EFFECTS OF PRE-THEORETIC INTUITION QUIZ AND PUZZLE-BASED CRITICAL THINKING MOTIVATION STRATEGIES ON STUDENTS' LEARNING OUTCOMES IN SELECTED ENVIRONMENT-RELATED CONCEPTS IN BIOLOGY.

BY

OGUNDIWIN , OLUYEMI AKINLEYE
MATRIC NO: 54489
B.SC (Agronomy); PGDE; M.Ed (Ibadan)

A THESIS TO THE DEPARTMENT OF TEACHER EDUCATION
SUBMITTED TO THE FACULTY OF EDUCATION IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY (PH. D) IN SCIENCE EDUCATION OF THE
UNIVERSITY OF IBADAN

2013

ABSTRACT

The traditional instructional strategy employed by most biology teachers in teaching environment-related concepts have resulted in low learning outcomes. Two strategies have been proved in literature to have exposed students to a higher thinking order needed to recognise assumptions, evaluate controversies, and scrutinise inferences in alleviating the problem of low students' learning outcomes in biology, but they have not been utilised in the teaching of environmental concept in biology. This study, therefore, examined the effects of Pre-Theoretic Intuition Quiz (PTI) and Puzzle-Based Learning (PBL) on students learning outcomes in selected environment-related concepts in biology.

The pretest-posttest control group quasi-experimental design with 3x2x2 factorial matrix was adopted. Four hundred and fifty one SS2 students from nine purposively selected senior secondary schools in three local government areas of Oyo State were used for the study. The schools were randomly assigned to experimental (PTI and PBL) and control (MCS) groups and the treatment lasted 14 weeks. Eight instruments were used: Instructional Guides for teachers; Students' Environmental Achievement Test (r=0.80), Students' Environmental Attitude Scale (r=0.81), Students' Environmental Practices Scale (r=0.82), Cognitive Style Test (r=0.81) and Assessment Sheet for evaluating research assistants. Seven null hypotheses were tested at 0.05 level of significance. Data were analysed using ANCOVA and Scheffe post hoc test.

Treatment had a significant main effect on students' achievement score ($F_{(2,438)} = 209.62$; $p<0.05$). Pre-Theoretic intuition quiz enhanced achievement scores ($\bar{x}$ =14.30) than PBL ($\bar{x}$ =12.61) and MCS ($\bar{x}$ =8.23). Treatment had significant main effect on students' environmental attitude ($F_{(2,438)} = 287.32$; $p<0.05$). Pre-Theoretic intuition quiz enhanced attitude scores ($\bar{x}$ =64.34) than PBL ($\bar{x}$ =57.81) and MCS ($\bar{x}$ =48.97).Treatment also had significant main effect on students' environmental practices ($F_{(2,438)} = 363.48$; $p<0.05$). Pre-Theoretic intuition quiz enhanced practices scores ($\bar{x}$ =65.34) than PBL ($\bar{x}$ =59.18) and MCS ($\bar{x}$ =48.33).There was a significant interaction effect of cognitive style and sex on students' environmental attitude scores ($F_{(1,438)} = 6.61$; $p<0.05$).The interaction effect of cognitive style and sex on students' environmental practices was significant ($F_{(1,438)} = 6.03$; $p<0.05$).Female analytical students had the highest mean score ($\bar{x}$ =58.75) while the male analytical students ($\bar{x}$ =56.51) had the least. The interaction effect of treatment, cognitive style and sex on students attitude scores was significant ($F_{(2,438)} = 3.22$; $p<0.05$).The mean score of analytical female students ($\bar{x}$ =65.03) in Pre-Theoretic intuition quiz was better than analytical male students ($\bar{x}$ =64.31); the mean score of non-analytical female students ($\bar{x}$ =57.15) in PBL was better than non-analytical male students ($\bar{x}$ =55.22), while the mean score of non-analytical female students ($\bar{x}$ =48.90) in MCS was better than analytical male students ($\bar{x}$ =48.07).

Pre-theoretic intuition quiz and Puzzle-based learning strategies improved students' achievement, attitudes and practices in environment-related concepts in biology. Biology teachers and curriculum developers should adopt these two critical thinking motivation strategies for the improvement of students' learning outcomes in environment-related concepts in biology.

Key words: Pre-theoretic intuition quiz, Puzzle-based learning, Cognitive style, Environment-related concepts in biology

Word count: 472

CERTIFICATION

I certify that this work was carried out by OGUNDIWIN, Oluyemi Akinleye Matric. No 54489 in the Department of Teacher Education, Faculty of Education, University of Ibadan, Ibadan.

.....

Supervisor
Professor Alice M. Olagunju
Ph.D (Science Education) M.Ed (Ib)
Department of Teacher Education
Faculty of Education
University Of Ibadan, Nigeria

DEDICATION

This work is gladly dedicated to Jesus, the Author of my soul, The Almighty God.

ACKNOWLEDGEMENT

I acknowledge with the highest regard and total humility, the favour of the Almighty God and His infinite love, protection, provision, grace and mercies over my life throughout the programme. Glory be to His Name.

I am greatly indebted to my supervisor, Prof. (Mrs.) Alice M. Olagunju, for her professional guide and motherly love, for she did not only serve as supervisor, but she stood as my professional mentor. She, despite her tight schedules diligently guided, directed and supervised this thesis and made it a reality and a success. Ma, I am very grateful to you for helping me to learn the spirit of thoroughness and forbearance. Thank you ma.

