EFFECTS OF PROBLEM SOLVING INSTRUCTIONAL STRATEGY ON ACADEMIC ACHIEVEMENT AND RETENTION IN ECOLOGY AMONG SECONDARY SCHOOL STUDENTS WITH DIFFERENT COGNITIVE PREFERENCES IN ZARIA EDUCATIONAL ZONE

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DECLARATION

I hereby declare that this dissertation titled **"EFFECTS OF PROBLEM SOLVING INSTRUCTIONAL STRATEGY ON ACADEMIC ACHIEVEMENT AND RETENTION IN ECOLOGY AMONG SECONDARY SCHOOL STUDENTS WITH DIFFERENT COGNITIVE PREFERENCES IN ZARIA EDUCATIONAL ZONE"**, has been written by me and that it is a record of my own research work. It has not been presented in any previous application for a higher degree. All quotations are indicated by quotation marks or indentation and the sources of information are specifically acknowledged by means of references.

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CERTIFICATION

The undersigned certify that this dissertation titled **"EFFECTS OF PROBLEM-SOLVING INSTRUCTIONAL STRATEGY ON ACADEMIC ACHIEVEMENT AND RETENTION OF ECOLOGY AMONG SECONDARY SCHOOL STUDENTS WITH DIFFERENT COGNITIVE PREFERENCES IN ZARIA EDUCATIONAL ZONE by BAWA MAIRIGA RIBAH,** meets the regulations governing the award of the degree of Doctor of Philosophy (Ph.D) of Ahmadu Bello University, Zaria and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This dissertation is dedicated to my beloved parents, Mr. Daniel Bawa Ribah (Deacon) and Mrs. Kande Yoro Bawa, my beloved wife, Mrs. Margaret Jemila Mairiga and children, Rebecca, Juliana, Jonathan, Salome and Ruth and to all those who toil day and night to see to the improvement of the quality of Science Education in Africa at large.

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ABSTRACT

This study was carried out to investigate the effects of Problem Solving Instructional Strategy on Academic Achievement and Retention in Ecology among Senior Secondary School students with different cognitive preferences four Senior Secondary Schools in Zaria Education Zone, comprising Zaria and Sabon Gari areas of Kaduna State, constituted the population for the study. A randomly selected sample of two hundred forty students (240) constituted the subjects for the study. A randomly selected sample of one hundred and twenty students who constituted the experimental group were taught using Problem Solving Instructional Strategy, while the remaining 120 students that constituted the control group were taught using the lecture method Instructional Strategy (LMIS). Two Secondary Schools served as the experimental group, while the other two served as the control group respectively. The study adopted the quasi experimental control group pretest-post-posttest design. Two instruments were used in this study for data collection, namely, the Cognitive Preference Test (CPT), and Ecology Achievement Test (EAT) in Ecology. The CPT was adopted from Heath (1964), while the (EAT) was developed by the researcher. A pretest was administered before the treatment to establish the equivalence of the experimental and control groups using Problem Solving Instructional Strategy (PSIS), while the control group was exposed to the Lecture Method Instructional Strategy (LMIS). The topics covered were basic ecological concepts, major biomes of the world, population studies and ecological factors. These topics have been established by researchers as being very difficult to learn in ecology. Seven null hypotheses were subjected to statistical analyses involving the use of t-test. ANOVA on Achievement and Retention. ANOVA was used to test for the difference in the level of significance in the mean scores of the experimental groups of Recall, Application, Principles and Questioning in favour of the experimental groups in these fields. The result of the study showed among others that there was significant difference between the posttest mean scores of the experimental and control group of recall variable in favour of the experimental group. Significant differences exist between the posttest mean scores of the experimental and control groups in Application variables in favour of the experimental group. There was significant difference] between the posttest mean scores of the experimental and control groups in principles, in favour of the experimental group. Posttest mean scores of the experimental and control groups in principles variable were statistically different in favour of the experimental group. Posttest mean scores of the experimental and control groups in Questioning variable were also statistically different in favour of the experimental group. The posttest mean scores of the experimental and control groups were found to be statistically significant in favour of the experimental group in Retention of the ecology concepts. Seven recommendations were made in the study, one of which was that the study of ecology results in the accruing of many benefits to mankind; therefore the study of ecology is viewed to be very important in Secondary Schools. It was therefore suggested that a wider coverage, patronage and publicity should be accorded the study of Ecology in the school curriculum syllabus, and all facets of human endeavour.

DEFINITION OF TERMS

The terms that were used in this study are defined operationally in this section.

Cognitive preference	-	is the student's preference to the four Variables as identified by Heath (1964) cognitive preference option mode namely:
(i)	-	recall or memorization of facts (Recall)
(ii)	-	identification of fundamental principles (principles0
(iii)	-	practical application of knowledge (application)
(iv)	-	critical questioning of information (questioning)
Cognitive Strategy	-	A guide that helps students/Learners develop internal procedures that enable them to perform higher level cognitive operations.
Problem-Solving	-	Is a process which focuses on knowing the issues, considering all possible factors that lead to finding a solution. Is the analysis and solution of tasks and situations that are somewhat complex or ambiguous and that pose difficulties, inconsistencies obstacles of some kind.

LIST OF ABBREVIATIONS AND SYMBOLS

CPT	-	Cognitive Preference Test
IPI	-	Individually Prescribed Instructions
CBT	-	Computer-Based Training
OJT	-	On-the-job-training
E.A.T	-	Ecology Achievement Test
W.M	-	Working Memory
LTM	-	Long-term memory
CUDIMAC	-	Curriculum Development and Instructional Centre

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CHAPTER ONE

THE PROBLEM

1.1 Introduction

One of the highest goals of science education concerns improving students' ability to think critically, reason logically and ultimately to solve problems (Aldridge, 1992). The World Declaration on Education for All (WDEFA, 1990), looks at education from the individual point of view and states that education should provide tools, knowledge, skills, values and attitudes required by human beings to be able to survive and develop their full potentials and capabilities, to live and work in dignity. Rosenshine (1996) posited that a major research in cognitive processing, one with important implications for teaching is the research on how information is stored and retrieved. Information is usually stored in long-term human memory, in interconnected networks called knowledge structures (Rosenshine,1996).

The number of interconnections between pieces of knowledge are very important for processing information and solving problems. When the knowledge structure on a particular topic is large and well connected, new information is more readily acquired and prior knowledge is more readily available for use (Kameani and Chards, 1997). Having a well-connected network means that any one piece of information can serve to help retrieve the entire pattern.

Having strong connections and a richness of relationships enables one to retrieve more pieces of the pattern. When information is "meaningful" to students, they have more points in their knowledge structures to which they can attach new information (Palinscar and Brown,1991). Asking students to organize information, summarize or compare new material with prior material are all activities that require processing and should help students develop and strengthen cognitive structures. In addition, Palinscar and Brown (1991) wrote:

> Understanding is more likely to occur when a child is required to explain, elaborate or defend his position to others, the burden of explanation is often the push needed to make him or her evaluate, integrate and elaborate knowledge in new ways

Well elaborated and connected structures are important because

(a) they allow for easier retrieval of old material

(b) they permit more information to be carried away in a single chunk, and

(c) they facilitate the understanding and integration of new information.

The instructional implications of the research revolve around the pivot that there is: the dire need to help students to develop background knowledge;

Rosenshine and Stevens (1986) in their study found relevant ways in which students could easily assimilate and pull out misconceptions in what was taught to them during learning as follows:

(a) the importance of teaching students in small steps,

(b) guided practice,

(c) the importance of extensive practice.

Another viable way in which students' learning is made meaningful, devoid of errors and misconceptions is through the inculcation of cognitive strategies. It is not a direct procedure, nor is it an algorithm to be precisely followed. Rather, a cognitive strategy is a guide that serves as the learner develops internal procedures that enable him/her to perform the higher level operations.

Teaching students to generate questions about their reading is an example of a cognitive strategy. Generating questions does not directly lead in a step-by-step manner to comprehension. Rather, in the process of generating questions, students need to search the text and combine information, and these processes serve to help students comprehend what they read (Englert and Raphael, 1989; Scardamalia and Bereifter, 1985).

Awodi (1984) compared the biology achievement of Nigerian secondary school biology students when taught either by inquiry method or traditional (lecture) method. The students were guided through the lessons by the nature of teachers' questions and they were also encouraged to ask questions. The result indicated that inquiry teaching improved the academic achievement of the students. Similarly, Martins (1994) tested the effect of lecture (i.e traditional approach) and inquiry strategies on the cognitive performance of integrated science students. The studies of both Awodi (1984) and Martins (1994) indicated that inquiry teaching strategy could afford students greater achievement in their science lessons than the traditional teaching method.

In science, cognitive preference refers to the ability of an individual to "choose" between alternatives and the possibility of rank-ordering of these alternatives, based on happiness, satisfaction, gratification, enjoyment and utility they provide (Kreps, 1999; Mas-collel and Green, 1995). Generally, it can be seen as a source of motivation. Individual preference or "taste" is a concept used in social sciences, particularly economics. Jensen (1998) believes that people with higher cognitive preference ability or intelligence quotient (IQ) differ from those with lower cognitive ability in a variety of ways. On the average, they have larger working memories, faster reaction time and more susceptible to visual illusions.

Frederick (2005) observed that there is paucity of literature on cognitive preferences of students that relate to:

(i) time preference

(ii) risk preference

(ii) probability weighting

(iii) ambiguity

(iv) aversion

(v) endowment effects, and

(vi) anchoring

These and other widely researched topics rarely make any reference to the possible effects of cognitive abilities. According to Abah (1986), cognitive preference construct is a dimension of cognitive style, originally proposed by Heath (1964). It is a science curricula that showed increased emphasis on four kinds of preferences namely:

1. Preference for memorization and recall of scientific facts and terms for their own sake, that is, without consideration of their implications or limitations (= Recall).
2. Preference for scientific information which exemplifies some fundamental scientific principles or generalization (= Principles)
3. Preference for scientific information in view of its practical application = (Application)

4. Preference for critical questioning or criticism of scientific information as regards its completeness, general validity or limitations (= Questioning).

Cognitive preference is looked at as a dimension of cognitive style, referring to an individual's generally preferred and habitual approach to organizing and presenting information (Riding and Cheema and Rayner,1998).

Robertson (1985), quoted Allport's (1937) pioneer definition of cognitive preference as "an individual's habitual way of perceiving, remembering, thinking and problem-solving". In an all-embracing definition of cognitive preference, McFaden (1986), cited in Peter (1995), wrote:

> Cognitive preference include consistent patterns of behaviours, student's consistence of responding to stimuli in processing information and using stimuli in a learning environment, how individuals organize information and experience, a person's characteristic style of acquiring and using information and an expression of psychological differentiation within characteristic modes of information processing (1995:1)

Boden (1991) equated cognitive preference to creativity and problem-solving, stressing the fact that in recent times, these terms have been found to be synonymous to one another (that is, cognitive preference and cognitive style). Lana (1987), and Franklyn (1998), classified cognitive preferences into three broad areas, namely:

(i) Visual preference

(ii) Auditory preferences; and

(iii) Kinesthetic preferences.

In order that students should be able to take ownership of tasks, and become effective problem solvers, there is thus the need to strategize their learning processes. All these three terms contribute in making the study of cognitive preferences a huge success. Pressley et al (1995) suggested the inculcation, adoption and enactment of instructional strategies that help in guiding students towards the attainment of meaningful learning. According to them, instructional strategies are guiding procedures that students can use to help in completing less structured tasks, such as those in reading, writing and comprehension.

In visual preference, understanding cognitive preferences means that one can ask for information, seek opportunities that will ensure optimum mastery/learning. Identifying and understanding the order of one's style or preferences will help in planning and implementing personal strategies. Visual preference relates to seeing what one is doing/learning. For example, asking for handout. To utilizing videos, computing resources, etc. In the auditory preferences, an individual would like to hear what he is learning, for example, attending lectures, asking questions for discussion time, etc. The kinesthetic preference involves the individuals moving from one place to the other, carrying out experiments and practical's, etc. All the three kinds of preferences could be employed in the teaching and learning experiences at a stretch. Thus, this in essence will help in enriching the students' knowledge-base.

In another development, Cooper Sandra, Peter and Greta (1986) advocated for the inculcation of a variety of pluralistic viewpoint approaches in teaching as well as in information dissemination in schools. They suggested the following teaching/learning approaches:

i. Authoritarian viewpoint

ii. Permissive approach

iii. Laissiez-faire climate

iv. Cook-book approach

In suggesting these approaches, they had in mind the preparation of a forum in which the teaching-learning climate of students is made very conducive for meaningful and effective learning to take place. They opined that the teacher could use the authoritarian viewpoint in teaching in order to improve on the classroom learning atmosphere and to save students from the mundane and monotonous learning difficulties that characterize the classrooms environment. Also the teacher could use force or coercion in his teaching strategy if that becomes necessary to draw the attention of his students to face their work seriously. They further advised that teachers should not at all times be so rigid or set draconian rules for students in the course of teaching, but should allow some degree of freedom to be exercised by students in the teaching – learning process. In all the different viewpoints propounded by Cooper et al (1986). The single and simple idea behind these suggestions, is to create a forum in which students are guided to acquire meaningful learning, acquisition of skills to enable them solve problems on their own, with little or no assistance from teachers or fellow students.

In this connection, Heath (1964) introduced the cognitive preference test, which is a new method of evaluating students' performances, different from the traditional methods. The interest in the new method is not in whether the students can identify correct and incorrect information intellectually, but to identify the pattern of their cognitive preference. Heath (1964) identified four modes of thinking used by students in attending to academic knowledge. These methods are:

i. Recall

Acceptance of scientific information for its own sake, without consideration of its implication, application and limitation.

ii. Principles

Acceptance of scientific information because it exemplifies some fundamental scientific relationships.

iii. Application

Acceptance of scientific information because it explains some fundamental scientific principles.

iv. Questioning

Critical questioning of scientific information because it exemplifies some fundamental scientific information as regards its completeness, general validity and limitation.

Heath pointed out that when a student is presented with scientific information, he may attend to such information in any of the following ways:

i. memorize the facts contained in the information;

ii. focus on the fundamental principles that underlie the information;

iii. question the information critically;

In this study, the four cognitive preferences used by Heath (1964) would also be used in this study, namely:

i. memory or recall of facts (= Recall)

ii. practical application (= A)

iii. Critical questioning of information (=Q)

iv. Identification of fundamental principles (=P)

The term instructional strategy is used to describe the process of sequencing and

Organizing content, specifying learning activities and deciding how to deliver the content and activities (Carey and Dick, 1993). Gagne 1988 calls the planning and analyzes steps the "architecture" of the course while the instructional strategies are the "bricks and mortar". This is where the teachers deal with how to actually instruct the students.

Ezenwa (1993) opined that in the search for making science teaching more meaningful, many science educators now advocate for instructional strategies to take students preconceptions into consideration. Biology teachers use lecture method to teach ecology (Lagoke, 1984). Lecture method is found to be ineffective in science instruction (Awodi, 1984, Okeke, 1995 and Oyegegbu, 1999). Ecology covers 45.17% of the entire Biology Curriculum and is found to be neglected by teachers during the teaching activities (Eguabor, 1997).

The academic achievement of secondary school students has been very poor in recent times especially in Biology. The 1998 WASC results showed a failure rate among the candidates in Biology as shown in Table 1.1. The trend has been consistent for the past number of years and 2006 recorded an all time low turn out for a period of eight years shown in Table 1.1. A breakdown of students poor performance in Biology in the SSCE for the years 2004 to 2009 is shown in Table 1.1

Table 1.1 Performance of Candidates in Biology at WASC (SSCE) May/June

	Biology	
Year	**Biology Enrolment**	**% Pass in Grades 1-6**
2000	641,541	19.14%
2001	620,950	16.5%
2002	711,456	15.83%
2003	704,347	27.1%
2004	724,425	27.3%
2005	1,072,607	14.56%
2006	1,162,046	11.99%
2007	1,261,971	15.75%
2008	1,286,048	15.11%

Source: WAEC, Records, Kaduna

Cognitive preferences enable students to attain and retain the knowledge acquired to solve problems effectively.

Achievement works hand in hand with retention Duyilemi (1986) pointed out that

an important factor which is often overlooked (in discussions) or if mentioned at all, is

glossed over and immediately dismissed from the mind, is the adverse effect that the foreign language as the medium of communication has in the primary school. He argued that the child's memory is strengthened by his experiences at school and at home. When he (the child) is taught in the mother tongue, his experiences in the classroom are very similar with those outside.

The issue of the problem in the ability of students to retain what was taught them was also echoed in language policies in Nigeria, in the National Policy on Education (NPE, 1981). Colonial master enacted language policies in the Nigerian Educational system to ensure that learners became beneficiaries of the educative system. Such policies were reversed due to non-clearcut guidance in the teaching learning activities that culminated into rote-learning, regurgitation and cramming of information. This singular act, in essence succeeded in reducing the learners to the level of 'functional illiterates'.

Fafunwa (1974) observed that in order to maintain an equilibrium in the level of retention of the learners in the educative process, teachers should employ pluralistic methods of teaching that include the discussion, problem solving, lecture and project

methods to help in marrying the HANDS, HEAD and HEART Knowledge (Van Dijk and Kintsch, 1978). To Brown (1993) the aspect of retention of the learnt information can only be maintained and enhanced, when there is constant review and renewal of the curriculum to promote innovation of new knowledge to be disseminated to the learners at all times.

Children learn by doing. The new knowledge to be introduced to the learner should be geared towards enabling and allowing students to take ownership of tasks with little or no help from both the teachers and fellow students as well. For example engaging students in a project method activity or an excursion (Slavin 1987).

The adoption of this approach is necessary, bearing in mind the individual differences and environments that are involved. Retention of meaningful learning is enhanced when such factors come into play. Bennett and Rolheiser (2001), added the dimensions of instructional organizers and tactics into the list to serve as well as develop conceptual frame works for thinking about instructional strategies.

Contemporary conceptions of instructional strategies acknowledge that the goals of schooling are complex and multi-faceted, and that teachers need to include many approaches to meet varied learner outcomes for diverse populations of students (Richardson 2001). A single method is no longer adequate in teaching. Effective teachers select varied instructional strategies that are both behavioural and cognitive levels of students problem-solving competence, especially in Ecology.

1.1.1 Theoretical Framework

Every society is confronted with ill-structured or complex problems that often have vaguely defined goals, possess multiple solution paths and potentially have multiple, non-guaranteed solutions. (Schraw, 1995). Thus developing problem-solvers has been central focus of educational and professional development. Problem-solving plays a very important role in Science Education, as it is used to train children to apply scientific knowledge and skills learned. Besides problems are seen as a vehicle for developing student's general problem solving capacity and for making the science lessons more pleasant and motivating

Problem-Solving is known to be influenced by variables. The literature suggests that success in problem-solving depends on a combination of strong domain of knowledge or ability knowledge of problem solving strategies and attitudinal components (O'Neil and Schraw, 1999). Kogan (1976) pointed out that general ability domain focuses on a level of cognitive style domain which deals with the manner in which individuals acquire, store, retrieve and transform information. As individuals are of different cognitive styles i.e have different preferred structural and process-orientation they exhibit as they gather, process and evaluate information to perceive, think, solve problems, learn and relate to others, it is reasonable to expect them to exhibit different skills. Those with cognitive styles or orientation that enhance high level organization of knowledge and ability establish relationship between knowledge they have acquired and the problems setting will tackle problems with ease and high level of dexterity than those with opposite orientation.

Two major theories have tried to account for variables involved in problem solving in science, i.e Lawson (1977) pointed out that the major determinants of abstract concepts, achievement or problem solving is students' formal reasoning. However, Neo-piagetians like Pascual-Leone and Goodman (1979) urged that formal reasoning alone cannot explain students' success and postulated a new model which provides explanatory constructs for cognitive development.

An influential model of development and learning was constructed by Piaget (1977) called genetic epistemology in which he proposed that logico-mathematical knowledge is progressively constructed by a child in interaction with his environment (Piaget, 1983). The development of cognitive structure is based on four factors: Maturation, Physical experience, social experience and equilibration (Piaget, 1970). Maturation is the development of the brain that opens up the possibilities of construction and expansion of structures. Equilibration is change in cognitive structure to resolve conflicts and contradictions encountered. Social experience provides cognitive conflict from social interaction which caused disequilibrium and thus enable learning to take place.

