, 1990).

According to Tracy sex-related differences could be related to three areas namely social, educational and personal. Social factors included sex-role mode, sex-role orientation and stereotyping. Educational factors included parents, teacher peer expectation, classroom and extra curricular activities.

Different teaching strategies too have been found to cause sex-related differences in science performance. 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 method 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 expository and discovery method.

The above findings from varying research works seem to reveal that there are differences in students achievement. The studies have focused on several contributing factors to this observed difference, while some are for the ascribed factors, others are against showing that explanations for gender-related differences in science achievement and learning may be inconclusive.

Since this study aims at developing a teaching strategy aimed at shifting students misconceptions and improving upon understanding and achievements in biology, it is hoped that the strategy will contribute its quota in minimizing gender related differences in science learning.

2.7 Attitude and Science Learning

Attitude plays a major role in students learning (Gardner, 1975; Mukherjee, 1978; Ajewole, 1991). Infact the science attitude of both classroom teachers and students has long been recognized as a major factor in the achievement of goals of modern science programmes in school.

The remarkable changes in science education in Africa in general and Nigeria in particular have resulted in a reappraisal and reorientation of science instructional objectives and classroom teaching strategies in schools. Today most of our newly developed science programmes lay emphasis on the following broad objectives.

(I) Development of mental and physical abilities that would enable pupils to cope adequately with problems in school and in community.

(II) Inculcation in the pupils the spirit of inquiry and scientific mode of thinking.

(III) Exposure of the pupil to scientific experiences that could ultimately help them in

developing scientific attitude and skills.

The achievement of these objectives depends largely on many factors the most important of hich is the students attitude towards science (Odunusi, 1988). According to Towse, 1983) :veloping positive attitude towards science in ones student is a goal for which every science acher strives.

The term attitude has been variously defined. Moore and Sutman (1970) defined attitude as opinion or position taken with respect to a psychological object in the field of science. Gagne 977) defined attitude as an internal state that influences the personal actions of an individual. ukherjee (1978) noted that attitudes are organized through experiences and impart a direct fluence upon the individual. Comb asserts that attitudes are regular of all behaviour. Attitude, terest, appreciation are all terms used to describe what educators call the affective domain.

Ezenwa, (1993) considered attitude to refer to ones feelings, thought and predisposition to :have or respond in some particular manner. According to Mukherjee (1978), attitudes are best :pressed when individuals make statement about their feelings or opinion. The learners attitude a subject is influenced by both internal and external factors (Alao, 1985), some of which must satisfied before attitudes are changed. The internal factors include individual skill and certain nount of relevant information that learner already possess about the concept to which the new titude will be directed. External conditions on the other hand are mainly human models appeal which the object attitude is applicable.

Bajah, (1986) remarked that attitude is an important outcome of science teaching. For the titude which an individual has influences to a considerable extent his learning of science and his se of scientific information, (Ajewole, 1991). Also for a person to be scientifically literate emands that the person develops a positive attitude toward science.

Ever since the realization that the instructional strategy could affect performance of students id attitude, several studies have been carried out to study this relationship. Some of such studies ive revealed the potency of certain strategies in improving students attitude towards science. His udies supported the view of Ngwagu (1976), which asserted that attitude must be learned and ay be modified by later instruction.

In some studies along this line, Ajewole (1991) investigated the effects of guided discovery id expository instructional methods in the attitude of students to Biology. Their results revealed at students taught using the guided discovery strategy, had significantly more favourable attitude biology than those in the expository group. However, the study revealed no significant

was found to have direct effect on science achievement (Schibeci 1981).

Towse (1983) carried an investigation to find out if new science courses could improve students attitude towards science using two groups of students. The results revealed that both boys and girls were very interested in science teacher. This seem to corroborate the suggestion of Ormerdod and Duckworth (1975) that girls interested in science are more likely to be influenced by their science teachers than boys.

Although MacMillan and May (1979) have suggested that good grades are not important to a liking of science, Eisenhardt (1977) has amassed very substantial evidence to show that improved achievement precedes positive attitude change. Similarly in the study of Towse (1983) the attitude which correlated the most significantly with science performance was interest.

There however, seems to be no reported study (to the knowledge of the researcher) on the influence of conceptual change strategy on attitude. Perhaps, this can be explained by the newness of the innovational strategy.

But in view of the powerful influence of attitude on science learner, the researcher finds it necessary to determined the potency of this instructional strategy in developing students positive attitude towards the learning of science. It is hoped that the study will bring out some valuable data.

2.8 Retention and Scientific Conceptualization

The relevance of retention in acquiring scientific concepts cannot be overemphasized. Science teaching and learning in school will foster scientific and technological revolution only if students are able to acquire fully, scientifically validated conceptions, principles and attitudes as personal activities and experiences; while the activities promote problems-solving in everyday life. Consequently, the appropriation of science learning that will aid these ideas must transcend memorization, coming into the realms of mastery learning (Oriaifo, 1987).

Although the concept of retention sometimes conjures the idea of memorization and rote learning, retention actually connotes mastery learning. That is, over learning which according to Pinsent (1989) implies "carrying on the learning process well beyond the critical stage of bare achievement". Yet this, cannot be feasible since there is increasing evidence in literature to show that several fundamental science concepts are being misconceived by students. (Okeke and Wood-Robinson; Okebukola, 1990). Hence the search for suitable learning approaches which encourage understanding in science and ensures both application and productivity must be pursued with utmost vigour and determination.

Very few works have been done on retention of scientific conceptions. In one such studies Ozsogomonnyam (1978) revealed that students taught using an active package strategy learned significantly more cognitive content and performed better on retention tests.

Oriaifor (1987) tested the incidence of retention among secondary school students who learn concepts in chemistry through the instructional package method and those who studied the same content through the regular classroom instruction techniques. He used a pretest-post test and control group plan. The results showed that all the subjects were homogenous at the point of entry, but that retention of knowledge was better among students who used the instructional package.

It is thus, hoped that an instructional package as this used in the present study, structured to improve upon status of the scientific conception, will enhance mastery and consequently, retention of such conceptions.

However, it has been noted that generally, studies on retention confirm that forgetting is a function of time and that much of the material learnt is usually forgotten within a short time after learning.

The view expressed by Pinsent (1968) and confirmed by research studies of Edward & Scanned (1960); Opeala, (1981); Oriaifo, (1987) and others corroborate the position taken by McGeoch and Irion (1952) to the effect that retention is better when the degree of original learning is high hence its relevance to the present studies.

2.9 Summary

The concepts of photosynthesis and respiration are crucial to a biologist's understanding of many aspects of the living system. Yet several studies have shown that teachers perceive the topics as difficult while students hardly understand them. Other researchers still have revealed numerous misconceptions students hold about these concepts. Unfortunately, very little has appeared in the literature detailing how these misconceptions can be changed. Where attempts have been made, they are largely in the physical sciences and other topics in biology.

Current science instruction is predominantly traditional in approach and consequently offers little opportunity to remedy these misconceptions. By this method, as reviewed in section 2.4, meaningful learning is hardly achieved. This is largely because traditional teaching approach does not probe into the learners' preconceptions and as such has no remedial effect on the commonly held misconceptions.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

To effectively tackle the research hypotheses, and ensure that the research objectives are met, instruments had to be drawn up, pilot tested and administered to an appropriate sample.

This section therefore, incorporates a description of the research design, and procedure. It gives a detail account of the construction of the research samples as well as the procedure for administering the instruments.

The procedure for analysing the accumulated data is also mentioned.

3.1. Research Procedure

The study was carried out in two phases as described below.

(i) Identification of misconceptions: The identification was done using diagrams and open ended questions. (Appendix 3.5.) The details of these are discussed in section 3.7. (Research instruments).

(ii) Teaching to effect conceptual shift:- This strategy is grounded in the constructivist theory of learning. The task here was to discover the set of experiences which were most likely to result in the student's constructing new sets of understanding which are very similar to those recorded by scientists. This was done because, it is believed that understanding cannot be transmitted but must be built by the individual learner. According to Pope and Gilbert (1983), significant learning is likely to occur only if the facts to be learned are construed by the learner as having personal relevance.

Consequently situations were created where students questioned their beliefs, got caught up in explanatory incoherences and eventually engaged in a process of changing these beliefs.

3.2. The Study Population

The study population was all the SSS1, Biology students in Benue State of Nigeria. The state comprises of three educational zones, each made up of six local governments. The total number of accredited schools was 232.

3.3. Sample and Sampling Procedure

As earlier mentioned, the study was carried out in two phases. The first phase was the stage of identifying students misconceptions. Data were collected from 340 students from eleven schools in the state. The names of the accredited schools for each of the three educational zones in Benue State were identified through the help of the state Teaching Service Board. By the use of stratified random sampling, the following types of schools were selected: 2 boys secondary schools; 2 girls secondary schools, and 7 co-educational secondary schools. It was not possible to use equal number of single-sex schools to co-educational schools because, the proportions of these schools to one another in the state are not the same. Out of the 232 accredited schools 199 are co-educational; 13 girls and 20 boys. A table of the distribution of school types, according to the educational zones and number of students drawn from each school is shown in table 3.1.

TABLE 3:1 Distribution of Schools Involved in Identification of Misconceptions

ZONE	NAME OF SCHOOL	STATUS	NO OF STUDENTS WITH COMPLETED FORMS
A	Bristow Sec. School Gboko	Co-education	21
	Govt. Girls College. Makurdi	Girls	40
	ECWA Secondary School Makurdi	Co-Education	26
	Tofi Memorial Grammar School Yandev	Co-Education	30
B	Govt. College Katsina-Ala	Boys	30
	Divine Love Sec. School Katsina/Ala	Girls	30
	Jato'Aka Com. Sec. Jato' Aka	Co-Education	30
C	Ujor Memorial College Otukpo	Co-Education	29
	Igede Comm. Sec. Sch. Okileme	Co-Education	30
	Govt. Sec. Sch. Oju	Co-Education	29
	St. Francis College, Otukpo	Boys	45
Total	11	11	340

For the second part of the study, four schools were randomly selected within Makurdi town. The BCAT was administered to SS1 Students of each of the schools. The scores were

subjected to a t-Test analysis, choosing a pair of school in each case. No significant difference was recorded between the mean scores of Government Secondary School North Bank and Padopads Harmony Secondary School (t=0.2473, P<O. 05). All other pairs showed significant differences in their performance (Appendix 3.4). Consequently, the two schools that showed no difference in mean scores were used for the study. Thirty six SSS1 student of Government Secondary School, (GSS), North Bank, served as the experimental group while Thirty seven PHSS High Level students were the control group. The choice of the separate schools was to avoid interaction between the two groups which would have otherwise led to reduction in the effect of the treatments.

3.4 **Research Design (Matched Group Design)**

The pre-test-post test design was used. The pre-test was first administered to the students after which they were exposed to their respective instructions. The control group was taught using the traditional method, while the experimental group was taught using the conceptual change instructional strategy. At the end of the treatment period, the post test was administered to both groups of students to evaluate the effectiveness of the treatment in remediating misconceptions. Both pre and post tests were the same. The design could be represented as follows

Control group	-	Q1	X1	Q2
Experimental group	-	Q3	X2	Q4

Where

X1 Traditional Instructional method

X2 Conceptual change instructional strategy

Q1 & Q3 - Pretests measurements

Q2 & Q4 - Post tests measurements

The design is preferred because of its many advantages, some of which include the following:

(1) It gives an indication of the superiority, if any, of one teaching strategy relative to the other

(2) It gives an indication of the concept attainment ability or understanding gained by students following teaching treatment for particular concepts.

(3) Scores obtained from the pretest can be used to statistically control for any differences between the groups at the beginning of the study.

(4) In this design, there is the assumption that any difference in the performance of the groups is due to the treatment used, since uncontrolled variables act equally on both i.e. its explicit consideration of external validity factors.

(5) It allows reasonable examination of incidence of retention in terms of test scores in achievement tests against the principal independent variable, i.e. teaching strategy.

3.5 Selection of Concepts Taught

The concepts, photosynthesis and respiration were used for the study. The choice of these concepts were motivated by a number of reasons:-

(i) They constitute areas of highly perceived difficulty in biology and are often poorly understood by students.

(ii) They are judged to be critical in the understanding of several of the organizing conceptual schemes of the discipline, including energy flow in the natural systems, and metabolic activities such as digestion, circulation and excretion (Stofflett, 1994).

(iii) These topics are taught at the secondary schools (both JSS and SSS) and University level and in a wide range of courses and contexts.

(iv) An understanding of these two concepts is a prerequisite for any systematic understanding of ecology, as food chains and food webs begin with photosynthesis and end with respiration.

(v) Inspite of their circular importance and the central role they play in a biologists understanding of most of the living systems, true understanding of the concepts consistently eludes students. Several studies (Abimbola, 1984; Soyibo, 1988) have revealed that majority of students hold important misconceptions about the concepts of photosynthesis and respiration in a variety of populations, both age wise and geographical wise. (Anderson et al., 1990).

3.6 Research Instruments

The instruments used comprised the following:

(a) **Instructional Instruments**

(i) Conceptual change instructional strategy

(ii) Traditional instructional method.

(b) **Measurement tests**

(i) Biology misconception test on photosynthesis and respiration.

(ii) Biology concept achievement test (BCAT)

(iiia) Biology attitude questionnaire (BAQ)

(IIIb) Attitude towards conceptual change instructional strategy

3.6.1. The Instructional Models

3.6.1(a) The Conceptual Change Model

The conceptual change instructural strategy was developed based on the model proposed by Posner et al. (1982). The Central Commitment in their model is that learning is a rational activity. Furthermore, they opined that learning is fundamentally coming to comprehend, and accept ideas because they are seen as intelligible and rational. Hence, for a student to abandon one framework for another, four conditions must be met.

These conditions are:

(a) The student must be dissatisfied with existing conceptions. He must have lost confidence in the ability of the existing conception to solve new problems.

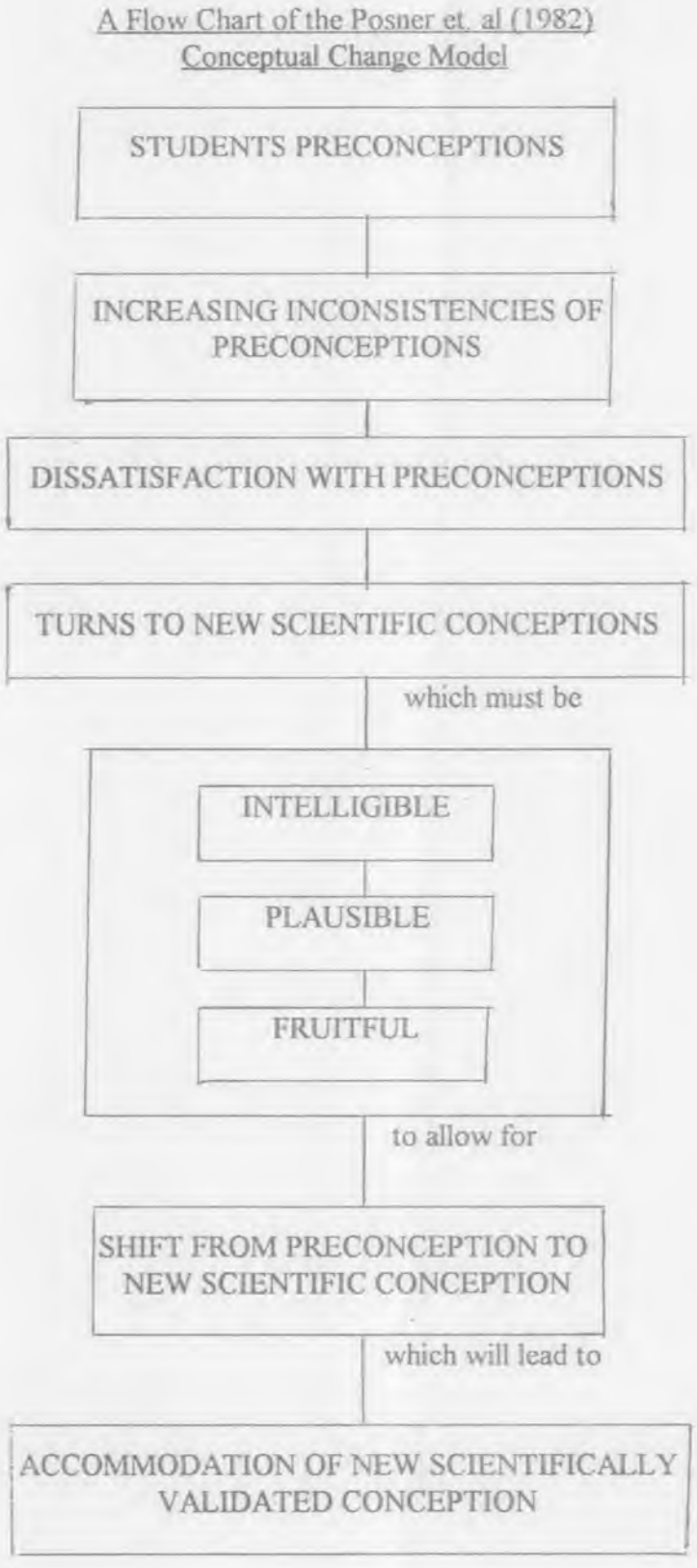
(b) The new conception must be intelligible,

(c) It must be plausible and

(d) Fruitful

The flow chart for the model is shown in figure 1.

Figure 1:


A Flow Chart of the Posner et. al (1982) Conceptual Change Model
STUDENTS PRECONCEPTIONS
INCREASING INCONSISTENCIES OF PRECONCEPTIONS
DISSATISFACTION WITH PRECONCEPTIONS
TURNS TO NEW SCIENTIFIC CONCEPTIONS
which must be
INTELLIGIBLE
PLAUSIBLE
FRUITFUL
to allow for
SHIFT FROM PRECONCEPTION TO NEW SCIENTIFIC CONCEPTION
which will lead to
ACCOMMODATION OF NEW SCIENTIFICALLY VALIDATED CONCEPTION

3.6.1.(b). A Teaching Strategy Sequence for effecting conceptual change Based on the model proposed by Posner et al. (1982).

In science education, the issue of knowledge restructuring is embodied in conceptual change teaching models. These argue for the implementation of instructional strategies which seek to ameliorate differences that exist between students theories and meanings of scientific concepts and scientists memories (Scitman & Clement, 1990).

In developing the strategy for this study, the four conditions proposed by Posner et al. were used as a guide. The strategy was organized into a five phase teaching sequence namely:

(1) Awareness or Orientation phase/Introduction

(2) Disequibrium/Elicitation of ideas.

(3) Reformative phase

(4) Application phase

(5) Evaluation and review phase.