I very much appreciate the contribution of my External Internal examiner, Professor A.A. Onilude for taking pains to read through this work. God bless you Sir. I very much appreciate the contributions of the Head of Department, Prof. F. A. Adesoji to the success of this work. My sincere gratitude to Prof. Akinsola and other lecturers in the department of Teacher Education for their combined effort which made this programme a success.

My very special thanks goes to my wife for her support, love, patience and understanding throughout the duration of the programme and always. God will bless and reward you richly in Jesus name. I specially acknowledge the contribution of my colleagues at work Mr. Oni, Mrs Abolaji, Mr Tijani and others who held fort and stood by me while I was away. God bless you all.

My thanks goes to Pastor Akinyemi, Dr and Mrs J.O. Adeleke, Dr John Oyundoyin and Dr Femi Adegbesan, for their love and contributions. God bless you all.

To my course mates, Mr. Ajadi, Mr. Adegoke, Mr. Babayemi, Mr. Ogundare, sister Tayo and others for their encouragement. God will bless you. I must not forget the contribution of My School Principal, Mrs.T.K. Olaniyan, you are a destiny helper, the Lord will reward you richly. To my brothers, sisters, in-laws and other relatives, I say thank you for your love and support. To Mr. Lawal and, Mr Akinyemi, I appreciate your support and love for me. To God be the glory.

.

OGUNDIWIN .O.A

Table of Contents

LIST OF TABLES **Page**

LIST OF FIGURES

Page

LIST OF APPENDICES **Page**

List of Abbreviations

EE - Environmental Education

EIA- Environmental Impact Assessment

FEPA - Federal Environmental Protection Agency

MCS - Modified Conventional strategy.

N.C.C.E.E - National Coordinating Committee on Environmental Education

NCF- Nigeria Conservation Foundation

NECO- National Examinations Council

NERDC- National Educational Research and Development Council

NPE- National Policy on Environment

PBS - Puzzle-Based Learning

PTI - Pre-Theoretic Intuition Quiz

REB- Responsible Environmental Behavior

S.D- Standard Deviation

STS - Science – Technology Society

WAEC- West African Examinations Council

CHAPTER ONE
INTRODUCTION

1.1 Background to the Study

Science is very crucial to human living. No wonder, the relevance of science to national goals, aspirations and economy dictates, to a large extent, the huge commitment and support, which most nations make and give to science and technological development. Its knowledge is used in the production of materials that reduce people's stress, suffering and hunger, protects as well as makes life more enjoyable and secured

Biology, as a science subject, and a prerequisite to many fields of learning, occupies a unique position in the senior secondary school's programme. The reason for this is the fact that biology deals with the study of living things and has relevance to human's existence. Biology involves the study of physiology, biochemistry, anatomy, systems, genetics, evolution and ecology of plants and animals that contribute immensely to the scientific growth of Nigeria. .Most secondary school authorities register their students for biology in the West African Senior School Certificate Examinations, National Examinations Council for Senior School Examinations and other equivalent examinations. Among The current senior secondary school science curriculum include Agricultural science, Biology, Chemistry and Physics.

Johnson (2006) pointed out that the importance of Biology will continue to have a profound impact on our lives for decades. He further stressed that Biological science stimulates human interest to find the truth with an intellectual rigor therefore its importance in culture and education cannot be overemphasized. Liras (2004) declared that everyone accepts Biology as the science of the twenty first century. The improvement in medicine and health issues meet human needs and so this period has been considered as 'The Age of Biology' (Jarman, Ruth, McClune & Billy ,2001).

The National Policy on Education (Federal Government of Nigeria, 2004) makes it compulsory for all students to offer at least a science subject at the senior secondary school in Nigeria in the old curriculum but the science subjects are no longer a requirement for senior secondary school students to offer as part of the core subjects (Abimbola,2013) in the new curriculum. However, biology is the subject most preferred and chosen by many science students (Abubakar, 2001, Nwosu, 2006). This will go a long way to produce a scientifically literate society devoid of ignorance and diseases (Abimbola, 2013).

Federal Ministry of Education/ National Education Research and Development Council (2009) state the following objectives in its curriculum for Biology:

- Understanding of the structure and function of living organisms as well as appreciation of nature;
- Acquisition of adequate laboratory and field skills in order to carry out and evaluate experiments and projects in Biology;
- Acquisition of necessary scientific skills for example observing, classifying and interpreting biological data;
- Relevant knowledge in Biology needed for future advanced studies in biological science;
- Acquisition of scientific attitude for problem solving;
- Ability to apply biological principles in everyday life in matters that affect personal, social, environmental, community health and economic problems.

The new 2009 edition of the biology curriculum (NERDC, 2009) now has only four themes namely:

- Organization of life,
- The organism at work,
- The organism and its environment including
- Continuity of life.

Environmental Education is one of the concepts infused into the theme as 'The organism and its environment'. Many Environmental Education concepts such as ecology, pollution, conservation techniques and population are found in the Biology Curriculum of West African Senior School Certificate Examinations (WASSCE)/National Examinations Council (NECO) Senior School Certificate Examinations syllabuses (Obioma, 2007).

Knapp & Benton (2006) noted that education is supposed to communicate effectively to the public including the nature and magnitude of the environmental problems, and array of alternatives available for their solution and sufficient insight towards the right attitude and sustainable use of the environmental resources must be emphasized in environmental education. This is corroborated by Ikoh (2009) in his statement that states "Development of any nation is a function of its educational state". With the understanding that our day-to-day living, at work, at home, in the neighborhood and at play revolves round the environment in which we live, we therefore owe the duty to learn and to know about the environment in order to plan for and take care of it for our use and the use of the future generation.