He further proposed that children are four different types of thinkers and learners from adults, who think in concrete terms, can not represent concepts with structure of scientific concepts and are limited in their inferial apparatus. According to Carey (1986), Piaget stage theory described several general reorganizations of the child's conceptual Schema or machinery for the shift from Sensori-motor to representational thought, from pre-logical to early concrete logical thought, and finally to formal thinking of adults. Discussions on Piaget theory is often centered on transition between the concrete operation and formal operation stages and the way instruction can be revised on this model. Proponents of the theory envisaged connection between a learner is capable. Thus his followers argue that students who have not attained formal operational ability will not be able to comprehend meaningful abstract concepts and principles of science to apply them to solve problems (Lawson, 1983). Positive linear relationships between formal reasoning activity and attainment in science problem solving have been described by a number of authors (Lawson, 1983).

The Neo-piagetical by Pascual Leone, 1989) provides the following postulates:

(a) Related ability to solve problems to increase in mental capacity (M-Space) i.e increase in students information processing capacity with age.

(b) The field factor which is the ability for subjects to dissemble information in a variety of complex and potentially misleading context.

(c) Mobile/fixed cognitive style which arises from combination of mental capacity and disembeddying ability

There are researchers in support of Neo-piagetian theories. For example, there are

studies that have established a positive relationship between working memory capacity with achievement in problem-solving in science (Reid, 2004). The working memory capacity represents the amount of information activated and retained while solving a problem. The more the working memory capacity i.e the more information in working memory the better the student's performance.

In the same vein, students with better dissembedding ability are better problem solvers (Niaz 1991, Reid, 2006) hypothesis that mobility fixing dimension can serve as variable tool in the students' performance in problem solving. The most mobile students perform best in creativity test, while fixed students performed better on test of formal reasoning, thus according to them, fixed students or convergers are better at intelligent tests or closed – ended tests, while mobile or divergers are better in creativity.

These theories tend to link the mode of thinking, information processing and problem solving to cognitive styles people adopt. There is strong evidence that problem solving strategy may have ranging effect on achievement and retention of students with different cognitive styles. This study is aimed at establishing that.

1.2 Statement of the Problem

The study of Ecology requires field work in which the practical aspect takes the centre stage of its activities. In order to maintain an equilibrium in the level of academic achievement and retention of knowledge of the learners in the learning process, teachers are implored to employ pluralistic methods in the teaching, so as to help in marrying the HANDS, HEAD AND HEART knowledge. Retention of information learnt in this area can only be maintained and enhanced, when teachers embark on constant reviewal and renewal of curriculum, to promote innovation of new knowledge to be disseminated to the learners at all times.

Okeke (1995) and Oyegebu (1999) found out that teachers use the lecture method in teaching Ecology which is found to be ineffective in teaching of science instruction. The teaching of Ecology is found to be neglected by teachers during the teaching and learning activities. Eguabor, (1997) found that only a chapter, page, or paragraph is normally given prominence in pages of textbooks, newspaper, Education news Bulletins of the study of Ecology etc. This could be the reason (s) behind students' poor performance, as well as shunning and fearing the learning of Ecology by students. The concern of this study is to investigate if the application of problem solving instructional strategy can be used to enhance the teaching and learning of ecology in particular and science education in general.

1.3 Objectives of the Study

The present study is aimed at determining the effects of problem-solving instructional strategies (PSIS) on students' academic Achievement and Retention of Ecology concepts. The main purpose of the study is therefore to determine effectiveness of problem-solving instructional strategy on:

a) Students academic achievement in Secondary Schools in the study of Ecology.
b) The type of theoretical framework on which the study hinges.
c) Students academic achievement and retention levels in problem-solving in Recall, Application, principles and Questioning modes.
d) Students skills acquisition in the inculcation of problem solving strategies.

e) The ability of students taking ownership of tasks, so as to enable them operate above the level of ‘functional illerates’.

1.4 Research Questions

The study specifically sought to answer the following research questions:

1. Is there any difference in the academic achievement of the subjects exposed to problem-solving instructional strategy and those exposed to lecture instructional method?
2. Is there any difference in achievement among the subjects that operate in the following cognitive preferences?
   a) Recall
   b) Application
   c) Principles
   d) Questioning
3. Is there any difference in the academic achievement between subjects in the experimental group that operate in the Recall cognitive preference and their counterparts in the control group?
4. Is there any difference in academic achievement between subjects in the experimental group that operate in the cognitive preference of Application and their counterparts that operate in the same cognitive preference in the control group?
5. Is there any difference in the academic achievement between subjects exposed to problem-solving instructional strategy group that operate in the cognitive preference of principles and those exposed to lecture instructional method that operate in the same cognitive preference of principles?

6. Is there any difference in the academic achievement of the subjects in the experimental group that operate in the questioning cognitive preference and their counterparts that operate in the same cognitive preference?
7. Is there any difference in the retention levels of the subjects exposed to problem- solving instructional strategy and those exposed to lecture instructional method?

1.5 Null Hypotheses

The following null hypotheses are stated for testing in respect of the stated research questions.

1. There is no significant difference in academic achievement of the subjects in the experimental group and their counterparts in the control group.
2. There is no significant difference in academic achievement among the subjects that predominantly operated in Recall, Application, Principles and Questioning cognitive preferences.
3. There is no significant difference in the academic achievement between subjects in the experimental group in Recall cognitive preference and their counterparts in the control group.
4. There is no significant difference academic achievement between subjects in the experimental group in Application cognitive preference and those that operate in the same cognitive preference in the control group.
5. There is no significant difference in academic achievement between the subjects in the experimental group that operate in the cognitive preference of principles and their counterparts in the same cognitive preference.

6. There is no significant difference in the achievement of the subjects that operated in the Questioning cognitive preference and their counterparts in the control group that operate in the same cognitive preference;
7. There is no significant difference in the retention levels of the subjects exposed to problem- solving instructional strategy and those exposed to lecture instructional method.

1.6 Significance of the Study

The findings from this study is expected to be significant in many ways. To start with, the study the study will avail curriculum developers and education planners the opportunity to concretize the process of evaluation of teaching and learning ecology concepts so as to give ecology its rightful place in the study of science.

The finding of the study, it is hoped would help to enhance students' cognitive preferences in acquiring viable skills to promote problem-solving competence in solving ecology problems.

The finding will also help in suggesting the way forward in the inculcation of problem solving instructional strategy in learning ecology concepts as well as aid towards solutions to arising problems. It is hoped that the result of this study will encourage ecology/Biology teachers to plan sequence, and organize properly, the contents of ecology in order to enhance and encourage students to avail themselves to the learning opportunities that are available in the study of ecology. It is also expected that the finding from this study will encourage ecology teachers in secondary schools to improve in the conventional classroom teaching activities by actively involving students in problem solving activities through the inculcation of problem solving instructional strategies.

The finding of this study will help in no small measure, the production of textbooks in ecology that take into account the needs, yearnings and aspirations as well as the requirements of the environmental factors, in the quest to improve the academic achievement and retention of students ecology concepts. There is a great need for improvements in the teaching and learning of ecology concepts in that the study of ecology seems to be relegated to the background, as observed/opined by Esiobu and Soyibo, 1997, Novak, 1990 etc. The problem solving instructional strategy approach in secondary school curriculum might provide a way forward.

The findings of this study, it is hoped, will help the Federal Ministry of Education and States Ministries of Education to re-orient their ecology teachers through workshops and seminars/conferences on how to include problem solving instructional strategy to enhance the quality of teaching and learning in schools, (especially that of ecology concepts).

1.7 Delimitation of the Study

The study is undertaken to identify the effects of problem solving instructional strategy on the Academic Achievement and Retention in Ecology among Secondary School Students with different cognitive preferences. The concepts of Ecology were chosen because the process is central to the student's understanding of science, more so that the study of Ecology is very important to the student in fully exploring the potentials of his environment. The problem solving instructional strategy involved the use of four variable methods, namely:

(a) Recall: Acceptance of scientific information for its own sake, without

consideration of its implication, application and limitation.

(b) Principles: Acceptance of scientific information because it exemplifies some

fundamental scientific relationships.

(c) Application: Acceptance of scientific information because it exemplifies some

Fundamental scientific principles.

(d) Questioning: Critical questioning of scientific information as regards its

completeness, general validity and limitation.

The study was delimited to four secondary schools in Zaria and Sabon Gari Local Government Areas of Zaria Educational Zone of Kaduna State namely:

1. Government Secondary School Chindit
2. Alhudahuda College
3. Government Girls Secondary School Kofar Gayan
4. Senior Secondary School, Kufena

There are thirty six secondary schools in Zaria Educational Zone of Kaduna State, details of which are presented in Table 3.1 in chapter 3.

Secondly, the schools selected are homogenous, having all categories of schools namely private, schools, Government secondary schools, and Federal Government Colleges availability of Co-Educational and single schools as well as the possibility of having sufficiently large samples for meaningful generalization. Besides the schools operate a common academic calendar, a common curriculum and are prepared for a common final examination (SSCE).

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

The concern of this study is to investigate effects of problem solving instructional strategy on the Achievement and Retention of Ecology Concepts among Secondary School Students with different cognitive preferences in Kaduna State.

2.2 Cognitive preference

Cognitive preference refers to the ability of rank-ordering of cognitive preference based on happiness, satisfaction, gratification, enjoyment and utility they provide (Mas Collel and Green, 1995; and kreps, 1999). Lana (1987) posited that cognitive preference can also be equated to cognitive style. McFaden (1986) in Peter (1995) describes cognitive preference to include:

> A consistent pattern of behavior within a range of variability, a students consistent way of responding to and using stimuli in a learning environment; how individuals process information and prefer to learn; the way individuals organize information and experiences; a person's characteristic style of acquiring and using information; and an expression of psychological differentiation characteristic models of information processing (1995: page 1)

2.3 Problem

Yevdokimov and Passmore (2008) observed that there are two major types of problem solving; Reflective and Creative. Regardless of the type of problem solving a class uses, problem solving focuses on knowing the issues, considering all possible factors and finding a solution. Because all ideals are accepted initially, problem solving allows for finding the best possible solution as opposed to the easiest solution or the first solution proposed.

Yevdokimov and Passmore (2008) went further to reiterate the purpose of engaging or teaching the art of problem solving to students as helping them to think about a problem without applying their own preconceived ideals. Defining what the problem looks like is separated from looking at the cause of the problem to prevent premature judgment. Similarly clarifying, classifying what makes an acceptable solution is defined before solutions are generated, preventing preconceptions from deriving solutions. Some people argue that problem solving is best used to help students to understand complex ethical dilemmas, think about the future or do some strategic planning.

In strategizing plans in problem solving, teachers are implored to put students in groups, which will enable them to define the problem, establish the criteria for evaluating solutions and action taken.

Solving problems used to be seen as a particular kind of activity usually a major obstacle for pupils, something they found very difficult (Bentley and Watts, 1990). For many, solving problems usually meant tackling less tedious calculations on the 'mole' or the laws of motion. Over time, the problems to be solved ranged from brain teasers to intelligent quotient style (I.Q), problems in mathematics, chemistry and physics. The standing conference on schools science and Technology (Engineering Council, 1985) for instance, categorizes problems into four basic types: those of a technological nature; ones with a scientific bias, decision making exercises that include role play and simulations; and exercises that mainly involve mathematics and language.

In the art of problem solving there abound numerous problems to be tackled, Munson (1988) classified such problems as 'open', 'closed', 'formal' or ‘informal’. ‘Given’ or ‘Goal-orientated’ and curriculum dedicated; Munson went further to analyze the different types of problems as:

‘Given Problems’ are problem where the solver is given the goal and nothing else – the solvers have to decide both the goal and the strategies (Bentley and Watts, 1989). For ‘Goal’ and ‘own’ problems, youngsters have to choose the best strategies from a wide range of possibilities to achieve their goal. These general strategies seem to be a combination of the design; process and the scientific method. In problem solving there abound numerous problems to be tackled in the field of science Education.

2.4. Cognitive Strategies in Science Education

Brown and New man’s (1989) study attempted to review the teaching strategies that are needed in identifying specific instructional procedures needed to teach students concrete prompts. In that review, an attempt was made to abstract procedures that serve as modeling, scaffolding thinking aloud and coaching. Other summaries of instructional procedures appear in the works of Carla and Meister, Rosenshine and Meister, 1994, 1996. Providing concrete prompts, modeling thinking aloud and guided practice and their use, are examples of scaffolding.

The concept of cognitive strategies represent at least two instructional advances. In the first instance, when teachers are faced with areas, it can be applied to the teaching of higher-order tasks in the content area. The second instance dealt with a large number of intervention studies in which students who were taught cognitive strategies obtained significantly high scores more than the students in the control group (Palinscar and Brown, 1984). The teaching of cognitive strategies do not only help students to complete tasks successfully but also the inclusion of instructional elements into the teaching pattern.

Dobrovolny (2004) observed that another name for "instructional strategies" is "learning strategies". According to Dobrovolny, learning strategies or "instructional strategies" are the various methods used to involve the learners in

the training programme such as questioning during lectures, simulations with computer-based training (CBT), reflection after reading, etcetera. They are used to obtain the "learning objectives" which are the new behaviour that one wants learners to use when they return to their jobs. The learning objectives in turn point towards the major avenue of "media", in which instruction is presented, such as through the use of computer-based training (CBT), self-study, classroom, on-the-job-training (OJT). Dobrovolny (2004), opined that although many people use the terms interchangeably, objectives, media and strategies all have separate meanings. For example, one's objective might be to "pull the correct items for a customer order". His media might be on-the-job training. One's instructional strategy is to have the learners watch a demonstration in order to get an overall view of the customer – order process, have a question and answer period, observe small group demonstrations and then receive hands-on practice by actually performing the job (Bloom and Associates,1964).

It does not cover each learner's type, for example, some people learn better by listening, while others learn better by reading. It also does not cover the skill of the designer and the instructor. For example, computer-based training (CBT) that only presents information for the learner to read or listen to, which would be more of a lecture or reading activity might involve the learners more than any CBT programme could. Learning strategies enable learners to plan different ways of solving problems. According to Borkowski, Relling and Pressley (1990), contemporary psychological research yielded three particularly important findings in relation to the students' learning as follows:

1. That students must be strategic and engage in strategies to build connections between new knowledge and prior knowledge.
2. That students must possess and utilize metacognitive knowledge to control their thinking; and
3. That students must believe that they are responsible for their own learning (Seifert and Wheeler, 1994).

Two types of learning strategies abound. They are those that involve plans or mental activities, which "students may use to acquire, retain and retrieve different kinds of knowledge and performance" (Rigney, 1978). These strategies are referred to as cognitive strategies. These include such activities as acquiring, selecting and organizing information, releasing materials, memory and retaining and retrieving different kinds of knowledge. Learning strategies that deal with strategy learning or "learning to learn", are called metacognitive activities.

Metacognitive activities include such activities as checking, monitoring, planning, prediction (Brown, 1987). Learning strategy generally includes both cognitive and metacognitive strategies. They have contributed in no small measures to the currency of cognitive psychology as well as instructional design (West, Farmer and Wolff, 1991). The theoretical framework for learning strategies deals with information theory. Metecognitive strategies become more effective when aided by instructional materials.

Learning strategies assist in acquiring different types of knowledge as well as in modifying and regulating each phase in the information processing system (Gagne, 1977). To Gagne, cognitive strategies should be seen as declarative and procedural knowledge which help in assimilating information into the long-term memory.

Weinstein and Mayer (1986) categorized learning into eight types, namely:

i. Basic rehearsal strategies
ii. Complex rehearsal strategies
iii. Basic elaboration strategies
iv. Complex elaboration strategies
v. Basic organizational strategies
vi. Comprehension monitoring strategies
vii. Affective and motivational strategies; and
viii. Complex, organizational strategies

Most of the strategies have been broadly researched and recognized as effective ways of learning. Park (1995), synthesized the research findings on cognitive strategies and listed three categories of learning strategies as follows:

a. Strongly effective strategies
b. Weakly effective strategies, and
c. Strategies that need more research.

Those strongly effective strategies included adjunct questions, note-taking, keyword method, method of loci and advanced organizers. Strongly effective strategies go a long way in enhancing the level of student's ability to retain the information learnt.

2.5 Retention

Retention works hand in hand with Achievement. Retention which is the ability to retain things experienced or learned, has an area of focus to some science educators in recent years (Barlettt) in Adeniyi 1997). Retention can be described as a form of reaction which has been presented in the past. In other words it is as a result of orientation or attitude which marked an original perception.

Barlett, in Adeniyi (1997) emphasized their imaginative reconstruction built out of ones attitude towards past experiences. He argued that this was possible as a result of the effect of ones capacity to turn around upon his on schemata. Thus, retention and what is retained depend on the individual frame of references. Barlett further observed that retention can hardly be exact even in the rudimentary case of rote learning. The problem therefore is how to maximize the level of retention and future recall of what is learned. This issue can not be well attended to until one has an insight into the factors contributing to retention. In essence any form of learning that encourages rote-learning cramming, regurgitation and Memorization should be eliminated.

Duyilemi (1986) pointed out that an important factor which is often overlooked (in discussion) or if mentioned at all, is glossed over and immediately dismissed from the mind, is the adverse effect that the use of language as the medium of communication has in the primary school. Duyilemi argued that the child's memory is strengthened by his experiences at school and at home. When he (the child) is taught in the mother tongue, his experiences in the classroom are very similar with those outside it.

Within the school setting, there are different categories of students in the classroom that the teacher has to contend with. For example, there are the socially withdrawn children, the gifted/talented, as well as the backward students. All these situations are examples the school management needs to come to their rescue. Many strategies for improving school performance are being debated upon, regarding what should be done to help large numbers of children/students who are not meeting the educational requirements. Schools are always searching for the most effective interventions to help children who fall behind academically or appear more immature than their peers (Foster, 1993).

There have been intense public cries to improve the quality of education globally. As a result, many schools have adopted rigorous practices over the years.

Retaining students in class/grade often is used as a way to increase or meet educational standards. Many educators assume that by catching up on pre-requisite skills, students will be less likely to fail when they go on to the next grade (Shepherd and Smith, 1990) Amidst an era emphazing educational standards and accountability, research examining the efficacy of grade retention warrants further review and consideration. “Grade retention”, also known as “non-promotion”, refers to the practice of requiring a student who has been given grade level for a full year to remain at the same grade level for a subsequent school year (Jackson, 1975, Shepherd and Smith, 1999). McCoy and Raynolds (1999) found the rate of retention for boys was 12.4 percentage point higher that

that of girls. Alexandar et al (1999) conducted a study comparing 317 retained students to 458 promoted students. Of the 317 retained students 57% were males and 43% females. Caplan (1973) reported reasons why boys are retained significantly more often than girls; the girls who are retained could easily be discriminated from their female counterparts who have been promoted by their more aggressive behviour. The majority of the retained students also are students of different ethnic backgrounds (Alexander et al 1994; Meisels and Liano, 1991).

Regardless of race, many demoted students come from disadvantaged family backgrounds. Another parental variable influencing decision to retain or promote is the level of parental involvement in the school. McCoy and Renolds (1999), found that the level of parental involvement in school significantly predicated retention during the early grades. Children whose parents were rated as more involved in school activities were 18% less likely to be retained (Renolds, 1992). Learning is said to effectively take place in a conducive atmosphere. Teachers should seek to explore better ways of achieving the feat.

A large proportion of the literature reviewed showed that emphasis in science education is no longer on the transmission of factual knowledge (a characteristic feature of the traditional method) but on teaching students how to learn (Anderson, 1970). The introduction of inquiry-based programme into schools prompted the teaching of science through inquiry approach. By this approach, students were expected to acquire scientific knowledge through the scientific processes of observing, comparing, classifying, experimenting, communicating and inferring as they try to find out things for themselves.

Barlett also opined that retention can hardly be exact even in the rudimentary case of rote learning. The problem therefore is how to maximize the level of retention and future recall of what is learned. This issue cannot be well attended to until one has an insight into the factors contributing to retention. In essence, any form of learning that encourages rote-learning, cramming and regurgitation and memorization should be minimized or eliminated. This will usher us in new ways of learning for retention of facts.

Adeniyi (1997) is of the view that retaining the effects of learning could be possible if learning is coded into memory. Appropriate coding of incoming information provides the index that may be consulted so that retention takes place without elaborate search in the memory lane. The nature of the materials to be coded contributes to the level of retention. Materials are related to the quality of retention in terms of their meaningfulness, familiarity, correctness and image ivoking characteristics. Adeniyi went on to state that generally, common, familiar, meaningful and structured materials are more easily retained than unrecognizable, haphazard data.