Figure II, gives a flow chart of the teaching strategy in question while Appendices 3.1a - c give lesson plans based on this model. (see page 52)

(i) **Awareness Phase:-**

The phase involved experimental and clarification "Manoeuvre" aimed at enabling students to recognize the existence of conflict. During this phase one or many of the following things were done-

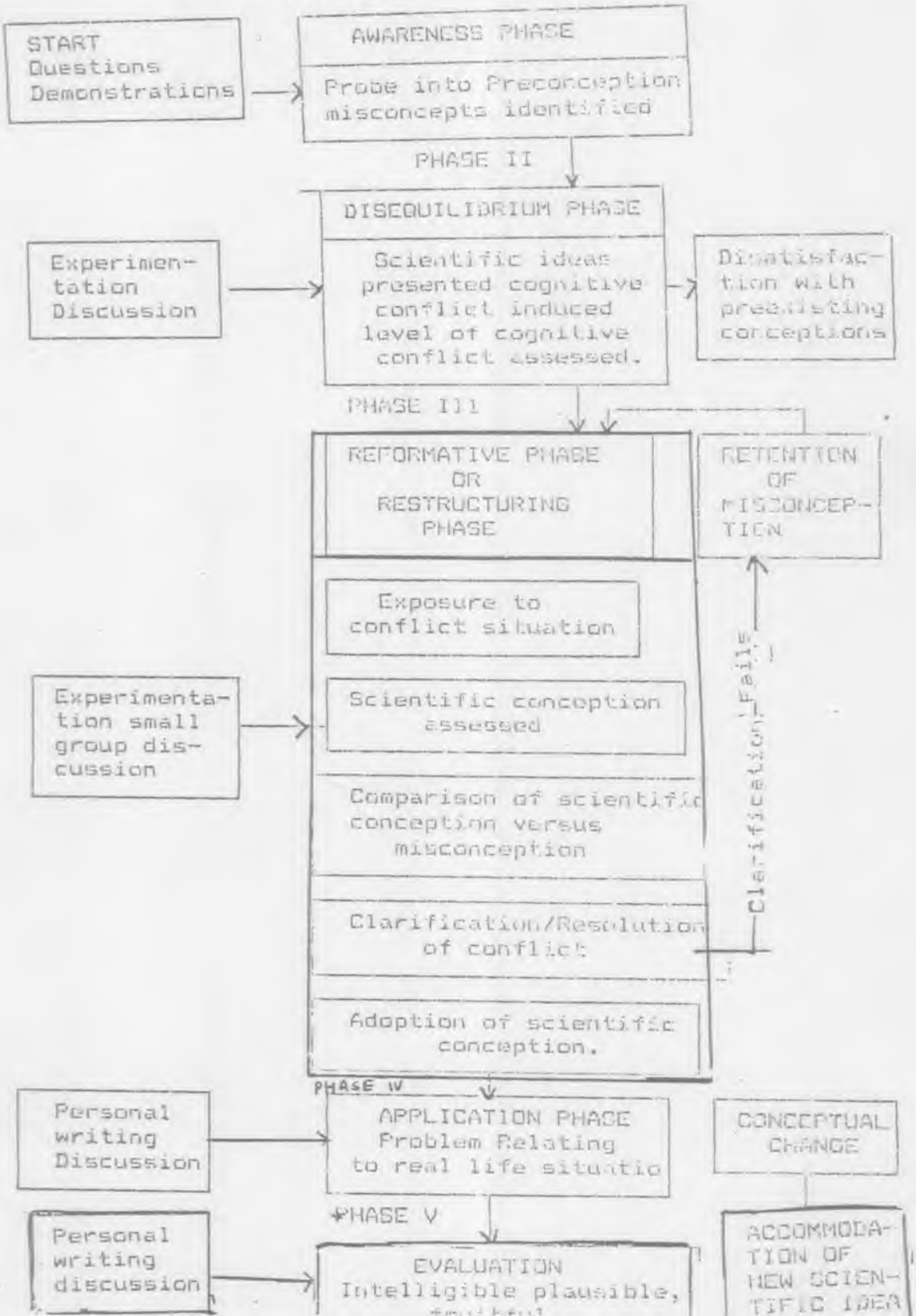
- relevant questions from the pretest were asked and answers written out-students were allowed to either carry out experiments or explore the phenomenon in question through small, group discussions. - students were asked to make their conceptions explicit where brainstorming questions were used.
- During exploration, focussing questions were asked. These guided students to observe or discuss their conception which some times were contrary to their own beliefs. This could naturally lead to a "cognitive conflict".

(ii) **Disequilibrium Phase.** It was expected that through exploration students would encounter some new information which could lead to disequilibrium. So students were allowed to test the validity of their existing ideas either through experimentation or works-sheets. More brainstorming questions were asked and some theoretical explanations offered re-emphasized.

Figure II, gives a flow chart of the teaching strategy in question while Appendices 3.1a - c give lesson plans based on this model.

FIGURE II

ILLUSTRATIONS OF INSTRUCTIONAL EVENTS



(iii) **Reformative Phase** Here the teacher helped or led the students to reduce their conflicts situations by reinforcing the appropriate scientific conceptions. All the while, results were discussed, new conceptions were discussed vis-a-vis the previous conceptions written out and copied on the board - a move aimed at generating dissatisfaction with the pre-existing conceptions and making the scientific one plausible. Further discussions, or practical work were done where there was need to bring up major reconceptualization, extending or modification of students ideas. The teacher acted as a facilitator providing relevant information or questions needed to lead students thinking towards the scientific descriptions.

(iv) Application phase: Opportunities were given to learners to

-explain novel phenomena using new conceptions

-solve some problems or

-give examples of phenomena in their real life situation.

(v) Evaluation: Students were allowed to compare their initial ideas with those currently held. Also questions were asked to determine their status of the new constructed idea.

Sometimes, the reformative phase had to be repeated to make ideas clearer. It is also noteworthy here that these stages are not stereotyped. Sometimes, some misconceptions could be elicited at the reformative stages while some disequilibration can even occur during the awareness phase as students respond to questions.

3.6.2 Traditional Instructional Method

As a measure against which to compare the effectiveness of the conceptual change instructional strategy, one set of students was taught using the traditional approach of science teaching. This set constituted the control group. Specifically, the lecture and demonstration methods were employed, to effect conceptual change. The lessons were planned based on the demands of the SSS1 Biology curriculum (Appendix 3.2)

3.6.2(a) Lecture Method.

This involved verbal presentation of ideas about the topics photosynthesis and respiration. The students listened and took down notes as the lecture went on. At intervals, the students were asked questions, and they were allowed to ask questions where they had doubts or where they did not seem to understand.

3.6.2(b) Demonstration Method:

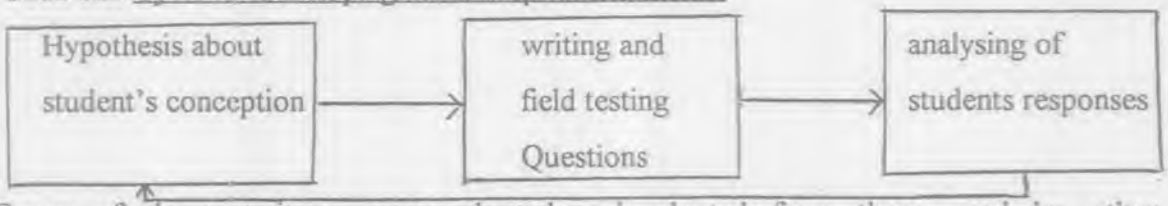
Demonstrations implies the act of displacing something. When the need arose the researcher

set up experiments to demonstrate any of the topics that was in progress, either on photosynthesis or respiration.

3.6.3 **Misconception Tests on Photosynthesis and Respiration**

This test was designed to diagnose the misconceptions that students hold about the concepts of photosynthesis and respiration. Initially 18 test items were prepared by the researcher. The pattern of construction of the test items followed the cycle prescribed by Anderson et al. (1990) as shown below. The test is included as appendix 3.5

FIGURE III: Cycle for developing misconception test items.



Seven of the test items were adopted and adapted from those used by other researchers.(appendix 3.5b) Generally the test items were drawn from; respiration, food, energy, and photosynthesis. The questions were meant to test the students understanding of

(a) definition of respiration

(b) definition of photosynthesis

(c) Definition of food/sources of food

(d) Sources of energy for plants and animals

(e) Relation between photosynthesis and respiration

(f) Respiration in plants and its relationship to photosynthesis.

Validation of test items: The technique used for validating this test was the same used for all other instruments. The test items produced, along with the scheme of work outlined for these concepts were given to some secondary school biology teachers. Thereafter they were taken to three biology lecturers in A.B.U. Zaria and four science educators one from B.S.U. Makurdi and three in A.B.U,. who evaluated the instrument for accuracy, clarity and level of phrasing. A set of scientifically acceptable propositions judged to be critical to a complete response of each task was provided and evaluated too (Appendix 3.6). The final test items were selected following the suggestions of Noll et al. (1979), who suggested that items to be selected must have been judged as appropriate by 80-100 per-cent of judges. The final test included 13 open ended questions, two multiple choice questions and two diagrams. The instrument was then pilot tested, as described in section 3.7

3.6.4. **Biology Concept achievement test**

This test was constructed specifically to measure students misconceptions and also to test their understanding and level of retention of the concepts. The items of the test were developed based on the scheme outlined for these concepts in the biology SS1 Syllabus and also on the identified misconceptions. On the whole, 40 multiple choice items constructed were validated positive and consequently used for the test. Each item had 5 options. Students responses in the misconception test on photosynthesis and respiration together with the related concepts, formed the basis of a conceptual inventory from which these options were selected. Each item therefore has one correct option and four distractors which were basically students misconceived ideas except of distractors of questions 5,14,21,32,35 and 38. The items were also constructed to cover the different levels of intellectual demands (Bloom's et al. 1971). However, synthesis and evaluation were termed "higher order" (H) while knowledge and comprehension levels were termed "lower order" (L) bringing the levels to four namely, lower order, application (Ap), analysis (An) and higher order.(appendix 3.7). An arrangement of this sort gave an insight into the students understanding of the concepts and the prevailing level of misconceptions. The Facility indices (F) and the Discrimination indices of the items were determined after pilot testing of the instruments as described in section 3.7.

Items with high discriminative indices. $D > 0.3$ and high facility indices, $40<F< 70\%$ and judged by 80% - 100% of experts as appropriate were selected. In all, 40 items were finally selected. (Appendix 3.7).

The reliability coefficient computed using odd-even split half method stepped up by Spearman Brown prophecy formula was 0.85.

3.6.5. **Biology Attitude Questionnaire (BAQ)**

The attitude test was adopted and adapted from Skurnik and Jeffs (1970) science attitude questionnaire and modified to suite the study at hand. Consequently, all attitudes referring to science in their question were changed to refer to biology in the present BAQ. In some instances, two items were merged to give one item in the BAQ. 66 items were initially produced. The items reflected an overall attitude towards biology, but covered these areas of greatest concern to students and teachers of biology. The areas included.

(I) interest

(II) difficulty

(III) influence of teacher

(IV) Social implications and

(V) attitude towards conceptual change instructional strategy.

(I)-(IV) were classified after Tweser (1983) while (V) was the researcher's addition. The students were expected to respond on five point scale devised by Likert, (Bloom, 1971):- strongly agree (SA), agree (A), not sure (NS), disagree (D), and strongly disagree (SD). Not all the statements were positive in nature. Some were the reverse-type or negative type. An example of a negative type item is" biology does more harm than good". The discrimination and facility indices were determined for each item of the test as described under section 3.7.2. Items with D > 0.3 F > 40 and F < 66 were acceptable. The reliability of the instrument calculated using the odd-even split half technique was 0.75. Validation of the instrument was done by four science educators, one sociologist and a language expert. After this exercise the items were reduced from 66 to 30. The options bore the weightings of 4.3.0. 2, and 1 for SA, A, NS, D, and SD respectively for positively skewed items and the reverse for items that are negative in direction. Final test, items are shown in Appendix 3.8.

3.7 The Pilot Study

Pilot studies were conducted at various stages of the work. However, the same school (GDSS) was used each time. The main purposes for the pilot studies were to determine

(a) the feasibility of the study through a trial run

(b) the appropriateness of the instruments:

The steps taken to assess the acceptability of the test items and the appropriateness of the instrument included:

(a) facility index and

(b) discrimination index

The facility index: Percentage of all respondents who make the correct response to the item. This was given by

$$F = \frac{R_u + R_L}{2N} \times 100$$

Where

R_u - Number among the upper 27 percent of respondents who scored item correct.

R_L - Number among lower 27 percent of respondents who scored item correct.

N - Number of respondent in each of the upper and lower 27 per cent.

Discrimination index. It was calculated for each item and for the whole test.The fomular is

$$D = \frac{N_H - N_R}{n}$$

where

N_H - Number of respondents giving the desired response in the upper 27%

N_L - Number of respondents giving the desired response in the lower 27%

n - 20% of all respondents in the sample.

Oyebanji (1978); Shuaibu (1979); Otuka (1986) and Inyang (1988) used the 27% proportion for their studies and argued that 27% provides the best practical compromise between making the extreme groups as large as possible and making them as different as possible.

(c) the appropriate timing for administration of tests and questionnaire

(d) the reliability coefficient of the tests instruments

(e) the discrimination and facility indices of instruments.

Based on the results obtained from the pilot studies, the following amendments were made.

(1) The misconception test was now produced on two sheets of papers to provide space for answering the questions

(2) Some of the questions of the misconception test were rephrased. For instance question 3 now reads "Describe respiration" instead of "how would a biologist describe respiration". Question 12 now read "explain the relationship among the following sets of terms" instead of "try to write sentences explaining the relationship". Also a number of the items were rephrased in one form or the other.

(3) The attitude test items were reduced from 53 to 20 and a section for attitude towards teaching strategy included.

(4) It was also discovered that there was the need to explain some of the words in the attitude questions before students could respond diligently.

3.8 Procedure for Administration of Research Instruments and Collection of Data

3.8.1 Administration of test for identificatin of misconceptions

All the tests, questionnaires and the teaching instruments were administered by the researcher personally. The main reason for this is that the conceptual change strategy is not well-known by most teachers in the schools involved. As such teachers if taught the strategy for the purpose of this research, might easily abandon it mid stream and when they get stocked somewhere and return to their traditional didactic method of teaching. Furthermore this also allowed for uniformity and consistency of treatments that was given.

During the administration of the misconception tests thirty-SS1 students were randomly selected from all the SS1 arms in the selected schools except in St. Francis College and Government Girls College, where intact classes were used because the other students were occupied and not available respectively. Three hundred and fifty five students participated in the test, but only three hundred and fourty had complete answers The incomplete answer sheets comprising 15 subjects were discarded.

3.8.2 Experimental treatment.

At the beginning of the experimental treatment, the researcher was introduced to the students by the class teacher in both schools. In each case, the teacher asked the students to co-operate with the researcher.

The questionnaire and the BCAT were administered a week before the students were exposed to their respective instructions. The researcher used this week too, to create rapport with the students while at the same time doing some revision of previous related work, (characteristics of living things). Thereafter, the conceptual change group was exposed to a series of four, two and half hours laboratory work and discussion periods. Each session started off with brain storming questions aimed at eliciting and highlighting the existence and nature of competing view points. The 36 students were then shared out into groups of 4 or 5 students each: and allowed to explore the phenomenon in question, through practical activities and small group discussion. During the exploration, students were asked focussing question which led them to observe/discuss the experiences illustrating particular conceptions and at the same time providing counter experiences from their naive memories. Such discrepant ideas stimulated the students to articulate inconsistences and discrepancies between the event under observation and their own frameworks. The students were allowed time to discuss their results and the team leaders given room to present and answer questions on their final decisions. Important decisions

from each group were written on the board; while the cardboard captioned: OUR IDEAS ON ...(TOPIC in question) was posted on the walls. The researcher then emphasized the correct theoretical explanations, resulting from the discussion of results. This was aimed at reinforcing the appropriate scientific conceptions and possibly changing students' misconceptions. The students were then asked to criticize their previous ideas as recorded on the board, suggest alternative explanations and compare them with their previous ideas. The new ideas, were tested against the scientifically acceptable ideas to nuture the resulting thinking towards scientific descriptions, possible to bring about re-conceptualization. This exercise in some instances generated disatisfaction with pre-existing conceptions and plausibility for new conceptions. However, in instances where the misconceptions still persisted, more counter experiences and further discussions were advanced. The students were then given opportunities to explain novel phenomenon using the new conceptions. They also solved some problems and answered some questions aimed at determining the status of their newly constructed scientific conceptions. Students of the lecture group were exposed to approximately (eleven) hours of lecture. (40 minutes lecture for 4 periods per week for 4 weeks). A pre-test was administered to them a week before the lessons commenced and the post test a week after the end of the lessons.

On the whole 78 students were involved in this second segment (54 boys 24 girls). However not all were used for analysing of results. Only results of those students who were consistent in all three tests were considered. Students of both control and experimental groups were given the same test as a post-post test a month after the date of the post-test, to determine the level of retention of the concepts. The scores obtained from these tests, and the responses from the questionnaire provided the data for testing the hypotheses stipulated.

3.9 **Treatment of Data**

3.9.1 Misconception Test

The purpose of this test was to explore, identify and document the description of students misconceptions about photosynthesis and respiration.

Consequently, the test results were not scored rather the frequencies of occurrence of the naive conceptions were noted, and used as distractors in the construction of the Biology concept achievement test.

Furthermore, the misconceptions were classified according to the class bounds within the conceptual change domain. These include (1) class differentiation (D)

(2) Class extension (F)

(3) Conceptual reconceptualization (R)

3.9.2 Biology Concept Achievement Test (BCAT)

Each item of the test was scored one point, with the maximum point being 40 marks. The performance, the degree of misconceptions held, and the retention ability of students both prior to, and after the instructions were compared based on the scores obtained. Gender-related differences were also computed within and between groups.

3.9.3 Biology Attitude Questionnaire (BAQ)

The responses of each of the likert type scale questionnaire was scored as follows:

-Strongly agree (SA) 4: Agree (A) 3: Not Sure (NS) (0),

-Disagree (D) 2 and Strongly Disagree (SD) 1, Negative items were scored in the reverse order. The scores obtained were used to compute and compare student's attitude towards biology both before and after treatment and between treatments.

3.10 Analysis of Accumulated Scores

(1) Descriptive Statistics

The descriptive statistic used were (a) mean, (b) standard deviation (a) median and point estimates. Mean and standard deviation were calculated for the pretest, post test and post-post test scores of the BCAT. The calculations were done for boys only, girls only, boys and girls combined for both control and experimental group.

Median and point estimates were calculated for the total scores of BAQ as well as for the attitude subscales for boys, girls and boys and girls combined for both control and experimental groups. These statistic were also calculated for boys and girls combined, boys only and girls only, from the experimental group for their scores of attitude towards the conceptual change instructional strategy. Frequency and percentage were done for the misconception test.

(ii) Inferential Statistics

The inferential statistics used to test the different hypotheses where appropriate were

(a) "t"-test

(b) Mann Whitney U Test

(c)Pearson correlation coefficient..

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 **Introduction**

In this chapter the analysis of data and the results obtained from them are presented. The discussion of the results are also contained in this chapter.

4.2 **Identified Misconceptions**

For conceptual change studies, the important aspect of student learning is the alternative conceptions that students bring to science instruction. Students use their prior knowledge (misconceptions inclusive) to attempt to make sense of the instructions that their teachers provide. Consequently students' misconceptions had to be identified for purpose of this study. In order to identify students' misconceptions about the concepts of photosynthesis and respiration, the question

> "what fundamental misconceptions do SS1 students hold about the concepts of photosynthesis and respiration?" was addressed by the researcher.