The science of teaching according to Ogunboyede (2011) is referred to as Pedagogy while Mcaughtry (2005) and Sidhu, Fook & Kaur (2011) stressed that pedagogical content knowledge refers to teaching and learning of the subject claimed that even at the integration of pedagogical knowledge into teachers education in Malaysia, the methodology being used by some science teachers in schools are not child- friendly, hence effective learning of science cannot take place.

Adegbile (2002) was of the opinion that teachers who wish to impact knowledge meaningfully, so that their students can achieve conceptual comprehension will often employ metacognitive teaching strategies. Metacognition is defined as the knowledge of one's knowledge, processes, including cognitive, affective states and the ability to consciously and deliberately

monitor and regulate them (Hacker, Dunlosky, &Graesser, 1998). With the ability to assess their knowledge in this way, students can study accordingly. Unless the teacher is environmentally inclined or trained, he or she is not likely to significantly improve or impart the teaching and learning of Environmental Education (Eguabor,2012). Environmental concepts and issue when taught effectively help to improve students' knowledge as well as develop skills, attitudes and practices needed to address environmentally based everyday problems, and help them to improve their achievement in the environmental concept addressed (Ferguson, Angell & Tudor 2001): Gough 2002 & Olagunju 2002).

Over the years, experts have continued to draw attention to the grave consequences of constant decline in the performance of our secondary school students in science subjects especially in public examinations such as National Examinations Council and West African Senior School Certificate Examinations (Ogunleye, 2002). This is corroborated by Abimbola (2013) that the performance level for science subjects did not show any significant rise for a twenty-year period between 1991 to 2011 and confirmed that candidates performance in Biology over those years never rose above 50% perhaps because non science students used to register for Biology as a core science subject. The analysis of Senior School Certificate Examinations' result in Table 1.1 below made available from the West African Examinations Council (WAEC) statistics unit on enrolment of students and their performance in biology revealed the enormity of this problem.

Table 1.1: Percentage Distribution of Students' Performance in May/June Senior School Certificate (SSCE) in Biology in Nigeria: 2002 – 2012

Year	Total Entry	Total sat	Credit Passes 1-6	Percentage Passes
	No of Candidates.	No of Candidates	No of Candidates	% of Candidates
2002	1,240,163	882,119	278,112	31.52
2003	1,006,831	909,101	392,249	44.15
2004	1,005,553	1,027,938	253,487	24.69
2005	1,080,162	1,072,607	375,850	35.04
2006	1,170,522	1,152,045	559,854	48.60
2007	1,270,137	1,238,163	413,211	33.37
2008	1,292,910	1,259,964	427,644	33.94
2009	1,372,567	1,340,206	453,928	33.87
2010	1,331,381	1,300,418	427,644	33.90
2011	1,540,141	1,505,199	579,432	38.50
2012	1,695,878	1,672,224	649,156	38.82

Source: Statistics Section, West African Examination Council (WAEC) National Office, Onipanu, Lagos, Nigeria.

From table 1.1, the number of percentage credit passes and above in Biology continues to fall below 50% for the period of eleven years reviewed, although grade 7 and 8 are considered to be Passes but these are not good enough for candidates gaining admission into tertiary institutions. Figure 1.1 shows the interpretation of table 1.1