The image ivoking words also provide a means of rehearsing the target word while it leaves a visual trace even when the word is no longer in view. In his concluding remarks, Adeniyi said that abstract ideas are difficult to retain because they are difficult to represent in memory and therefore difficult to generate for retrieval. Generally it appears that the level of arousal and emotionality generated by the learning material could affect the rate of retention. There are however, diverse opinions on this.

Before reviewing how retention and achievement impact students, it is imperative to consider the characteristics that make students more susceptible to retention. Pryel and Weitzman (1994) asked some fundamental questions to this effect as: what makes students to be promoted from one grade level to another. Being aware that the child is at risk for retention can lead to increased efforts towards referring such children and families of services that might enhance the child's preparedness for school (Jimerson Carlson, Robert, England and Shroufe, 1997). The child's preparedness could also play a significant role in enhancing the choices made in the teaching learning process.

2.6 Link Between Problem Solving and Cognitive Preferences

Yevdokimov and Passmore (2007) highlighted that problem solving in various forms and context, takes significant time in classroom activities throughout primary and secondary school. This area attracts the interest of both mathematics educators, seeking powerful activities in teaching and learning, and researchers considering problems solving as a research domain. As a consequence many fundamental research papers on different aspects of problem solving came up on performance in problem solving and analysis of their thinking were considered. In problem solving, a series of tasks have to be followed. Once students are set in groups, they would be able to define the problem, analyze the problem, establish the criteria for taking action (Hembree, 1992).

Cognitive preferences assist in acquiring different types of knowledge as well as in modifying and regulating each phase in the information system (Gagne, 1977). Providing concrete prompts, modeling, thinking aloud and guided practice and their use, are all examples of scaffolding. Collins made the following summary on the use of cognitive preference as follows.

a. Strongly effective strategies

b. Weakly effective strategies

c. Strategies that need more research

Van Djick (1991) opined that in the teaching and learning process, when the HANDS, HEAD AND THE HEART are used, effective and efficient learning occurs, students learn by doing or by constant practicing, which in essence may lead to perfection. Teaching and guiding students to make choices fast tracks the ability to take ownership of tasks especially in the study of ecological concepts.

2.7 The Problem of Teaching Ecology in Secondary Schools

Ecology teaching necessarily involves field as well as indoor experiences. According to Okeke (1981), the factors that prevent the teaching of ecology are manifold, among which are:

i. lack of enough textbooks written in the local Nigerian flora and fauna;

ii. lack of adequate equipment;

iii. lack of low level of teachers;

iv. occurrence of natural seasonal variations.

In order to teach ecology effectively, the teacher must ensure that there are enough textbooks for both students and teachers to make use of at all times. Teachers should be encouraged to attend conferences and seminars so as to update their knowledge-base, by rubbing minds with fellow colleagues. Schools and colleges should be well-equipped with the necessary facilities, for example, well-furnished laboratories. Where and when necessary, some specimens to be used could be procured and preserved ahead of time. This will help students to derive the maximum benefits in the teaching and learning of ecology. The knowledge of ecology should prepare students to contribute their quota both inside and outside the school setting. This process will also go a long way in helping both teachers, students and curriculum specialists, in evaluating secondary school ecology.

A series of workshops were stemmed up to enhance the teaching and learning of ecology. Okeke (1981) observed that one of such workshops was organized in 1977 by Curriculum and Development and Instructional material centre (CUDIMAC), University of Nsukka, on the teaching of High School Ecology. Prior to the workshop, the UNESCO 1976 report indicated that the teaching of Ecology is a problem in Nigerian High Schools. The workshop targeted identify the areas of difficulty in teaching through interaction between the practicing Biology teachers and ecologists. The objectives of teaching Ecology in the Biology Curriculum are not specifically spelt out. Even in Examination bodies like WAEC and JAMB objectives of teaching are not spelt out, but could be deduced from the notes given. Such guidelines are available in the study of Ecology. This could be one of the reasons for the poor performance of students in this subject area during examinations as well as the fears students harbor in the study of Ecology, thereby believing the subject to be very difficult.

According to Okeke (1981), to evaluate is to appraise the value of anything. In a school situation, evaluation is the gathering of evidence performance for the use in the making of judgement about the amount of learning that has occurred. Macintosh and Hale (1976) differentiate between periodic and continuous updating of judgement about students' performance.

This is in relation to specific criteria that will permit the making of cumulative judgement, periodic assessment which implies intermittent probe as a measure of attainment. The process of evaluation enables the teacher to find out the level of students' comprehension and assimilation of subject matter. It also helps the teacher to find out the suitability or otherwise, of the instructional materials used as well as the methods applied.

To clarify the procedure employed by Bloom and Broder (1950), one of their problems and the responses of several students to it are reproduced below. The statements are roughly scaled from least to most acceptable. The students were asked to rank the following life forms in the order of their appearance in the geologic record. They were to blacken the answer spaced A for the one that appeared first, etc as follows:

		A	B	C	D	E
81.	Mammals	□	□	□	□	□
82.	Sponges	□	□	□	□	□
83.	Amphibians	□	□	□	□	□
84.	Fishes	□	□	□	□	□
85.	Plants	□	□	□	□	□

Some six students' scores in the protocols were extracted for further discussion.

These were

1. Pauline M (Score O);
2. Mary, W Score 1);
3. Val, H (Score O);

4. David F (Score 1);

5. Ned, M (Score 2);

6. Bernice Y (Score 3)

This problem required that the student understands he was to rank the items in a specified order. Several kinds of information could be utilized by the student in arriving at the preferred order. He might remember that the geologic record or the evolutionary scales are science-based terms. Lacking this information, he might differentiate the items on the basis of their complexity, whether land or water animals or plant and animal forms. Given some such principle for sorting out the items, the student must still know enough about each of the items named to place them at the appropriate points in the sequence.

Pauline M's record is instructive for what it reveals about the absence of every specific knowledge about the geologic records. Although her score is zero (she did not place any of the items in the correct sequence) and she repeatedly announced that she is guessing at the answers, the answers, she separates the items into plant and animal and assigns the first place to flowering plants.

Like Pauline, Mary W. protests her lack of knowledge about the geologic record and the fact she must guess at the answer. Both these protocols testify to the critical role of knowledge in problem-solving. Furthermore, Mary appears to have difficulty interpreting the directions of the problem.

It was indicated earlier that paying attention only to the products of problem-solving can severely limit the information the teacher gains about his pupils' thought processes. If Pauline M and Val H. are considered together, their scores of zero suggest that neither was successful in solving the problems.

Analysis of the protocols, however, would contradict such a conclusion. Val was highly successful in ordering the four types of animals. His error was placing flowering plants first in the geologic record, resulted in the misplacement of each of the animals, thus earning him a score of zero.

David appears to have lost track of the demands of the problem. Although he begins by reminding himself that the items are to be ranked, it is not clear that he followed through on this basis. To the extent that he was successful with the problem, his success seems to stem from his ability to translate the problem into terms that are meaningful for him, that is, about which he feels with the geologic record. Presumably, he would have solved the problem more adequately than he did in fact had he been able to use that translation appropriately.

The protocols of Ned and Bernice, and the scores assigned to them, indicate that these two students' best understood the problem and solved it with the greatest degree of success. Bernice's answers, particularly, illustrated an attempt to make a systematic analysis of the demands of the problems.

It is pertinent to note that in Bloom and Broder's sample, successful students sometimes skipped through the directions, but they seemed to do this purposefully and in a way that helped them understand more quickly what the critical elements of the problem were.

Some of the difficulty encountered by the non-successful problem solvers in launching their attack seems to be attributable to the difficulty they had with the directions for the problem. The unsuccessful students frequently tended to read the directions of the problem with little evidence of comprehension. Other students seemed to fail to read the instructions or to read them in an indiscriminate way. This seemed often to be an effort on the part of these students to hasten or shorten the time involved in problem-solving.

The unsuccessful solvers would typically read the statement of the problem,

perhaps re-read it several times and comment that the problem either made no sense to them or that they failed to understand it. One of the main difficulties encountered by the non-successful problem solvers was that they undertook the solution of a problem, handled it appropriately, arrived at a correct solution, but the problem which they solved was not the problem which had been presented to them. Frequently, these students appeared either to have forgotten part way through what the demands of the problem were or to have failed as was indicated earlier, to read the directions carefully and in a way that would help them to structure and to direct their attack upon the problem. As might be anticipated, the two groups of subjects used by Bloom and Broder (1950) performed differently in tasks assigned to them with respect to their bases of judgement. The non-successful solvers seemed often to be aware of the fact that the knowledge they possessed could indeed be applied to the problem at hand. In some cases the student, while talking his way through a problem, would indicate that he simply did not have information at his command which he could use to solve the problem.

However, upon probing by the investigator with some appropriate cues and suggestions, it often turned out that the student did as a matter of fact know the information, which could appropriately be transferred to the problem. But without such assistance from the experimenter, it seems highly unlikely that the problem would have been solved. Indeed the attitude of the unsuccessful students seems to have been much more one of, “unless I can look at the problem and immediately see that I have information which will help me more directly toward the solution, there is very little that I can do to attack the problem”.

A particular obstacle to the non-successful solvers was encountered when the

problem that they were asked to solve was formulated in terms which were unfamiliar to them. In these cases, it seemed especially difficult for the student either to translate the concepts which were presented in the problem into terms knowledge he had that might in some way be subsumed under the concepts which were presented in the statement of the problem. In some cases also, the students had difficulty in using relevant knowledge at their command because of unfamiliar words; or, in some cases, also, statements of problems were so highly abstract that the students felt overwhelmed at being asked to suggest solutions to the problems.

A good and quick reminder to the characteristics of successful and poor solvers is found in their performances on the test on the geologic record. The performances of Pauline M, Mary W and Val, H who scored O (zero) and 1 (one) out of 5 (five) questions respectively (is a reference point for researchers/readers to ponder upon) especially in the study of ecology. The performances of the two categories of the problem solvers necessitate the inclusion of problem solving instructional strategies in the teaching and learning process of students.

2.8 Problem Solving Instructional Strategies

Somewhere between open-ended, creative thinking and the focused learning of content lies problem solving, the analysis and solution of task and situations that are somewhat complex or ambiguous and that pose difficulties, inconsistencies, or obstacles of some kind (Mayer and Wittrock, 2006). Problem solving is needed for example, when a physician analyses a chest a chest x ray; the photograph of the chest is far from being clear and requires skills, experience and resourcefulness to decide which foggy looking blobs on the x-ray to ignore, and which to interpret as real physical structures (and real medical concerns).

Problem solving happens in classrooms, too, when teachers present tasks or challenges that are in some ways complex or for which the path to the solution is not straight forward or obvious. The responses of students to such problems as well as the strategies that teachers use to assist them, show some of the key features of problem solving when it happens in school. Joyce and Weil (2000) observed that since the inception of formal classroom based instruction, a fundamental aspect of teaching has been the way teachers arrange the classroom environment so that students can interact and learn. The instructional strategies teachers use help shape learning environments and represent professional conceptions of learning and of the learner. Some strategies consider students empty vessels to be filled under the firm direction of the teacher; other strategies regard them as active participants learning through inquiry and problem solving. Still others tell children they are social organisms learning through dialogue and interaction with others.

Joyce and Weil (2000) alluded to the fact that the early work of the progressives, fueled later by new theories and research about learning by such eminent theorists as European psychologists Lev. Vygostky and Jean piaget and American Jerome Bruner and Albert Bandura, extended thinking in the profession about instructional strategies in the post-sputnik reforms of the 1950s and 1960s. Cognitive psychology and constructivist perspectives produced instructional strategies such as discovery learning and inquiry teaching that were at the centre of the curriculum reforms of that era, and the cooperative learning and problem-based strategies popular today because more widely known and used.

In the early twenty-first century there are many instructional strategies. Similarly, there are tactics used by teachers to support particular strategies. The following provides a framework for thinking about instructional strategies, and then provides descriptions of seven strategies used frequently by teachers in solving problems. These strategies if harnessed properly will promote the process of both long-life education in the teaching and learning experiences of the teachers and the taught (learners).

i) **Instructional Organizers, Strategies and tactics:** A number of educators over

the years, such as Bennett and Carol Rolhelsier, have developed conceptual frameworks for thinking about instructional strategies. The frameworks often include instructional organizers, instructional strategies, and tactics. Instructional organizers are at one end of a continuum, and provide the "big ideas" that allow us to think about instructional practices. Examples of instructional organizers would be Howard Gardner's multiple intelligences or Benjamin Bloom's taxonomy for organizing instructional objectives (Bennett and Rolhelsier, 2001). On the other end of the continuum are what are often labeled instructional tactics.

These are specific, and for the most part, simple actions taken by teachers within the confines of particular teaching strategies. Asking questions, checking for student understanding, providing examples or visual representations, or examining both sides of an argument are examples of instructional tactics. Many tactics have grown out of the practices of experienced teachers. In the middle of the continuum are instructional strategies that involve a series of steps, are supported by theory and research, and have been designed to produce certain types of student learning. Examples of instructional strategies would include direct instruction, cooperative learning, and others described later in this article.

ii) **Direct Instruction:** Direct instruction is a method for imparting basic knowledge

or developing skills in a goal – directed, teacher-controlled environment. The teacher identifies clearly defined learning outcomes, transmits new information or demonstrates a skill, and provides guided practice. Direct instruction is designed to maximize academic learning time through a highly structured environment in which students are "on task" and experience high degrees of success (Gagne, 1985, Schmuck and Schmuck, 1997).

iii) **Simulation.** Simulation involves students playing roles in simulated situations in

order to learn skills and concepts transferable to "real life". Students make decisions and learn from successes as and failures. Simulations enable the learning of complex concepts or mastery of dangerous tasks in more simple and safe environments. Simulations include hands – on games such as monopoly (real estate), social-political – economics role – playing or problem solving (model, United Nations or feeding a family of four on $100 a week; software games ("where in the world is Carmen Sandiago?" for geography) and experiments (chemical changes) and simulators (driving a care or landing a plane). Although some simulations are done individually (such as (driving) others occur in groups (Schmuck and Schmuck, 1997).

iv) Concept teaching. Tennyson and Cocchiarella (1986) stated that concept teaching helps students to learn concepts and develop higher level thinking skills concepts (such as round and integer in mathematics, scarcity and freedom in social studies, energy and motion in science and comedy and tragedy in literature) serve as foundation for knowledge, increase complex conceptual understanding and facilitate social communication. There are several different approaches to concept teaching. The approach described here is called concept Attainments and is an inductive process in which students construct, refine and apply concepts through teacher – directed activities using examples and non examples and in which students learn to classify, recognize members of class, identify critical and non critical attributes and define and label particular concepts.

v. Discussion. Discussion is central to all aspects of teaching. Classroom discussion may serve as a strategy in itself or as part of another strategy. Teachers and students talking about academic content and students displaying their ideas and thinking processes to the teacher and to teach other characterize discussions. Theoretical support for classroom discussions stems from the study of language and patterns of discourse and from constructivist psychologists, such as Lev Vygotsky, who believed that most learning occurs through language – based social interactions.

Wittrock, (1986) observed that Discussion is an appropriate strategy for improving students thinking; promoting engagement in academic content; and learning communication and thinking skills in a social environment. Discussion is particularly appropriate for topics that are subjective or controversial and that involve several points of view, such as the causes of World War 1, or funding of stem-cell research.

vi. **Cooperative Learning**. In cooperative learning students work together in small groups on a common learning task, coordinate their efforts to complete the task and depend on each other for the outcome. Cooperative learning groups are characterized by student teams (of 2-6) working to master academic goal (Slavin, 1997).

Cooperative learning is rooted in two traditions. First, it is based on the progressivism of John Dewey, particularly his idea that the school should mirror the values of the society and that classrooms should be laboratories for learning democratic values and behaviours. Students are prepared for civic and social responsibilities by participating in democratic classrooms and small problem solving groups.

Cooperative learning also has its roots in constructivist theory and the perspective that cognitive change takes place as students actively work on problems and discover their own solutions.

Cooperative learning has three distinctive goals: academic achievement, acceptance of diversity through independent work, and development of cooperative social skills.

vii) Problem-based instruction. In problem-based instruction students are presented with authentic, meaningful problems as a basis of inquiry learning, or authentic investigation, this strategy is designed to promote problem solving and higher level thinking skills. All problem-based instructional strategies include more or less the following features: a driving question or problem, interdisciplinary focus, authentic investigation, production of artifacts or exhibits and collaboration. This strategy is designed to involve students in the kinds of real-world thinking activities they will encounter outside of school from childhood through adulthood.

Like cooperative learning, problem-based instruction has its roots in the progressivism of John Dewey and the constructivism of Jean Pigeat, Lev Vygostky, and Jerome Brunner. Bruner argued that learning should be relevant and engaging through the involvement of students in group projects of their own interest. Piaget theorized that learning occurs through active investigations of the environment in which students construct personally meaningful knowledge. Vygotsky (1987) stressed the importance of social, language-based learning. Bruner emphasized the importance of learners working with their own ideas and find meaning through active involvement and personal discovery.

The primary goal of problem-based instruction is learning content through inquiry that can be applied in authentic situations. Students learn to think and behave like adult workers, scholars, and problem-solvers and to regulate their own learning. They learn collaboration skills and research and inquiry strategies, and gain an understanding of knowledge as complex, multifaceted, and uncertain. Problem-based instruction is the most student-centred of the strategies presented.

Students work actively and independently on problems that interest them. This requires an environment that is open and safe for asking questions, forming hypotheses, and sharing ideas. The teacher's role is to pose problems, ask questions, facilitate investigation and dialogue, and provide support for learning.

2.9 Review of Similar Studies

Problem Solving Studies on Instructional Strategy on the academic achievement and retention of students' learning outcomes abound.

Awodi (1984) compared the biology achievement of Nigerian Secondary School biology students when taught either by inquiry method or traditional (lectuure) method. The students were guided through the lessons and were also encouraged to ask questions. The result indicated that inquiry teaching improved the quality of science instruction with subsequent higher achievement in science by Nigerian Science students.

Similarly, Martins (1994) tested the effect of lecture (Viz traditional approach and inquiry strategies on the cognitive performance of integrated science students. The mean achievement scores of the lecture and inquiry groups were compared. The t-value obtained was significant at P = 0.05. It was observed that the inquiry group performance better than the lecture group. The studies of Awodi (1985) and Martins (1994) indicated that inquiry teaching strategy could afford students greater achievement in their science lessons than the traditional teaching method.

Olubunmi (1991) investigated the effect of laboratory and lecture traditional method on the cognitive achievement of integrated science students. The study involved 210 students from six classes randomly chosen from form two of each school. Three classes of 105 students formed the experimental group and the other three classes formed the control group. Each of the groups experimental and controlled) included a unsex female class, a unisex male class and a mixed class. The study was designed as a two-group pretest – treatment – posttest format. Two treatments were applied, the talk and chalk method and laboratory method. The ability level were established on the basis of the performance of students on the ability test statistics was used to determine the significant difference between the means of the different groups.

The results showed that high achievers of both groups had identical achievement but the low achievers in the experimental groups performed better than their counterparts in the control group. The males also prefer laboratory method to lecture method when compared to the female counterparts. The study revealed that females in the control classes performed better than the males of the same groups. The studies of Odubunmi etal, (1991) suggest that it is possible to enhance students science achievement through the use of laboratory (another form of inquiry method). Also, low achievers can be encouraged to perform through the laboratory (inquiry) method.

Lawal (2009) studied the effectiveness of conceptual change instructional strategy in remediating misconceptions in genetic concept among secondary school students. The results indicate that the conceptual change instructional strategy helps to shift misconceptions students harbor, thereby creating a suitable conceptual framework necessary for subsequent meaningful learning. It also enhances academic achievement in the subject taught. The use of the strategy also helped in enhancing retention ability better than the traditional method.

2.10 Implication of Literature Reviewed for this Study

Cognitive preference test (CPT) is a new method of evaluating students' performances different from the old traditional methods. The interest in the new method is not in whether the student can identify correct and incorrect information, but in what he does with the information intellectually. Since the launching and orbiting into space of the "SPUTNIK' spaceship by the Russian in 1957, different curricula reform projects were triggered off globally. These curriculum reform projects spread faster in the United States of America and United Kingdom. Since this spectacular feat by the Russians, science teachers, curriculum theorists and educators, have been restless in searching for effective instructional strategies and viable curriculum materials to improve the teaching and learning experiences of students.