To this effect therefore, students' responses were compared with validated scientifically correct responses, (Appendix 3.6), (which had been written out by the researcher and validated by experts in the field). Based on this comparison, the following misconceptions were identified and categorized under different classes meant to address different issues of students understanding of the concepts. The categorization also followed the pattern advanced by Dykstra (1990), as shown in table 4.A. Appendix 4.1

TABLE 4.A Classification of Some Identified Misconceptions by the Students

Ideas being tested	Categories of conceptual change domain		
	Class extension (B)	Differentiation (D)	Reconceptualization (R)
Definition of photosynthesis	-Green plants turn sun and CO_2 into chlorophyll - Plants take in CO_2 from air and exchange it with Oxygen - Inappropriate relationship between sunlight food and photosynthesis (60%)	-Other functions of sunlight -Other functions of chlorophyll 20%	-Plants get, absorb food, not make food. -Photosynthesis is plants form of respiration. 20%
Definition of respiration	-Oxygen replaces CO_2 in cells -Respiration is related to photosynthesis in terms of food but not energy -Process by which living things take in Oxygen (33.3%)	-Breathing -air in, air out -Confused respiration with digestion -Confused respiration with gaseous exchange. 53.3%	_Exhaling CO_2 for human and exhaling O2 for plants -Plants don't respire 13.3%
sources of Energy for plants and human beings	-Inappropriate relations between Respiration, Energy & Food. -Mainly misconceived forms of energy 22.2%	-Gets energy by process of photosynthesis 66.7%	-Plants get energy from the soil with help of the root. 11.1%
Definition and Sources of food for plants and animals	-Incorrect and incoherent definitions -Food for plant as absorbed from the soil (62.5%)	-Confused idea of different classes of food. (25%)	-Food for plant defined as nutrition which burns in air to produce energy. (12.5%)
Note:- See Appendix 4.1 for full details of misconceptions within each idea and class bound, Table shows example of each category			

Ideas being tested	Categories of conceptual change domain		
	Class Extension (B)	Differentiation (D)	Reconceptualization (R)
Relationship between photosynthesis and cellular respiration	-Difficulty in explaining other sources of CO_2 -Inability to explain energy conversion during photosynthesis and respiration. (21.4%)	-Plants undergo cellular respiration but different from us 21.4%	-Alternate role of oxygen -Alternative sources of energy. -Plants don't respire 57.2%
Application of knowledge of photosynthesis and respiration	-Mere description of bacteria distribution -Incoherent responses. (30%)	-Misconceived experiment to be light and dark phases of photosynthesis -Alternative function of chlorophyll. -Alternative role of light in experiment 70%	

Note: See Appendix 4.1 for full details.

Misconceptions are wrong explanatory knowledge or any conceptual idea a student holds that differs from the commonly accepted scientific consensus. The results on table 4.A revealed that the students had a poor understanding of the concepts of photosynthesis and respiration, which resulted into various types of misconceptions.

Approximately 80% of these misconceptions, fell within the conceptual classification known as differentiation and class extension (Dykstra, 1990) while 20% fell within the class bounds of conceptual Reconceptualization (Table 4.A, Appendix 4.1). Misconceptions falling within differentiation and class extension demand for real restructuring. Restructuring in these instances involve the arrangement of relationships between existing concepts. Concepts are not changed but their applications are extended, restricted or rearranged. In differentiation new concepts emerge from existing more general concepts, while in class extension existing conceptions are found to be cases of one broader notion. Conceptual reconceptualzation on the other hand demands for strong restructuring, which involves changes in the conceptions themselves. Here there is a significant change in the nature of and relationship between conceptions.

A good number of students viewed respiration as synonymous with breathing while some confused it with gaseous exchange. Most of them too failed to distinguish between aerobic and anaerobic respiration and most often considered air to be synonymous with oxygen. Student generally provided a common language definition for respiration. A finding that is in line with those of (Anderson et al; (1990); Songer and Mintzes (1994). The idea that plants do not respire and that plants give up oxygen while animals give up carbon dioxide was very common.

One significant alternative idea that pervaded the students' understanding of photosynthesis was their lack of understanding of the role of sunlight in the process. In giving answers to the question"do plants and animals need energy?. Almost all the students said yes. However a good number of them failed to understand that plants obtain energy from only one source - the sun. Consequently students mentioned alternative sources such as: air, soil, fertilizer as sources of energy for plants. The role of chlorophyll in photosynthesis was not well understood. Students were also of the opinion that photosynthesis is the plants form of respiration and as such they most stated that plant do not need oxygen. Students took all the essential factors of photosynthesis to be synonymous with raw materials of photosynthesis.

Generally students showed lack of understanding of certain basic concepts like food and energy which are fundamental to the understanding of photosynthesis. The major trend was an attempt to reproduce the definition of photosynthesis or give fragments of the equation for photosynthesis. The students responses showed that they had a poor understanding of the concept. Students also failed to understand the relationship between respiration and photosynthesis.

From the foregoing it can be concluded that students coming into SS1 harbour lots of misconceptions

about the concepts of photosynthesis, and respiration (table 4.A & Appendix 4.1). These tend to impede their understanding of these concepts at higher levels. Also, lack of understanding of certain basic concepts like food, energy and its sources also tended to impede their grasping of these concepts.

4.3 Effects of Instructional Strategies

This section addresses the second part of the work. Here the students were taught the concepts of photosynthesis and respiration for 10 hours each. One group, the control was taught using the traditional instructional method and the other (experimental) was taught using conceptual change instructional strategy. The data collected was used to test the nine hypotheses, as described below:-

4.4 Pretest Performances of Experimental And Control Groups

Results of the analysis of pretest scores for the experimental and control groups are shown in Table 4.1.

Table 4.1 Performance of experimental and control groups in pretest

Test	Group	N	X	SD	t-value
Pre-Test	CG	37	8.95	2.81	0.64**
	EG	36	9.44	2.62	

**. Not significant, $P<0.05$, CG = Control Group, EG = Experimental group.

The result indicates no significant difference between the control and experimental groups in their pretest scores ($t=0.64$; $P<0.05$). This implies that students of both groups were equivalent in terms of their prior knowledge on photosynthesis and respiration at the point the investigation commenced.

4.5 Comparing The Effectiveness of Conceptual Change Instructional Strategy And Traditional Instructional Method in Improving Performance

$H0_1$ There is no significant difference in performance between groups taught using conceptual change strategy and traditional instructional method.

To test this hypothesis the data collected from the BCAT post test scores from both groups were analyzed using the t-test as shown in table 4.2.

Table 4.2 Comparison of Post test means scores of experimental and control groups.

Test	Group	N	X	SD	t-value
Post Test	CG	37	11.89	2.46	9.36*
	E.G.	36	20.44	4.97	

P≤0.5, *=Significant; E.G. - Experimental group, CG Control group

The statistical analysis of the post-test mean scores as shown in table 4.2 revealed that the experimental group differred significantly from the control group following treatments ($t=9.36$, $p<0.05$). Based on this analysis, the null hypothesis was rejected. This result showed that the experimental group performed significantly better than the control group. The indication from this is that the conceptual change instructional strategy was more effective than the traditional instructional method in remediating misconceptions and improving students understanding of photosynthesis and respiration. (Appendices 4.2 & 4.3) show that students in the experimental group retained fewer misconceptions than these in the control group, after instructions.

4.6 **Gender Related Differences in The Performance of Subjects**

$H0_2$ There is no significant differences in the performance of boys and girls taught using the conceptual change instructional strategy and traditional instructional method.

To determine whether the performance of boys and girls differed following respective treatments the pretest and post test mean scores by gender category were subjected to t-test and the results shown on table 4.3.

Table 4.3 Comparison of pretest and post test mean scores of control and experimental groups by gender category

		PRETEST				POST TEST			
Group	Gender	N	X	SD	t-value	N	X	SD	t-value
CG	Girls	10	9.10	2.3		10	12.70	2.83	
					0.21**				1.21**
	Boys	27	8.88	2.28		27	11.59	5.43	
EG	Girls	11	10.23	1.6		11	21.23	3.39	
					2.03**				0.91**
	Boys	25	8.88	2.83		25	20.12	5.43	

CG - Control Group, E.G. - Experimental Group, **= not significant, P≤0.05

The results showed that there was no significant difference in the post test mean scores obtained by boys and girls using the respective strategies. Similarly there was no significant difference in the pre-test mean scores obtained by boys and girls of the control groups. The pretest mean scores of girls in the experimental group was very high compared to that of boys.

However the difference was not significant. The null hypothesis was therefore not rejected.

From the results, one could deduce that

(I) boys in the conceptual change instructional strategy group benefitted more than girls in the same group though the difference was not significant.

ii) the use of conceptual change strategy in remediating misconceptions was useful to both boys and girls though boys were favoured more.

4.7 Performance Per Respective Instruction

$H0_3$: There is no significant difference between the mean scores of students in Biology concept achievement-test (BCAT) before and after respective instructions.

To determine the performance of students after treatment was administered, the data was subjected to t-test analysis and the results shown on table 4.4 below.

Table 4.4 Comparison of pretest and post test mean scores of the respective groups.

	PRETEST			POST TEST			
Group	N	X	SD	N	X	SD	t-value
CG	37	8.95	2.81	37	11.89	2.46	4.80*
EG	36	9.44	2.62	37	20.44	4.97	11.75*

CG - Control Group, EG. - Experimental Group, *= significant, $P \leq 0.5$

The results of the t-test analysis revealed a significant difference in the performance between pre and post-test mean scores of students in both control and experimental groups. Based on this result the null hypothesis was rejected.

The implication of this result is that both strategies improved the students knowledge of the concepts of photosynthesis and respiration. However the conceptual change instructional strategy tended to be more effective in remediating misconceptions than the traditional instructional method as revealed in table 4.5a below and Appendix 4.2

Table 4.5a

Frequency and Percentages of Misconceptions Held by Both Control and Experimental Subjects Before and after Treatments.

		"F" of Misconceptions within				Difference between Pre & Post	"F" with S.A	
Group	Test	R	E	D	TOTAL		TOTAL	
CG	Pre Post	386(32)	255(30)	366(30)	1007(83)	100	213(17)	93
		318(26)	231(19)	358(30)	907(75)		306(25)	
EG	Pre Post	339(30)	237(21)	310(28)	886(79)	311	234(21)	382
		180(15)	158(13)	237(20)	575(48)		625(52)	

CG - Control Group, EG - Experimental Group,R -Reconceptualization,

E - Class Extension, D - Class Differentiation, F - Frequency, SA - Scientifically Accepted ideas.

From table 4.5a it is apparent that more students (75%) retained misconceptions after the control treatment than with the experimental treatment (48%). Whereas the percentage of students holding misconceptions dropped from 79.0% to 48% in the experimental group, those of the control group dropped from 82% to 74%.

Further analysis using chi square statistics (table 4.5b) revealed no significant difference between the frequency of students' holding misconception before and after traditional instruction treatment. However, there was a significant drop on the frequency of students holding misconceptions in the experimental group.

Table 4.5b

Frequencies of Misconceptions and Scientifically Correct Conceptions Held by Students Before and after Treatment for Both Groups and Corresponding Chi Square Tests.

	Pre test frequency of		Post test frequency of		
Group	M	S.A	M	S.A	X^2
CG	1007	213	907	306	2.64**
EG	886	243	575	625	13.15*
X^2	0.61**		8.43 *		

$P \leq 0.05$, **= Not significant; * = Significant

M - Misconception

SA - Scientifically accepted

x^2 - Chi square

CG - Control Group

EG - Experimental group

The frequency distribution and chi square analysis of the pretest scores revealed that there was no significant difference in the frequency of students holding misconceptions in both control and experimental groups (table 4.5b x^2=0.61 P≤0.05). Analysis of post test frequency revealed a significant difference in the frequency of students holding different types of misconceptions between control and experimental group (x^2 = 8.43, P ≤ 0.05). This finding suggest that the frequency of occurrence of misconceptions among students still remained significantly higher in the control group than in the experimental group.

It is thus evident from the result that the conceptual change instructional strategy appears more effective in remediating misconceptions, compared to the traditional method.

4.8 **Retention**

$H0_4$ There is no significant difference in the level of retention of concepts between groups taught using conceptual change strategy and traditional method.

To determine the retention ability of students of both control and experimental groups the means scores of post post test of both groups were subjected to a t-test and results shown in table 4.6.

Table 4.6 Comparison of the Performance of Experimental and Control Groups in the Retention Test

Test	Group	N	X	SD	"t" value
Post Post test	CG	37	9.27	2.64	10.98*
	EG	36	17.88	3.96	

KEY EG - Experimental group P≤0.05

CG - Control group

* - Significant differ

From the t-value in table 4.6 it can be seen that there was a significant difference in the comparison of the post post mean scores of control and experimental group (t=10.98, P≤ 0.05). Based on this analysis, the hypothesis was rejected. This implies that the students in the experimental group retained more knowledge of the concepts of photosynthesis and respiration

than those of the control group.

4.9 Retention by Gender Category

HO_5. There is no significant difference in the level of retention of concepts between boys and girls in the control and experimental groups.

The null hypothesis seeks to determine whether the level of retention of concepts had any gender-related differences. To determine this the post and post post test mean scores of boys and girls in the two groups were compared using t-test statistic. The results are shown below.

Table 4.7 Performance of Gender Categories of Experimental and Control Group in the Retention Test.

		POST TEST			
Group	Gender	N	X	SD	t- value
CG	Boys	27	9.56	2.49	1.08**
	Girls	10	8.50	3.14	
EG	Boys	25	17.76	4.37	0.23**
	Girls	11	18.17	2.37	

CG - Control Group, E.G. - Experimental Group, **=not significant. $P \leq 0.05$

There was no significant difference in the mean score of post-post test obtained by boys and girls using the two strategies. The null hypothesis is therefore not rejected. The indication of the results is that the level of retention of concept is independent of gender irrespective of the method used.

4.10 Attitude Towards Biology

HO_6 There is no significant difference between the attitude of students taught using the conceptual change instructional strategy and traditional instructional method towards Biology. The BAQ scores were subjected to Mann Whitney U test and the results are shown on table 4.8a and 4.8b.

Table 4.8(a) Comparison of Students Attitude Scores to Biology Between Experimental and Control Groups.

Attitude Subscale	Group	N	Median	W	P.E	U
Interest	CG	37	16	1387.5	0.00**	0.45
	EG	36	16			
Difficulty	CG	37	8	1709.5	3.00*	0.000
	EG	36	10			
Teacher	CG	37	18.0	1552.0	2.00*	0.02
	EG	36	20.0			
Social Implication	CG	37	14	1609.5	2.00*	0.0022
	EG	36	20.0			
Total Attitude	CG	37	37	1682.5	4.00*	0.0001
	FG	36	36			

P≤0.05

**- Not significant

CG - Control group

EG - Experimental group

PE - Point Estimate for ETA 1 - ETA 2

* - Significant

There was a significant difference in the attitude to biology between students of experimental and control group. The attitude subsets as defined in the study, namely interest, Difficulty, Teacher Influence and Social Implication were also analyzed. All the subsets except interest were significantly different between groups. The highest differences were recorded in the difficulty subset, followed by social implication and the least was the teacher influence. The null hypothesis which states that there is no significant difference in the attitudes towards biology between the two groups was thus rejected.

This shows that the conceptual change strategy improved, student's attitude towards biology compared to traditional instruction method. This is supported by further analysing pre-attitude and post attitude scores of experimental group as shown on table 4.8.b.

Table 4.8b.

Mann Whitney U Values of Pre and Post BAQ Test Scores for Experimental Group

Attitude Subscale	BAQ Test	N	Median	Point Estimate	W	U
Interest	Pre	36	16	0.996**	1219.0	0.289
	Post		16			
Difficulty	Pre	36	8	2.500*	1072.0	0.0065
	Post		10			
Teacher influence	Pre	36	18	-2.99*	1035.0	0.0017
	Post		20			
Social implication	Pre	36	14	-2.99*	1014.0	0.0008
	Post		16			
Total Attitude	Pre	36	55	-8.00*	890.0	0.000
	Post		63			

* - Significant

** - Not Significant

It can be observed from the table (table 4.8b) that the use of the conceptual change strategy significantly improved the attitude of the students. It however appears that interest was not significantly improved.

The observations from tables (4.8a & b) suggests that the conceptual change instructional strategy significantly improved the attitude of students over the traditional method.

4.11 **Performance and Attitude**

HO_7 There is no significant relationship between students performance in the Biology concept achievement test and their attitude following instruction.

The responses of the students in the control and experimental groups to the BAQ test and their post test means scores were used in testing this hypothesis. The frequencies of the responses of the students to BAQ in both control and experimental groups after instructions are contained in Appendix 4.4 and 4.5 respectively. Table 4.9 shows the correlation between the students attitude to biology and performance in the post BCAT. Coefficient of determination is indicated in parentheses.

Table 4.9 Pearson's Correlation Between Attitude to Biology and Performance in Bcat after Treatments for Control and Experimental Groups.

BCAT Performance for the group	N	STATISTICAL TEST	ATTITUDE SUBSCALE				Total BAQ score
			Interest	Difficulty	Teacher influence	Social implications	
CG	37	r	.28	.45*	.24	.29	.386*
		r^2	(.08)	(.20)	(.295)	(.085)	(.15)
EG	36	r	.41*	.18	-.15	.11	.15
		r^2	(.17)	(.03)	(.02)	(.01)	(.02)

* - Significant

CG - Control group

EG - Experimental group.

The correlation between the performance and attitude (BAQ) to biology as a whole was significant (at $P \leq 0.01$ level) for control group and not significant for experimental group. For the subscale, the correlation was significant with ($P \leq 0.01$) for control and interest for experimental ($P \leq 0.05$). The rest were not significant. From the table, the results seem inconclusive.

Further computation using coefficient of determination (figures in parenthesis) showed that whereas only 2.0% of student's performance in the experimental group was accounted for by students attitude towards biology, 15% was responsible in the control group. This suggests that one of the reasons why students performed well in the BCAT for control group compared to experimental was because of their positive attitude towards the subject.

4.12 **Attitude Towards Conceptual Change Instructional Strategy**

Hypothesis (08)

There is no significant difference between attitude of Boys and girls to the teaching of biology using conceptual change instructional strategy .

4.12.1 Evaluation of the Approach Used in Teaching of Biology.

The frequency and percentages of students responses to the questions aimed at diagnosing their attitude towards the approach is shown in table 4.10.

Table 4.10 (a) the Frequency of Responses of Students to the Attitude Towards Conceptual Change Strategy Questionnaire.

	Statement	SA	A	NS	D	SD
The approach the Teacher used in teaching biology during the past week has						
21)	Helped me to be more active in class	26 (72.2)	10 (27.8)	0	0	0
22)	given me opportunity to apply knowledge gained in biology lessons to my daily activities	22 (61.1)	13 (36.1)	01 (2.8)	0	0
23)	made biology topics more difficult to understand	1 (2.8)	0 0	2 (5.6)	5 (13.8)	28 (77.8)
24)	So much exited me that I would prefer to be taught biology with that approach only as from now on	14 (38.9)	15 (41.7)	2 (5.6)	1 (2.8)	4 (11.1)
25)	Increases my reasoning ability	22 (61.1)	13 (26.1)	1	0	0
26)	Been the worst I have ever experienced since this school	2 (5.6)	2 (5.6)	4 (11.1)	5 (13.8)	23
27)	made the lesson boring	0	7 (19.4)	3 (8.3)	1 (2.8)	25 (69.1)
28)	helped me to see a lot of biology/science activities which goes on in the home.	24 (63.9)	12 (33.3)	0	0	0
29)	made biology lessons more lively and interesting	25 (69.4)	11 (30.6)	0	0	0
30)	made me score lower marks than	2 (5.6)	0	2 (5.6)	5 (3.8)	27 (75.0)

It can be seen from the percentages that most students agreed that the conceptual change instructional strategy increased their interest, (63.9%) encouraged their involvement in the class

activities, (72.2%) created anxiety for the lesson in the students and made them maintain good grade scores (75%). Most of them also agreed that the approach improved their reasoning ability,(61.1%) made biology less difficult(77.8%) and helped them to be able to apply knowledge gained in biology classrooms to their daily activities (61.1%).

4.12.2 **Gender related differences in the approach**

Table 4.10b

Mann Whitney U Value for Attitude Towards Conceptual Change Instructional Strategy by Gender Category.

Gender	N	Median	W	PE	U
Boys	25	36			
			4560	-0.0006*	0.84
Girls	11	36			

Note: * = significant, $P \leq 0.05$

There was a significant difference between the attitude of boys and girls towards the conceptual change approach. Thus, the null hypothesis was rejected. This indicates probably that attitude towards the strategy is sex - related being more in the favour of boys.