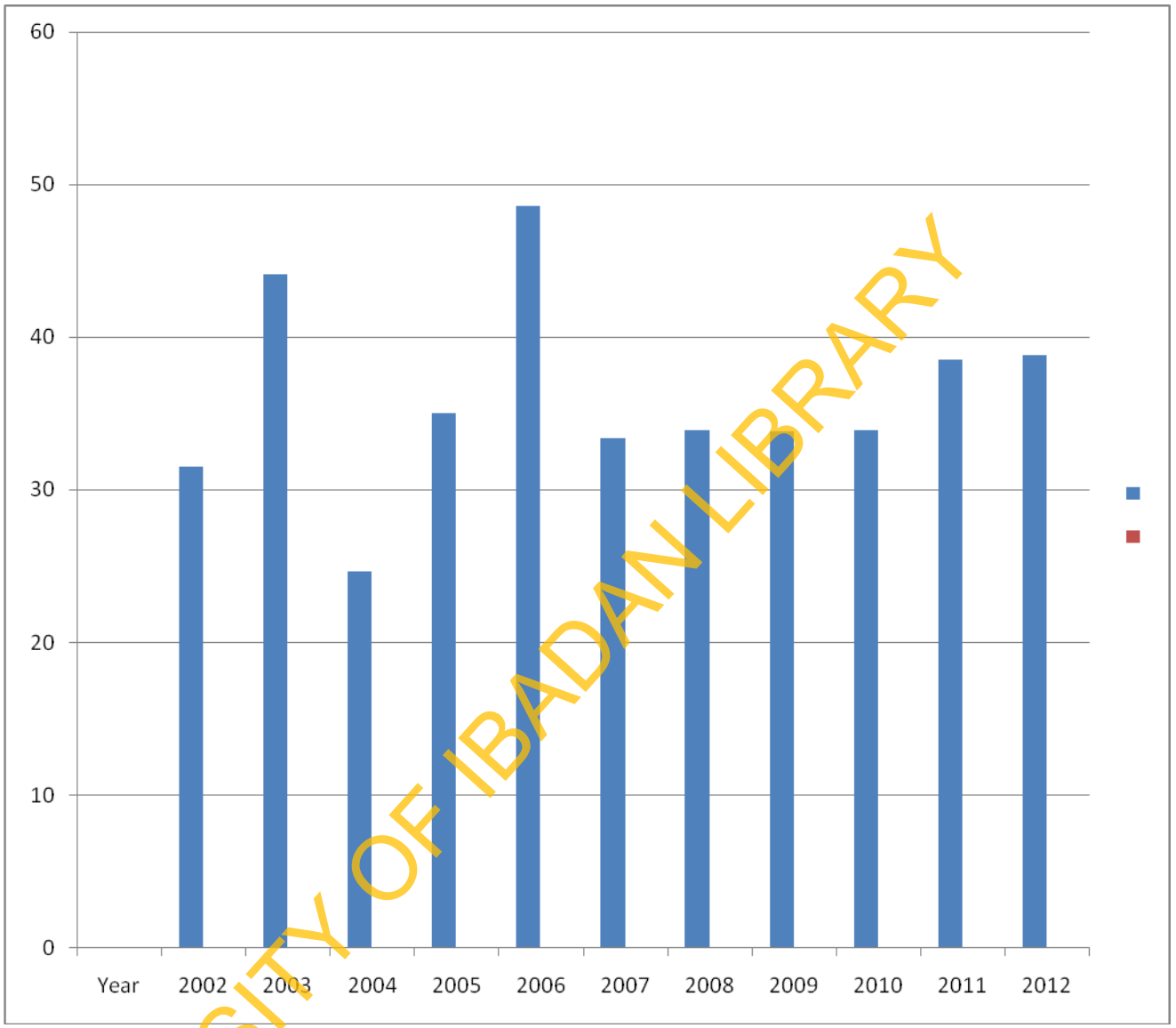


Figure 2.1: Bar chart showing Percentage Credit Passes of Students' Performance in May/June Senior School Certificate Examinations (SSCE) in Biology in Nigeria: (2002 – 2012)

Despite all efforts to improve students' performance in Biology, it has been observed, unfortunately, that the educational system is to a great extent not achieving its predetermined goals and objectives due to high failure in public examinations such as the Senior School Certificate Examinations (Ndioho,2007).

The percentage passes for the year 2002 to 2012 are not good enough especially for candidates that want to study biological sciences and biology based courses or for any candidate that may include biology as one of the relevant five subjects, passed at credit level in order to be admitted into any higher institutions in Nigeria as seen in the admission rate between 1995/1996 academic session and 2007/2008 academic session has been slow in improving as stated by Jekayinfa, Yusuf, Yahaya & Yusuf,(2010) and supported by Abimbola (2013) who concluded that the percentage of candidate admitted did not reach 20 percent during this period, except1998/1999 academic session when it was 23.09 percent.

Ayanda (2006) while citing from WAEC chief Examiners' reports maintained that students' performance in Biology was poor despite the fact that several crucial efforts have continually been made over the years to remedy the yearly poor performance and also improve students' performance.

The West African Examinations Council (WAEC) (2003, 2002a), Chief Examiners' report stressed that candidates showed poor grasp of the concepts of ecology contributed a lot to the poor performance of the candidates. Some did not attempt questions raised on ecology concepts and those who attempted the questions performed badly. Also, According to Chief Examiners' Reports in Nigeria (2002b), most candidates did well in items that require listing the correct alternative (knowledge level Bloom taxonomy) but a few made spelling errors and could not spell some environmental concepts terminologies. Most candidates could not state the roles of decomposers in the ecosystem but few did well in this question.

The trend occurs in the Chief Examiners' Reports in Nigeria (2003) where few candidates performed better in questions on adaptive features of climbing animals for example presence of prehensile tails, opposable digits, sticky/adhesive discs on fingers etc. and generally did not score well on this sub-number. In stating uses of water to rainforest organisms, some candidate wrote on uses of water to man and wrote 'drinking, washing and cooking' rather than

maintaining body temperature, essential for plant turgidity, necessary for photosynthesis.

The trend continues in the Chief Examiners' Reports in Nigeria (2004). Many candidates could not state three precautions necessary to get accurate result in the experiment to measure transpiration. A few candidates wrote that the amount of water in the soil rather than in the atmosphere affects the rate of transpiration.

In the Chief Examiners' Reports in Nigeria (2005), it was reported that most candidates merely define the habitat they did not list the various types of habitat or give examples. The same thing applied to the ecological niche; the candidates could not differentiate between defining and writing short notes, some candidates could not state the correct uses of the ecological instrument listed and a few made spelling errors and so lost marks for example Secchi dish instead of secchi disc. Few candidates named dogs and goats as animals found in the savanna region.

Chief Examiners' Reports in Nigeria (2007) indicated that candidates performed fairly on the definition of pollution and pollutants of water. In describing the effects of the named pollutants on aquatic organisms, some candidates wrote on general effects of pollution on the environment. A few candidates who wrote on effects of the pollutants on aquatic organisms did not separate the effects of each pollutant. They lumped the effect of all the pollutants which led to loss of marks.

Candidates failed to perform better on items requiring answers on the effects and prevention of Noise Pollution. The same trend occurred in Chief Examiners' Reports in Nigeria (2009) where few candidates were able to answer questions on the flow of Energy through the food chain.

The same trend occurred in 2010 where candidates failed to explain convincingly the terms; Niche, Population density and Climatic Community.

Majority of the candidates that sat for 2010 Biology examination was unable to explain the interaction between abiotic and biotic components of an ecosystem.

In 2011, a lot of candidates find it difficult to state and explain the second law of thermodynamics. There was no difference in the performance of candidates that sat in 2012 from the previous year 2011, Many Candidates in 2012, were unable to explain the term ENDANGERED SPECIES, though many candidates were able to explain conservation decomposition linking their specific examples.