In this research study, a lot of literatures have been reviewed leading to greater insight into the topic being investigated. This collection of theories and informed criticisms exposed by literature search have some implications for the present study. Permanent and meaningful learning is the ultimate target of educational endeavours. Effective strategies and metacognitive strategies have been found to contribute immensely towards the growth and development of science education. The traditional method of science instruction has been found to be relatively inferior to several other strategies in terms of effectiveness and students' achievement. In this study, the problem-solving method was compared to the lecture method to see which of the two would yield greater achievement and retention for Nigerian secondary school students of different cognitive preferences.

Heath (1964) identified four models of thinking used by students in attending to academic knowledge, namely: Recall (R), Principles (P), Application (A) and Questioning (Q). Individualized instruction as an instructional strategy, played a prominent role in the improvement of students' learning competences in the 1960s and 1970s (Slavin, 1987). This is a form of cognitive preference which relates to the ability of rank-ordering of alternatives.

The problem-solving strategy, Heath's model and individualized instruction approaches have been found fruitful in improving the quality of the teaching-learning experiences of secondary school students. These approaches would be employed in this study.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

In this chapter the various processes involved in data collection are described in this chapter. These include the research design, development of the instruments, treatment and administration of the instruments.

3.2 Research Design

The research design for this study is the quasi- experimental/control group, pretest, posttest design (Kerlinger, 1973). This design is used to describe the effects of problem-solving instructional strategy and on achievement of the selected subjects in comparison with the lecture instructional method. This approach is expected to give insight into the effectiveness of the problem solving instructional strategy in relation to achievement and retention of ecological concept by selected students of different cognitive preferences.

The research design is represented as follows:-

$$EG \longrightarrow 0_1 \longrightarrow PSIS \longrightarrow 0_2 \longrightarrow 0_3$$

$$CG \longrightarrow 0_1 \longrightarrow LMIS \longrightarrow 0_2 \longrightarrow 0_3$$

Where

EG = Experimental Group

CG = Control Group

0_1 = Pretest

PSIS = Problem Solving Instructional Strategy

LMIS = Lecture Method Instructional Strategy

0_2 = Posttest

0_3 = Post-Posttest

3.3. The Population

The population of the study is made up of all the Senior Secondary Schools in Zaria Education Zone. Zaria Education zone comprises of Sabon Gari and Zaria Local Government areas of Kaduna State. The zone has a total of thirty six senior secondary schools. The students in these schools which are considered as the population for this study comprise senior secondary schools 1 (SS1), senior secondary school 2 (SS2), and senior secondary school 3 (SS3).

The suitability of the secondary school students for this study is due to the fact that they have earlier been exposed to study of Biology for at least one year. This included exposure of the study of Ecology which is an integral part of the biology syllabus taught to the students at that level i.e senior secondary school level.

Table 3:1 Population of the Study Area Showing the Senior Secondary Schools and Students Enrolment in each school

S/No	Name of School	Year Established	Student Population	Gender	
				M	F
1.	Barewa College Zaria	1921	2301	2301	-
2.	Alhudahuda Collge Zaria	1910	2745	2745	-
3.	Government Secondary Zaria (Snr)	1977	1548	1548	-
4.	Government Secondary School Chindit, Zaria	1981	1934	1934	-
5.	Government Secondary Zaria (Jnr)	2001	1533	1533	-
6.	Government Secondary School, Pada	1990	1110	-	1110
7.	Government Girls' Secondary School,	1992	830	-	830

	Chindit, Zaria				
8.	Government Girls Secondary School Dogon Bauchi (Snr)	1983	1235	-	1235
9.	Government Girls' Secondary School Dogon Bauchi (Jnr)	2002	1331	-	1331
10.	Government Girls' Secondary School, Zaria	1971	1625	-	1625
11.	Government Girls Secondary School, Kofan Gayan	1980	2219	-	2219
12.	Senior Secondary School, Kufena, Zaria		1183	1183	-
13.	Government Secondary School, Magajiya	1990	1545	1241	304
14.	Government Secondary School, Muchiya	2001	1664	1203	461
15.	Government Secondary School, Likoro	1990	619	561	58
16.	School of Islamic and Arabic Secondary School, Zaria	1993	945	650	304
17.	Government Secondary School, Kofar Jatau	1990	869	589	280
18.	Government Secondary School, Kofar Kunyanbana	1998	1300	967	333
19.	Government Secondary School, Tudun Jukun	1990	1875	1133	742
20.	Government Secondary School, Tudun Tsaibu	1982	1385	1185	200
21.	Government Secondary School, Dinya	1983	403	387	16
22.	Government Secondary School, Awai	2005	317	302	15
23	Government Secondary School, Katari	2006	76	75	1
24.	Government Secondary School, Dakace	1998	1097	900	197
25.	Government Secondary School, Rimim Doko	2002	713	573	146
26.	Government Secondary School, Kugu	2005	500	461	39
27.	Government Secondary School, Kaura	2006	200	146	54
28.	Government Secondary School, Tudun Wada	2004	1985	840	945
29.	Government Secondary School, Zaria City	1991	2182	1250	932
30	Government Secondary School, Chikaji	2003	852	613	127
31.	Government Secondary School, Gyellesu	206	354	227	127
32	Government Secondary School, Kofan Doka	2003	479	270	209
33.	Government Secondary School, Mangi	2006	52	46	6
34.	Government Secondary School,	1990	495	437	58

	Yakasai				
35.	Government Secondary School, Bogari	2001	180	166	14
36.	Government Commercial College, Zaria	1959	759	434	325
Total			**30,250**	**25,900**	**4,350**

3.4 Sample and Sampling Procedure

Sample comprised the targeted elements of a population used for the study and on whom measurements or inferences are actually made (Bichi, 2001). The simple random method of sampling technique was used to select four secondary schools from the population. Names of all the thirty-six secondary schools in Zaria Education Zone were compiled and written on pieces of papers squeezed, juggled together and were later put in a hat. Four pieces of papers were later "drawn randomly from the hat". The four pieces of papers picked out represented the four secondary schools selected for the study. The schools selected comprised two from Sabon Gari and Zaria township. And from each of these schools, 60 students were selected also using the simple randomization technique which involve students "drawing from the heart" exercise. With the help of research assistant that helped the researcher, this exercise was made easy A "Yes" or "No" information was written in pieces of papers. All the students offering Science/Biology in each of the four schools randomly selected were made to participate in the exercise of selection. Pieces of papers were wrapped and put inside a hat container. Research Assistant helped in organizing students individually to come out in turns and pick or "draw from the hat". The research assistants checked thoroughly the pieces of papers "drawn from the hat" and registered all those that picked the papers into a 'Yes' or "No' group. The papers were later on counted to determine the 60 students that were eligible to form the required sample of students to be used for the study.

Simple random stratified sampling technique was also adopted in selecting the total number of respondents required for the study from the four schools randomly selected. The method used involved the "drawing from the hat" approach. A total of one hundred and eighty students (180) boys and sixty girls (60) were selected giving a total of two hundred and forty students that constituted the sample for the study.

Table 3.2 Sampled Schools and Subjects Selected from them.

S/No	Name of School	Status	Gender	
			M	F
1.	Govt. Sec. School Chindit	Experimental	60	-
2	Alhudahuda College	Experimental	60	-
3	Senior. Secondary School Kufena	Control	60	-
5	Govt. Girls Sec. School Kofar Gayan	Control		60
	Total	**180**	**180**	**60**

The total sample size was two hundred and fourty (240) comprising one hundred and eighty (180) boys and sixty (60) girls, as can be seen from Table 3.2.

3.5 Instrumentation

Two instruments were used in this study to collect relevant data. These were the Cognitive Preference Test (CPT) and Ecology Achievement Test (EAT).

The cognitive preference Test (CPT) was developed by Heath (1964) and adapted by the researcher. Heath (1964) conducted his research in Biology, while the researcher conducted his research in ecology.

The Ecology Achievement Test (EAT) on the other hand was designed to determine what a student does with a given science question in the attempt to arrive at a solution. In this case, only one of the four options in a given question is correct. The remainders are distractors.

3.5.1 Cognitive Preference Test (CPT)

The Cognitive Preference Test (CPT) was designed and developed by Heath (1964). The researcher used the model of Heath instrument as guide to construct the one used in this study.

The student was required to respond to each question by allotting 4 marks to his/her first opinion or option, 3 marks to the second, 2 marks to the third, and 1 mark to the least favoured option to demonstrate the manner in which he/she preferred to respond to a question in order of preference. Each response is adjudged to be correct as the central idea is not of looking for correct or incorrect answers to guage how the subjects preferentially attend to the questions in the cognitive order as earlier stated.

In modifying Heath (1964) instrument the language and conceptual difficulties of the test items contained in the instruments were affected in line with the assessors' suggestions (as contained in 3.7 page 61).

The Cognitive Preference Test (CPT) which formally had fifty (50) test-items was reduced to 30 quest-items, while the Ecology Achievement Test (EAT) which had eighty (80) questions was reduced to fifty (50) test – items as recommended by validiting panelists. Some of the questions of the test – items in both Appendices A and B were reframed while others were discarded due to their difficulty. For instance:

In Appendix A, question 1 reads “Ecology as course of study is among the woollies of all the science subjects”. “The term Ecology has many meanings as there are many Ecologists” Question 6 now reads, “The teaching of ecology at various educational levels” instead of “the study of Ecology in Secondary Schools”.

Question 19 now to read “The atmosphere is the gaseous portion of the earth”, instead of “the atmosphere is the first layer of the earth crust”.

In the Ecology Achievement Test (EAT) section, question 30 to read “In cold climates or high attitudes, some small animals fall asleep” instead of “Weather conditions cause animals to hibernate”.

The time allocated for the students to write or attend to the questions in the test-items for the two Appendices (A & B) which was formerly 60 minutes for Appendix A and 50 minutes for Appendix B was increased to 90 minutes 1hr 30 minutes for the two appendices. This was sequel to the fact that the 80 minutes given the examination was inadequate.

The result of the test conducted in the pilot study enable the researcher to classify the students into different groups of pretest and posttest students. This in essence also helped to determine the type of method(s) to be employed in the teaching and learning activities of students towards skill acquisition.

3.5.2 Ecology Achievement Test (EAT)

The Ecology Achievement Test (EAT) was constructed by the researcher to determine what a student does with a given question in order to arrive at a solution. The Ecology Achievement Test (EAT) was also designed to measure the subject's achievement in the items contained in the test. The test contained 50 multiple choice items, each of which consists of the stem, the key and distractors.

3.6 Pilot Study

In order to refine test – items of the two instruments, Cognitive Preference Test (CPT) and Ecology Achievement Test (EAT) for the study, a pilot study was carried out in two senior secondary schools, namely, Government Day Girls Secondary School Samaru (GDGSS) and Government Secondary School Bomo (GSS) in Sabon Gari Local Government area of Kaduna State. The two schools were stratified randomly. These schools are within the target population for the study, but did not form part of the final study.

Cognitive Preference Test (CPT) consisted of 30 multiple – rank – ordered test items, while the Ecology Achievement Test (EAT) consisted of 50 multiple choice items, administered to 100 senior secondary, SS1 ecology students. The researcher administered the instrument which lasted one and a half hours personally through face-to-face contact. Instructions on how to answer the questions was read and explained to the students by the researcher. This was done to ensure that the students answered the items (i.e test items CPT and EAT) carefully, problems and difficulties arising from the pilot study were carefully noted in order to improve upon the final instruments. Split-half method was employed in the study. The test was administered once. The reasons and benefits of the pilot study include:

i) to identify problems or difficulties that might arise before the final administration of the instruments to the study samples;

ii) to determine the appropriateness of the instruments;

iii) to determine the difficulty and discrimination features of the items;

iv) to determine the reliability of the instrument.

v) To determine the item characteristics

On the basis of the results obtained from the pilot study, necessary amendments were made to the instruments.

3.6.1 Validation of the Instruments (C.P.T)

The content validation of the Cognitive Preference Test (CPT) was carried out by a panel of experts comprising the following:

(a) four Biology specialist; three Science Education Section, one from Faculty of Education, Ahmadu Bello University, Zaria.

(b) two Biology teachers at the secondary school level (one from Government Secondary School, Chindit, Zaria; and the other from Alhudahuda College, Zaria.

(c) a specialist in Educational Statistics

(d) a specialist in English Language from Ahmadu Bello University, Zaria

These experts among other things, critically assessed CPT with respect to these criteria:

a. the appropriateness of the items;

b. whether or not the statements in the tests were clear, readable, hard or too simple for SS1 students;
c. whether or not the text items are related to ecology concepts of the senior secondary school syllabus;
d. give suggestions and criticisms that would be helpful in improving the quality of the test items. Their suggestions were taken into consideration in the final formulation of the test instruments before administration. One of such suggestions was on how to analyze the problem solving instructional strategy skills to become useful to the objectives of the study.

3.7 Validity and Reliability of the Instruments

In order to make sure that the final copy of the questionnaire is valid for the study, the researcher employed the services of four experts in the Department of Education to help validate the instruments. Three experts possess doctoral degrees while the four possesses a master's degree. Based on their expert input and advice, a draft of the questionnaire was submitted to the supervisors for validation. On the basis of their expert inputs, a well structured questionnaire consisting of fifty questions on cognitive preferences categorized into experimental and control groups were to be administered on respondents. Fifty questionnaires were thus distributed to respondents in two schools in Sabon Gari Local Government Area namely, Government Girls Secondary Schools, Samaru (GGSS) and Government Secondary School, (G.S.S) because they are not within the local government area of Sabon Gari and Zaria which will be used for the final study but share similar characteristics in almost all respects. These questionnaires were distributed and personally retrieved by the researcher.

3.7.1 Validity

The data collected from the pilot study were statistically analysed for purpose of obtaining co-efficient. The Gutman split-half and Spearman-Brown product reliability co-efficient technique was used. The reliability co-efficient obtained was 0.98. This reliability co-efficient was considered adequate for the level of the internal consistency of the instruments. This is in line with Steven's (1990) preposition who states that an instrument is considered reliable is the instrument. This goes to affirm that the instruments designed for the study is suitable.

3.7.2 Reliability of the Instruments

In order to ascertain the level to which the instrument is reliable. Gutman option of reliability co-efficient was used to statistically estimate the internal consistency of the items in the instrument. Data thus collected from the pilot study were subjected tom correlation using the Pearson Product Moment correlation coefficient method.

The result showed a reliability coefficient of 0.85 which was considered reasonably reliable for this study. Moreover an instrument is considered reliable if the reliability coefficient lies between 0.50 and +1.0. Thus the instrument is considered reliable for the study.

3.8 Selected Ecology Concepts

Four Ecology topics were chosen for this study. The selected topics had not been taught to the study groups. The topics chosen are hereunder listed as Table 3.5. The four topics chosen to be taught are from Biology textbooks used in secondary schools (i.e Modern Biology and STAN Biology).

The selected topics are basic Ecological Concepts, major becomes of the world, population studies and Ecology factors. The researcher taught the experimental and control groups respectively.

3.9 Treatment

Problem Solving instructional strategy model developed and used by (Polya, 1957), was used in treating the experimental group. The control group was taught by the use of lecture method instructional strategy (a traditional method of teaching). The two groups were taught the same randomly selected topics as shown in section 3.8. The lesson plans/noted used are contained in Appendix C for experimental control groups. The lesson notes are based on the selected topics. A panel of four experts from Ahmadu Bello University, Zaria and three teachers from Secondary schools in Zaria validated the lesson plans for use. The schools were visited one after the other by the researcher for treatment. The treatment period covered a period of twelve weeks for both groups.

3.10 Administration of the Instrument

There are two instruments developed for this study – Cognitive Preference Test (CPT) and Ecology Achievement Test (EAT). The administration of the instruments was done by the researcher according to the following steps:

Step I: Pre – Test Administration

Pre-test was administered using CPT and EAT to the experimental and control groups. All the tests and the teaching instruments were administered by the researcher personally. This in essence allowed for the uniformity and consistency of treatments that was given. The first CPT was first served to the subjects. The subjects were allowed some few minutes to go through the instructions and item statements in order to identify and problem before starting. The researcher verbally explained the areas of confusion for the subjects.

Step II: Post – Posttest Administration

After treatment the study subject groups were served with posttest. The CPT and EAT were administered respectively within the period of one and half hours (i.e 1hr.30 minutes).

Step III: Post – Posttest Administration

The study subjects were served with a post-posttest using CPT and EAT respectively within one and half hours interval. The post-test items are the same with the pretest and posttest items. A student who answered correctly all the multiple choice items earned a maximum score of 50 points, such responses yielded the pretest, posttest and post-posttest means scores which was used in analyzing the null hypotheses.

3.11 Method of Data Analysis

The collected data were analysed by the use of the appropriate statistical tool. Each hypothesis earlier stated in chapter one is restated and the contents statistical methods for the analysis indicated as follows:

Hypothesis 1: There is no significant difference in the performance of the subjects in the experimental group and that of their counterparts in the control group. t-test statistics was used to test the two groups of the experimental and control groups.

Hypothesis 2: There is no significant difference in achievement among subjects that predominantly operated in Recall, Application, Principles and Questioning Cognitive preferences. ANOVA was used to analyse the data.

Hypothesis 3: There is no significant difference in the academic achievement of the subjects in the experimental group that predominantly operate in the cognitive preference of Recall and their counterparts in the control group t-test statistics was used to test these two groups.

Hypothesis 4: There is no significant difference in the academic achievement of the subjects in the experimental group that predominantly operate in the cognitive preference of Application and their counterparts in the control group.

t-test statistics was used to test the two groups of the experimental and control.

Hypothesis 5: There is no significant difference in achievement between the subjects that operate predominantly in the cognitive preference of principles and their counterparts in the same cognitive preference

t-test statistics was used to test the experimental and control groups

Hypothesis 6: There is significant difference in the achievement of the subjects that operate in the Questioning cognitive preference of the experimental group and their counterparts in the same cognitive preference.

t-test statistics was used to test the experimental and control groups.

Hypothesis 7: There is significant difference in the posttest and the post – posttest mean scores of the experimental and control groups respectively. t-test statistical method was used to test the hypothesis.

In test all the above null hypotheses, the probability level adopted for use in either rejecting or retaining any of the hypotheses = 0.05 i.e $P \leq 0.05$.

CHAPTER FOUR

ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

The purpose of this study was to determine the effects of problem solving instructional strategy on the Achievement and Retention of Secondary School Students with different cognitive preferences. The results obtained from the analysis of data collected and the discussion of the results are presented in this chapter. The data were computer analysed using the SPSS package for social sciences software.

4.2 Data Analysis and Results

The results are anaylsed in line with the stated hypotheses as shown in the following pages.

Research Question 1

Is there any difference in the academic achievement of the subjects exposed to problem solving instructional strategy and those subjects exposed to lecture instructional method?

Hypothesis 1: There is no significant difference in the mean scores of the subjects in the experimental group and their counterparts in the control group.

t-test was used to test the hypothesis and the result shown in table 4.1. This hypothesis based on the following research question earlier stated in chapter one is shown in Table 4.1.

Table 4.1: t-test statistics comprising the Mean Scores of the subjects in the experimental group and their counterparts in the control group.

Variables	N	Mean	S.D	S.E	t-cal	t-crit.	df	Sig
Experimental Group	120	78.13	17.92	1.63				
					20.97	1.96	2.38	0.001
Control Group	120	35.59	13.2					

Significant at P≤ 0.05

The results of the t-test showed that significant difference exists between the mean scores of the subjects in the experimental group and their counterparts in the control group. This is because the calculated t 20.97 is higher than the t-Critical of 1.96 just as the P value of 0.000 is lower than the 0.05 level of tolerance. Therefore the null hypothesis which states that there is no significant difference in the mean scores of the subjects in the experimental group and their counterparts in the control is hereby rejected.

Hypothesis 2: There is no significant difference in academic achievement among the subjects that predominantly operate in Recall, Application, Principles and Questioning Cognitive preferences.

This hypothesis is based on the following research question earlier stated in chapter one which states; Is there any difference in achievement among the subjects that predominantly operate in the following preferences in Recall, Application, principles and Questioning?