4.13 **Relationship between retention and performance**

$H0_9$ There is no significant correlation between retention and performance in the biology concepts of photosynthesis and respiration for students taught using the conceptual change strategy and those taught using the traditional approach.

Table 4.11 Pearson Correlation of Performance and Retention of Boys Only, Girls Only and Boys and Girls of Both Control and Experimental Groups

GROUP	Category	N	Post test	Post Post	r	r^2
	Boys	27	11.59	9.56	0.46 *	.21
CG	Girls	10	12.7	8.5	0.58 *	.33
	Boys & Girls	37	11.89	9.86	0.45 *	.20
	Boys	25	20.12	17.76	0.74 *	.54
EG	Girls	11	21.73	18.17	0.65 *	.42
	Boys & Girls	36	20.44	17.89	0.72 *	.52

$P \leq 0.05$, * = Significant

CG - Control Group

EG - Experimental Group

Results of the post test and post post test scores for both groups were used for the correlation to test for this hypothesis.

An examination of the table 4.11, shows significant correlation between retention and performance, in both control and experimental groups, and for the gender categories too. The highest correlation was between retention and performance for boys ($r = 0.74$, $P \leq 0.01$) of the experimental group; followed by Boys and girls of same group ($r = .72$, $P \leq 0.01$) and girls alone for the same group combined ($r = 0.65$, $P \leq 0.05$). The lowest correlation was for girls and boys of the control groups ($r = 0.45$, $P \leq 0.01$). As can be seen from the table r-values vary from 0.045 to 0.74. Based on this result, the hypothesis was rejected.

Further computation using coefficient of determination indicated that over 54% of the level of retention in the experimental group for boys and 52%for boys and girls combined could be accounted for by their performance in the post test. Whereas only 20% of that of the boys and girls combined, and 21% of boys in the control group could be attributed to their performance. Despite the superiority of the conceptual change strategy over the traditional method, in the correlation between performance and retention, r-values for both groups were significant (control $r = 0.45$, Experiment $r = 0.72$). The hypothesis is therefore rejected.

4.14 Discussion

4.14.1 Misconceptions Addressed

Effective teaching in the conceptual change domain relies on the teacher having some understanding of students viewpoints. However in the teaching of science in schools, it would appear that few teachers pay attention to, and make use of the personal experiences and spontaneous reasoning of students (Pope and Gilbert, 1993). For students to understand any concepts they must construct their own meaning through cognitive assimilation of the phenomenon into their existing notions, or by accommodating the existing notions to make more powerful assimilation framework (Driver and Easely, 1978; Nussbaum and Novick, 1983) some of which are not congruent with scientific ideas. According to Nussbaum and Novick (1983) these preconception, misconceptions inclusive, have a crucial role in determining the longevity and qualitative content of what is learned and remembered. Pines (1977) has shown that when misconceptions are not uprooted, they may become even more elaborate and stable as a result of instruction.

The diagnostic test and even the pre-test revealed an array of misconceptions that the students hold about the concept of photosynthesis and respiration. The most crucial of the identified misconceptions were those that bordered around the nucleus of these concepts. In expressing their understanding of respiration and photosynthesis, students said amongst others that;

- photosynthesis is the plants' form of respiration
- plants exhale oxygen while animals exhale carbon dioxide
- plants' do not respire
- plants get or absorb food from photosynthesis, sunlight, water, etc.
- plant get energy from soil.....

These misconceptions give the concept each a different identity altogether. These results are in line with those of Wandersee (1983) and those of Songer and Mintzes (1994). These misconceptions fall within the bounds of conceptual reconceptualization and they demand for installation of a totally new cognition.

Another alternative idea that pervaded the students understanding of photosynthesis was their lack of understanding of the role of sunlight in the process of photosynthesis. Most of them showed faint ideas about the major function of sunlight as energy source in the process of photosynthesis. Also a good lot of them confused the role of chlorophyll in absorbing sunlight energy and converting same to chemical energy. Instead chlorophyll was seen as a by-product of the process or attraction of sunlight. Many students mentioned that plants make food through

the processes of photosynthesis, but at the same time described photosynthesis as plants' form of respiration. As a consequence most of them haboured the idea that plants don't need oxygen rather they need only carbon dioxide. Not even a single student made mention of the idea that carbon dioxide from the plant can be recycled. The common notion was that carbon dioxide used for photosynthesis must came from the atmosphere.

The role of sunlight energy and chlorophyll as essential factors in whose presence, the raw materials of carbon dioxide and water will be converted to carbohydrate was seldom mentioned by the students'. Rather they did mention water, Carbon dioxide, sunlight energy and chlorophyll as raw materials for photosynthesis. This findings lends credence to the finding of Ryman (1974) who found that many children considered sunlight as a reagent in photosynthesis along with carbon dioxide and water.

Also it was not uncommon to find students who defined food using the common, everyday language. Attempts at defining food were rarely correct but showed fragments of acceptable biological definitions. The correct biological definitions (chemical and functionally) were seldom mentioned. Most students defined food as substances that plants like animals take in from their environment.

It has been confirmed that the school science definition of food, as organic compound, which organisms can use as a source of energy for metabolic processes is not consistently used even by science teachers Eisen and Stary (1988). Students tended to define the concept depending on the context in which it is being used, but none ever mentioned that food material serves as a substrate for respiration. The misconceptualization of the concepts of respiration and food could probably have arisen from the mixing of attributes of these concepts and/or everyday life usage of the concepts. Anderson et al (1990) suggested that the prevailing misconceptions about respiration and food could be as a result of the fact that students definition conformed with normal English usage which is not acceptable for scientific usage. Bell (1985), reviewed the work of many scholars and concluded that a universal and very persistent intuitive conception in all groups is that plants get their food from their environment while roots are organs of feeding. Some on the other hand appear to believe that plants have numerous sources of food (Roth and Anderson, 1985).

The prevailing misconceptions about these photosynthesis and respiration identified in this study could be linked to the lack of understanding of supporting concepts like energy; forms of energy and sources of energy. This probably explains why students recognized the importance of sunlight in photosynthesis, yet failed to grasp its role as an energy source. This is further

supported by the answers students gave to question 5 in the diagnostic test "where do you think the plant gets its energy from?". Most of them who encircled sun still circled other distractors. Similarly when asked to mention human sources of energy students gave more than just food or food types but went on to mention other things like exercise and air. This finding is supported by those of Barker, 1985; 1986; Roth et. al. (1985).

One other reason for the existence of these misconceptions, could be attributed to rote learning. Tasker (1981), found that students tended to consider each lesson as an isolated event, while the teacher assumed that the students appreciated the connecting link between the lesson and the previous learning experience among others. Secondly, students knowledge structure against which learning materials were considered, were frequently not the same as the teacher assumed.

Apart from the rote learning it has been confirmed that most teachers teaching the students are not qualified (Akpan, 1984).

It is appropriate to summarize therefore that,

students hold numerous misconceptions about photosynthesis and respiration.

4.14.2 **Effects of Teaching Strategies**

In this section the results presented earlier in this chapter are discussed. A part from the questions used to identify students misconceptions, nine hypothesis were tested in the study..

Teaching Strategies and Performance

The analysis for pretest scores of students in both groups showed that there was no significant difference ($t=0.6361$, $P\leq0.05$) between them. This implied that the two groups were equivalent in terms of their prior knowledge on photosynthesis and respiration at the point the investigation commenced. However, after treatment results, (table 4.2,) showed that the experimental group performed significantly better than the control group though the performance of students in both groups improved significantly after their respective instructions were given them.

One may deduce from this result that the conceptual change instructional strategy was more effective than the traditional method in improving students understanding of photosynthesis and respiration. It is also to be noted that even though the conceptual change instructional strategy was used for the first time and within a limited period of time, the students from the experimental group still performed significantly better than those of the traditional instructional method group. This means that the conceptual change instructional strategy actually facilitated students understanding of the concepts more compared to the traditional instructional method. The superior performance achieved through the conceptual change instructional strategy is in

agreement with earlier findings of (champagne et al; 1991; Nussbaum, 1982, Stofflett, 1994).

A salient issue raised by the results is the significant improvement obtained by both control and experimental groups after respective instructions. Rather than the experimental obtaining a significant improvement and the control having no significant improvement, they both improved significantly. This however does not water down the efficiency and superiority of the conceptual change instructional strategy over the traditional method. The conceptual change strategy was designed to foster theory building while at the same time taking cognizance of the belief systems held by students. The target of course was to remediate or shift the misconceptions existing within the student cognitive framework, and to create suitable subsuming models so that meaningful learning can take place. The traditional method on the other hand, imparted facts to the students which they could use to pass the teacher's test. This of course could have given the students enough knowledge to advance a little off the starting point. However, this result also shows that the traditional method has displaced some misconceptions albeit to a point.

Moreover, in considering the frequency and percentages of students harbouring various misconceptions after their respective instructions. (Table 4.5 and Appendix 4.3), it could be realized that students of the control consistently had more misconceptions than their counterparts in the experimental group (table 4.5a appendices 4.2 & 4.3). This result is consistent with those obtained by Gunstone et. al. (1992) who studied conceptual change on Grade 10 student and have a very clear evidence of change in mechanic concepts for most students. Upon further analysis using chi square (table 4.5b) it was also evident that students having misconceptions after being taught with the conceptual change instructional strategy was significantly reduced. Whereas there was no such significant reduction in the control group. On the whole, the students in the control group still selected significantly higher misconceptions than those of the experimental group. This brings to focus the fact that the conceptual change strategy is more effective in remediating misconceptions than the traditional method. The implication of this is that students in the experimental group performed better as a result of progressively changing their conceptual schemes, rather than accumulation of bits of information or facts derived from the teachers' notes as the case with the student in the traditional method group. Probably the conceptual change strategy, enabled the students to become dissatisfied with their preconceptions thereby creating room for them to accept, assimilate and accommodate the scientifically valid ideas. The traditional method did very little in displacing misconceptions already existing in the students repertoire. thereby making learning less meaningful and productive. The superiority of the conceptual change strategy group could also be explained in terms of the fact that, the approach

allowed students to disagree, negotiate and come to a consensus. This led them to have a deeper clearer and more meaningful understanding of the concepts. This knowledge in a clear and meaningful form could have contributed to the shift from unscientific to scientifically valid ideas which was reflected in their performance. This result is in agreement with findings of Stavy (1991) and Lagoke (1992). Lagoke used analogies and showed significant pre-post results. Stavy on the other hand used conceptual change strategies to overcome misconceptions about static, frictional forces and Newton's third law of motion and reported significant pre-post gains.

4.14.3 **Retention and Teaching Strategies**

The experimental group, performed better than the traditional group ($t=10.98$, $P\leq0.05$) in their post post test scores. This implies that the conceptual change instructional strategy enabled the students retain more knowledge of the concepts than the traditional instructional method. The mean scores were 17.88 for conceptual change group and 9.27 for the traditional method group. The implication of this is that the students of the control group retained significantly less knowledge of the concepts. It could also be that the traditional method simply helped the students to pass their examinations, leaving them with poor retentive knowledge of what they had learned thereafter. Yager (1993) supports this idea when he concluded after his studies that students taught using the traditional method learn principally for testing which usually result in short retention.

The superiority of the conceptual change strategy over the traditional instructional method in enhancing students retention ability was further demonstrated by the t-test analysis of post-post test scores ($t=10.9787$, $P\leq0.001$). This gives an indication that the students in the conceptual change group choose fewer misconceptions than their counterparts in the traditional method group, since the approach gave the students room to explore the plausibility of their preconceptions vis-a-vis the scientific conception. Furthermore, it could be that since the students viewpoints were not ignored, but rather modified or built upon, the students found the scientific conception to be more intelligible plausible and fruitful and so could retain the concepts more. It could also be that the brainstorming exercise that characterized the discussion period created many route for remembering. Moreover during such exercises many students were caught up in their own inconsistency and inability of their own ideas to explain scientific concepts. In addition since the model encouraged an interplay of thought and action and also developed the ability of creative and reflective thinking which together could enhance retention more.

However, there was an overall deterioration in performance overtime. The drop is consistent with other results such as Musen and Reisman (1990), Ezenwa, (1993), Otuka, (1986). The

had attributed this dropping off of retention scores to interference. This is most likely to happen when incentives to encourage retention are lacking. In this study students were not informed of any further testing and as such did not make any deliberate attempt to remember. Therefore, since no deliberate efforts were made by the students at studying and maintaining information, there was an increase in mediation which manifested in the reduced, though not significant mean scores of experimental retention test. The high loss by traditional group could be attributed to the fact that ideas learnt were seen as isolated from one another.

4.14.4 Relationship Between Retention and Performance

The result presented in Table (4.11) show a high correlation between the performance and the retention test scores, for all groups and for all the sexes involved. The highest correlation was obtained for correlation between retention and performance scores of the experimental group while the lowest was recorded for the control group.

The correlation values are with intuitive expectation as a high score in the performance test is likely to be accompanied by a high score in the retention test, except there is an interference during the retention interval. This probably explains why the lowest r-value (table 4.11) can be comparable to the lowest mean value of the post performance test (table 4.6 $\bar{x}$ for control post post = 9.27). While the highest r-value corresponds to the highest mean value of post-post scores for the experimental group (table 4.6, $\bar{x}$ for EG = 17.88).

The implication of the result is that students who performed very well after being taught with the conceptual change instructional strategy retained more of the scientifically valid conceptions, long after they were taught, despite interference. The slightly higher correlation of boys over girls could be traced back to their performance at the post test, where the boys did slightly though not significantly better than girls.

A further analysis using coefficient of determination revealed that over 50% of the level of retention of experimental boys and the group as a whole and 41% of experimental girls was an indication that the conceptual change strategy enhanced meaningful learning.

4.14.5 Attitude to Biology

It can be observed from table 4.8) that there was a statistically significant difference between the control and experimental groups in their attitude towards biology. The experimental group demonstrated a more favourable positive attitude to biology than those of the control group.

Implicit in this result is the fact that conceptual change instructional strategy had a direct influence on the attitude of the students. The more favourable attitude demonstrated by the

students of the experimental group could be attributed to one of the following reasons. First and foremost, the students were exposed to scientific experience that could ultimately help them in developing scientific attitude and skills secondly, through the brain storming question session and discussion periods, students were trained to develop mental abilities that could help them cope adequately with daily problems, both at school and the community at large. Probably too, the strategy could have made the subject to appear less difficult, with the students well involved on constructing the knowledge. More over, the students could have realized that the strategy helped them to retain concepts more than the previous methods.

This probably explains why the students in the experimental group, performed better than their counterparts in the control group. On the correlation of attitude to biology and performance, however, the attitude of the students in the control group was significantly correlated with the performance. This suggest that the performance of the students in this group was highly influenced by the students attitude to biology. Going by the attitude subscales, facility of the subject appeared to be the strongest predictor of the performance of students in the biology test administered to the traditional instructional method group. This was closely followed by interest. The high r-value obtained between interest and performance seemed to corroborate the suggestion by Mcmillan and May (1979) that good grades are not important for a liking for science. It is noteworthy here that, though the control group performed poorly, 15% of this result was accounted for by the students attitude.

In the experimental group, although interest correlated the most significantly, the BAQ as a whole had no significant correlation with the performance. This suggest that the performance of the experimental group, was not influenced or dependent upon the attitude to biology. The coefficient of determination showed that only 2% of the performance can be accounted for in terms of students attitude to the subject. This probably suggests that performance was influenced here by the teaching strategy.

On the relationship between gender and attitude scores, (Appendix 4.5) showed differences between boys and girls. The performance of boys of the control significantly correlated with all attitude subscales namely interest, facility, social implications and were subjected to teacher influence. This is in contrast to the findings of Towse (1983) and Ajewole (1991) Towse (1983) found that though boys and girls were very interested in the sciences girls were more subjected to the influence of their teachers. Ajewole (1991) in his study revealed no difference between the attitude of boys and girls in the strategies he used. Boys in the experimental group, were also subjected to the influence of the teacher than the girls.

It is therefore logical to conclude from this study that instructional methods and gender have effects on the students attitude. This is even more glaring when the Mann Whitney U test comparing the attitudes of boys and girls towards the conceptual change instructional strategy, showed a great significant difference.

4.14.6 Gender Related Differences in the Performance of subject.

Concerning the relationship between gender and performance, tables 4.3 and 4.7 showed that performance was not significantly dependent on gender.

Table 4.3 showed no significant difference between the performance of boys and girls in the post-test. The implication of this is that, the performance of students was not dependent on gender, but rather on the strategy used. However, the mean scores of girls were slightly better than those of the boys in both the control and experimental groups.

The slightly higher mean scores of post test for girls in experimental group over the boys will invariably imply that girls were superior over the boys. Nonetheless, a look at the pretest means, scores revealed that boys performed significantly lower than girls. Consequently the fact that there was no significant difference in the mean scores of boys and girls after treatment, indicates a great improvement in the performance of boys. On this basis, one may deduce that

I) boys in the experimental group benefitted more than their girls and

ii) that the use of conceptual change instructional strategy in remediating misconceptions was useful to both boys and girls; though boys were more favoured.

The finding that boys and girls performed differently, but not significantly is in agreement with the findings of Welch (1985) and Meece and Jones (1996). Welch, (1985) reported that girls were not achieving as well as boys, while Meece and Jones (1996) observed that boys when compared with girls reported greater confidence in their science ability. Although the boys in this experimental group appear to have an edge over the girls, there is a need of research evidence to support the superior intellectual capabilities of boys over girls, since their superiority may not be totally accounted for by their intellectual endowment as revealed in the pre-test score. The situation calls for an examination of some other factors which may have contributed to the performance recorded.

One such reason could be attributed to the demands placed on the students by the conceptual change instructional strategy i.e the conceptual change strategy demands boldness, courage, reasoning and the ability to talk logically among peers. Probably since the girls were shy, the boys could have tended to have overshadowed them in the discussion, which probably might have made

them to gain more. Shemesh (1990) suggested that one of the gender related difference could be attributed to reasoning skills. It could be applicable in this situation too. May be the reasoning skills of the boys was superior over that of girls - an entire new area to be investigated.

Results of table 4.7 on the whole showed no significant difference in the retention level between boys and girls. This result lends credence to the works of Tobin (1989) Erickson and Erickson (1984) and Ezenwa (1993) who reported no observed differences between the performance of boys and girls in science.

Looking at the mean scores of the results on gender categories, there seemed to be difference between boys and girls. However, these being significant, both in the control and experimental group, one could concluded that the teaching strategies influenced the students performance rather than gender.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, LIMITATIONS AND RECOMMENDATION

5.1 Introduction

In this chapter, the following aspects will be dealt with summary, conclusion, limitations and recommendations.

5.2 Summary

The purpose of the study was to determine the efficacy of a conceptual change instructional strategy developed based on Posner et al. (1982) model in remediating identified misconceptions on photosynthesis and respiration amongst SSI students. Consequently the study;

I) Identified some misconceptions common among SSI students in Benue state (Section 3.1.)

ii) determine the efficacy of the conceptual change instructional strategy in remediating misconceptions as compared with the traditional teaching method.

iii) It also attempted to find out whether the instructions

(a) Promoted any gender related differentials.

(b) enhanced students attitude towards biology and

c) improved students level of retention.

The first step towards the investigation was to

(a) ascertain the existence and nature of misconceptions held by the subjects and

(b) ascertain the effectiveness of the instructional strategies in

I) remediating these misconception,

ii) promoting retention level of students

iii) enhancing students attitude towards the subject and

iv) whether there will be gender differences in performance and retention. Consequent on the questions, nine hypotheses were formulated in the null form.