In all these years mentioned, candidates' weaknesses were also found to be in the following areas:

- Inability to identify some illustrated organisms;
- Inability to give correct reasons for identifying labeled parts of illustrated diagrams, and
- Errors in spelling biological terms .

Several factors have been identified as being responsible for this poor performance in biology and other related sciences. They include large class sizes (Abubakar,2001); textbook and laboratory based reasons (Ayanda, 2006), misconceptions identified by Abimbola, (2013) in which all known misleading terms and wrong assertion are common in many Biology textbooks and among students .

According to Abimbola (2013) a misunderstood word, concept, symbol, or situation is the one which is wrongly understood. He established that misconceptions and alternative conceptions exist in Biology students, teachers, and textbooks. Other researchers that worked on related examples include (i) students –(Abimbola, 1984) on human respiration; Aworanti & Abimbola, 1997 on Ecology concepts (ii) Teachers – Abimbola, 1984 on human respiration; and Olatunji, 2005 on biology concepts; (iii) Textbooks --- Abimbola, 1991; Abimbola & Baba, 1996. Abimbola 2013 also reiterated that critical experiments performed

on STAN Biology textbook showed it to be technically difficult to read, two grade levels above the school certificate level, and contained misconceptions and alternative conceptions, despite its expert touch.

Ayanda,(2006) found that students generally perceive Biology as relatively easy subject compared with other science subjects. He also concluded that students generally believed that Biology is the least intellectually demanding of the three traditional school science subjects such as physics, Chemistry, and Biology. Other known misleading terms and wrong assertion in environmental concepts as identified by Smith & Anderson, (1986) include some middle-school students think dead organisms simply rot away. They do not realize that the matter from the dead organism is converted into other materials in the environment. Some middle-school students see decay as a gradual, inevitable consequence of time without need of decomposing agents (Smith & Anderson, 1986). Some high-school students believe that matter is conserved during decay, but do not know where it goes (Leach, Driver, Scott,& Wood-Robinson(1992).Middle-school students seem to know that some kind of cyclical process takes place in ecosystems (Smith & Anderson, 1986). Some students see only chains of events and pay little attention to the matter involved in processes such as plant growth or animals eating plants. They think the processes involve creating and destroying matter rather than transforming it from one substance to another.

Local research has shown that Ghanaian students and teachers are not immune to the problem of misconceptions related to basic scientific phenomena (Amphiah 2002) many in-service teachers in the High schools either do not have science background or are only practicing science teaching for a small part of their time.

Another factor being identified as been responsible for this poor performance in biology is instructional strategy adopted by teachers. There seems to be consensus of opinions among science educators concerning the important role played by instructional strategy adopted as a classroom variable in affecting

students' achievement and attitude towards Biology (Ige, 2001) including practices(Olagunju ,2002). Nwozu,(2003) was of the opinion that ineffective teaching strategies contributed to the poor performance in biology and other related sciences.

Six strategies identified by Okebukola, Akpan, Ahove, Kola-Olusanya & Ogunsola, Bandele (1997) as potentially effective for teaching some selected environmental concepts in biology are; lecture/discussion, project method, concept mapping, use of analogies, topic study and dramatization. Efforts at improving Environmental Education learning strategies such as the use of full and quasi participatory learning (Ajitoni, 2005); use of video drama by Aremu and John (2005) and outdoor educational activities in primary schools by Olatundun (2009) have also been made. Other strategies suggested include Moral dilemma and problem-solving strategies by Chukwuka (2006), Video CD and Audio Cassette Instructions by Qjo (2008), Enter Educate by Abiona (2008), Computer-Assisted and Programmed Instruction by Oduwaye (2009).Environmental Education Outdoor Ajiboye,.& Olatundun , (2010) to mention but a few.

The strategies have also been used by teachers but the subsequent performance of students in the Senior School Certificate Examinations is still very low as seen in Table 1.1.The performance of our candidates should be examined, while considering the recommendations from the WAEC Chief Examiners' report (2002, 2008 and 2009) including misconceptions observed by the researchers. Hence educators like Hestenes (2006) suggested the use of a higher thinking ordered strategies in which students need to be guided in order to clarify issues for more critical thinking and analysis, and where students will be able to present concepts based on intuition that will excite correct feedback. This is supported by Donkor,(2006) including Orlich, Harder, Callahan , Trevisan & Brown , (2010)

Also, one of the aims of Biology Curriculum is to develop broadly applicable skills in communication, critical thinking and objective reasoning ability to prepare the students for workplace and self sustainability in the World

Economy (Federal Ministry Education, 2008). In their review of research on critical thinking, Burbach, Matkin, & Fritz, (2004) pointed out that students' critical thinking abilities are not widespread. Most students do not score well on tests that measure ability to recognize assumptions, evaluate controversy, and scrutinize inferences. Thus, students' performances on measures of higher-order thinking ability revealed a critical need for students to develop the attitude and skills of effective thinking.

Numerous studies provide anecdotal evidence for pedagogies that improve critical thinking, but much of existing research relies on student self-report, which limits the scope of interpretation. From the literature it is clear that, although critical thinking skills are some of the most valued outcomes of a quality education, additional research investigating the effects of instructional factors on critical thinking performance is necessary (Tsui, 2002).