Results of the ANOVA statistics used in the analysis of the results show that

significant difference exists in level Mean scores among subjects that operate in Recall, Application, principles and Questioning preferences, therefore Scheffe's test (post Hoc multiple comparisons) was employed to find out where such differences lies among the four cognitive preferences to Recall, Application, principles and Questioning.

Table 4.2(a) ANOVA comparing the Mean Scores among subjects in the Experimental Group that predominantly operate in Recall, Application, Principles and Questioning Preferences

	Sum of Squares	df	Mean Square	F	Sig
Between groups	8346.20	3	2782.06	10.79	0.001
Within groups	29903.56	116	257.79		
Total	38249.86				

Significant at ≤ is 0.05

Results of the ANOVA statistics show that significant difference exists in the level mean scores among subjects in the experimental group that operate in Recall, Application, principles and Questioning preferences with mean scores of

83.200, 81.900 and 63.733 respectively. The calculated ANOVA, F=10.79 is higher than F critical of 2.60. This indicates that there is significance in the mean scores of the four groups. Hence the stated null hypothesis is rejected.

Table 4.2(b) Scheffe's Test (Post Hoc Multiple Comparisons) showing differences among subjects Mean Scores
Dependent Variable
Experimental Scores, LS

Experimental Scores	J. Experimental groups	Mean Difference (I-J)	Std Error	Sig	95% Confidence Interval Lower Bound	Upper Bound
Recall Cognitive preferences	Application Cognitive preferences	180000	4.14560	.665	.64100	100109
	Principles Cognitive Preferences	50000	4.14560	.904	-77100	8.7109
	Questioning Cognitive Preferences	1996667	4.14560	.000	11.7558	28.1776
Application Cognitive preferences	Recall Cognitive Preferences	-180000	4.14560	.665	-10.0109	64109
	Principles Cognitive Preferences	-130000	4.14560	.754	.95109	26.3776
	Questioning Cognitive Preferences	1816667	4.14560	.000	9.9558	7.7109
Principles Cognitive Preferences	Recall Cognitive Preferences	.50000	4.14560	.094	-67109	95109
	Application Cognitive Preferences	1.30000	4.14560	.754	.69109	276776
	Questioning Cognitive Preferences	19.46667	4.14560	.000	11.2558	276776
Questioning Cognitive Preferences	Recall Cognitive Preferences	1996667	4.14560	.000	-281776	1167568
	Application Cognitive Preferences	.18.16667	4.14560	.000	.263776	-99558
	Principles Cognitive Preferences	..1946667	4.14560	.000	.276776	-112558

Significant at 0.05 level

In the light of the significant differences in the result realized in the level

Mean Scores among subject that operate in Recall, Application, principles and

Questioning Preferences using ANOVA Statistics, Scheffe's Test (Post Hoc Multiple Comparisons) was employed to find out where such differences lie among the four cognitive preferences.

The results of Scheffe's Test (Post Hoc) multiple comparison test compared the mean differences of the experimental groups pair – wise in order to reveal where sufficient differences exist.

According to the table, significant difference exist between mean scores of Recall cognitive preferences and questioning cognitive preferences because, the calculated significant (P) value of 0.001 is less than the 0.05 level of tolerance and their mean scores was + 19.96667.

In the same vein the difference between the Mean Scores of subjects in Application cognitive preference was + 18.16667 and the calculated significant (P) value of 0.001 is less than 0.05 tolerance level. Confirming existence of significance among the pair.

The multiple comparison test further showed that the Mean difference between the Mean Scores of subjects operating in the cognitive preference and questioning preference was + 19.46667, just as the calculated 0.001 is less than 0.05 tolerance level confirms the significance between the pairs.

Hypothesis 3: There is no significant difference in the academic achievement between subjects in the experimental group in Recall cognitive preference and their counterparts in the control group. This hypothesis is based on the following research question earlier stated in chapter one which states: Is there any difference in the academic achievement between subjects in the experimental group that operate in the Recall cognitive preference and their counterparts in control group?

Table 4.3 t-test statistics comparing the mean scores of the subjects in the experimental group that operate in the Recall cognitive preference and their counterparts in the control group.

Recall group	N	Mean	S.D	S.E
Recall Experimental groups	30	83.700	10.19	1.86
Recall Control group	30	36.533	13.27	2.42

The Table above showed the level of performance between subjects in the experimental group that operate in the Recall cognitive preference and their counterparts in the control group that operate in the same cognitive preference subjects operating in Recall cognitive preference in experimental group perform higher than their counterparts in control group. This is because the mean performance of subjects operating in Recall cognitive preference in experimental group mean performance was 83.700, while their counterparts operating in Recall cognitive preference in control group mean performance was just 36.533 clearly indicating a huge difference between the two groups in their performance.

Hypothesis 4: There is no significant difference in the mean scores of the subjects in the experimental group that operate in the Application cognitive preference and their counterparts. This hypothesis is based on the following research question. Is there any significant difference in the academic achievement between subjects in the experimental group that operate in the cognitive preference of Application and their counterparts that operate in the same cognitive preference in the control group?

Table 4.4: t-test statistics comparing the mean scores in the experimental group operating in Application cognitive preference.

Variables	N	Mean	S.D	S.E	t-cal	t-cri	df	sig
Experimental group	30	81.90	10.55	1.92				
				15.92	15.92	1.96	58	.001
Control group	30	33.66	12.93	2.36				

Significant at P≤ 0.01

From the results in Table 4.4 there is significant difference in the mean scores of the subjects in the experimental group that predominantly operate in the Application cognitive preference and their counterparts in the control group. This is shown from the obtained result in which the obtained t-value = 15.92 and P-value = 0.001. Consequently the stated null hypothesis is rejected. This means that the Application experimental group cognitive preference performed significantly better than their counterparts in the control group who were exposed to lecture method instructional method during treatment.

Hypothesis 5: There is no significant difference in the mean scores of subjects in the experimental group that operate in the principles cognitive preference and their counterparts in the control group. This hypothesis stems up from the following research question that states: Is there any difference in academic achievement between subjects exposed to problem solving instructional strategy group that operate in the cognitive preference in principles and those exposed to lecture instructional method?

Table 4. 5: t-test statistics of the mean scores of the subjects in the principles experimental group that operate predominantly in the control group.

Variables	N	Mean	S.D	S.E	t-cal	t-cri	df	Sig
Experimental group	30	82.20	10.44	1.9	17.49	1.96	58	0 .001
Control Group	30	36.23	13.28	2.42				

Hypothesis 6: There is no significant difference in the mean scores of subjects in the experimental group that operate predominantly in the control group. This hypothesis is based on the following research question which states: Is there any difference in the academic achievement of subjects in the experimental group that operate in

the questioning cognitive preference and their counterparts that operate in the same cognitive preference?

Table 4.6: t-test of the difference between subjects mean scores that operate in the Questioning cognitive preference and their counterparts in the control group.

Variables	N	Mean	S.D	S.E	t-cal	t-cri	df	Sig
Experimental group	30	63.73	26.58	4.85				
					16.93	1.96	58	0.001
Control Group	30	36.23	13.39	2.44				

Significant at P≤ 0.05

The result in Table 4.6 show that the value of t=16.93 and the corresponding P=value = 0.001 which is lower than the set P-value of 0.05. Thus the statement of the hypothesis is rejected.

Hypothesis 7: There is no significant difference in the post – posttest mean scores among subjects in the control group that predominantly operate in Recall, Application, Principles and Questioning preferences

Table 4.7 t-test statistics to test the difference between posttest and post-posttest mean scores in Retention experimental and control groups

	N	X	SD	SE	df	t	P	Remarks
Experimental	60	85.18	12.5050	1.0075				
			11.04	1.42	59	37.73	0.001	sig
Control	60	31.36						

Significant at the P≤ 0.05 levels

The result in Table 4.7 show that the value of t = 37.73 and the corresponding P-value = 0.001 which lower than the set p-value of 0.05. Thus the statement of the hypothesis is rejected.

Summary of Findings

The respective statistical analyses of all the seven tested hypotheses were carried out. The results showed that in all the seven hypotheses tested, the experimental control groups. Subjects out-performed their counterparts in the control group. This goes to prove the supremacy of the problem-solving instructional strategy over the lecture method in the teaching and learning of ecology concepts at the secondary school level.

4.3 Discussion of Results

The study sought to find out the effectiveness of problem solving instructional strategy in improving the academic achievement and retention of ecology concept among secondary school students of different cognitive preferences. To achieve this, seven hypotheses were tested and the results from the analysis are presented in line with the stated research questions.

Research Question 1

Is there any difference in the academic achievement of the subjects exposed to problem-solving instructional strategy compared to those subjects exposed to the Lecture instructional method?

The results in Table 4.1 show a significant difference in the academic achievement of ecology concepts by the subjects in favour of the experimental group. The experimental group performed significantly better than their counterparts in the control groups. This finding tends to imply that the problem – solving instructional strategy is more an effective instructional tool in comparison to the lecture method. The finding is in agreement with those of other scholars. These include:

Musconda (1999), Novak and Godwin (1984), Gowin and Johnson (1983), Soyibo, (1990), Esiobu and Soyibo, (1995). They found that the teaching of problem – solving instructional strategy help in enhancing the academic achievement of students in biology.

According to Oloke (1981), Okeke (1981), and Johnsstone and Mahmoud (1983), students taught ecology concept using problem-solving instructional strategy tend to achieve significantly higher than their counterparts in the control group exposed to the lecture instructional method. The finding is also in agreement with the previous findings of researchers like Esiobu and Soyibo (1995) and Okebukola (1990) who found that students taught through the use of problem-solving instructional strategies enhance higher levels of academic achievements in the sciences, especially biology. They further reported that students taught biology using Vee-Diagram Instructional, strategy (VEDIS) achieved significantly higher than their counterparts in the control group who were not exposed to the same instructional strategy.

The reason for the significant difference between the experimental and control group in this study might be due to the fact that the problem-solving instructional strategy employed for use in this case of the experimental group was activity-based which the students attempted to solve problems on their own and thus were exposed to a condition of constructing knowledge for themselves, thus resulting in a more functional and more qualitative learning in comparison with their counterparts in the control group who were not exposed to similar instructional environment. Studies by Jegede (1997) and Usman (2001) have shown that teaching strategies that are activity based or problem-solving-oriented enhance students performance in science, ecology in this case.

Research Question 2

Is there any difference in academic achievement of the subjects in the experimental group that operate predominantly in the following cognitive preferences?

(a) Recall

(b) Application

(c) Principles

(d) Questioning

The results shown in Table 4.2 indicate that significant differences exist in the Mean Scores of subjects in the mean scores of subjects in the mean scores of subjects in the experimental group that operate in Recall, Application, principles and Questioning respectively with the following scores to each variable, i.e 83.70, 81.20, 83.20 and 63.73.

On the basis of the significant differences that existed when t-test statistics was used in Table 4.2(b), Scheffe's Test (post Hoc) multiple comparisons) was employed in order to find out where such differences lie within the four cognitive preferences.

The result of Scheffe's test compared the mean scores differences of the experimental groups pair – wise in order to reveal where sufficient differences exist. According to the table, significant differences exist between the mean scores of Recall cognitive preferences and Questioning cognitive preferences in that the calculated significant (P)-value of 0.001 is less than 0.05 tolerance level, confirming the existence of significant among the pairs. Scheffe's test furthermore showed that the mean difference between the mean scores of subjects operating in the cognitive preference of Recall and the cognitive preference in questioning preference was +19.46667, just as the calculated 0.001 is less than 0.05 tolerance level confirms the significance between pair. This result is in agreement with the findings of the earlier researchers such as Gowin and Johnson (1983), Okebukola (1990) and Orji (2001).

Research Question 3

Is there any difference in the academic achievement of the subjects in the experimental group that operate predominantly in the Recall cognitive preference and their counterparts that operate in the cognitive preference in the control group?

The results in Table 4.3 show that the subjects that operate in the experimental group of Recall performed significantly higher than their counterparts that operate in the cognitive preference of the control group. This is because the mean scores of subjects operating in Recall cognitive preference in the experimental group is twice as much as that of the cognitive preference in the control group, i.e experimental group 83.70, while the control group has 36.53 respectively.

Research Question 4

Is there any difference in academic achievement of subjects in the experimental group that expert pre dominantly in the recall cognitive preference and their counterparts in the control group?

The result in table 4.4 showed that is there is significant difference in the mean scores of the subject in the experimental group that predominantly operate in the application cognitive preference and their counterparts in the control group.

This is in agreement with earlier students of Okebukola 1985) and Olorukooba (2002) which reported that problem solving instructions strategies improve students attitude change in Biology concepts when taught using the vee-Diagram Instructional strategy (VEDIS).

The finding from the study is also in agreement with that of samba (1998) who compared the effectiveness of conceptual change instructional strategy with that of lecture method she found that the experimental group out performed the control group that used the lecture method of instruction. The finding goes to support the view that instructional strategies that are activity oriented help in improving student learning competence as well as academic achievement. This finding is in agreement with Ausubel's (1978) report in which he found that when students are exposed to activity based strategies, their levels of learning competence would be greatly enhanced the finding is also in agreement with Ayodele's (2010) results in which he found that socio-economic status, motivation and self-esteem moderately corrected with students academic achievement in integrated science. Activity-based instructional strategies such as the ones employed in this study help to enhance self-egotism and hence motivation of students towards learning and consequently academic achievement.

Research Question 5

Is there any difference in academic achievement of the subjects in the experimental group that operate predominantly in the cognitive preference of principal and their counterparts in the control group?

The results in table 4.5 showed that the subject in the experimental group who operate predominantly in the cognitive preference of principles achieved significant higher than their counterparts in the control group.

Research Question 6

Is there any difference in academic achievement of the subjects in the experimental group that operate predominantly in questioning cognitive preference and their counterparts in the control group?.

The results in table 4.6 show that the subjects in the experimental group in questioning cognitive preference out performed their counterpart in the control group. This is likely because actability problem solving instructional approach exposes learners to doing things on their own then those exposed to solving problems through the lecturer instructional method in the study. The results of this study are in line with the study of Barnett (1974) who reported that students with strong preference for application or questioning tend to be higher achievers than those who prefer memory. The problem solving strategy employed in this study provided opportunities for social interactions. It was also observed from the study that the practical activities provided student with concrete experiences necessary for enhancing cognitive development, particularly at the higher level of science teaching.

The finding of this studying is also in agreement with the study of Okoronka (2000), who studied the comparative effects of Anology, problem solving, and concept mapping model based instructional strategies on students achievement on student achievement in physics. The results of the study show that model based instructional strategies were superior to the lecture method in enhancing achievement in physics. This agrees with the view expressed by Woolnoogh (1994) and supports the advocates of model-based instruction such Redish (1994), Greca and Moreira (2000) and Newton (2000). This could explained by the fact that this strategy of teaching emphasized self construction of knowledge, the making of connections and the use of models (mental, conceptual and physical) which are enhanced through active engagement of the learning. Active engagement is said to aid understanding and to improve academic performance (Ablard & Lipshultz 1998). The result equally reveals that the problem solving group achieves the highest followed by the concept mapping, analogy and the lecture method groups. This also agrees with Onwuegbh, (1998); Orji (1998); and Ige (2001). Problem-solving involves the use of complete intellectual and cognitive skills from learners (Hudson, 1994). This probably explains why students exposes to this strategy achieved the highest when compared to other strategies namely analogy, concepts mapping and lecture method.

Research Question 7

Is there any difference in the scores of retention levels of the subjects exposed to problem-solving instructional strategy and those exposed to the lecture instructional method?.

Results from the t-test statistics carried on this research question 7 confirmed that significant differences exist between the posttest mean score of the subject exposed to problem-solving instructional strategy and those in the lecture instructional method. The significant difference in favour of the problem-solving instructional strategies which was used to teach the experimental group over the traditional instructional strategy used to teach the control group. The problem solving instructional strategy thus tended to have helped in shifting the subjects' problem solving pattern thus influencing their performance positively. This finding is in agreement with the findings of Samba 1998 who separately reported that conceptual change instructional strategy can displace misconceptions, enhance understanding of concepts and consequently lead to improved performance compared to the traditional instructional strategy or lecture instructional method.

This finding in this study is also in agreement with the findings of Lawal (2009) who used conceptual change instructional strategy and traditional instructional strategy in teaching both the experimental and control group, the result showed that there is a significant difference in the post-posttest mean scores of the experimental and control groups with that of experimental group being higher than that of the control group. This shows that the conceptual change instructional strategy used enabled subjects in the experimental group to retain more knowledge of the concept taught than the subjects taught using lecture instructional method. The higher performance of subjects in the experimental group in the post-posttest can be attributed to the teaching strategy us

CHAPTER FIVE
SUMMARY, FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter is centered on the summary of the study, findings, conclusion and recommendations. Also highlighted are the limitations of the study and suggestions for further studies.

5.2 Summary

The study was carried out to determine the effects of Problem Solving Instructional Strategy on the Academic Achievement and Retention on Ecology Concepts among Secondary School Students. The researcher used the model of Heath instrument to construct the one used in this study. Heath's instrument contains four cognitive variable preferences, namely, Recall, Application, Principles and Questioning respectively.

The study identified students Cognitive preferences in Ecology using Problem Solving Instructional Strategy and Lecturer instructional strategy involving the experimental and control groups in the study.

The study population comprised all SS1 students of Zaria Education Zone of Kaduna State Ministry of Education. Two hundred and forty students (240) who served as study sample. The ecology topics taught were.

Seven null hypotheses were developed for testing in the attempt to answer the seven stated research questions. The research instruments developed and used are:

1. Cognitive Preference Test (CPT). This is made up of a 30-item-ranking test. The test (CPT) was pilot tested, validated and facility and discrimination indices determined. Also validated were the lesson plans/notes used for treatment and teaching the control groups.
2. Ecology Achievement Test (EAT). This is made up of 50test items multiple choice test which was validated by a panel of experts from the Science Education Division of the Department of Education A.B.U Zaria, as well as the Faculty of Science of the same university.

The study design used as pre-test, treatment post test and post-post test. The treatment involved:

1. Teaching the experimental
2. The use of Problem Solving Instructional Strategies (PSISS) in the teaching the same topic as in 1 above was withheld from the same control group. Instead, the control group was taught using Lecture Method Instructional Strategy (LMISS). The data collected was computer analyzed using SPSS software and presented in chapter four.

5.3 Summary of Findings.

The summary of findings from the study are as follows:

1. There was a significant difference between the academic achievements of the experimental and control groups in favour of the experimental groups.
2. There was a significant difference between the academic achievements of the academic achievement of the experimental and control groups in Recall, Application, Principles and Questioning in favor of the experimental group.

3. There was a significant difference between the achievement of the experimental and control groups in cognitive group in favor of the experimental group.
4. There was a significant difference between the achievement of the experimental and control groups in application in favor of the experimental group.
5. There was a significant difference between the achievement of the experimental and control groups in principles in favor of the experimental cognitive preference in principles cognitive preference.
6. There was a significant difference in the mean scores experimental and control cognitive preferences of the questioning in favor of the mean scores of the experimental cognitive preference
7. There was a significant difference between the post test and post-post test mean scores of the experimental and control groups in favor of the mean scores of the experimental groups

5.4 Conclusion

From the findings of this study, it is concluded that problem solving instructional strategy can be used effectively to teach ecology concepts in secondary schools. Problem solving instructional strategies have positive effects on students' achievement in ecology, retention of ecology concepts and the tendency to reduce the fear that made students to shun the domain of ecology because of its perceived difficulty of understanding and retention.

1. The experimental group achieved significantly higher than the control group.

2. The experimental group achieved significantly higher than the control group in Recall, Application, Principles and Questioning Variables in problem solving instructional strategies on the test of Ecology Achievement Test (EAT) during the posttest.
3. The experimental group achieved significantly higher than the control group that operate in recall Cognitive preference on the test of EAT. The problem solving instructional strategy enhanced students retention of ecology concepts significantly more than the lecture method instructional strategy (LMIS).

   The use of problem instructional strategy in teaching and learning ecology concepts appears to enhance students retention of ecology concepts.
4. The experimental group achieved significantly higher in the Application cognitive preference than their counterparts in the control group. The experimental group achieved significantly higher than their counterparts in principles cognitive preference.