The purpose and significance of the study resided in the acquisition of prior knowledge or appropriate conceptual framework which could enhance meaningful learning. And also create an environment that would enable learners to recognize the inadequacies of their misconceptions, get cut up in explanatory inconsistences and consequently becoming dissatisfied with these misconceptions. In view of the above, the author found the conceptual change instructional strategy much more adequate in providing such an environment, compared to the traditional approach.

The study, therefore, attempted an integration of this approach into the classroom conditions. While the intention of the study was to evaluate the effectiveness of this strategy in remediating misconceptions. Some variables such as attitude, retention and gender were also considered.

The study was experimental in nature. The first portion which involved identification of misconception was done using 340 students drawn from eleven (11) schools in Benue state, comprising four single sex schools, (2 boy and 2 girls) and seven co-educational schools.

For the second portion that involved the teaching exercise, two schools were randomly selected from Makurdi town. The schools were equivalent in terms of their knowledge of the experimental concepts at the point of commencement of the investigation. To reduce interference and infiltration effect one school served as control and the other as the experimental group. The concepts selected for the study were photosynthesis and respiration.

The lessons were planned based on the scheme of work for these concepts as outlined in the SSSI Biology syllabus. Lesson presentation in the control group was done for 40 minutes for 4 periods per week for 4 weeks after administration of BCAT and BAQ during the first week. The experimental group was exposed to a series of four 2½ hours laboratory work and discussion periods. Each session started off with brain storming questions, followed by practical activities aimed at exploring specific phenomena. The pretest-post test design was used for the purpose of data collection. This test was a 40 item test. The questions were prepared to include some misconceptions as distractor options and also to cover the four intellectual levels of blooms classification viz "higher order," Analysis, Application and lower order. The test used for pre was same for post test.

In the first instance the pretest was administered, followed by intensive teaching after which the post-test was administered. The frequency of students picking misconceptions before and after treatment was counted. A delayed post-test (post-post-test was administered four weeks after the post test was given, to test the level of retention of the concepts. In addition to this tests, a biology attitude questionnaire was administered to both control and experimental groups, while an attitude towards the conceptual change instructional strategy questionnaire was given to the experimental group only. The attitude questionnaires were meant to assess the attitude of students to biology and attitude to teaching strategy respectively.

The raw data for the first portion included all the misconception that were given or written by at least 20% of the sample. For the second portion the raw data included all students scores collected before and after exposure to the appropriate teaching strategy. Analysis of the data was

carried out as described in chapter 4.

At the end of the study, the following results were obtained.

1. There was a significant difference in the performance between students of the control and experimental groups in favour of the conceptual change instructional strategy group.
2. The frequency of students in the conceptual change strategy group picking misconceptions after instruction was significantly lower than those picking similar misconceptions from the traditional instructional group.
3. The experimental group showed improved retention of biology concepts compared with the control group.
4. There was a significant difference between the attitude of boys and girls towards the conceptual change instructional strategy.
5. Conceptual change instructional strategy, significantly improved students attitude towards biology.
6. Though mean score values for girls were slightly higher than those for boys in both control and experimental groups for the post and post tests, the differences were not significant; however
7. The attitude to biology correlated significantly with performance for the control group but was not significant for the experimental group.
8. The level of retention was significant with performance in both groups with the highest significant value being that of the boys in the experimental group followed by boys and girls of the experimental combined.

Table 5 .1 gives a graphic presentation of the results.

5.1 GRAPHIC REPRESENTATION OF RESULTS

Hypothesis	Group	Sex	Statistical Method used	Hypothesis rejected or accepted	Remark Index
HO_1 Control Vs Experimental Performance	CG EG	Entire	T-test	Rejected	P<0.05
HO_2 Performance by gender category	CG EG	Boys & Girls Boys & Girls	T-test Post test.T-test	Not rejected Not rejected	P≤0.5 P≤0.5
HO_3 Performance after respective Instructions	CG EG	Entire Entire	T-test T-test	rejected rejected	P≤0.5 P≤0.5
HO_4 Retention Level	CG & EG	Entire	T-test	rejected	P≤0.5
HO_5 Retention Level by gender category	CG EG	Boys Vs Girls Boys Vs Girls	T-test T-test	Not rejected Not rejected	P≤0.5
HO_6 Attitude to Biology	CG Vs EG		Mann Whitney U test	rejected	P≤0.5
HO_7 Attitude and Performance	CG EG	Entire Entire	Pearson's Correlation analysis	Not rejected Not rejected	P≤0.5
HO_8 Attitude to approach	EG	Boys Vs Girls	Mann Whitney U-test	Rejected	P≤0.5
HO_9 Retention and Performance	CG EG	Entire Entire	Pearson's Correlation analysis	Rejected	P≤0.5

5.3 CONCLUSION

In this study, misconceptions that SSI students hold about photosynthesis and respiration were identified. Lessons were then planned based on the conceptual change instructional strategy to see if these misconceptions could be remediated. The traditional instructional method was used as a standard to compare the effectiveness of the conceptual change instructional strategy. The traditional group served as control, while the conceptual change group was the experimental. Both groups were pre and post tested and results analyzed using t-test, Mann Whitney u. test and Pearson Product Moment correlation.

Based on the findings of the research, the following conclusions were drawn

1 students entering SS1 biology class possess a variety of misconceptions about the scientific concepts of photosynthesis and respiration, 80% of which fall within the conceptual domain of weak restructing and 20% within strong restructuring.
2 The conceptual change instructional strategy could effectively shift or displace misconceptions, enhance understanding of concepts and subsequently lead to improved performance more than the traditional approach.
3 It also improved upon knowledge retention and positively improved students attitude towards the subject, biology.
4 Furthermore the conceptual change instructional strategy appears to be gender-related though the differences were not glaring in this study.
5 While some misconcerned ideas were shifted others were created while some still remain resilent even after instructions.

5.4 Limitations of the Study

A few limitations are apparent from the methodology and literature review.

1) The limited number of studies in biology relating to conceptual change was a major limitation of the study.
2) This study was carried out in conventional schools where every student was in the position to benefit from the ordinary school curriculum. If the findings of this research generally and the first portion in particular are to be applicable to schools with exceptional children, then it must be with caution.
3) Realizing the time constrain, it was possible that all misconceptions were not identified.

4) The study was rather specific as it considered only two concepts.
5) Though precautions such as using the same note of lesson for teaching both experimental and control groups were taken during the research period, the very fact that the researcher taught both groups could be a possible limitation.

5.5. Implications of the study

Emerging from this study are the facts that:-

1. Students habour a wide range of misconceptions about some scientific concepts.
2. These misconceptions can be remediated using a conceptual change instructional strategy.
3. The conceptual change instructional strategy promotes meaningful learning and enhances retention of scientific conceptions and
4. It also improves upon students' attitude towards the subject.

In a science teaching-Learning situation, teachers teach with a view of imparting scientific products and process skills in the learner to foster scientific and technological revolution. The students on the other hand, study to acquire well built conceptual frameworks, knowledge skills and reasoning abilities that will make them grow and sustain themselves, fit in the society and make meaningful contributions to the society and the scientific community in particular. For students to achieve these aims they must acquire fully scientifically validated conceptions, principles and positive attitudes. Implicate in this is faith at misconceptions the which exists within the students conceptual framework must be shifted to the scientifically valid ideas.

Biology educators in particular and science education researchers as a whole therefore, need to focus their attention on these alternative frameworks possibly with a view of bringing out the mis conceptions along side with the scientifically validated ideas so that people become aware of possible problem areas.

The researcher believes that it is important to make these views explicit, to discuss and analyze them critically and to provide these students with the appropriate views from the very start. This of course will provide the students with relevant prerequisite knowledge, necessary for meaningful learning in subsequent classes.

It is for this reason, that the researcher suggests after careful experimentation, the adoption and adaptation of a conceptual change instructional strategy in the teaching-learning of biology concepts. The strategy was useful in remediating misconceptions, enhancing meaningful learning and promoting the retention of scientific concepts.

Therefore, in a classroom situation, identification of misconceptions, and formulation of a well-thought out conceptual change instructional lesson will serve a useful purpose towards this end, particularly in certain concepts in biology which do not fall under a system of laws.

5.6 Recommendations

Inspite of the limitations of this study, the over all results appear to have important implications for science teachers, educators, curriculum developers and the teaching and learning of science as highlighted in the preceding section. It is against this background that the following recommendations are proposed.

i) Teachers must endeavour to make conscious efforts to probe into the students prior knowledge concerning any topic that is about to be taught, before planning such lessons.

ii) Curriculum planners should consider the introduction of conceptual change instructional strategy in the teaching and learning of biology concepts and other science courses were misconceptions prevails. This is because this instructional stratery has the potentials of remediating such misconceptions and consequently creating a suitable conceptual framework necessary for meaningful learning.

iii) Associations and Research centers such as Science Association of Nigeria (SAN), Science Teachers Association of Nigeria (STAN) and National Educational Research and Development Centre that carry out researches, organize conferences, seminars and workshops, should incorporate conceptual change in their science instruction innovation programmes.

iv) In view of the fact that students taught using this strategy do not only acquire knowledge and enquiry skills, but do end up being objective, open-minded and have a questioning attitude, the curriculum planner should reconsider the place given to written examinations and also revisit the type of questions usually set.

v) Futhermore, examination bodies, should strife to set questions that test meaningful understanding of concepts rather than mere recall.

vi) The conceptual change instructional strategy should be popularized and incorporated into the teacher training curricula at all levels.

vii) Textbooks and teacher guides can be produced using new approaches based on this research model.

5.7 Suggestions for Further Research

Though the conceptual change strategy has been shown to remediate misconception, and improve upon students understanding of concepts, it would appear that further research would be helpful to confirm and support the effectiveness of the strategy. Moreover, results bordering around some variables are not clear cut in this study and so needs attention. The most important for further work include the examination of

1) How the changes in the knowledge restructuring occurs and how to build a learning environment that facilitates this restructuring.
2) How assessments can provide the opportunity whereby student's current conception could be confronted and challenged.
3) The effect of the strategy over a longer period.
4) More works in the area of gender to see whether gender related differences are likely to occur when using this strategy.
5) The effect of this strategy on various ability groups.

It is hoped that further investigation in these areas will increase our understanding of this field of studies.

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APPENDIX 3.1

TEACHING MODEL (CCIS)

TOPIC - CELLULAR RESPIRATION

STEPS.	Activities of Teacher and Students
1. ORIENTATION OR AWARENESS PHASE	The teacher introduces the topic and asks a series of questions - What is respiration? - Which are the organisms that respire? - Can plants also respire? - How do they respire, if they do? - What is the difference between respiration in plants and that in animals? Activities:- Close your nostrils for a while- explain how you feel. Small animals (mouse) were placed in individual air tight bell jars with food, and water and students asked to note temperature and other observations. The thermometer will be left inside. Similarly potted plants were placed in individual bell jars and temperature noted other observations too were made and the thermometer left inside.
2. ELICITATION OF IDEAS OR DISEQUILIBRIUM PHASE	- Students to form small groups (maximum 5 and at least 3) - Different groups will then observe the containers and discuss it within themselves - The conclusion of such discussion will be written out on a poster by the team leader. The caption of the poster will be "OUR IDEAS ABOUT RESPIRATION" Team leaders will be allowed to present posters and give very brief explanations about their ideas.

3.	REFORMATIVE PHASE	-Reports from small groups will be posted on the board, thereby -displaying the range of ideas that the students have produced. - As students explain their ideas alternative viewpoints are identified and student's helped to recognize and critically examine such. - Teacher then acts as a facilitator provides learning experiences and questions which upon discussion will to interact with the pupils prior knowledge either to I) extend student's knowledge where ideas are limited. ii) Help students to refine their own ideas vis-a-vis scientifically validated ideas. The teacher then re-emphasizes on the scientifically correct ideas.
4.	APPLICATION PHASE	- How can this lesson help you to manage a colony of animals? - What advice can you give to a prison's office who intends to put many inmates in one room?
5.	EVALUATION PHASE	- What then is respiration? - Can you list things that respire? - Will you adequately explain the differences between plant and animal respiration? - Is it possible to show the relationship between plants and animal respiration? - What is the relationship between respiration and photosynthesis? - Why did the animal suffocate while the plant did not? - Where did the plant get its oxygen from? - Where did the carbon IV oxide produced go to?

TOPIC 2 PHOTOSYNTHESIS

(Emphasis on sources of raw materials and functions of essential factors.)

STEPS	Activities of Teacher and Students
ORIENTATION OR	What is nutrition? How do you define food for a plant? where do plants obtain their food from - soil, water, air worms, fertilizer, manure sunlight or insects?
AWARENESS	If they obtain food from any of these sources, is it like there's 's ready made rice and beans for them to eat/ or what do they do? How do they obtain food from any of these sources, it is like there's ready made rice and beans for them to eat? or what do they do it? How do they do? How do they obtain food? They make it (shift from get food, and food for plant to making of foods.) Plants make food. Imagine you are going to make food e.g jellof rice. You'll need a spoon, pot fire etc. is that how plants do too...? No So what do they need to prepare food?
DISEQUILIBRIUM PHASE	Essential factors of photosynthesis were mentioned and described, equation of photosynthesis written on the board by the students .The different types of nutrition were also written and discussed. As the discussion is going on the teacher directs and also emphasizes on the correct points. After which treatment or sources of raw materials for photosynthesis commenced with a series of questions followed by a period of experimentation. Where do these raw materials come from? where does water come from? rain water? soil or through watering of the plant? How does the water get to the site for photosynthesis?.

Where does the carbon dioxide come from? Imagine that a plant is placed as sealed container and placed under the sun and another plant exposed to the atmosphere will photosynthesis occur both plants?.

Experiment: Each group was provided with two pots, each contain plants (cowpeas) that had been destarched for 48 hours. A leaf was plucked form each pot and out of the two pots one was placed in a sealed container (bell jar) with adequate supply of water and exposed to a source of sunlight. The other potted plant was allowed to stand near a source of light but not sealed. Both plants were allowed to stay for about 24 hours.

meanwhile the plucked leaves were then tested to be sure that there was no starch in them. The teacher highlighted the procedure for testing the presence of starch.

DISCUSSION Team leaders were allowed to present their results after testing their leaves for the presence or absence of starch. They were then asked to suggest possible reasons for the lack of starch in the leaves. This brought us to the role of light another area that constituted a source of misconceived ideas..

PERFORMATIVE PHASE

Students were presented with the diagrams of spirogyra and bacteria that are oxygen loving. See attached sheet. They were than asked to explain. As they were explaining their ideas were being noted on the board.

The teacher then helped them with bits of information or questions which could lead them to scientifically correct responses and emphasized the role of light in photosynthesis. They were then led to see why a plant kept in darkness for long cannot photosynthesis. The mechanism

of photosynthesis was then explained to them using the ideas students brought up during the discussion

APPLICATION

Students were asked to give the importance of potted plants in the house and to say when it is most convenient for it to be kept inside and why student were given a chance to compare scientific ideas and their previous ideas

TOPIC 3

RELATIONSHIP BETWEEN PHOTOSYNTHESIS AND RESPIRATION

STEPS	Activities of students and Teacher
AWARENESS	Students were asked to write out the equation, recall definitions of photosynthesis and respiration, mention the similarities and differences between the two process and also to say how these two processes can be useful in improving the welfare of home. Experimentation: students were asked to pluck a leaf from each of the potted plant of the previous day and keep aside. Then, toads, food (worms and insects) and water were introduced into the bell jar containing the potted plant, and another bell jar void of plant. In which case. Each group had two bell jars. (1) One with potted plant, toad and food and water (2) Second with just toad, food and water. The set up was allowed to stand for $1^1/_2$ hours, during which time the students were making observations at intervals of 10 minutes. They were then allowed to discuss among themselves and write down the conclusion arrived at - captioned - OUR IDEAS ABOUT PHOTOSYNTHESIS AND RESPIRATION. The plucked leaves were used to test for the presence of starch and explanations were also written down on card board papers and captioned - OUR IDEAS ABOUT THE SOURCE OF CO_2.
DISEQUILIBRIUM PHASE	Team leaders were then allowed to present and explain their conclusions giving possible reasons. During which time alternative view points were picked out and written on the board, along side correct responses.

REFORMATIVE PHASE	During this period the alternative view points were discussed. the teacher acted as the facilitator, providing guiding question that led the students to the formulation of scientifically accepted responses. Correct responses given by the students were reemphasized by the teacher. As the discussion and presentation was going on, the misconceived ideas written on the board were being thrashed one after the other, After comparison with the scientifically valid ones. The teacher then gave a summary of the ideas arrived at and placed emphasizes on those that constituted a common source of misconception.
APPLICATION PHASE	The teacher then gave a summary of the ideas. What is the advantage of putting a potted plant inside the house in the day over putting it in the night ? - what is the scientific explanation of this?. How can this lesson help you to manage your plants and animals at home?
EVALUATION PHASE	Where else can plant get CO_2 from? why was the toad placed in the seal bell jar with a potted plant more active at the end of the experiment then that which was left alone?. Can these two organisms stay on together for long? Suggest reasons. Is it possible to show the relationship between plants and animal respiration? Will you adequately explain the differences between plant and animal respiration? Where did the plant get its oxygen from?

APPENDIX 3.2

TRADITIONAL INSTRUCTION METHOD

TOPIC - CELLULAR RESPIRATION

		Teacher's Activities	Student's Activities
STEP I	INTRODUCTION	The lesson is introduced with students activity, followed by close your nostrils for a while. How do you feel? Why do you feel that way? What is the importance of air to you? What will happen to a small animal in a container? What will happen to a plant too if placed in an air tight container? Which part of air do you use and which is vital for plants?	Students to perform the activity and answer the questions.
STEP II	ACTIVITIES/ LECTURERS	Teacher lectures the students and give notes on (I) Definition of respiration (ii) Types of Respiration - Aerobic - Anaerobic	Students listen, copy notes and ask questions.
		(iii)Equation for respiration (iv) Respiration in plants and animals	
STEP III	EVALUATION	Teacher will answer questions asked by students and also ask the students more questions in addition to the questions asked in step I	Students ask and answer questions posed to them
STEP IV	CONCLUSION	Teacher writes a brief summary of all that has been taught and assignment given to the students.	Students copy

TOPIC 2 - PHOTOSYNTHESIS

		Teacher's Activities	Student's Activities
STEP I	INTRODUCTION	Questions will be asked 1. What is nutrition? 2. Name types of nutrition 3. How is plant nutrition different from animal nutrition	Students will be allowed to answer questions
STEP II	LECTURE/ NOTES TAKING	Students will be lectured and given on 1. Definition of Nutrition 2. Types - Holophytic - Saprophytic - parasitic 3. - Definition of photo-Synthesis 4. - Light & Dark Phases of Photosynthesis. 5. - Raw materials needed for photosynthesis. 6. - Sources of the raw materials.	Students will listen, then copy and also allowed to ask questions
		7. - Tests for starch. 8. - Roles of sunlight and chlorophyl in the process of photosynthesis.	
STEP III	EVALUATION	At the end of the lectures students will be given a small quiz after which oral questions will also be asked different from animal	Answering of questions.
STEP IV	CONCLUSION	Summary of the whole lesson will be given to the students. Previous assignment will be collected and another given to them.	Copy.

TOPIC 3. - CELLULAR RESPIRATION AND PHOTOSYNTHESIS

TRADITIONAL APPROACH.