Ndukka, (2005) noted that research studies on the use of active learning strategies in developing countries, particularly Nigeria are still very low, except in South Africa where it has been tested. Donkor, 2006 has therefore suggested its use in other African countries in teaching and learning of science. Research indicates that thinking skills instruction makes a positive difference in the achievement levels of students (Maal, 2004). Studies that reflect achievement over time show that learning gains can be accelerated. These results indicate that the teaching of thinking skills such as critical thinking strategies can enhance academic achievement of participating students (Pithers and Sodens ,2000). Ajala and Kpangban (2000) gave hint on how to enrich teaching and learning of Biology while Ajayi (2001) suggested that those instructional strategies should be varied. In spite of all these teaching strategies, students' academic performance trends are neither at low level nor has students' attitude towards Biology improved significantly.

Critical thinking is cited as an important issue in education today. Attention is focused on good thinking as an important element of life success (Meinhardt, 2009). *"Perhaps most importantly in today's information age, thinking skills are viewed as crucial for educated persons to cope with a rapidly changing world. Many educators believe that specific knowledge will not be as important to tomorrow's workers and citizens as the ability to learn and make sense of new information"(Gough, 2002). Some studies purport that students exhibit an insufficient level of skill in critical or creative thinking. Furthermore, another reason that supports the need for incorporating thinking skills activities is the fact that educators appear to be in general agreement that it is possible to increase students' creative and critical thinking capacities through instruction and practice. Pg 10*

Current and anticipated environmental problems are receiving increased attention in the media, by all levels of government, by citizen groups, and by individuals concerned with the potential implications for humans and other lives on Earth. These problems are local, regional, national, and international in scope. Developing workable solutions to environmental problems will require choices and decisions based on a critical examination of information and opinions. According to Dillon and Scott (2002), Environmental education provides a good mechanism for developing critical thinking skills by;

(1). Providing topics and problems that cut across the school curriculum and can enhance the integration of knowledge,

(2). Providing real problems that can be studied or simulated, and

(3). By providing topics and problems that can be adjusted to the developmental levels of students which also motivates student to learn.

The Critical Thinking Motivator Strategy also supports the differing learning experiences within a classroom. Students learn and excel when provided multiple, varied opportunities. A classroom that offers an array of learning experience increases the likelihood of success for more students (Orlich et al, 2010). Studies involving multi-sensory teaching experiences show students achieve more gains in learning than when taught with a single approach, whether it is a visual or an auditory approach. Multi-sensory instruction or a combination of approaches appears to create the optimal learning setting, even for students with disabilities (Maal, 2004). The two modes of Critical thinking motivation instructional strategies are The Pre-Theoretic Intuitions Quiz and Puzzle-Based learning.

Lundy, Irani ,Rickett, Eubanks, Rudd & Gallo-Meagher (2002),assert that the basic premise that can make students learn to think better is, if the schools teach them how to think. Adu-Febiri (2002) agrees that thinking can be learned. Research indicates that thinking skills instruction makes a positive difference on the achievement levels of students (Maal, 2004).

In a research conducted by Tessier (2006), using Pre-Theoretic Intuitions Quiz strategy, this study surveyed students that enrolled in a non major ecology course at the beginning and the end of the academic term and also tracked student progress during the quarter. It was found that these students significantly improved writing technical skills and committed fewer errors of fact regarding environmental issues in response to a writing treatment. It was also discovered that Attitudes toward environmental issues also improved tremendously. Sellappah, Hussey, Blackmore, & McMurray (1998) were of the opinion that educators can use Pre-Theoretic Intuitions Quiz strategy to develop critical thinking, decision making, and problem solving in students because the questioning techniques in this strategy are key parts of active learning.

According to Lozano (2001), answering questions may show the instructor that the student remembers the answer to a question or problem, it also shows that students are actively thinking and making use of their Intuition. Phillips and Duke (2002) concluded that for every question posed by an instructor, in Pre-Theoretic Intuition Quiz, feedback is possible from the students.

In a study by Kendalls, Parks & Spoerer (2008) it was noted that puzzles are important resources to introduce new ideas to pupils and a great way to get pupils excited about learning new ideas and concepts.

Scott,(2006) recognize the following ways to use puzzles-based instructional strategy in Environmental Education, these include Classroom resources, Arts and craft,, Introducing new ideas, Illustrative strategies, Physical manipulation, Public event, Skill testing, Problem posing and Original research. Evidence abounds that puzzle-based instructional strategies in teaching and learning of science education in Korea Universities improved understanding of abstract concepts and develop problem-solving abilities in students (Anany& Mary 2002), this is also supported by Lauric and Robbert (2001) in Korea University in their experiment with the use of Puzzle in teaching and learning computer science education showed that students understood abstract concepts by solving puzzle. Kendall,et al (2008) concluded that puzzle-based active learning engages students with materials more than passive type of review does. They further stressed that the use of puzzles make learning more exciting and easily takes place in learners, thereby leading to the achievement of desired learning outcomes. Puzzle-based strategy when compared with conventional strategy by Anany, (2002) in analysis of algorithms showed that Puzzle-Based strategy was more effective. The findings further shown that there was better improvement in the learning outcomes of the participants treated with Puzzle-Based strategy than their counterparts treated with conventional method in algorithms. Aremu & Olasunkanmi (2007) concluded that Puzzle as educational resources impart critical thinking skills.

Abimbola, (2013) agreed that Teacher centered Methods of teaching science predominate in Nigeria secondary schools. Wood and Gentile (2003), Blair, Schwartz, Biswas & Lewlawong (2007) expressed their opinions that the conventional strategy of teaching science is inadequate for effective learning in science. Olatoye &Adekoya (2010), James & Olajide (2011) and Oludipe & Oludipe (2010) in previous studies relating to methods of teaching science in Nigerian secondary schools also express the opinion that the conventional method of teaching science is ineffective.