   The problem solving instructional strategy proved to be more effective in the teaching of ecology.
5. The experimental group achieved significantly higher in the principles cognitive preference than their counterparts in the control group.
6. The experimental group achieved significantly higher in the Questioning cognitive preference than their counterparts in the control cognitive group.
7. The experimental group achieved significantly higher in the posttest and post-posttest mean scores than their counterparts in the control group. The problem solving instructional strategy seemed to help in enhancing the

retention level of students in the experimental group much better than those in the control group

5.5 Implications of the Findings for Science Education

The concern in this study was to explore the effectiveness of problem solving instructional strategy on the academic achievement and retention of ecology concepts among Secondary school students with different cognitive preferences. The findings from this study have some implications for teaching and learning of ecology at secondary schools.

The use of PSISS in teaching and in teaching and learning of ecology at the secondary school students with different cognitive preferences has the potential to enhance students' academic achievement and retention to ecology concepts. It is therefore important for ecology teachers to consider the use of PSISS in teaching secondary school ecology. This method of teaching gives room for active classroom participation, skills acquisition, broadening the students' knowledge base. It also promotes and enhances retention ability of students. This might be due to the fact that there is involvement of students' ample classroom interactions, as well as cross breeding information between the students and students and the teachers as well as between the students and instructional materials provided.

The strategy (PSISS) promotes student's active participation in classroom activities than the lecture method instructional strategy (LMIS) of teaching. This is as a result of the involvement of the students in the process of learning and knowledge construction. It enables students to take ownership of tasks. It promotes the learning of meaningful knowledge.

5.6 Recommendation

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

1. The use of Problem-Solving Instructional Strategy (PSIS) in teaching different science subjects in schools should be encouraged by all stakeholders in science as a whole and Science Education in particular.
2. Authorities in Science Education (Ministry of Education, School Principals, School Proprietors, etc) should organize workshops and seminars to popularize the use of problem – solving instructional strategy as an instructional strategy and acquaint science teachers especially ecology teachers on how to use problem solving instructional strategy (PSIS) effectively in schools.
3. There should be adequate provision of instructional materials by the relevant authorities in order to enable teachers use PSIS effectively and efficiently in schools. The availability of adequate instructional materials during lessons involving the use of PSIS will enhance classroom interactions and thus improve achievement and retention of facts.
4. There should be adequate literature on PSIS available to schools. This will help students and teachers to be more informed on how to use problem

solving instructional strategy in teaching and learning ecology concepts specifically and Biology generally.

5.7 Limitation of the Study

The following limitations have been observed in the course of this study.

1. The samples used for the study were limited to only secondary schools owned by Kaduna State Government. Schools owned by private organizations or individuals could not be sued for the study due essentially to the nature and design of the study. Thus the results and conclusions are restricted to Zaria and Sabon Gari Local Government areas from where the samples were drawn. This is therefore limitation on the scope of the generality of the findings.
2. The subjects of this study were not familiar with PSIS. Therefore, sometime was used for explanations and orientation in order to acquaint them with PSIS. This tended to affect the findings from this study. The time taken to control such situations is accepted by the researcher as a limitation.

5.8 Suggestions for Further Study

From the findings of the study the following suggestions are made for further studies:

1. There very few research studies in the area of problem solving instructional strategy especially in the basic sciences. As such more studies are required especially in other stales of Nigeria in order to complement the findings in this study in such areas as:-
   a) Using PSIS to develop process skills in students

b) The effect of PSIS on retention ability of students.

2. Studies on the effect of PSIS on academic achievement in sciences should carried

   out at tertiary institutions to see if similar results can be obtained. This is due to the fact that at the tertiary level students often learn on their own and therefore might possibly react different to the use of problem solving instructional strategy in comparison to the secondary school students.

3. Studies should be carried out on teacher's attitude to the use of PSIS in order to find out if they are favourably disposed to teaching ecology using PSIS.

4. Studies are required PSIS with other innovative teaching strategies or models like problem based learning, cooperative – competitive strategy, activity-based methods, etc.

   Studies on effect of PSIS on academic achievement and retention should carried out at the primary level of our educational system.

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APPENDIX A

COGNITIVE PREFERENCE TEST (CPT)

Dear pupils

This science test is to find-out the way you think about science. It is not a test of how much you know but of what you actually do with a given statement in science.

After each statement are four options which indicate the manner in which you prefer information to be given. You are to indicate your choice by giving four marks to the most preferred option, three to the next, two to the third preferred option and one to the least preferred option.

Please note that the options to each item are all correct. Read all the four options given to an item carefully before giving your vote. You may begin the test.

1. The term ecology has almost many meanings as there are ecologists

(a) Haeckel's concept of ecology deals with nature's household (Haeckel, 1966)

(b) Its published definitions range from the traditional study of the relationships between organisms and their environment to the Hughes and Walker (1965) all-embracing study of structure and function of nature

(c) It is also referred to or called 'scientific natural history by Elton

(d) In a more provocative manner, it is called glorified nature study' by those who doubt its status as a serious discipline.

2. With such diversity of definitions and approaches ecology has been considered by many scientists as one of the Wolliest and least valuable parts of a general scientific training.

    (a) It is a branch of biology

    (b) Many teachers in schools find it a very difficult course to teach.

    (c) A brief mention is mostly done referring to it in most schools syllabuses

    (d) It deals with the study of wildlife in so-called natural habitats.

3. Ecology is regarded as a soft option in a given science course

    a. It is a course of study which any people believe students fail rather than pass

    b. Teachers who teach this course of study in our schools are very few.

    c. Ecological work is often regarded as a hallmark of a modern scientist

    d. Like any other courses of study, it has its strength and weakness.

4. Many criticisms have been leveled against ecology

    (a) Impression of teachers in thought and terminology of teachers of ecology help in relegating it to the background.

    (b) It is a field course that involves constant out-of-classroom activities

    (c) It has no well-defined and attainable objectives

    (d) Ecology should be defined by subject-matter, rather than by where it is done.

5. The theoretical importance of ecology is unlikely to be disputed in the scheme of events:
   (a) The conception is that it is primarily conceived as the study of living organisms in relation to their environment.
   (b) Ecosystems are involved in this study.
   (c) The study of ecology is becoming increasingly accepted as an integral part of education.
   (d) Ecology is fast gaining increasing recognition as an environmental popularity science.

6. The teaching of ecology at various educational levels, gives a critical awareness of difficulties as well as the disadvantages
   a. Every course of study has to go through this critical scrutiny to gain recognition and acceptance.
   b. There are arguments to be raised against the teaching of ecology.
   c. Many advocates of the subject want its conversion into a general studies or a specialized course.
   d. The course relates very well with the physical environment.
7. A fully equipped ecologist needs not to be only knowledgeable in his own field alone
   a. He needs to be knowledgeable in geology, climatology, physiography, cartography, history archeology and maths as well.
   b. The subject is married to many disciplines
   c. There is a need to subdivide ecology into different sections for examination purposes.
   d. Higher degrees are awarded in some universities in ecological studies.
8. One of the performance objections of the basic ecological concept relates to a students' ability to name components of any ecosystems.
   a. Environment, biosphere and lithosphere are some of the ecological concepts taught to students of ecology.

b. The studying of a waterlog, a puddle and pond are some of the activities students ecology engage themselves in

c. Nitrogen cycle is one of the functioning cycles of an ecosystem

d. Students study data, photographs, films of different biotic communities.

9. Students study ecosystems by measuring and estimating their sizes

   a. An ecosystem is a life supporting environment which includes all the living organisms interacting together.

   b. It also consists of a network of several habitats and communities associated with them.

   c. The largest ecosystem is the biosphere associated with the planet earth.

   d. There are other types of ecosystems referred to as biomes, for example, deserts, woodland, shrubs and forests.

10. Tropical rainforests have become part of our everyday language through high-profile international conservation efforts

    a. These occur at low latitudes where the rain falls abundantly all the year long and the temperature is warm.

    b. The high humidity, warmth and sunlight provide ideal growing conditions, so that trees grow very tall, supporting many species of orchids, vines and fungi.

    c. Animal species tend to be concentrated either in the canopy 40 metres or 50 above the ground, or on the forest floor, which is relatively clear of vegetation because very little light penetrates the dense canopy.

    d. There is a great richness and diversity of species in tropical rain forest.

11. Forests are a very good source of protection on the land, vegetation and animals.

    a. Tropical seasonal forests occur where the climate is rather drier than in the areas of rain forest.

    b. The trees may lose their leaves when the drier seasons come.

    c. The forests are a diverse ecosystem.

    d. Dry seasons and strong winds hasten the rapidity of foliage in plants.

12. Deserts are areas of very little rainfall

a. There are some that are entirely barren, while others have seasonal rainfall and soc an support some vegetation.

b. Relatively few species can cope with the extremes of a habitat such as a desert and must have very specific adaptation to allow them to succeed in harsh conditions.

c. Many species adapt to allow them succeed in harsh conditions.

d. Grasses and shrubs are the major vegetation of this area.

13. Temperate grass lands are similar to savannahs but occur in cooler climates

a. America, Eurasia and the pampas of Argentina are typical examples of countries where these climates could be located.

b. One of the characteristics of this climates, is that they usually have rich deep soil and are often used for human agriculture.

c. Fewer number of species are found in deciduous and evergreen forests than in the tropical forests.

d. Hot, dry summers and cool wet winters are a common climate in this environment.

14. Ecology is an important component branch of biology

a. Ecological concepts form the subject matter of study

b. Ecology is divided into two main branches

c. Environmental science is an integral branch of ecology

d. What kinds of damage are caused by non-inclusion of ecology into the school syllabus?

15. Environment includes all the factors, external and internal living and non-living factors affect an organism.

a. The plants and animals around us constitute an environment.

b. Many species and individual organisms live around us

c. How can human beings and other species interact with each other?

d. The study of single animals like rats can be embarked upon in the locality.

16. The biosphere is the zone of the earth occupied by living organisms

a. It is a layer of life which exists on the earth surface.

b. Complex biological and chemical activities occur in this zone.

c. This zone of the earth is occupied by living organisms which exists on the earth surface.

d. What kinds of organisms are found in this area?

17. Lithosphere is the solid portion of the earth

    a. It is the outer most layer or zones of the earth crust

    b. It is made up of rocks and mineral materials.

    c. What kinds of mineral materials are common in this portion made up of?

    d. It forms the basis of all human settlement.

18. Hydrosphere is the liquid part of the earth of the living world?

    a. How can this part of the living world cover about 70% or 2/3 of the earth's crust?

    b. All the substances in this region are in a liquefied form

    c. It is the fourth layer of the earth's crust

    d. Water exists here in various forms, namely solid (ice), liquid (water) and as gases (water vapour).

19. The atmosphere is the gaseous portion of the earth

    a. It is a layer of gases surrounding the earth.

    b. Over 90% of the atmosphere lies within 30km of the earth's surface.

    c. It contains 78% nitrogen, 21% oxygen, 0.03% carbon dioxide and 0.97 rare inert gases.

    d. What kind of damage are caused by nitrogen deficiency in living organisms?

20. Habitat is defined as an area occupied by a biotic community

    a. It is looked unto as any environment in which an organism lives naturally.

    b. Organisms have natural homes to live in

    c. Some animals lives in water.

    d. How can some animal live on land and in water?

21. A biotic community is any naturally occurring group of different organisms living together and interacting in the same environment.

    a. A biome is the largest community of organisms

    b. Rain forest and guinea savannah are typical example of this community.

c. How can a group of naturally occurring organisms live together and interact in the same environment?

d. Today it is possible to have different species of animals living and interacting with one another.

22. Ecological niche refers to the specific portion of a habitat which is occupied by a particular species or organism.

a. It is the functional position of an organism within the community.

b. The habitat is the address of the organism.

c. The niche describes the profession.

d. Organisms may live on the same plant but occupy different positions.

23. A population is defined as the total number of organisms of the same species living together in a given area

a. The total number of Tilapia fish in a pond constitutes the population of Tilapia fish in that habitat.

b. Some countries engage on population head count seasonally.

c. Densely populated areas of plants and animals are all commonly found in tropical rain forests.

d. Many different populations of organisms live independently as a complex community.

24. An ecosystem refers to a community of plants and animals functioning together with their non-living environment

a. Ecosystem consists of the living factors (plants and animals) interacting with the non-living factors in an environment.

b. It consists of a network of several habitats and communities associated with them.

c. The biosphere is the largest ecosystem

d. Biome is another word for an ecosystem.

25. A biome is the largest community of organisms

a. There are many major biomes all over the world

b. There is high humidity, warmth and sunlight enabling trees to grow so, high.

c. Many species of orchids, vines and fungi are supported.

d. The forest floor supports or concentrates in the canopy or above the ground.

26. A savannah is a great tropical grasslands well known to Africa

a. The driest savannahs consists almost entirely of grasses

b. Savannahs support enormous herds of grazing animals as well as the predation

c. Acacia species are the commonest trees in this region.

d. They loose their leaves and grow very little during the dry season.

27. Tundra is found in the Arctic

a. The Tundra is situated on the world's highest mountains

b. It consists of treeless plains with grasses and mosses as predominant species

c. Water freezes into ice on the Tundra mountain region.

d. Many migrants use the Tundra during the summers.

28. The biotic components include the living things (plants and animals)

a. Produces consumers and decomposers are found in a habitat

b. The presence of suitable prey species affect the numbers of predators in a habitat.

c. Life becomes suitable for the survival of organisms/photosynthesis and chemosynthesis are processes of food production in the biotic community.

d. Green plants and some microorganisms manufacture their own food from simple inorganic materials

29. Consumers are the heterotrophic animals and some plants which cannot manufacture their own food.

a. Parasites depend on other organism to get their own means of livelihood

b. Plants manufacture their food in the presence of chlorophyll and sunlight.

c. Bacteria and fungi breakdown the remains of animals and plants.

d. How can plants and animals, bacteria and fungi interact together in a food chain?

30. Ecosystems are made up of biotic and abiotic components.

a. The organisms which comprise the biotic component are collectively known as the community.

b. There is a close association between living biotic and non living abiotic components

c. Both affect each other and are equally important for the ecosystem.

d. Ecosystems can be studied at any level of organization.

APPENDIX B

ECOLOGY ACHIEVEMENT TEST (EAT)

Instruction:

Please do not open the answer booklet until you are told to do so. Read the following instructions carefully.

1. You must use pencil for the examination.
2. Write your name in the space provided in the answer sheet.
3. Write your class and class number on the in the space provided in the answer sheet.
4. Read each question carefully before answering it.
5. Do not waste time on any question. If you find a question difficult, go on to the other questions and finish them first.
6. After you have selected what you take to be the correct answer, go to you answer sheet and circle the appropriate alphabet in the space that corresponds with your choice.
7. Circle only one letter for your answer.
8. If you change your mind on an answer, completely erase the first circling.

From the multiple choice answers Lettered A – D on each question, choose the best option that satisfactorily completes each sentence.

1. The word ‘ecology’ is a branch of biology concerned with the study of:

a. Interrelationships between living organisms and their external environment

b. The study of living organisms only

c. The study of salamaneis, snails and snakes

d. The capillary movement of water in plants

2. In ecology, the total surrounding of an organism is called its:

a. Surrounding

b. Environment

c. Temperature

d. None of the above.

3. The study of an individual organism or a single species of an organism and its environment is known as:

a. Biosphere

b. Synecology

c. Autecology

d. All of the above

4. The study of interrelationships between groups of organisms living together in an area is called:

a. Gyneacology

b. Autecology

c. Synecology

d. Topography

5. The main kinds of habitats are

a. Arboreal and ground habitat

b. Underground habitats

c. Aquatic and terrestrial habitats

c. Salt and fresh water habitats

6. One of the commonest habitats found in the terrestrial habitats is

a. Underground habitats

b. Fresh water habitats

c. Marine habitats

d. Brackish water habitats

7. The factors which influence living organisms in their habitats and control their survival and distribution are called

a. Habitat factors

b. Ecological factors

c. A and B only

d. Physical factors.

8. Abiotic factors refer to

a. Physical factors

b. Biotic factors

c. Climatic factors

d. Edaphic factors

9. An example of topographic factors is:

a. Temperature

b. Rainfall

c. Elevation

d. Soil texture

10. A typical example of an edaphic factor is

a. Soil texture

b. Soil profile

c. Soil erosion

d. Earth crust

11. Animals that live both in water and on land are referred to as:

a. Aquatic animals

b. Sea anemone

c. Sea gulls

d. Terrestrial animals

12. The ecological unit composed of organisms and their physical environment is:

a. Niche

b. Population

c. Ecosystem

d. community

13. The orderly change from one ecological community to another in an area is called:

a. Converence

b. Climax

c. Dispersal

d. Succession

14. Organisms which breakdown the compounds of dead organisms are called:

a. Phagotrophs

b. Parasites

c. Saprotrophs

d. Producers

15. Which of these must be present in an ecosystem if the ecosystem is to be maintained

a. Producers and carnivores

b. Producers and decomposers

c. Carnivores and decomposers

d. herbivores and carnivores

16. The relationship between fungi and algae in lichens is known as:

a. Mutualism

b. Parasitism

c,. Commensalisms

d. Saprophytism

17. All ecosystems have three basic living components. Which one of the following is not necessarily found in all the ecosystems?

a. "Producer" plants

b. Animal "consumers"

c. Decomposers

d. Parasites and commensalists

18. A sequence of species related to another predator and prey is a (n):

a. Trophic level

b. Ecosystem

c. Food chain

d. Climax

19. Which of the following pairs represents ecological equivalents

a. Squirrel and rattle snake

b. House cat and lion

c. Sea gull and codfish

d. Wild horse and zebra.

20. Choose the statement that best describes the climax stage of an ecological succession

a. It is usually populated only by plants.

b. It remains until there are several changes in the environment.

c. It represents the initial phases of evolution

d. It changes rapidly from season to season.

21. The climax organism growing above the tree line on a mountain would be the same as the climax organism found in the:

a. Taiga

b. Tundra

c. Tropical forest

d. Desert

22. The character of an ecosystem is determined by the environmental factor that is in shortest supply. This is:

a. the law of minimum

b. Borty's law

c. Charles' law

d. Mendelism

23. Very low rainfall sparse vegetation, high day temperatures and cold nights are the characteristics of the biome known as:

a. Swamp

b. Tropical forest

c. Southern guinea savannah

d. Desert

24. An association between two organisms in which both benefit is called:

a. Parasitism

b. Symbiosis

c. Commensalisms

d. Predation

25. The following measures are useful for conserving forests except:

a. Preventing and controlling accidental forest fires

b. Encouraging the use of charcoal for industrial and domestic purposes

c. Combating and preventing plants diseases

d. Reforestation of depleted forest.

26. The following practices are aimed at soil conservation except:

a. Contour ridging

b. Application of manures

c. Strip cropping

d. Bush burning

27. Which of the following natural resources is most readily available to all organisms”

a. Water

b. Air

c. Food

d. Mineral resources

28. Which of the following is not a structural adaptation of desert plants for water conservation:

a. Tiny leaves

b. Sunken stomata leaves

c. Siems and leaves with heavy culice

d Broad leaves with numerous stomata.

29. The burning of farmlands should be discouraged because it:

a. Destroys some plant pests

b. Reduces the population of wild animals

c. Makes bush clearing more difficult

d. Destroys the organic part of the soil.

30. In cold climates or at high altitudes, some small mammals fall asleep in some specially prepared nests or burrows. This process is known as:

a. Hibernation

b. Masturbation

c. Conservation

d. Contraction

31. The role of dead organic matter in the soil is to:

a. Make the soil black

b. Increase the mineral salt contents

c. Provide food for all living organisms

d. Make the soil more porous.

32. Species do not change in order to survive. The environment determines which organisms survives to reproduce. These statements:

a. Explain the theory of the acquired characters

b. Support Jean Larmarck's theory of use and disuse

c. Supports the idea of survival of, the fittest

d. Are refuted by fossil records.

33. Fewer number of trees is a characteristic of the savannah zones of Nigeria because:

a. There is too much sunlight

b. They are usually exposed to grazing animals.

c. There is limited amount of rainfall

d. The driest savannahs consist almost entirely of grasses.

34. The number of individuals in a habitat in relation to the unit space available to each organism is referred to as the:

a. Birth rate

b. Density

c. Mortality

d. Frequency

35. The failure of a species to adapt to any environment leads to:

a. A prairie

b. A water pond

c. A small ecosystem

d. a never-ending cycle.