		Teacher's Activities	STUDENT'S ACTIVITIES
STEP I	INTRODUCTION	Teacher begins by asking questions on previous lessons. What is respiration? What is photosynthesis? What is the similarities?	Students will answer questions
STEP II	LECTURE/ NOTES	Teacher will explain the differences between photosynthesis and respiration similarities between the two process. - Importance of these process in life	Students will listen, copy notes and ask questions.
STEP III	EVALUATION	Equations for both respiration and photosynthesis will be written down as a summary of the two processes	
STEP IV	CONCLUSION		

APPENDIX 3.3

LESSON NOTE

3.3.1 **RESPIRATION**

DEFINITION OF RESPIRATION

Respiration is a series of chemical changes which release energy from food material. Though respiration, carbohydrate is broken down to release energy. Also carbon dioxide and water are released as by products. It is this energy that is released during respiration, that living organisms used for other metabolic process such as growth, secretion of enzymes, muscular contraction moistens conduction etc.

There are two types of respiration

(a) aerobic respiration

(b) anaerobic respiration

Aerobic respiration, involves the use of oxygen to break down the carbohydrates or fat. Whereas in anaerobic respiration oxygen is not used to breakdown the carbohydrate.

Aerobic Respiration may be divided into two processes

(1) Organismic respiration- a process which helps in getting oxygen into the body and into the cell. In animals this process is achieved through breathing (ventilation of the lungs) and through (gaseous exchange) intake of oxygen and output of carbon dioxide. During this process carbon dioxide is delivered to the environment, while oxygen is delivered to the cells. Gases move into and out of the cells by diffusion.

(2) Tissue, respiration/cellular respiration also called internal respiration. This involves the complex series of reaction by which the cell breaks down the fuel molecules (Carbohydrate) releasing carbon dioxide and energy, using oxygen.

EQUATION FOR AEROBIC RESPIRATION

$$C_6H_{12}0_6 + 60_2 \longrightarrow 6C0_2 + 6H_20 + 2830kj$$

glucose Oxygen carbon dioxide water energy

This equation shows that food and oxygen must be taken in and react together.

Method of demonstrating respiration

(a) how carbohydrate is used up.

(b) intake of oxygen

c) give out carbon dioxide

(d) production of water or water vapour

(e) release of energy

Gaseous exchange in plants

Plants posses a lower respiratory activity because they don't move and so have a lower metabolic rate and relatively lower body temperature. How do the cells at the centre of twick roots and stem obtain adequate supply of oxygen and how is accumulation of carbon dioxide in these tissues prevented?

Plants lack the ventilation mechanism like lungs. To obtain oxygen.

- Some oxygen can be taken in solution form from the soil and this passed up the plant in the transpiration stream.
- oxygen can also diffuse from soil airspaces into the roots.
- In addition there is continues network of airspaces which pervades the whole plant. The airspaces are particularly well developed in the leaves and make contact with the anterior of the plant through special pores called stomata . These are found on leaves and herbaceous stems. Other breathing pores called lenticulas occur in woody stems and roots.
- In general photosynthesis provides enough oxygen for aerobic respiration, so that during the day there is surplus available in the intercellular spaces of plants. This diffuses to reach the cells and tissues.

In the dark when respiration alone is taking place, there's less oxygen in the airspaces then outside the plants. Thus a concentration gradient is set up the which oxygen diffuses inward through the epidermal cells) Since the stomata closes at night. The carbon dioxide produced at night diffuses out by the same route.

Respiratory surfaces in animals

Types of respiratory systems.

(I) Body surface in unicellular organisms and some multicellular organisms - cutaneous respiration in toad/frogs.

(ii) Gills in fish and some aquatic veterbrates

(iii) Lungs in terrestrial vertebrates.

3.3.2 PLANT NUTRITION - PHOTOSYNTHESIS

Performance objective:

1) Student's should be able to correctly represent it by a chemical equation.
2) State material and conditions necessary for photosynthesis.

What is nutrition?

Nutrition is the process by which organisms obtain and use food. Some organism are able to manufacture their own food, while others must obtain it from their environment. There are therefore different types of nutrition. These include 1) Holophytic nutrition. Which means feeding like plants. Here simple compounds like carbon IV oxide, H_20, and salts are absorbed and built up into complex substances that can be oxidized for energy or synthesized into living protoplasm and cell wall.

(ii) Holozoic nutrition - common in animals. Here complex food materials is broken down by digestion into simple substances, that are then absorbed and incorporated into body structures or oxidized to obtain energy.

(iii) Saprophytic nutrition - Here fairly complex chemical compounds are absorbed into the organism. Some of the chemicals are absorbed directly, while others are digested outside the organism by enzymes secreted on or in the material e.g fungi in rattening wood.

(iv) Parasitic nutrition where the organism derives its food from another individual without necessary killing it. Green plants make their food through a process called photosynthesis.

What then is photosynthesis?

Photosynthesis is a process by which green plants (autotrophs) manufacture food (organic compound) from carbon dioxide and water (simple in organic substances) using the energy absorbed from sunlight by the chlorophyll with the help of enzymes, while oxygen is liberated as a by-product.

The chemical equation for photosynthesis is as follows.

$$6C0_2 + 6H_20 \xrightarrow[\text{Enzymes}]{\text{sunlight and Chlorophyll}} C_6H_{12}0_6 + 60_2$$

Mechanism of Photosynthesis

The process of photosynthesis is not as simple as the equation for photosynthesis suggests. Photosynthesis consist of a series of complex reactions. These reaction take place in two phases namely.

(a) light reaction and (b) dark reaction.

(a) Light reaction This takes place in the grana of the chloroplast. the chlorophyll a & b trap the sunlight energy and converts it to chemical energy. The light energy absorbed by chlorophyll in green parts of plants is used to split water molecules into hydrogen (H^+) and hydroxy (0H-) ions. The reactions between the hydroxyl ions lead to the formation of oxygen and water molecules. Hence, water and not ($C0_2$) is the source of excess oxygen liberated during photosynthesis as a by-product.

This can be represented as follows.

$$H_20 \xrightarrow[\text{Chlorophyll}]{\text{Light energy}} H^+ + 0H^-$$

$$20H^- + 20H^- \rightleftharpoons 2H_20 + 0_2$$

This process is called photolysis of water.

(b)Dark reaction It takes place in the stroma of the chloroplast.

Although the dark reaction normally occurs in the absence of light either in the day or night it is conventionally called a dark reaction because neither chlorophyll nor light energy is needed.

First hydrogen and carbon IV oxide ($C0_2$) molecules combine chemically in a complex series a particular enzymes , Simple sugars are first formed, followed by other carbohydrate, lipids and proteins. The overall chemical equation is this

$$4H^+ + CO_2 \xrightarrow{\text{enzyme}} CH_2O = H_2O$$

CH_2O - is the carbon skeleton from which simple sugars and other organic foods or compound are synthesized.

Part of the radiant energy absorbed by the chlorophyll is stored as chemical energy in the organic molecules (foods) synthesized is an endodermic reaction.

Materials and conditions necessary for photosynthesis carbon Iv oxide water, light energy mineral salts and suitable temperature.

A) Raw Materials

Carbon IV oxide: From the atmosphere diffuses through the stomata into the intercellular air spaces and then to the spongy mesophyll. This will then dissolve in the water film the spongy mesophyll cells. Form here, the CO_2 will then diffuses to the chloroplast CO from mitochondria also diffuses through the intercellular air spaces to the mesophyll cells.

Water

Water is absorbed from the soil by the process of osmosis by the root hairs. This passes from the root system and then conducted to the stem system, from there, it is conducted to the leaf veins, then to the mesophyll cells and finally to the chloroplast by osmosis.

Mineral Salts

These are required for the formation of fats, and oil and proteins. They are absorbed along with the water.

B) Conditions necessary

light Energy Part of the light energy is absorbed from sunlight by the chlorophyll. Most of the radiant energy is reflected by the leaf's chlorophyll. It is the red and blue ends of light spectrum that are mainly used in photosynthesis.

Chlorophyll This pigment is found in the palisade and mesophyll cells of the leaf. It is made of chlorophyll a (blue-green), chlorophyll b yellow - green. xanthophyll (yellow) carotene (orange and phacophytin (grey).

chlorophyll (a) is the must abundant pigment and is of universal occurrence in all photosynthesizing plants. Its function is to absorb light energy and convert it into chemical energy.

Suitable Temperature Photosynthesis proceeds by a series of chemical reactions controlled by many enzymes. The optimum temperature for photosynthesis is around 30^0CV. At lower to, the rate is slowed down. If the temperature exceeds 40^0C the process stops altogether, since the enzymes needed are protein in nature and will become denatured.

Evidence of photosynthesis

The first main product of photosynthesis is simple sugar. In many plants leaves, it is immediately converted into starch for storage. Some may convert the simple sugar into fats and oils or proteins, depending on their food requirement. Since many plants usually convert their simple sugar into starch. The simplest way of testing whether a plant has photosynthesis or not is to test its leaves for starch.

Testing for starch in green leaves

The addition of a dilute solution of iodine to starch gives a dark blue colour. This identifies the presence of starch. However, the green colouring matter in leaves would obscure the blue colour and might lead to false results. Therefore to apply such a test, the colouring matter in the leaf must be removed first. Examples of common leaves include tecoma, balsam and cocoyam.

Procedure

Deep a leaf in boiling water for 5 minutes. This kills the protoplasm inactivates the enzymes and increases the permeability of the cells, as well as breaking open the starch grain.

(2) Next boil the leaf in methylated spirit. To do this roll up the leaf loosely and place it in a boiling tube about 1/3 full of 70% alcohol. Plug the top of the tube with cotton wool. Place the tube in a beaker of water and warm the water, until the alcohol begins to simmer. This will decolourize the leaf. As a result, the leaf will become brittle.

(3) Wash the leaf in water to remove the alcohol. This will soften the leaf.

(4) Place in a petri-dish containing dilute iodine solution for five minutes and observe.

Observation the leaf changes to blue-black colour if starch is present.

It can then be concluded that the leaf has photosynthesized.

TO SHOW THAT CARBON DIOXIDE IS NECESSARY FOR PHOTOSYNTHESIS

(1) destarch two potted plants (A & B) by keeping them in dark any cupboards for two days.

(2) put a dish of dampened soda lime on the soil beside one of the plant. Cover the plant with a polythene bag. The soda lime will absorb any $C0_2$ inside the bag so that the plant will be deprived of carbon IV oxide.

(3) Put a dish of saturated sodium bicarbonate solution on the soil in B. This will slowly give out $C0_2$ into the bag so that the plant will have plenty of $C0_2$.

(4) Place both plants side by side in a well lit place for about 48 hours

(5) After this period take a leaf from either pot and test for starch.

Test to show that oxygen is given off as a by - product during photosynthesis.

Spirogyra and oxygen loving bacteria.

APPENDIX 3.4a

MEANS, VARIANCE & STANDARD DEVIATION FOR SCHOOL USED FOR SELECTION OF EXPERIMENTAL SCHOOLS.

Schools	Means $\bar{X}$	Variance	Standard deviation
Padopads Harmony Sec. Sch	8.667	7.18	+ 2.680
Govt.. Day Sec. School	8.45	5.62	+ 2.370
ECWA Sec. School	9.71	9.9	+ 3.14
Govt.. Sec. Sch.. N/Bank	8.79	6.54	+ 2.557

APPENDIX 3.4b

'T' test for selection of experimental school.

Schools Compared	t-test
GSS N/Bank & Padopads Harmony Sec. School	0.2473
GDSS & ECWA SEC. School	2.56047
GDSS & GSS N/Bank	0.6679
GSS N/Bank & ECWA Secondary School	2.5775
Padopads & GDSS	0.4094
Padopads & ECWA	2.0950

The two tables above show that students from Government Secondary School North Bank and Padopads Secondary School are of the same ability group.

APPENDIX 3.5

QUESTIONS ON PHOTOSYNTHESIS AND RESPIRATION

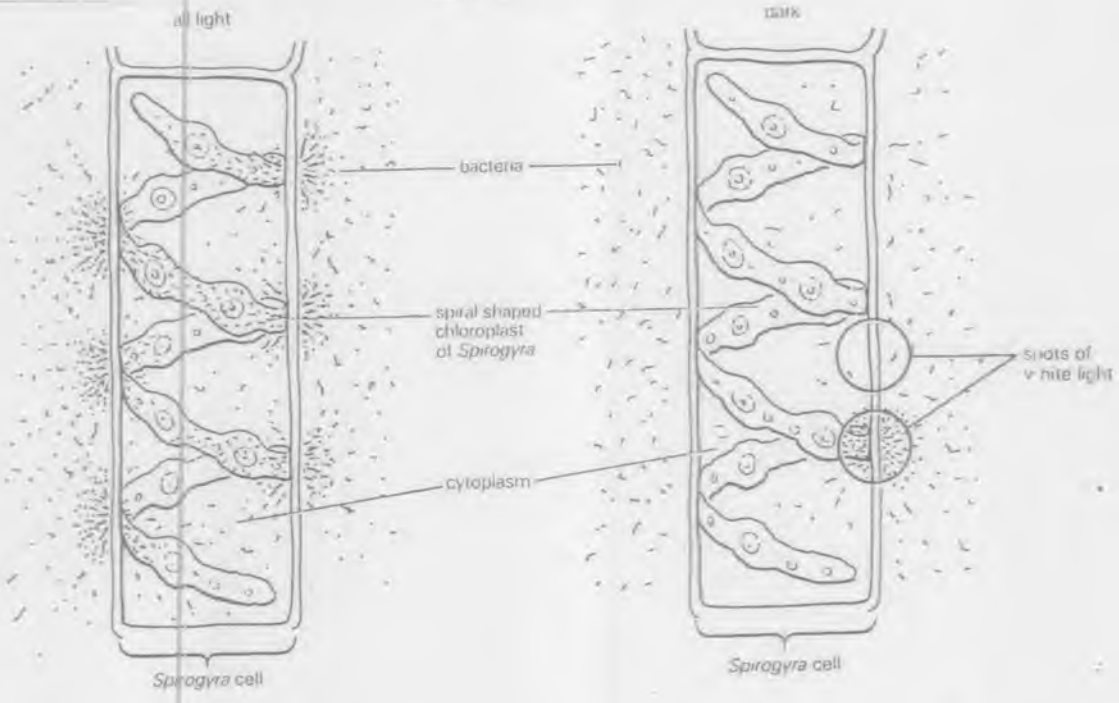
Answer all the questions on the sheets provided. Express yourself as freely as you can.

1. What do biologists consider as the characteristics of living things?
2. Which of these characteristics are very vital for the production of energy in living things?
3. Describe respiration.
4. Describe photosynthesis.
5. A green plant need energy to survive and grow, where does the plant get its energy from (circle all correct answers and explain if necessary).
   (a) air (b) water © sun (d) soil (e) worms
   (f) fertilizer and insect.
6. A human being also needs energy to grow and survive, where do you think a person gets the energy he or she needs?
7. Do plants need light? Give reasons for your answer.
8. How does the preparation of food in plants differ from the preparation of food in animals?
9. How do you define food for a bean plant?
10. How do you define food for a human being?
11. What would happen if we put a mouse and a plant in a sealed container? Assume the mouse has an unlimited supply of food and water and the plant has an unlimited supply of water and sunlight.
12. Explain the relationship among the following sets of terms. Write sentences including only two terms if you do not feel that all three belong together.
    (a) Respiration Photosynthesis Energy
    (b) Photosynthesis Sunlight Food
    © Respiration Energy Food
    (d) Glucose Food Energy

The questions below refer to the following diagrams, where spirogyra and a fresh water bacterium, which swims towards a high oxygen concentration are kept together.

In A = Spirogyra and bacteria ib bright light

In B = Two small spots of light shown



A

All light

B

Dark

13. Give possible explanations for the distribution of bacteria in:

    (1) A with light

    (2) B dark with 2 spots of light

14. Which part of the spirogyra cell is responsible for producing oxygen? Give reasons for your answer.

15. How does the above diagram show the fact that plants photosynthesizes only in the presence of light?.

(APPENDIX 3.5b)

TEST ITEMS DEVELOPMENT FOR APPENDIX 3.5

1. How do you think a biologist would define the term "respiration"?

2. How do you think a biologist would define the term "photosynthesis"?

3. A bean plant needs energy to survive and grow. Where does the energy that bean plant uses come from? (Circle all correct answers & explain if necessary)

   air water sun soil worms & insects fertilizer

4. A human being als needs energy to grow and survive. Where do you think a persons gets the energy he or she needs? (Circle all correct answers and explain if necessary)

   air water sun exercise meat potatoes

5. Do plants need light? Why or why not?

6. How do you define "food" for a bean plant?

7. How do you define "food" for a person?

In question 8-10, circle the response you feel is most accurate. Use (?) only if you have no idea. If necessary, explain your answers in the space following the question.

8. What portion of their food do bean plants get by making it inside their bodies? ALL SOME NONE ?

9. What portion of their food do bean plants absorb through their roots? ALL SOME NONE ?

10. What portion of their food do bean plants absorb through their leaves and stem? ALL SOME NONE ?

11. Try to write sentences explaining the relationships among the following sets of terms. Write sentences including only two terms of the if you do not feel that all three belong together.

    a. respiration, photosynthesis, energy

    b. photosynthesis, sunlight, food

    c. respiration, energy, food

    d. glucose, food, energy

APPENDIX 3.6

KEY TO MISCONCEPTION TEST

Propositional Statements judged to be scientifically Accepted for Question on Misconception test.

(A) Definition of Photosynthesis (Q. 4,8,12b)

- Process by which green plants build or manufacture their food.
- Manufacture food from simple inorganic substances using sunlight energy.
- The process involves a chemical reaction in which $CO_2 + H_2O$ give glucose

  OR

  Building of carbohydrate from CO_2 and water using sunlight energy in the presence of chlorophyll.
- Oxygen is given off as by-product
- Process also involves energy conversion process in which the energy in sunlight is converted to chemical energy in glucose
- The sunlight energy is trapped by the green pigment - chlorophyll.
- Equation -$6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Sunlight Energy}} C_6H_{12}O_6 + 6O_2$
- Reaction takes place in two stages
- Light reaction $4H2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} 4(H^+) + 4(OH^-)$

  (Photolysis of water) $4(OH) \rightleftharpoons 2H_2O + O_2$
- Dark reaction $CO_2 + H_2O \longrightarrow CH_2O + H_2O$

  (fixation of H to CO_2) & condenses CH_2O+H_2O

B Definition of respiration (Q3)

- Respiration is vital for energy production
- Process by which organisms breakdown food (glucose)
- The food (glucose/carbohydrate) is (oxidized) broken down into $CO_2 + H_2O$ (Chemical reaction)
- The chemical potential energy in the food is converted to Heat or stored in ATP.
- Respiration therefore involves a series of chemical reaction and an energy conversion sequence

- The chemical reactions are often accelerated by enzymes.
- The chemical equation is often given of

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + H_2O + 2830kj$$

glucose — oxygen — carbon dioxide — water — energy

- In anaerobic respiration, no oxygen is used
- While aerobic respiration makes use of oxygen.
- Appropriate relationship between a (12a)
- Appropriate relation 4($^1/_2$c)
- Internal and external respiration Mentioned.

C Sources of Energy for Plant and for Animal's (Q5,6,&7)

- According to biological theory, plants obtain Energy only from one source - that is sunlight.
- Animals obtain metabolic energy only as chemical potential energy in food.
- therefore, energy comes from the food animals eat.
- Food needs to be digested and end products sent to cells through circulation of blood.
- Energy in the food is then converted to ATP (stored energy) through cellular respiration.
- Therefore energy in food is converted to ATP in animals
- Vital processes for energy production are nutrition and respiration

D Definition and sources of food for plant and animals (Q8,9,&10)

- Food is defined chemically as a class of substance containing usable organic substances such as carbohydrates, proteins and fats.
- Functionally, it is defined as a class of substance that organisms can use as a source of energy for metabolisms or materials for growth.
- Plants do manufacture their food from simple inorganic substances, through the process of photosynthesis (authotrophs).
- animals depend on already manufactured food

E Relationship between photosynthesis and cellular respiration (Q11 & 12)

- Mouse and plant will both survive
- Plant will produce its food through photosynthesis using carbon dioxide water and sunlight energy
- The by-product of photosynthesis, oxygen, will be used for respiration
- Carbon IV oxide, bye-product of respiration, will be recycled or used for photosynthesis by plant
- The process of respiration (plant and mouse) requires oxygen and sugar.
- and the process produces carbon dioxide and water
- The oxygen for respiration is supplied by photosynthesis in plant.
- During photosynthesis, sunlight energy is trapped and converted to chemical potential energy and stored in (glucose) food.
- The energy in glucose is converted during respiration to heat or chemical potential energy and stored as ATP.