It has also been observed by Youssef (2004) that the foundations of pre-adult attitudes toward the environment are formed during childhood and that these attitudes govern behaviour throughout adult life. Young people's environmental attitudes are particularly important because young people ultimately will be affected by and will need to provide solutions to environmental problems arising from present-day actions. Akpan (1995) observed that the attainment of sustainable development in Nigeria requires some fundamental changes in attitude of Nigerians towards the environment and the need to protect it. He further noted that every strategy for successful education on environmental management should be geared towards a change of this attitude. Olagunju (2002) supported this view when she asserted that any strategy that will be successful should aim at developing positive environmental attitude and actions among people, seek to stimulate people's awareness about their behavioural patterns and how best to get involved in pollution management activities and a development of a training programme that goes beyond theory but incorporates practical activities.

According to Egu (2001), one way of influencing our attitude and behavior to our environment will be through education from infancy to adulthood and must transcend both formal and informal sectors. Environmental Education is of critical importance for promoting Responsible Environmental Behavior (REB) and sustainable development (Rim-Rukeh, 2007). Teachers thus play a very significant

role in developing desirable attitude towards awareness about environment among students.

Several factors have been identified as being responsible for student's negative attitude towards the environment. Such factors include teachers' poor attitude to environmental issues (Eguabor, 2005) which will ultimately affect the teaching of environmental topics to students, inadequate conceptual understanding of environmental issues (Ahove, 2007); inadequacy of environmental concepts or topics in Biology, Chemistry, Physics and Agricultural Science Curricula (Adara and Eguabor, 2004) and poor teaching strategies used by teachers in the classrooms (Njoku, 2004; Obioma, 2006).

The actual environmental practices of the people are a necessary factor towards attainment of a clean and healthy environment. Younger students also get excited when they learn that they can care for the environment through recycling projects, joining others in cleaning and beautifying local parks, starting a community garden, or planting a tree. These themes could be adapted for students from elementary school through high school. Noddings(1995)

Noibi (1993), citing the earliest studies that reported strong positive correlation between knowledge and attitude. He concluded that one's level of ignorance of the environment determines the extent to harm through practice, he will do to the environment. Generally, daily experiences in Nigeria would reveal very poor environmental practices. The rural dwellers who are predominantly peasant farmers, fishermen, hunters, petty traders and cattle rears are still engaged in their practice of indiscriminate bush – burning, over-grazing, over-cropping, over-fishing and pollution of water bodies, cutting down of bushes and trees for hunting thereby causing extinction of some plant and animal species (Mabawonku 2001).

In the urban centers, there is an alarming rate of poor waste generation and disposal by both families, sellers of various items in the market places and corporate bodies as well as ineffective waste management system and legislation by the government (Abiona, 2008). All these may rightly be attributed to earlier submission that ignorance or lack of environmental awareness of the right action to take is the greatest single contributor to environmental degradation problems (Ojo, 2008). A consideration for practical solutions for the conservation of all environmental resources in a sustainable manner will be of national interest because the majority of Nigerians will benefit from an improved environment (Ajiboye and Olatundun, 2010).

To this end, environmental practices is necessary because environmental degradation, if not checked, can have a great impact on natural resources, human health and ecosystems with adverse consequences for the present and future generations of Nigerians. Oladapo,(2011) was of the opinion that the public needs to be informed about issues that affect their well-being especially pollution and national resources depletion with adverse and or disastrous health consequences including the common practices which are becoming the order of the day in all the towns and villages without environmental considerations. Sometimes liquid and solid wastes are buried in the ground hoping that out "of sight is out of mind', and believing that the ground is safe sanctuary for poisonous wastes. Waste burning or incineration is also practiced especially in the dry season thereby causing air pollution.

Work on the roles of sex and students' achievement has shown that the roles of individual sex seem to be relevant factor to be associated with school achievement. Fadoju (2001) pointed out that the inability to cope with the problems of living in the society that sees the female as a second class citizen provides a good ground for psychological disorders. The factors causing psychological disorder evolve from different human experiences that could be

biological, environmental, interpersonal relationship, psychological function, role conflict and personal values (Asagba 2005).

The effect of gender on learning outcomes in science-related subjects is still a major issue of controversy among educators. This may be as a result of conflicting results obtained from such gender-related studies. Researchers have come up with different findings on the effect of gender on learning outcomes. While some found no significant differences based on gender (Hamuyiwa and Akinsola (2008),Morribend (2004), Chukwuka (2005)and Ogunleye (2002) some others like Raimi, 2003) had shown that boys perform better than their female counterparts in science subjects. Okeke 2001, Adebayo (2002) and Aremu (2005) also reported significant effect of gender on learning outcomes in favour of the male students. Osokoya, (2002) found that in the Nigerian Primary and Secondary Schools, girls were given less time to tasks than boys which no doubt hinders the performance of the female and girl-child. Ogunkola (2000), in this study found that there were no significant main effect of gender on student attitude and achievement towards Biology. In the same trend, using gender as the moderating variable, Ayanda (2006) observed that within the limits of experimental accuracy, gender did not significantly influence the level of science achievement.

This inconsistency in the test performance of boys and girls need to be further investigated especially in close relation with the instructional strategies designed to be tested in this study. Hence there is need to further research on it.