36. Some ecosystems are very small. A pond surrounded by fields and woods is an example of:

a. Domination

b. Competition

c. Extinction

d. Stunted growth

37. In complex food relationships in a community the primary, secondary and tertiary consumers are referred to as:

a. Symbionts

b. Omnivores

c. Heterophs

d. Autotrophs

38. Predators are beneficial in pest control because they:

a. Are natural enemies of small mammals

b. Feed on pests of crops

c. devour farm animals

d. Compete for food with the pests.

39. Which of the following may not contribute to environmental pollution?

a. Solar energy radiation
b. Industrial wastes
c. Waste disposal
d. Smoke

40. The practice of warming soup regularly as it concerns food preservation is essentially to:

a. Retain the taste

b. Raise the temperature

c. Remove excess water

d. Kill the bacteria in it.

41. Which of the following limiting resources is competed for by organisms in the desert?

a. Light

b. Temperature

c. Oxygen

d. Water

42. The adaptation for water conservation in organisms include the following except:

a. Scales in fishes

b. Scales in leaves

c. Thick leave

d. Succulent stems

43. Which of the following statements best explains the term aestivation?

a. A device for survival during the period of extreme food and water shortage.

b. A method of survival adopted by plants during the dry season

c. Movements of animals over long distances

d. A method of survival adapted by animals under favourable condition.

44. Guinea grass, grasshopper, toad, snake, hawk

(Producer) (Primary consumer) (Secondary consumer) (Tertiary consumer)

The above examples of a food chain belongs to:

a. Terrestrial habitat

b. Aquatic habitat

c. Ecosystem

d. Food web

45. Diatom Mosquito larvae Tilapia fish Whale

(producer) (primary consumer) (Secondary consumers) (Tertiary consumers)

This is a typical example of:

a. Primary succession

b. Secondary succession

c. Decomposers

d. Aquatic habitat

46. A complex feeding relationship among organisms in the same environment with two or more interrelated food chains is an example of a:

a. Food web

b. Pyramid of numbers

c. Pyramid of biomass

d. Symplified food chain

47. An interaction between two species in which one species attacks and kills the other is known as:

a. Inter-specific competition

b. Intra-specific competition

c. Predation

d. A only.

48. An ecosystem is the relationship of plants and animals with each other and with the environment. An example of the largest kind of a ecosystem is found in:

a. Praine

b. Desert

c. Forest

d. Ocean

49. Without the sun, no green plants could exist. And without green plants no animal life could exist. The green plants are called:

a. Primary consumers

b. Secondary consumer

c. Tertiary producer

d. Primary producer

50. Some of the food chains we eat involves a very long food chain. A man eats fish which grew munnoros, the munnoros ate crayfish. Crayfish ate larvae of insects and the insects fed on protozoa, while the protozoa ate algae, which are the green plants found living in water. From the original food producing algae to the person eating fish, there is a food chain with:

a. Three links

b. Four links

c. Five links

d. Seven links

APPENDIX C

LESSON PLANS/LESSON NOTES

LESSON NOTES - CONTROL GROUP

Lesson 1 - Problem-Solving Method

Date - March 2008

Subject - Ecology

Topic - Basic Ecological Concepts

Class - SS I

No. of Pupils in Class- 68

Average age - 17 years

Instructional Materials - Charts illustrating ecological concepts, Essential Biology Textbook

Previous knowledge - Students have been taught the meaning and concepts of ecology

BEHAVIOUR OBJECTIVES

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

1. Explain in their own words the following ecological concepts:

(a) Autecology

(b) Synecology

(c) Lithosphere

(e) Hydrosphere

(f) Biotic community

(g) Ecological niche

(h) Environment

(i) Biosphere/Ecosphere

(j) Atmosphere

(k) Habitat

(l) Population

(m) Ecosystem

2. Describe in their own words the importance of these terms in the study of ecology

Previous Knowledge- Students have been taught different concepts of Ecology, e.g. Autecology, Synecology etc.

Introduction

Class, in the previous lesson held the discussion was centered on the relevance of biology to agriculture. Have you ever heard of the word ecology? Have you also wondered how the word ecology came into the scene of our discussion? In this and other subsequent lessons, we shall be examining the different concepts of ecology. We shall discuss about the meaning of ecology and ecological concepts.

Presentation: (Using the lecture method)

Step 1: The concept of "ecology: - a branch of biology that deals with the study of plants and animals in relation to their environment. Ecology is derived from a Greek word "Oikos" which means home or dwelling place.

Problem No. 1 to solve

Step II: Some schools of thought on the origin of ecology

(a) Defines ecology as a field of study which deals with the relationships of living organisms with one another and with the environment in which they live.

(b) Describes ecology as an environmental biology

(c) Classified ecology into two main branches namely, Autecology and synecology.

Step III (a) Define the basic ecological concepts, thus

(i) Autecology – is concerned with the study of an individual organism or a single species of organism and its environment. For example, the study of a single rat and its environment.

(ii) Synecology – is concerned with the study of the interrelationships between groups of organisms or species of organisms living together in an area. For example, the study of different organisms in a river in relation to their aquatic environment.

(b) Ecological concepts

(i) Environment: This includes all factors external and internal living and non-living factors which affect an organism.

(ii) Biosphere or ecosphere: This is the zone of the earth occupied by living organisms. It is a layer of life which exists on the earth's surface.

(iii) Lithosphere: is the solid portion of earth. It is the outer most layer of zone of the earth's crust. It is made up of rocks and mineral materials, and it also represents 30% of the earth's surface.

(iv) Hydrosphere: is the liquid/aquatic part of the earth or living world. It covers about 70% of the earth's crust. It holds water in various forms – solid ice, liquid (water) and as gases (water vapour).

(v) Atmosphere: The atmosphere is the gaseous portion of the earth. It is a layer of gases surrounding the earth over 99% of the atmosphere within 30km of the earth surface.

(vi) Habitat: Habitat is defined as an area occupied by a biotic community. In other words, habitat is any environment in which an organism lives naturally.

(vii) Biotic community or biome: A biotic community is any naturally occurring group of different organisms living together and interacting in the same environment. A biome is a largest community of organisms, e.g. rainforest, guinea savannah, etc.

(viii) Ecological niche: ecological niche refers to the specific portion of a habitat which is occupied by a particular species or organism. It is the functional position of an organism within a community.

Problem 1 to Solve (5 minutes)

(a) What is ecology?

(b) What is meant by ecological concepts

Step IV: students to answer the following:

(a) What is environmental biology?

(b) Define in your own words the following terms:

(i) Autecology

(ii) Synecology

(iii) Environment

(iv) Biosphere

(v) Ecosphere

(vi) Lithosphere

Step V: Problem No. 2 to solve

List five ecological concepts you know and state what each stands for.

Problem No. 3 to solve

(a) What are components of the ecosystem?

(b) List them and state what role each plays in the study of ecology

Step VI

Give a comprehensive summary of what basic ecological concepts entail e.g. Autecology; As a branch of ecology which deals with the study of an individual organism e.g the study of a single rat and its environment.

Evaluation – ask the following questions

(1) Explain the importance of the study of ecology to ,you as a student

(2) What is meant by a biome?

(3) Define the following:

i. Biotic community

ii. Ecological niche

iii. Population

iv. Ecosystem

v. Abiotic components

SUMMARY AND CONCLUSION

Highlight the main points of the lesson along with the students.

Lesson 2:	**Problem-Solving Instructional Strategy**
Date	March, 2008
Subject	Ecology
Topic	Local biotic communities
Class	SS IIB Biology
Duration	40 minutes
No. of pupils in Class	55
Period	
Average age	17 years
Instructional method	Lecture method
Teaching Aids	Charts, maps of Nigeria and Africa.
Previous knowledge	Basic ecological concepts

Behavioural objectives

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

(1) Identify the different basic ecological concepts

(2) List the different branches of ecology

(3) State the relationship of living organisms with one another and with the environment in which they live.

(4) Identify the interrelationships between groups or organisms or species of organisms living together in an area.

Introduction

Step I

In our last lesson, we learnt about the basic ecological concepts and what each entails. We also learnt the meanings of different ecological concepts. Explain what is meant by ecology and synecology. What relationship exists between a single species and its environment. What is the importance of studying ecology to you as a student?

Presentation

Local biotic communities

The local biotic communities in Nigeria are grouped into two major zones. These are:

(a) Forest zone: The forest zone is made up of vegetation having mainly trees and consist of the following local biotic communities

 (i) Mangrove swamp forest (salt and fresh water swamp, (ii) tropical rainforest

(b) Savanna zone: The savanna zone is made up of mainly grasses and is further subdivided into three savanna belts and Sahel savanna mangrove swamp forest.

Location

The mangrove swamp forest is found in areas along the coast especially in states like Delta, Cross River, Rivers, Akwa-Ibom, Bayelsa, ogun and Lagos.

Characteristics of swamp forest:

(i) It has tall woody trees

(ii) Plants mainly have aerial roots

(iii) It has evergreen trees with broad leaves

(iv) It has high rainfall over 250cm throughout the year which results in water logging

(v) It is a combination of fresh and salt water.

(vi) Common plant species found are white mangrove, red mangrove, raffia palm, coconut etc.

(vii) Animals found in the biotic community include tilapia fish, oysters, crabs, snakes, birds, king fishers, chameleon an squirrel, etc.

Problem No. 4 to solve

What is meant by a community?

Explain the types of biomes you have studied

Describe in your own words what the following words stand for:

(i) Forest zone

(ii) Savanna zone

Students' activity

From your study of ecology, write an account of the different examples of a high forest.

1. Which are the common areas in Nigeria where the mangrove swamp forest is located?
2. What are the characteristics of a mangrove swamp forest?
3 (a) Draw a map of Nigeria showing the following

(b) Forest zone

(c) Savanna zone

(d) Mangrove swamp forest

Summary and Conclusion

Highlight the main points of the lesson with the students.

Explain how biotic communities in Nigeria have been formed (discuss with a partner)

Problem No. 3 to solve in the class (2-5 minutes). Show where you can locate mangrove and rainforest swamps in the map of your country.

Step 2: Tropical Rainforest

Location: This biotic community can be found in states like Edo, Delta, Ondo, Imo, Abia, Lagos, Ogun, Anambra, Bayelsa and Akwa-Ibom.

Characteristics of tropical rainforest

(i) The vegetation has tall trees with buttress roots, evergreen and broad leaves

(ii) The trees exist in different heights or layers, i.e. bottom or lower, middle and upper layers.

(iii) It has numerous climber, creepers, epiphytes and parasitic plans

(iv) It has little undergrowth due to canopy formed by all trees

(v) Plant species are not in pure stand, i.e trees are scattered.

(vi) The biome experience high rainfall of over 200cm, high temperature and high relative humidity.

(vii) Plant species include Iroko, Obeche, Mahogany, African walnut, Opepe, ebony, etc.

(viii) Animals commonly found include monkeys.

Lesson 3: Lecture Method

Date March 2008

Subject Biology

Topic Tropical rainforest

Class SS I

Duration: 80 minutes

No. of pupils in Class

Average age: 17 years

Instructional method: Problem solving method

Teaching Aids: Map of Nigeria showing locations of rainforest zones

Previous knowledge: Mangrove swamp forest

BEHAVIOURAL OBJECTIVES

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

(a) Explain fully the characteristics of a swamp forest

(b) Explain the commonest types of woody trees, aerial roots having evergreen trees with broad leaves.

Introduction

Step 1 Class

You could recall our discussion during the last lesson that mangrove swamp forest is found in areas along the coast especially in states Like Delta, Cross River, Rivers, Akwa-Ibom etc. It is divided into major zones. Could you briefly list these zones? What do you think are the similarities and differences that can be found in forest and savanna zones?

Step 1

The tropical rainforest is a biotic community found in states like Edo, Delta, Ondo, Imo, Abia and Akwa-Ibom. It has the following characteristics:

(i) The vegetation has tall trees with buttress roots, evergreen and broad leaves

(ii) The trees exist in different heights or layers, i.e. bottom or lower, middle and upper layers.

(iii) It has numerous climber, creepers, epiphytes and parasitic plans

(iii) It has little undergrowth due to canopy formed by all trees

(iv) Plant species are not in pure stand, i.e trees are scattered.

(v) The biome experience high rainfall of over 200cm, high temperature and high relative humidity.

(vi) Plant species include Iroko, Obeche, Mahogany, African walnut, Opepe, ebony, etc.

(vii) Animals commonly found include monkeys, birds, snakes, chameleon, squirrel, etc.

Problem No. 3 to be solved in class. Draw a map of Nigeria and label the different forest zones studied, compare your work with one another/partner

Southern Guinea savannah;

Location: This biotic community is found in states like Enugu, Kogi, Benue, Kwara, Oyo, Ebonyi, Osun and Ekiti.

Characteristics

It is the largest of all biotic communities in Nigeria, having moderate rainfall of between 100 – 150cm. It has tall grasses, tall trees, broad leaves with scattered trees and deciduous (i.e. trees shedding leaves during the dry season).

Important trees include the locust bean trees, shea-butter and isobelina. Important animals commonly found in the biome include antelopes, lions, leopards, zebra, etc.

Northern Guinea Savannah

The biome is found in states like Plateau, Kaduna, Bauchi, Niger, Taraba, Adamawa and Kano. It has low rainfall of, about 50 – 100cm per annum, having scattered and short deciduous trees. Has short but numerous grasses. Some of the trees have thorns while others have thick barks. Some of the trees wither in dry season. The common plant species found include acacia, date palm, silk cotton plants and baobab. Common animals include lizards, deer, lions, leopards, antelopes, etc.

Step II

Sahel savanna

The local biotic community is found only in the extreme northern parts of Nigeria such as Bornu, Katsina, Sokoto, Yobe, Kebbi, Zamfara, Kano and Jigawa. The characteristics of the biome include among others, high temperature and very low rainfall (below 50cm per annum), short and scanty grasses, short and tough shrubs. Grasses are fewer, poorer and in patches, has many drought resistant and scattered plants. Important plant species include acacia, gum Arabic and date palm.

The biome is located at the northern borders of Sokoto, Katsina, Dutse, Yobe and Bornu states.

Characteristics of this biome include having little or rain in most of the year high temperature and very low humidity. It has fewer grasses and shrubs. The plants have special features which enable them to live in desert e.g. absence of leaves, swollen and succulent stems, long roots, etc.

Common examples of trees are baobab and the cacti trees.

Students' activity

List down any two characteristics that are common to all the types of savanna you have studied. List down two characteristics each that make them differ from one another. Name the animals that are common to the vegetation.

Evaluation

Ask students the following questions in the evaluation process.

1. What is a savanna?
2. How does a savanna differ from a tropical rainforest?
3. In which parts of Nigeria do you find the following;

(a) Mangrove swamp forest

(b) Desert biome

Summary and conclusion

Highlight the main ideas of the lesson. Provide chalkboard summary for the students to copy.

Home work: Draw a map of Nigeria showing all the biotic communities.

APPENDIX D

GROUP EXPERIMENTAL

Lesson 1: **Lecture Method Strategy**

Date March, 2008

Subject Ecology

Topic Major biomes of the world

Class SS I Ecology

Average age 17 years

Instructional method: Problem Solving Method

Previous knowledge: The students have been taught Local Biotic Communities, for example Forest and Savannah zones.

Behavioural objectives

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

(1) Explain in their own words the meaning of a biome

(2) Describe in their own words the different types of biomes globally

(3) Describe in their own words the types of biotic communities that are found in their country/locality.

(4) Outline and describe the characteristics of each biome.

Introduction

Class: You could recall in our last lesson, we discussed tropical Rain forest and its characteristics.

Could you explain briefly what it entails?

Explain what the components of the rainforest are?

How would you differentiate between a tropical rainforest and a mangrove swamp forest?

Presentation: Using the problem-solving method

Step 1: Major biomes of the world

(i) Tropical rainforest

(ii) Savanna

(iii) Desert

(iv) Shrub

(v) Afro-alphine

(vi) Swamp

Problem No. to be solved in class

What is the location of the tropical rainforest?

What are the common vegetations of the forest? List down the manor biomes of the world and where each could be located.

Tropical rainforest

Its location is around the Equator (i.e. within 5^o North and South of the Equator. The forest is found in the Amazon basin of South America, Zaire basin of Central Africa, the Coasts of West Africa and interior Malaysia).

Characteristics

(i) Has a high temperature of between $25^oC – 37^oC$ with a small annual range of $2-3^oC$

(ii) Rainfall is throughout the year with two peaks (double maximum)

(iii) Has an annual rainfall of over 2000am, and abundant sunshine.

(iv) The relative humidity within the forest is very high.

(v) The forest trees in the forest have broad evergreen leaves, with various layers of trees – upper, middle and bottom storeys or canopies.

(vi) The trees are of great variety, that is, heterogeneous.

(vii) An abundance of tall hardwoods, e.g.Iroko, Obeche, Mahogany, African Walnut, Ebony, etc.

(viii) Creepers, climbers, epihytes and parasitic plants are commonly found in this forest.

(ix) The forest has little undergrowth.

Step 2:Savanna/Grassland

Covers very extensive areas of the world, i.e. about 20% of the total land mass. Grasslands are distinguished from the forest by the relatively absence of trees and the abundance of grasses. The grassland is a traditional biome between the forest and the desert. Grassland or savanna is grouped into tropical grassland and temperate grassland.

Tropical grassland

The tropical grassland is located between 5^o and 20^o North and South of the Equator. Areas where the grassland are found include Central America, North West part of South America, interior Brazil, West Africa, part of East Africa, South East Asia and Northern Australia.

Characteristics of tropical grassland

(i) The temperature of tropical grassland ranges from $21^oC - 30^oC$ which is at extremes.

(ii) It has an annual rainfall of about 600 – 1500mm

(iii) It has a seasonal conceptional rainfall with single maximum.

(iv) It has an annual temperature range of 11^oC.

(v) The tropical grassland has tall grasses that are fibrous when old.

(vi) The trees are deciduous, i.e. they shed their leave during the dry season to reduce the rate of transpiration.

(vii) Popular trees in the community include acacia, baobab and shear butter.

(viii) The grasses are called savanna in Africa and Australia campus in Brazil and Ilanos in Ovinoco (South America).

Problem No. 6 to be solved in class:

Draw a map of Africa and locate where the savanna/grassland and tropical grasslands are located. Compare your work with your partner.

Step 2: Temperate grassland

It is found in the interior continents in Asia, North America, South America (Argentina), South Africa and Australia.

Characteristics of temperate grassland

(i) The vegetation of the temperate grassland is associated with the temperate continual climate.

(ii) It has hot summer with temperature of over 20^oC.

(iii) It also has cold winter with temperature below 0^oc

(iv) Temperate grassland has average rainfall of about 508mm

(v) The rainfall is usually conventional and light.

(vi) There is abundance of grasses.

(vii) The grasses tend to have uniform height or a bit short

(viii) Trees are scarce in the temperate grassland

(ix) The grasses have different names in different areas where they are found. These are:

a. The Steppe of Central Europe and Russia
b. The prairies of North America
c. The pampas of Argentina
d. The vield of South Africa
e. The Downs of Australia

Step 4: Deserts

Deserts are areas generally associated with aridity (dryness). The environment is usually very hot with little or no rainfall. There are two types of deserts. These are thehot deserts and cold deserts.

Hot deserts

Hot deserts of the world are located on the Western coasts of continents within latitudes 15^o and 30^o North and South of the Equator. Hot deserts include Sahara desert (North Africa), Arabian desert (Arabia), Iranian desert (Iran), Namibia and Kalahari deserts (South Africa), Great Australia desert (Australia) and Atacama desert (South America).

Characteristics of a hot desert

(i) Hot desert has high temperatures between 30^{o}C and 60^{o}C
(ii) Aridity or rainlessness is common.
(iii) Annual rainfall is about 250mm
(iv) Evaporation is high while the relative humidity is very low
(v) The deserts are associated with cold current
(vi) Vegetation is sparse or scanty
(vii) Common vegetation include grasses, shrubs and herbs
(viii) Most plants are aerophyphtes (drought resistant plants) like thorny bushes, the bulbous cacti, writing grasses, date palm and acacia.

Cold desert

Cold deserts are located or found in the interior of continents around $45^o - 60^o$ North and South of the Equator. Cold deserts are found in the interior of Eurasia, North America and Pantagoria South America.

Characteristics of cold deserts

(i) Cold Desert has hot summers and cold winters

(ii) Winters are cold with temperature below 70oC while summers are hot (38oC)

(iii) Summers are hot and dry while winters are mild and rainy

(iv) It has drought resistant shrubs, aromatic plants and dwarf trees such as magquis, thorny acacia.