F Application of the Knowledge of Photosynthesis and respiration (Q 13, 14, & 15)

- Photosynthesis takes place in the spiral chloroplast of the spirogyra cell.
- During this process, the spirogyra releases oxygen
- Oxygen attracts the bacteria
- The bacteria then swim towards the areas of high oxygen concentration.
- Hence more bacteria are found around edges of chloroplast were light is present.
- This is because photosynthesis takes place in the presence of light releasing oxygen.
- Bacteria are found at all the edges of spiral chloroplast in a spiral chloroplast in A, and spiral chloroplast of B with light because of photosynthesis releasing oxygen.

APPENDIX 3.7

BIOLOGY CONCEPT ACHIEVEMENT TEST (BCAT)

(QUIZ CARD FOR B.C.A.T)

Instructions: Do not write anything on the quiz card. Answer all questions on the answer sheet only. Return the quiz card along with the completed answer sheet.

1. Which of the following do plants need for respirations? (L)
   - A Chlorophyll, Carbon dioxide and water
   - B Oxygen, glucose and cells
   - C Carbon dioxide, water, and sunlight
   - D Carbon dioxide and water
   - E Carbon dioxide water, chlorophyll and sunlight.
2. The end-products of aerobic respiration in plants are:- (L)
   - A Water, Carbon dioxide and energy
   - B Oxygen, glucose and water
   - C Carbon dioxide glucose and energy
   - D Carbon dioxide and water
   - E Carbon dioxide, water and starch.
3. Which of the following equations best represents aerobic respiration in plants? (L)
   - A $6CO_2 + 6H_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} C_6H_{12}O_6 + 6CO_2$
   - B $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$
   - C $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$
   - D $C_6H_{12}O_6 \longrightarrow 2C_2H_5O + 2CO_2 + \text{Energy}$
   - E $6CO_2 + 6H_2O \xrightarrow{\text{light}} C_6H_{12}O_6 + CO_2$
4. Aerobic respiration in animals is best represented by the following equation:- (L)
   - A $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + \text{Energy}$
   - B $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$
   - C $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$
   - D $6CO_2 + 6H_2O \longrightarrow 6O_2 + C_6H_{12}O_6$
   - E $6C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$

5. By what process does oxygen reach the mesophyll of a leaf? (An)

   A Osmosis D Diffusion

   B Transpiration E Respiration

   C Transpiration Stream.

6. What structures are concerned with the intake of oxygen and the release of carbon dioxide in flowering plant. (L)

   A Lenticels, Air spaces and Stomata

   B Stomata, chloroplast and air spaces

   C Chloroplast, stomata and lenticels

   D Lenticels, chloroplast and air spaces

   E Chloroplast and stomata.

7. In which specific structure of a plant cell can oxygen be released/produced (H)

   A Nucleus

   B Cytoplasm

   C Chloroplast

   D Cell wall

   E Pyrenoids

8. Tissue respiration occurs in (L)

   A Plants only

   B Animals only

   C Animals with lungs

   D Plants and animals

   E Animals and green plants

9. Inhalation and exhalation are also called (H)

   A Gaseous exchange

   B Respiration

   C Breathing

   D A and C

   E B and C

10. From what source do plants obtain their energy for growth? (L)

A Air and sun B Sun

B Soil D Sun and fertilizer

E Air.

11. Respiration is generally defined as (L)

A A process by which animals take in oxygen and send out carbon dioxide.

B Breathing out of carbon dioxide by human beings, and exhaling oxygen for plants.

C Break down of glucose to produce energy in living organisms.

D Exchange of carbon dioxide and oxygen in plants.

E Process by which living things take in oxygen and send out carbon dioxide.

12. Photosynthesis is defined as the process by which:- (L)

A A sequence of chemical reactions, produces glucose and oxygen from carbon dioxide and water, using sunlight.

B All plants get their food, in the presence of sunlight.

C Green plants turn sun and carbon dioxide into chlorophyl and food, using sunlight.

D Green plants break down glucose in the presence of sunlight, to release oxygen.

E Plant use light to make their food.

13. What would happen to a bean plant placed in a sealed bell jar with an unlimited supply of water adequate temperature and sunlight? The bean will:- (An)

A Survive and grow because it will manufacture food.

B Die of suffocation in the bell jar.

C Not live long because it will run out of carbon dioxide to manufacture food in the bell jar.

D Survive because it does not need oxygen.

E Survive because O_2 and carbon dioxide can be recycled by the planting in the bell jar.

14. What would happen if a mouse is put in a sealed container with adequate temperature unlimited supply of food and water? The mouse will:- (H)

A Survive due to plenty of food

B Die for lack of oxygen

C Die due to excess food

D Die due to excess water

E Survive due to plenty of food and water.

15. What will happen if the mouse and the bean plant are placed in the same sealed jar with adequate temperature, unlimited supplies of water, food and sunlight? (An)

A The mouse and plant will die because of no air from outside.

B The mouse will eat the plant

C Both mouse and plant will survive because of the recycling of carbon dioxide and oxygen.

D The mouse will die while the plant will survive because plant doesn't need oxygen.

E There will be competition for water and sunlight between the plant and the mouse.

16. The above experiment suggests that the carbon dioxide used by plants during photosynthesis can also come from:- (An)

A Animal respiration

B Decay of plant and animal bodies

C Plant respiration

D A, and C

E A and B

17. Which among the following statements is correct? (H)

A Photosynthesis is plants form of animal respiration which produces energy.

B During respiration carbon dioxide and energy is produced, which is used by pants for photosynthesis.

C Respiration by animals produces carbon dioxide which together with energy is used by plants during photosynthesis to produce food.

D Plants use energy during photosynthesis is brokendown during respiration to release energy.

E Starch produced during photosynthesis is broken down during respiration to release energy.

The questions below refer to the following diagrams, where spirogyra and a fresh water bacterium which swims towards a high oxygen concentration are kept. In: A: the spirogyra and shown on the spirogyra placed in darkness.

18. Which of the following statements best explains the distribution of bacteria in A. (An)

A. Bacteria with multiply in the warm place provided by the light.

B. Bacteria are scattered all over the spirogyra because of the warmth provided by the light.

C. More bacteria are found around areas of spirogyra where photosynthesis takes place.

D. Bacteria are found all around the spirogyra because it responds to light and produces oxygen.

E. The bacteria and spirogyra are united during photosynthesis.

19. How do these diagrams show that oxygen is only produced in light when a plant is photosynthesizing? (H)

A. Low or very few bacteria found around areas of the spirogyra

B. A high concentration of bacteria is found around chloroplast of spirogyra which release oxygen.

C. Plants use carbon dioxide and water in the presence of sunlight and chlorophyll to manufacture food.

D. Spirogyra receives light and manufactures its food, sending out oxygen as by-product.

E. None of the above explanation is suitable.

20. In this experiment, the principal function of sunlight is to (L)

A Provide warmth for the bacteria

B Make it more clear and brighter for the bacteria to be seen.

C Attract the bacteria to the plant cell.

D Provide energy for manufacturing food.

E Enhance photosynthesis, thereby promoting the release of oxygen.

21. Which part of the spirogyra cell is responsible for releasing oxygen. (L)

A Nucleus

B Cytoplasm

C Chloroplast

D Cell wall

E Pyrenoids

22. It is advantageous to put a potted plant in the house during the day because (Ap)

A There is no competition between plants and human being for the available oxygen since plants do not respire.

B. The carbon dioxide produced during respiration by humans is used up by the plants during photosynthesis.

C. No carbon dioxide is produced by plants, since they do not respire in the day.

D During photosynthesis, the plant uses up the carbon dioxide produced during respiration, while releasing oxygen.

E. Plants will photosynthesize releasing oxygen into the house.

23. Why is it not advisable to keep a plant in the house during the night. (Ap)

A Only respiration will occur leading to more carbon dioxide and less oxygen in the house.

B Plants might die due to lack of food

C The plants will not grow well in the absence of sunlight.

D Plant will not be able to get oxygen since the stoma stomata will be closed.

E Carbon dioxide produced by humans will kill the plant, since it will not make use of it, in the absence of light.

24. Which amongst these equations best represents the equation for photosynthesis. (L)

A $6CO_2 + 6H_2O \xrightarrow[\text{Light Energy}]{\text{Chloroplast}} C_6H_{12}O_6 + 6O_2$.

B $6CO_2 + 12H_2O \xrightarrow[\text{Sunlight}]{\text{Chloroplast}} C_6H_{12}O_6 + 6O_2 + 6H_2O$.

C $C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + CO_2 + \text{Energy}$.

D $C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$.

E $C_6H_{12}O_6 + 6O_2 \xrightarrow[\text{Sunlight}]{\text{Chloroplast}} 6CO_2 + 6H_2O + \text{Energy}$

25. Where does a human being get the energy he or she needs to grow and survive. (L)

A Air

B Sun

C Exercise

D Potatoes

E All of the above.

26. What is the most appropriate biological relationship between respiration, food and energy. (H)

A Chemical potential energy stored in food is converted to ATP during respiration.

B Respiration, food and energy are very vital for the survival of living things.

C Respiration gives energy which breaks down the food substances we eat to make us grow.

D Respiration is the means by which human beings break down food to obtain energy.

E Food is necessary for cellular respiration.

27. How do Biologists define food? (L)

A A substance which provides necessary minerals for proper functioning of the systems.

B Any substance that has nutritional values that help in protesting the body from diseases.

C A class of substance containing usable organic compounds.

D A class of substance that organisms use as sources of energy for metabolism.

E Substances that plants like animals take in from their environment.

28. Where do green plants get their food from? (L)

A They get their food from the liquid content of the soil.

B They convert sunlight energy and carbon dioxide into food.

C They synthesize their food using raw materials from their immediate environment.

D They manufacture their food from Chemicals which they receive from Sunlight, soil & fertilizer.

E They make their food from simple inorganic substances using sunlight energy.

29. Where do plants get the raw materials for photosynthesis? (L)

A Soil

B Air

C Water

D Soil, air and water

E Soil and air.

30. Sunlight energy is very important during photosynthesis because: (An)

A It helps in the formation of chlorophyll

B It develops the cells in the plant

C It helps in the formation of photosynthesis

D Helps in splitting the water and to release Hydrogen

E Provides a warm environment which is (conducive) good for the process.

31. What are the raw materials for photosynthesis? (L)

A Air, Sun, Water and Chlorophyll

B Carbon Dioxide, Water, Sun light and Chlorophyll

C Carbon Dioxide, water, air & mineral salt

D Carbon dioxide, mineral salts, and water

E Water and Carbon dioxide.

32. In which cell structure of the plant are the raw materials for photosynthesis, combined together. (L)

A Chloroplast D Chlorophyll

B Cytoplasm E Protoplasm

C Nucleus.

33. Photosynthesis in a means by which green plants (L)

A Respire

B Exchange carbon dioxide for oxygen

C Get food

D Manufacture food

E Use carbon dioxide to synthesize energy.

34. During photosynthesis the chlorophyll (L)

A Colours the plant green

B Traps light energy from sunlight

C Traps light energy and converts it to chemical

energy

D Combines important pigments together

E is eliminated as one of the by-products

35. The inputs of the light-independent reactions are (An)

A Carbon dioxide

B Reactive hydrogen

C ATP

D Carbon dioxide and reactive hydrogen

E Carbon dioxide, reactive hydrogen and ATP

36. The oxygen released during photosynthesis is derived from:- (An)

A Carbon dioxide

B Water

C Hydrogen and water

D Carbon dioxide and hydrogen

E Water and carbon dioxide

37. During what phase is oxygen actually released in the process of photosynthesis (An)

A Dark phase

B Light phase & Dark phase

C Hydrogen fixation phase

D The end phase or at the end of the process

E Light phases.

38. What is the function of the chloroplast? (L)

A Exchange of carbon dioxide for oxygen

B A store of organs for respiration

C A site for photosynthesis to take place

D The "power house" of the plant

E A site for plant respiration.

39. Through what process(es) is the energy in food converted to ATP in animals. (H)

A Chemosynthesis

B Digestion

C Circulation

D Respiration

E Digestion and respiration.

40. Respiration can best be described by one of these statements (L)

A Plants need air to respire, they take in CO_2 from air and oxygen is given out.

B Breaking down of food substances taken into the body into smaller units releasing energy.

C A mechanism that facilitates inspirations and expiration of gases.

D A process which enables aerobic organisms to obtained energy from food.

E A process by which CO_2 combines with water, releasing oxygen and energy.

ANSWERS TO BCAT (APPENDIX 3.7)

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

BIOLOGY CONCEPT ACHIEVEMENT TEST (BCAT)

ANSWER SHEET FOR BCAT

Instructions: There are 40 questions presented to you on the Quiz card. DO NOT WRITE ANYTHING ON THE QUIZ CARD AND RETURN THE CARD ALONG WITH THE COMPLETED ANSWER SHEET.

Read each Question carefully and the five possible answers given after each questions. Select one from the five answers as your choice and enter it on the answer sheet by shading the letter (A or B or C or D or E) that corresponse to your choice.

Example:- If your choice is answer C for question No. 20, then you should cross letter C as shown 20 = A==B==C==D==E

Class..... Serial Number.....

(Enter your class and the serial number given to you.

Do not write your name anywhere)

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

APPENDIX 3.8

BIOLOGY ATTITUDE QUESTIONNAIRES

Here is a chance for you to express how you feel about the biology course you have been taking.

Listed below are a set of statements and responses. Tick the response which best describe your feeling, personal attitude and motivation towards biology. The responses are strongly Agree = SA; Agree = A; Not Sure = NS: Disagree = D and strongly Disagree = SD.

	STATEMENT	RESPONSES				
		SA	A	NS	D	SD
1.	I am usually interested in biology, so I always look forward for our biology lessons.	....	...	...	....	....
2.	I usually do quite well in biology, so I get worried when I do badly in any biology test	....	...	...	....	....
3.	If we give the wrong answer the teacher is generally careful to discuss it with us.	....	...	...	....	....
4.	Biology makes it easier to understand many of the worlds problems	....	...	...	....	....
5.	Our teacher enjoys the subject and passes unto us his enthusiasm for biology.	....	...	...	....	....
6.	Biology shows us how we can solve some of our daily problems in Nigeria.	....	...	...	....	....
7.	I find it difficult when I am asked to use what I have learned to solve new problems	....	...	...	....	....
8.	I like biology class less than I use to do	....	...	...	....	....

9. I cannot see the point in many of the experiments in biology, since most of them are often talked about or demonstrated ....
10 I often find the biology teacher's instructions difficult to follow. ....
11. Biology teachers you to question ideas and opinions. ....
12. When we ask a question, the teacher helps us to work out the answer for ourselves. ....
13 I would like to spend more time on biology even if it means there is less time for other subjects ....
14 I have difficulty understanding the words and expressions used in biology ....
15 The teacher always tries to relate biology to situations in daily life. ....
16 There is too much practical work and drawings needed in biology. ....
17. Biology has had a harmful effect on our culture and traditional setting in Nigeria. ....
18. I would like a career which involves biology ....
19. Biology does more harm than good. ....
20. There is too much to do in biology and this requires a lot of hard work. ....

Attitudes Towards Teaching Approach

The approach the teacher used in teaching biology during the past weeks has:

		SA	A	NS	D	SD
21	Helped me to be more active in class	....	...	..	....	....
22	Given me opportunity to apply knowledge gained in biology lesson to my daily activities	....	...	...	....	....
23	Made biology topics more difficult to understand	....	...	...	....	....
24	So much excited me that I would prefer to be taught biology with that approach only as from now on.	....	...	...	....	....
25.	Increased my reasoning ability	....	...	...	....	....
26.	Been the worst I have experienced since this school	....	...	...	....	....
27	Made the lessons boring	....	...	...	....	....
28	Enable me to see a lot of biology/sciences activities which goes on in the home	....	...	...	....	....
29.	Made biology lessons more lively and interesting	....	...	...	....	....
30.	Made me score lower marks than I used to do	....	...	...	....	....

APPENDIX 3.8b

ATTITUDE TOWARDS SCIENCE QUESTIONNAIRE FROM WHICH THE BAQ (Appendix 3.8) WERE ADOPTED AND ADAPTED

Statement	Components Loading	Factor Loadings I	II	III	IV
1. I am usually interested in science.	-.64	.71	.11	.12	-.22
2. I usually do quite well at science.	-.51	.35	.18	.05	-.41
3. The teacher does not give us much help.	.35	-.09	-.57	.13	.16
4. There is too much mathematics needed in science.	-.04				
5. Science will help me to get a job when I leave school.	-.37	.49	.02	.21	.02
6. The teacher does not give us enough time to answer his questions in class.	.27				
7. It is possible to do quite well in science by learning a lot of the work by heart.	.11				
8. I want to learn a lot more about science.	-.61	.78	.06	.15	-.12
9. Science requires a lot of hard work.	.06				
10. The teacher makes the subject lively and interesting.	-.56	.17	.67	.04	-.26
11. Science helps me to work things out properly.	-.44	.28	.13	.47	-.05
12. Science is not as interesting as other subjects.	.60	-.54	-.07	-.15	.36
13. There is too much to do in science.	.06				
14. If we give the wrong answer the teacher is generally careful to discuss it with us.	-.46	.19	.61	-.04	-.15
15. Science makes it easier to understand many of the world's problems.	-.37	.18	-.03	.65	-.06
16. I do not like reading books on science.	.51	-.58	-.04	-.16	.14
17. Science would be easier if taught in Sesotho, at least to start with.	.28				
18. We should have more lesson notes to help us remember what we have learned.	-.15				
19. Science has helped to improve our standard of living.	-.34	.17	.10	.52	-.01
20. There should be more field work and other outside activities.	-.14				
21. I would like to do more of the experiments on my own, not in groups.	-.18				
22. The teacher is usually so busy that I do not like to ask him questions at the end of the lesson.	.31	.01	-.37	.02	.30
23. Science does more harm than good.	.39	-.16	-.05	-.28	-.29
24. I would like to spend more time on science even if it means there is less time for other subjects.	-.39	.47	.02	.17	-.07
25. Science is rather difficult.	.41	-.12	.02	.01	.68
26. When we ask a question the teacher helps us to work out the answer for ourselves.	-.17				
27. We should be allowed to suggest some of the experiments ourselves.	-.27				
28. Our teacher enjoys the subject.	-.30	-.05	.54	.19	-.02
29. Science shows us how we might solve some of the problems in Lesotho.	-.35	.13	.16	.55	-.01
30. There is too much practical work.	-.07				
31. I have a chance to discuss my own ideas.	-.35	.07	.29	.12	-.24
32. I have difficulty understanding the words and expressions used in science.	.34	.02	-.05	.04	.67
33. The teacher passes on to us his enthusiasm for science.	-.30	.12	.43	.10	.02
34. Science teaches you to question ideas and opinions.	-.35	.18	.02	.49	-.09
35. There is too much writing in science.	-.03				
36. If the teacher does not know the answer to a question he will say so.	-.04				
37. I find a lot of the apparatus difficult to use.	.28				
38. I would like a career which involves science.	-.59	.66	.06	.23	-.14
39. The teacher encourages us to take a greater interest in science.	-.39	.09	.55	.32	.07
40. Science is more concerned with things than people.	.07				
41. We always seem to be in a hurry when we are doing experiments.	.21				
42. Science makes us think about what is happening in the world.	.30	.07	-.02	.65	-.04
43. We should spend more time finding out why some experiments do not give the expected results.	-.17				
44. I find it difficult when I am asked to use what I have learned to solve new problems.	.45	-.20	-.09	-.06	.53
45. I like science less than I used to.	.33	-.40	-.15	.09	.11
46. The teacher always tries to relate science to our everyday lives.	-.39	.02	.47	.26	-.13
47. I cannot see the point of many of the experiments.	.47	-.12	-.10	-.24	.50
48. Too many of the experiments are talked about or demonstrated.	-.08				

APPENDIX 3.8b CONTINUED

Table I (continued from previous page)
Factor Analysis of Questionnaire Statements

Statement	Principal Components Loading	Varimax Factor Loadings I	II	III	IV
49. Science lessons pass too quickly.	.08				
50. I am not sure what I am doing half the time.	.52	-.17	-.16	-.08	.62
51. Science has had a harmful effect on our Basotho traditions.	.26				
52. I look forward to our science lessons.	-.60	.56	.11	.27	-.19
53. The teacher tries to get round the whole class during practical work.	-.33	.11	.60	-.09	-.04
54. I do not like handling the apparatus in science.	.37	-.33	-.14	-.10	.12
55. I often find the teacher's instructions difficult to follow.	.46	-.22	-.17	.08	.53
56. I like our science teacher.	-.40	.04	.68	.01	-.10
57. Science is easier than it used to be.	-.54	.28	.26	.12	-.41

APPENDIX 4.1

STUDENTS' MISCONCEPTIONS

A Definition of respiration (Questions 2, 3, 12)

R - Human beings exhale carbon dioxide while plants exhale oxygen.

D - Breathing

D - Air in, air out

D - Breaking down of food substances taken into the body into smaller units. (Confused respiration with digestion).

D - Plants need air to respire, they take CO_2 from the air and oxygen is given out.

E - Process by which oxygen is absorbed into the body through the nostrils.

D - mechanism that facilitates inspiration and respiration of gaseous exchange in cells.

E - Process by which living things take in oxygen.

D - Alternative process for question 2

E - oxygen replaces CO_2 in the cell

D - Confused respiration with gaseous exchange

- Unclassified relationships in Q 12 (A & C).

R - Plants don't respire

E - Taking in and utilization of food in order to release energy out carbon dioxide.

E - Respiration is related to photosynthesis in terms of food but not related to Energy.

E - Process by which living things take in oxygen.

B Definition and sources of food for plants & Animals (8, 9, & 10.)

R - Define food for plant as nutrition which burn in and to produce energy.

D - Define food as substances that plants like animals take in from their environment e.g. food for plant as the chemicals it receives from sunlight, soil and fertilizer.

E - Food for plant as holozoic nutrition because they manufacture food through photosynthesis.

E - Define food for humans as burning to produce energy.

E - Define food for humans as burning to produce energy.

E - Attempts at defining were rarely correct and coherent but included or showed fragments of acceptable biological definition. Options of Q27 (BCAT).

D - Confused ideas of different classes of food.

E - Food for plant is absorbed from the soil Option of Q28 (BCAT).

C Relationship between Photosynthesis and Cellular Respiration

R - Inability to explain relationship between mouse and plant e.g. mouse will eat the plant. air options.

D - Plants undergo cellular respiration but deferent from us.

R - Photosynthesis is plants form of respiration

R - Alternative role or uses of oxygen e.g. plants don't need oxygen.

E - Difficulty in explaining other sources of CO_2 other than atmosphere e.g. plant will die for want of CO_2 or air.

R - Alternative sources of food. e.g. plants get food from water and nutrients in soil.

R - Alternative sources of energy e.g. plants need CO_2 to synthesis energy.

E - inability to explain energy conversion during photosynthesis and respiration

R - Plants don't respire and will die because it will run out of CO_2.

D - Plants exchange CO_2 for oxygen

D - Mouse will die for want of oxygen

- Mouse will die for want of food.

R - inability to explain relationship between respiration photosynthesis and energy

E - Plants and CO_2 to synthesis energy

R - Plants get food from water and nutrient in soil

D Application of knowledge of photosynthesis and respiration

D - Photosynthesis occurs in other parts of the plant cell other than the chloroplast e.g. nucleus; Pyrenoids; cytoplasm.

D - Alternative role of light in the experimental other than light develops the cells in the plant: provides warmth attracts the bacteria: makes it more clear

and bright for bacteria to be seen.

D - Alternative function of chloroplast e.g. contains organs for respiration; exchanges CO_2 for O_2;

D - Alternative reasons for high concentration of bacteria at specific regions other than presence of oxygen. in areas where photosynthesis in taking place e.g. Bacteria are scattered all over the spirogyra (Q18 options) Bacteria multiply in warm places provided by light

D - Misconceived experiment to be light and dark phases of photosynthesis

D - Alternate roles of light and dark in the experiment.

E &D - Incoherent responses

E - Attempts at explaining the process of photosynthesis without relating it to the experiment.

E - Mere description of bacteria distribution

E <u>Definition of Photosynthesis (Q 12bsd, and 4)</u>

E - Green plants turn sun and CO_2 into chlorophyll

E - Plants take in CO_2 from air and exchange it will oxygen.

E - Past formula given i.e. confused attempt at recalling the formula for photosynthesis

R - Plants get, absorb food, not make e.g. green plants get food from the soil.

E - Plants take in CO_2 from air only.

E - Change CO_2 to Oxygen

E - Confused attempts at recalling definition of photosynthesis e.g. photosynthesis is the reaction whereby plants make CHO and oxygen through CO_2 and water in the presence of sunlight and chlorophyll

E&D - Confused attempts at recalling the formula of photosynthesis

R - Plants get food from sunlight

D - Other functions of sunlight than providing energy during photosynthesis e.g. absorb chlorophyll; formation of chlorophyll, providing warmth. helps in formation of photosynthesis.

R - Photosynthesis is plants form of respiration.

D - Other functions of chlorophyll, than absorbing sunlight energy and converting to chemical energy. e.g. chlorophyll is hy-product; chlorophyll colours the plants; chlorophyll absorbs sunlight energy;

E - Inappropriate relationship between photosynthesis sunlight and food e.g.

E - Inappropriate differentiation between the way pants and animals prepare their food.

F Sources of energy for plants and human beings -2,5,12 anc &D

D - Plants get energy from other sources than sun.
air, soil, works.

D - Animals get energy from other sources than food e.g. sun; exercise, water

D - Other processes for energy production than respiration and nutrition

D - Gets energy by process of photosynthesis

E - Mainly misconceived forms of energy e.g. energy is capacity or ability to perform work.

- Inappropriate relation between energy food and glucose

E - In appropriate relation between respiration, Energy and food.

D - No relationship between energy, food and glucose e.g. Glucose is a sugar, while food is anything taken into the body and energy is the ability to do work - so there is no relationship.

R - Plants get energy from the soil with the help of their roots

D - Committed to a broad and vague conception of energy.

APPENDIX 4.2

FREQUENCY OF STUDENTS HOLDING VARIOUS MISCONCEPTIONS BEFORE AND AFTER RESPECTIVE TREATMENTS.

RECONCEPTUALIZATION					EXTENSION					DIFFERENTIATION				
Opt.	Pre C	Post C	Pre E	Post E	Opt.	Pre C	Post C	Pre E	Post E	Opt.	Pre C	Post C	Pre E	Post E
A	2	0	6	2	2D	1	1	2	0	2C	5	13	4	2
C	10	3	5	3	3C	1	11	3	3	E	14	6	0	12
D	0	5	0	2	4E	7	2	2	13	3D	1	4	5	1
E	25	29	0	13	C	8	2	6	0	4A	10	8	2	0
2B	8	9	9	5	8	6	10-	6	1	7A	7	6	9	0
3A	34	15	30	4	C	10	1	3	2	B	15	12	8	4
E	0	3	3	1	9D	10	13	8	6	D	3	1	12	4
4D	6	10	5	1	11A	17	9	22	3	9D	5	13	8	5
5B	15	9	12	3	E	2	0	5	1	E	9	7	10	11
C	2	3	7	1	12C	10	11	4	8	12D	3	4	4	4
D	4	4	9	0	E	3	6	0	1	15E	6	7	2	6
E	6	4	3	0	13A	3	7	4	8	16E	11	3	13	3
8A	6	3	4	0	D	0	2	0	0	E	1	4	5	0
8B	9	12	8	4	16A	11	18	13	24	17B	8	11	11	6
9B	6	5	10	5	C	5	3	1	1	18A	13	9	5	2
10A	16	14	16	11	17D	10	0	4	3	B	2	7	4	4
C	5	5	5	5	18E	3	4	4	0	19C	21	4	10	4
D	7	4	5	4	D	10	9	11	15	20A	2	5	0	0
E	2	0	1	1	19A	4	8	4	1	20B	8	4	6	5
11B	3	2	2	2	D	6	5	7	4	C	3	5	2	1
D	2	2	1	0	20D	12	6	11	0	24C	1	0	1	0
12B	12	5	19	7	20E	4	5	9	15	D	3	0	4	0
13B	15	19	12	4	23C	13	23	9	0	E	4	5	7	6
C	14	8	16	8	D	11	1	7	11	25A	6	4	4	5
15A	17	10	21	1	24A	18	14	14	5	B	3	6	4	1
B	3	2	0	2	26B	9	7	11	3	C	2	1	1	3
D	7	2	7	3	E	0	1	2	0	E	23	23	25	18
17A	0	4	0	1	27D	2	6	5	0	26C	10	14	6	12
C	15	14	15	13	28B	10	11	9	3	28D	9	12	7	3
22A	5	12	4	6	C	9	8	5	7	29C	0	0	3	1
E	10	11	4	4	20A	9	5	9	4	D	25	23	20	19
C	7	1	7	2	B	0	4	1	0	30B	7	4	4	3
23B	1	2	1	0	33E	4	3	2	0	E	6	12	3	8

APPENDIX 4.2 CONTINUED

RECONCEPTUALIZATION					EXTENSION					DIFFERENTIATION				
Opt.	Pr C	Post C	Post E	Post E	Opt.	Pre C	Post C	Pre E	Post E	Opt.	Pre C	Post C	Pre E	Post E
E	4	3	4	4	B	2	0	4	1	31A	11	2	9	4
26D	15	8	7	8	34B	5	5	15	15	B	22	27	21	18
28A	4	0	4	3	39D	5	5	5	7	C	2	2	5	0
30A	13	15	21	9	B	15	3	10	3	D	2	1	0	0
C	10	4	3	5						34D	3	5	0	4
33	1	2	3	4						38A	13	8	9	10
C	3	2	1	0						39A	3	8	2	4
34A	23	23	10	5						C	5	5	5	0
E	1	2	5	0						40B	18	25	9	21
38B	5	5	5	4						C	4	0	5	0
D	3	8	8	5						27A	16	16	21	19
E	5	4	4	2						B	19	12	9	3
40A	14	1	5	5						C	2	6	5	0
E	8	5	8	3										

Pre - Pre test

Post - Post test

APPENDIX 4.3.

Frequency and Percentages of students picking various BCAT Options before and after treatments

ITEMS	EXPERIMENTAL OPTIONS														CONTROL OPTIONS													
	A		B		C		D		E		%		OM		A		B		C		D		E		%		OM	
	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Po	Pr	Pc
1	6	2	1*24		5	3	0	2	23	5	3	67	1	-	2	0	0*0		10	3	0	5	25	29	0	0		
2	5*	27	9	5	4	2	2	0	0	13	14	75	3	-	0	*0	8*9		5	13	1	1	14	6	22	22		
3	30	4	0*26		3	3	0	1	3	1	0	74	-	-	34	15	1*3		1	11	1	4	0	3	3	8		
4	2	0	18*22		6	0	5	1	2	13	50	61	3	-	10	8	6*10		8	2	6	10	7	2	16	27		
5	10	3	2	1	10	1	8*	20	6	10	22	56	-	1	11	11	9	14	4	8	4*	1	9	3	11	3		
6	3*	32	12	3	7	1	9	0	3	0	9	89	2	-	10*	16	15	9	2	3	4	4	6	4	27	44		
7	9	0	8	4	6*	28	12	4	1	0	17	78	-	-	7	6	15	12	11*	15	3	1	1	2	30	41		
8	4	0	8	4	3	2	15*	29	6	1	42	81	-	-	6	3	9	12	10	1	6*	11	6	10	16	30		
9	8	6	10	5	0*	9	8	5	10	11	0	25	-	-	13	10	6	5	4*	2	5	13	9	7	10	5		
10	16	11	9*	14	5	5	5	4	1	1	25	40	-	1	16	14	6*	13	5	5	7	4	2	0	16	35		
11	22	3	2	2	5*	30	1	0	5	1	14	83	1	-	17	9	3	2	6*	22	2	2	9	2	16	60		
12	9*	16	19	7	4	8	4	4	0	1	25	44	-	-	9*	11	12	5	10	11	3	4	3	6	24	30		
13	4	8	12	4	16	8	0	0	3*	16	8	44	1	-	3	7	15	19	14	8	0	2	5	*0	14	0	1	-
14	1	1	26*	30	0	0	2	0	7	5	72	83	-	-	8	0	17*	27	3	3	3	0	6	7	46	73		
15	21	1	0	2	6*	24	7	3	2	6	17	67	-	-	17	10	3	2	4	*16	7	2	6	7	11	43		
16	12	14	13	2	1	1	4*	18	5	0	11	50	-	1	11	18	11	3	4	3	9*	6	1	4	24	17	2	-
17	0	1	11	6	15	13	4	3	4*	13	11	36	-	-	0	4	8	11	15	14	10	0	3*	8	8	22	1	-
18	5	2	4	4	8*	15	11	15	4	0	25	0	4	-	13	9	2	7	9*	8	10	9	3	6	24	22		
19	4	1	9*	24	10	4	7	4	4	2	26	69	2	1	4	8	6*	13	21	4	6	5	0	7	16	35		
20	0	0	6	5	2	1	11	0	17*	30	47	93	-	-	2	5	8	4	3	5	12	6	11*	17	30	46		
21	6	1	16	4	9*	28	5	2	0	1	25	78	-	-	3	7	15	10	13*	10	3	2	3	5	35	27		
22	4	6	4	4	7	2	10*	9	9	15	29	25	2	-	5	12	10	11	7	1	10*	7	4	5	29	19	1	1
23	15*	20	1	0	9	0	7	11	4	4	42	56	-	-	7	*8	1	2	12	23	11	1	4	3	19	22	1	-
24	14	5	10*	25	1	0	4	0	7	6	28	69	-	-	18	14	11*	18	1	0	2	0	4	5	31	49	1	-
25	4	5	4	1	1	3	2*	9	25	18	7	25	-	-	6	4	3	6	2	1	3*	3	23	23	8	8	-	-
26	10*	13	11	3	6	12	7	8	0	0	28	36	-	-	3*	6	9	7	10	14	15	8	0	1	8	17	-	1
27	21	19	7	6	2*	11	5	0	1	0	6	31	-	-	16	16	19	12	0*	1	82	6	0	2	0	3	-	-
28	4	3	9	3	5	7	7	3	11*	20	31	56	-	-	4	0	10	11	9	8	9	12	5	*6	14	16	-	-

29	9	4	1	0	3	1	20	19	3*12	8	33	-	-	9	5	0	4	0	0	25	23	3*	5	8	14
30	21	9	4	3	3	5	5*11		3	8	14	31	-	-	13	15	7	4	10	4	1*	2	6	12	3	5
31	9	4	21	18	5	0	0	0	1*14	3	39	-	-	11	2	22	27	2	2	2	1	0*	5	0	14
32	12*28		3	0	6	3	13	2	2	3	33	78	-	-	12*10		2	2	10	18	10	5	3	2	32	27
33	3	4	4	1	1	0	25*31		2	0	71	86	1	-	1	2	2	0	3	2	27*	30	4	3	73	81
34	10	5	15*15		5	12	0	4	5	0	43	42	1	-	23	23	5*6		5	1	3	5	1	2	14	16
35	5	4	2	3	5	4	6	8	16*17		44	47	-	-	3	2	7	2	8	9	7	5	12*19		32	51
36	9	4	3*	6	7	4	11	10	6	12	8	16	-	-	9	7	8*	0	6	6	10	5	4	19	22	0
37	5	4	14	8	6	0	4	1	7*23		19	64	-	-	9	10	17	11	3	1	4	2	4*13		11	35
38	9	10	5	4	10*14		8	6	4	2	28	39	-	-	13	8	5	6	8*11		3	8	5	4	22	30
39	2	4	10	3	5	0	5	7	14	22	39	61	-	-	3	8	15	3	5	6	5	6	9*14		24	38
40	14	1	9	21	5	0	3*13		5	1	8	36	-	-	5	5	18	26	4	0	2*	0	8	5	6	0

NOTE:

A-E	OPTIONS
%	PERCENTAGE OF CORRECT RESPONSES
OM	OMITIONS
PR	PRE-TEST
PO	POST TEST
*	CORRECT OPTION

APPENDIX 4.4

The frequency of responses of students to the BAQ after treatment with conceptual change strategy and traditional metho

ITEM	EXPERIMENTAL					CONTROL				
	SA	A	NS	D	SD	SA	A	NS	D	SD
1	29	7	-	1	-	31	6	-	-	-
2	19	14	1	1	1	25	12	-	-	-
3	21	13	1	1	1	22	10	2	3	-
4	21	8	3	4	-	16	12	4	4	1
5	18	16	1	1	-	17	16	3	1	-
6	17	10	4	4	1	18	8	5	6	-
7	2	4	3	11	16	2	7	10	12	6
8	7	12	1	10	6	9	9	-	16	3
9	3	1	4	14	14	3	3	6	16	10
10	1	4	4	10	17	14	12	3	7	1
11	17	14	1	4	-	17	15	4	1	-
12	18	14	-	3	1	9	12	8	5	4
13	8	9	4	9	6	7	11	5	8	6
14	3	3	3	20	7	20	14	2	1	-
15	20	13	2	1	-	19	13	3	-	2
16	14	16	2	1	3	5	5	7	8	12
17	3	5	3	8	17	27	9	-	-	1
18	16	18	-	-	2	3	2	6	8	18
19	1	4	4	9	18	21	12	-	3	1
20	19	15	1	1	1	23	12	1	-	1
	Attitude towards approach									
21	26	10	-	-	-					
22	13	1	-	-	-	No of Students				
23	1	-	2	5	28	Experimental 36				
24	14	15	2	1	4	Control 37				
25	22	13	1	-	-	SA Strongly Agreed				
26	2	2	4	5	23					
27	-	7	3	1	25					
28	24	12	-	-	-					
29	25	11	-	-	-					
30	2	-	2	5	27					

APPENDIX 4.5

Correlation between attitude and performance of Boys and Girsl in control and experimental group.

BACT Performance for		N	ATTITUDE SUBSCALE			
			Interest r	Difficulty r	Teacher influence r	Social implication r
CG	BOYS	27	.424 S (.18)	.563 S (.28)	.427 S (.18)	.412 S (.17)
	GIRLS	10	-.192 (0.04)	.085 (.01)	-0.233 (0.05)	-0.206 (0.04)
EG	BOYS	25	.319 (.10)	.177 (.03)	-0.192 (0.04)	0.106 (0.11)
	GIRLS	11	.452 (.20)	.272 (.074)	-.0015 (0.00)	0.647 S (0.42)

CG - CONTROL GROUP
EG - EXPERIMENTAL GROUP
S - SIGNIFICANT