(v) Shrub has patches of grasses which may even be absent in some cases

(vi) Low thorny trees/bushes with shrubs and herbs are common.

Afro-Alphine

Afro-alphine is a kind of vegetation associatd with high mountains or highlands. The Afro-Alphine as it relates to Africa is found in highlands such as Cameroun mountain, Kenya highland, Kilimanjaro mountain (East Africa).

Characteristics of Afro-Alphine

(i) Temperature and pressure of Afro-alphine decrease with altitude

(ii) Heavy rainfall is experienced on the windward side of the mountain while lesser rainfall is experienced on the leeward side.

(iii) The windward side of the mountain may have a luxuriant forest type of vegetation.

(iv) The leeward side may experience a savanna type of vegetation.

(v) Vegetation decreases with height of the mountain.

(vi) The peak of the mountain may experience ice-cap or permanent snow.

Problem No. 7:

Describe the temperate grassland. List down the different names given to this vegetation in different areas where they are located.

Step 4: Swamp

The swamp forests are usually found in the tropics, along coastal regions and river mouths in West Africa, East Africa and South Africa. Swamps are generally found along the coast all over the world.

Characteristics of swamp

(i) Swamp has high temperature of about 27oC throughout the year

(ii) It has high rainfall of over 2500 mm with no distinct season.

(iii) Relative humidity in swamp is very high. It is close to 90%.

(iv) The dominant plants are the white mangroves, red mangroves and raffia palm.

(v) The plants have stilt roots which grow downward and branch into the mud surface.

(vi) The white mangrove has roots which enable it to carry out gaseous exchange.

(vii) Animals commonly found include mud skipper, crabs, Tilapia fish, etc.

Students' activity

Compare and contrast the vegetation found in swamps and deserts. Explain how their common features will assist a farmer to plan for a successful farming season.

Evaluation

Ask these questions to evaluate:

(1) How do climatic or physical conditions of tropical grassland relate to that of temperate grassland?

(2) In which of the forest areas do you find the following vegetational plants?

a. Creepers (b) climbers and (c) parasitic plants?

(3) Define the following

a. Afro-Alphine
b. Shrub
c. Swamp
d. Mangrove

(4) What is meant by the terms "rainfall with no peaks double maxima?"

Summary and conclusion

Highlight the main salient features of the lesson provide a chalk
board for the pupils to copy.

Home work

(1) Describe in your own words what a biome means

(2) Differentiate between an ecosystem and a biome

Lesson 5: Problem Solving Strategy

Date March 2008

Subject Ecology

Topic Population studies

Class SS I

Duration 80 minutes

No. of pupils in class 68

Average age 17 years

Teaching Aids: Map of Nigeria showing states of the federation, chalkboard and textbooks, essential biology textbook

Previous knowledge: Students have been taught Biomes, the different type of Biomes and their characteristics.

Behavioural objectives

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

1. Explain in their own words the meaning of population
2. Identify basic concepts of population
3. Identify the different types of species found in particular habitats and relationships that exist between various organisms (plants and animals) in a habitat.
4. List the names of species that exert a greater influence or a major species controlling effect on other members of the community.
5. Enumerate population characteristics
6. Identify factors that affect population

Introduction

Class, who can help us define the word population?

Name the common species that are found in your locality or community. What is meant by population characteristics?

Presentation

Step I

Population is defined as the total number of organisms of the same species living together in a given area at a particular time. In an ecosystem, the community is made up of many populations of different species. In population studies of a habitat, the following are usually studied:

(1) Types of organisms: This involves the listing of the various types of populations that are found in the particular habitat. It helps to determine the relationships that exist between various organisms (plants and animals) in a habitat.

(2) Dominance: Dominance refers to those species that exert a greater influence or a major controlling effect on the other members of the community. The relative importance of a species in the community is expressed by dominance. Dominance could be expressed in terms of (i) their number, (ii) occupation of largest portion of space (iii) possession of the lightest biomass and (iv) the largest contributions to the energy flow in the habitat. For a species to be dominant in a habitat, it should possess some of these attributes over other species.

Problem No. 9 to be solved in Class

In the study of population, what areas are given maximum attention? What do you consider to be the dominance of species in a habitat?

What are that factors to help you in determining the importance of a species in a community?

Step 2

Population characteristics

These characteristics include:

(a) Population size: This refers to the total number of the species of the same kind in a given area or habitat. A large population stands a better chance of surviving dangerous and unfavourable conditions such as fire, diseases, etc, while a small population can easily be wiped out.

(b) Population density: Population density is defined as the number of individual organisms per unit area or volume or volume of habitat mathematically, population

$$\text{density} = \frac{\text{Total population or population size}}{\text{Area of habitat}}$$

Population density can be used to estimate the total number of individuals of a population or population size. Mathematically, population size = population density x area of habitat.

(c) Population frequency: This refers to the number of times an organism occurs within a given area of a habitat.

(d) Percentage cover: This refers to the area or space covered or occupied by a given species in its habitat and it is expressed in percentage.

(e) Population growth rate: This refers to the net result of the influence of natality (birth rate) and mortality (death rate) of organisms in a given habitat.

Problem No.10 to be solved in Class

What are the characteristics of a population? Discuss your answer with your partner.

Briefly explain what is meant by population density = $\frac{\text{Total population size}}{\text{Area of habitat}}$

Step 3:

Factors affecting population

Factors which may affect the population of organisms in a given habitat include:

(1) Natality (birth rate): This refers to the rate of given birth to new organisms. This generally (be it plants or animals) leads to increase in population.

(2) Mortality (death rate): This refers to the rate at which organisms die in a habitat, generally leads to a decrease in population.

(3) Immigration (dispersal): This is the movement of organisms from different habitat into a new habitat. This tends to increase the population of the new area.

(4) Emigration: This is the movement of organisms out of a habitat due to either scarcity of food or unfavourable conditions or for feeding purposes. This, however, reduces the population of a habitat.

(5) Availability of food: The availability of food in a given habitat tends to increase the population of that habitat through rapid rate of reproduction and other organisms coming into feed.

(6) Seasonal climatic changes: Unfavourable climatic changes may result in the decrease of population since most organisms may die or migrate out of the habitat while the reverses of the case when the conditions are favourable.

(7) Breeding periods: Most organisms move out of a habitat during breeding period or season, thereby reducing the population of the habitat. For example, population decreases during the breeding season in fish, food, termite, etc.

(8) Natural disasters: Natural disasters like fire, drought, floods, earthquakes etc may lead to a decrease in population as many organisms may die or move out of that habitat to a new area.

Problem No. 10 to be solved in Class

1. Enumerate the characteristics of a population
2. What are the factors that affect population in a habitat?
3. Compare and contrast immigration and emigration factors in a given habitat
4. List their merits and demerits

Students' activity

Define the following

(1) Natality

(2) Mortality

(3) Seasonal climatic changes

(4) Breeding periods

Evaluation

Ask the following questions to evaluate:

(i) Population density

(ii) Population size

(iii) Percentage cover; and

(iv) Population size

Summary and conclusion

Summarize the lesson by highlighting the main points of the lesson

Lesson 6: Lecture Method

Date March 2008

Topic Ecological Factors

Subject: Ecology

Class SS II Ecology

Average age 17 years

Teaching Aids Essential Biology Textbook, Chalk and Board

Previous knowledge: Population studies

Behavioural objectives

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

1. Define the term ecological factors
2. Explain in their own words the meaning of the following terms under biotic factors

(i) Competition

(ii) Parasitism

(iii) Commensalism

(iv) Predation

(v) Pathogens

(vi) Mortality

(vii) Migration

(viii) Dispersal

(ix) Natality

(x) Food

(xi) Diseases

(xii) Pests

Introduction

Class, who can help us define the term ecology factors? Give the meaning of the following: biotic factors, competition, parasitism, commensalisms, predation, pathogens, mortality, mirgration, dispersal, natality, food, diseases and pests.

Presentation

Step 1

Ecological factors are those factors in the environment which can influence living organisms or cause changes that are found in your locality/community.

Competition: Involves interactions among two organisms of the same species or different species in which one outgrows the other and survives while the other cannot grow nor survives.

Commensalisms: Commensalisms is an association between two organisms living together in which only one (the commensal) benefits from the association while the other neither benefited nor is harmed.

Predation: Predation is a type of association between two organisms in which the predator kills the other called the prey and feeds directly on it.

Parasitism: This is a close association between two organisms in which one called the parasite, lies in or on and feeds at the expense of the other organism called the host. The parasite benefits from the association while the host usually suffers harm or dies.

Pathogens: These are microorganisms which can cause diseases in plants and animals leading to their reduction through death.

Mortality: Mortality is the death rate of organisms (plants or animals) in an environment. Mortality generally reduces the population of organisms in any habitat.

Migration: This is the movement of organisms either into a new habitat (immigration). These movements usually have effect on the other organisms in habiting that habitat.

Dispersal: Dispersal is the spreading of new individuals from their parents to new habitats so as to start a new life in the new environment. Such spreading habitats may affect the lives of other organisms in the new area.

Natality: This is the rate of giving birth to new offspring. Natality is generally known to increase the population of the habitat which will subsequently lead to certain problems among the organisms in that habitat.

Food: Availability of food in a habitat generally leads to increase in a population while lack of food leads to starvation and death.,

Diseases: Diseases are known to reduce the population of organisms (both plants and animals) in any habitat.

Pests: Pests are also known to affect the performance of plants in terms of yields and growth. In severe cases, the plants may even die.

Step 2 Abiotic factors

The abiotic factors comprise the following:

(i) Climatic factors: These are temperature, rainfall, wind, pressure, sunlight or sunshine, humidity, etc.

(ii) Chemical factors: These are made up of oxygen, carbon dioxide, mineral salts, water and nitrogen.

(iii) Edaphic factors: This consists of soil, its water, chemical and physical composition, its pH, its nutrients, profile, structure and texture.

(iv) Topography: These are caused as a result of the shape of the earth's surface, e.g. effects of rivers, hills, mountains and valleys.

Step 3

Ecological factors common to all habitats

Factors affecting/common to all habitats (both aquatic and terrestrial habitats) include (i) temperature, (ii) rainfall, (iii) light,(iv) wind, (v) pressure, (vi) hydrogen ion concentration of these factors, temperature and rainfall determine the major biomes of the world temperature.

(i) Temperature determines the vegetation of an area.

(ii) It is necessary for germination of seeds

(iii) It affects the distribution of plants and animals

(iv) It regulates the activities of majority of the living things

(v) High temperature affects evapo-transpiration and reduces the performance of animals.

(vi) It affects the wilting of field crops, ripening and maturity of crops.

(vii) It leads to loss of soil nutrients through voltization.

(viii) Unfavourable temperature may result in seed dormancy.

Rainfall

(i) Rainfall determines seasons in some places, e.g. Nigeria, where we have rainy and dry seasons

(ii) It determines the type of vegetation in an area.

(iii) It determines the distribution of plants and animals

(iv) Rainfall provides a dwelling place or habitat for some organisms, e.g. fish, crab, shrimps, seaweeds

(v) Rainfall is necessary for seed germination

(vi) It helps to dissolve nutrients in the soil thereby making them available to plants.

(vii) It is the main source of water in rivers, ponds, lakes, oceans, etc.

(viii) Plants use water for photosynthesis

Wind

(i) Wind determines seasons in Nigeria, for instance, the South-West wind is responsible for any rainy season while the North-East wind brings harmattan or dry season.

(ii) It helps in the distribution of rainfall

(iii) It aids the pollination of flowers

(iv) It also aids the dispersal of seeds and fruits

(v) High velocity wind may cause wind erosion

(vi) Wind is responsible for water currents and waves.

Light

(i) Sunlight is necessary for photosynthesis to take place in green plants.

(ii) It affects evapo-transpiration

(iii) It affects the productivity of crops due to length of day, i.e. photoperiodism

(iv) Light affects flowering and fruiting in plants

(v) Light is the ultimate source of energy for all organisms

(vi) It affects the activities of animals, e.g. some animals are active during the day while others are active at night.

Pressure

i. Atmospheric pressure decreases as one goes up from the sea level.

ii. In aquatic environment, pressure increases as one moves down the water.

iii. Plants and animals have special adaptations to particular level of pressure to enable them survive.

iv. Too high or too low pressure will affect the lives and activities of plants and animals.

v. Pressure is responsible for the movement of winds.

Hydrogen ion concentration (pH)

i. pH values range from 1 to 14, with pH being very acidic, pH 7 neutral and pH 14 very alkaline

ii. Living organisms are highly sensitive to pH changes.

iii. Plants and animals are adapted to special pH values, e.g. pH of fresh water is low while marine ph is high.

iv. Most plants thrive well in neutral or slightly alkaline soils while acidic soils support very little vegetation.

Problem No. 11 to be solved in the class.

1. What is meant by ecological factors?
2. What are abiotic factors and their importance in ecology?
3. List the ecological factors that are common to habitats

Students' activity

Fill in the blank spaces suitable words that best complete each statement.

1) The process that involves the interactions among two species in which one outgrows the other and survives while the other cannot grow nor survive is referred to as : ------------------------

2) The association between two organisms living together in which only one benefits from the association while the other neither benefited nor is harmed is known as: --------------

3) The type of association between two organisms in which the predator kills the other called the prey and feeds directly on it is called: -----------------------

4) Microorganisms which can cause diseases in plants and animals leading to their reduction through death are called: --------------

Write true or false on the statements that follow:

5) An example of a climatic factor is temperature: -------------------

6) Edaphic factors include oxygen, carbon –dioxide and nitrogen: --

7) Topography deals with soil, its water, chemical and physical compositions: --------

8) Dispersal is the spreading of new individuals from their parents to new habitats so as to start a new life in the new environment: ---------------------

9) Light determines seasons in Nigeria: ------------------

10) Atmospheric pressure decreases as one goes up from the sea level: -------------

Evaluation

Ask the following questions to evaluate

1) Name five ecological factors that are found in your locality/community

2) Define the following terms

(i) Mortality (ii) Food (iii) Parasitism (iv) Natality (v) Migration (vi) Pests.

List down 5 ecological factors that are common to all habitats.

Summary and conclusion

To summarize the lesson by highlighting the main points of the lesson.

APPENDIX E

(Scoring Key for CPT)

1a-	R, Q, P, A	2a-	R, Q, A, P
b-	A, P, R, Q	b-	A, P, Q, R
c-	P, A, R, Q	c-	P, A, R, Q
d-	Q, A, P, R.	d-	Q, R, A, P
3a-	R, A, Q, P	4a-	R, P, A, Q
b-	A, R, Q, P	b-	A, P, R, Q

c- P, A, R, Q
d- Q, R, A, P

c- A, R, Q, P
d- Q, P, R, A

5a- R, Q, P, A
b- A, R, P, Q
c- P, A, Q, R
d- Q, R, P, A

6a- R, P, Q, A
b- A, R, P, Q
c- P, A, Q, R
d- Q, R, P, A

7a- R, Q, P, A
b- A, R, P, Q
c- P, R, A, Q
d- Q, R, P, A

8a- R, Q, P, A
b- A, P, R, Q
c- P, A, R, Q
d- Q, R, A, P

9a- R, P, A, Q
b- A, R, Q, P
c- P, A, R, Q
d- Q, P, R, A

10a- R, Q, P, A
b- A, P, R, Q
c- P, Q, A, R
d- Q, R, P, A

11a- R, P, A, Q
b- A, R, P, Q
c- P, A, R, Q
d- Q, R, A, P

12a- R, Q, P, A
b- A, R, P, Q
c- P, A, R, Q
d- Q, R, P, A

13a- R, Q, P, A
b- A, P, R, Q
c- P, A, R, Q
d- R, Q, A, P

14a- R, Q, A, P
b- A, R, P, Q
c- P, A, Q, R
d- Q, R, P, A

15a- R, Q, P, A
b- A, P, R, Q
c- P, A, Q, R
d- Q, R, P, A

16a- R, Q, A, P
b- A, P, R, Q
c- P, R, A, Q
d- Q, A, R, P

17a- P, R, Q, A
b- A, P, Q, R
c- R, P, A, Q
d- Q, R, A, P

18a- R, Q, P, A
b- A, R, P, Q
c- P, A, R, Q
d- Q, A, R, P

19a- R, Q, P, A
b- A, P, R, Q
c- P, A, R, Q
d- Q, R, A, P

20a- R, Q, A, P
b- A, R, Q, P
c- P, A, R, Q
d- Q, R, P, A

21a- R, P, Q, A
b- A, Q, P, R
c- A, Q, R, P
d- Q, P, R, A

22a- R, P, Q, A
b- A, R, P, Q
c- P, A, Q, R
d- Q, R, P, A

23a- R, Q, P, A
b- A, P, R, Q
c- P, R, A, Q
d- Q, R, P, A

24a- R, A, Q, P
b- A, P, R, Q
c- P, Q, A, R
d- Q, R, A, P

25a- R, Q, P, A
b- A, Q, P, R
c- P, R, Q, A
d- Q, A, R, P

26a- R, A, Q, P
b- A, Q, P, R
c- P, R, A, Q
d- Q, R, A, P

27a- R, P, Q, A
b- A, R, Q, P
c- P, R, Q, A
d- Q, R, A, P

28a- P, Q, R, A
b- A, P, R, Q
c- P, R, A, Q
d- Q, R, A, P

29a-	Q, R, P, A	30a-	R, P, Q, A
b-	A, P, R, Q	b-	A, R, Q, P
c-	A, P, R, Q	c-	P, Q, A, R
d-	R, Q, P, A	d-	Q, P, A, R

APPENDIX F

(Scoring Key for EAT)

1.	A	29.	C
2.	B	30.	A
3.	A	31.	D
4.	C	32.	C
5.	A	33.	A
6.	B	34.	B
7.	D	35.	D
8.	A	36.	B
9.	A	37.	C
10.	C	38.	B
11.	B	39.	C
12.	A	40.	B
13.	C	41.	D
14.	C	42.	C
15.	A	43.	B
16.	D	44.	D
17.	A	45.	A
18.	B	46.	A
19.	D	47.	C

20.	C	48.	D
21.	C	49.	D
22.	A	50.	C
23.	D		
24.	B		
25.	B		
26.	D		
27.	B		
28.	C		

APPENDIX G

Table 3.3 Item Difficulty (F.1) for the Ecology Achievement Test (EAT)

Item	Difficulty Index (F.1)	Item	Difficulty Index (F.1)
1.	0.2	26	0.41
2.	0.61	27	0.38
3.	0.72	28	0.37
4.	0.54	29	0.42
5.	0.50	30	0.40
6.	0.11	31	0.72
7.	0.15	32	0.59
8.	0.14	33 R	0.28
9.	0.45	34R	0.27
10.	0. 29	35R	0. 29
11.	0. 25	36	0. 68
12.	0. 21	37	0. 66
13.	0. 19	38	0. 64
14.	0. 34	39	0. 69
15.	0. 48	40	0. 64
16.	0.24	41	0.43
17.	0.64	42	0.32
18.	0.70	43	0.35
19.	0.73	44 R	0.27

20.	0.08	45	0.70
21.	0.09	46	0.79
22.	0.35	47	0.53
23.	0.79	48	0.36
24.	0.80	49	0.37
25.	0.61	50	0.18

KEY

- Discarded for being too difficult

R Reframed and accepted

APPENDIX H

Table 3.4(b) Discrimination Indices D.I (P1-P2) for the Ecology Achievement Test (EAT)

Item Index	Discrimination Index (P1-P2)	Item	Discrimination (P1-P2)
1.	0.40	26	0.41
2.	0.61	27	0.38
3.	0.72	28	0.37
4.	0.54	29	0.42
5.	0.50	30	0.40
6.	0.11	31	0.72
7.	0.15	32	0.52
8.	0.14	33 R	0.28
9.	0.45	34 R	0.27
10.	0.29	35 R	0.22
11.	0.25	36	0.68
12.	0.21	37	0.66
13.	0.19	38	0.64
14.	0.34	39	0.69
15.	0.48	40	0.44
16.	0.24	41	0.43
17.	0.64	42	0.32
18.	0.07	43	0.35

19.	0.73	44 R	0.30
20.	0.08	45	0.70
21.	0.09	46	0.79
22.	0.35	47	0.53
23.	0.79	48	0.36
24.	0.80	49	0.37
25.	0.61	50*	0.18

KEY

- Discarded for being too difficult

R Revise and retained