Student's cognitive styles have been found to mediate learning (Ige, 2001). Most of the differences encountered in students' learning could be described in terms of different manners in which students perceive and analyze a stimulus configuration (i.e. their cognitive styles). Each individual responds differently when exposed to a stimulus world. Some act on first impulse, some examine isolated components of what is presented to them before responding while others respond on the basis of contextual or holistic manner (Awolola, 2009). This calls for its better understanding by the teacher in his/her choice and usage of teaching

strategies. Lovelace (2005) concluded that matching a student's cognitive style with the instruction can improve academic achievement and student attitudes toward learning. According to Berg (2001) various cognitive styles or activities that focus on the strengths of how students learn best need to be addressed in the classroom.

This research seek the effect of The Pre-Theoretic Intuitions Quiz and Puzzle-Based learning will have on student's achievement, attitude and practices towards Environment-related concepts in Biology. It will also seek to examine whether gender of the students and their cognitive style will have any effect on the students learning outcomes in Environment-related concept in biology.

1.2 Statement of the problem

The prevailing poor outcomes of students in environmental concepts in biology every year in Senior School Certificate Examinations suggest that the instructional strategies employed by teachers may be inappropriate and that students are not equipped with critical thinking skills that can aid concept learning. This could result in producing fewer students who would go to higher institution to read Biology related courses.

A number of studies have been carried out using instructional strategies to address students' performance in Biology. However, educators suggested the need to carry out a study using critical thinking motivational strategies where students will be equipped with the instructional materials needed for critical thinking to ascertain its effect on students' performance.

From literature, there is dearth of resources in Nigeria on the use of two modes of critical thinking strategies in teaching environmental education concepts in biology for sustainable development. This study, therefore investigated the effects of pre-theoretic intuition quiz and puzzle-based critical thinking motivation strategies on students' achievement in, attitude and practices towards environment-related concepts in biology. It also examined the moderating effect of

gender of the students and their cognitive styles on learning outcomes in environment-related concept in biology.

1.3 Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

$H0_1$: There is no significant main effect of treatment on students' Environmental
(a). achievement
(b). attitude and
(c). practices

$H0_2$: There is no significant main effect of cognitive style on students' Environmental:
(a). achievement
(b). attitude and
(c). practices

$H0_3$: There is no significant main effect of gender on students' Environmental;
(a). achievement
(b). attitude and
(c). practices

$H0_4$: There is no significant interaction effect of treatment and cognitive style on students' Environmental
(a). achievement
(b). attitude and
(c). practices

$H0_5$: There is no significant interaction effect of treatment and gender on students' Environmental
(a). achievement
(b). attitude and
(c). practices

$H0_6$: There is no significant interaction effect of cognitive style and gender on students' Environmental

(a). achievement

(b). attitude and

(c). practices

$H0_7$: There is no significant interaction effect of treatment, cognitive style and gender on students' Environmental

(a). achievement

(b). attitude and

(c). practices

1.4 Scope of the study

This study was carried out in nine different co-educational secondary schools drawn from Ibadan North, Ibadan North East and Akinyele Local Government areas of Oyo state, Nigeria. The students involved were SS2 Biology students. The study focused on the effects of Pre-theoretic intuition quiz and Puzzle-based critical thinking motivation strategies on students' environmental achievement, attitude and practices towards Environment-related concepts in Biology. The moderating effects of gender and cognitive styles of the students in their learning outcomes were also investigated.

1.5 Significance of the study

The findings of this study would be significant in that it will provide an empirical basis for evaluating the effectiveness or otherwise of the effects of Pre-theoretic intuition quiz and Puzzle-based critical thinking motivation strategies on students' environmental achievement in, including attitude and practices towards Environmental Education concept in Biology at the Senior Secondary School level in Nigeria. The result of this study would help students;

(a) learn more meaningfully thereby improving their achievement in biology especially in environmental education concepts in biology;

(b) acquire good practices in tackling prevalent environmental problems individually and in groups in their community; and

(c) develop positive attitudes towards the preservation and protection of environment for sustainable development.

Science educators could use the instructional strategies to improve their pedagogical competence in the area of critical and creative thinking strategies that is needed to reduce stress and boredom encountered in the conventional strategy. It can also help Biology teachers by providing them with appropriate teaching methods for handling large classes for meaningful learning.

The significance of this study to science education planners will improve the teaching and learning of some basic EE concepts in biology, not only in identifying the problems associated with acquisition and utilization of environmental education knowledge in terms of methodology of teaching but to create the need for holistic environmental consciousness and awareness in students as a key to future participation in community action and decision making on issues of environment. Curriculum planners NERDC, and school teachers could use the result of the research work by including Pre-theoretic intuition quiz and Puzzle-based critical thinking motivation strategies as the instructional strategies in teaching Environmental concepts in biology.

The outcomes of this study would contribute significantly towards curriculum planning and development for better classroom effectiveness and provide information to science educators on learner's characteristics such as cognitive style and gender towards their performance in Biology. The findings would therefore provide additional empirical support for improvement and modification of the methods of biology teaching and learning which should be of interest to curriculum planners as to what to include in biology curriculum package. It may

eventually bring about new educational policy/curriculum change, especially in the areas of teaching methods and materials for teaching that would stimulate participatory learning by students. Furthermore, the result of this study is expected to provide additional information on the extent to which the use of Pre-theoretic intuition quiz and Puzzle-based critical thinking motivation strategies can affect learning outcomes in biology.

The study would perceive how far environment change can be achieved through critical thinking activities especially when a holistic view of environmental problems and issues is portrayed through this method. This is because the use of experience and environment of education researchers as sources of information in the process of carrying out a research, the result of which is expected to bring about a change in the right direction towards the environment.

To authors by bringing to their awareness the efficacy of Pre-theoretic intuition quiz and Puzzle-based critical thinking motivation strategies which has to be included in their texts in order to remove misconceptions often created by textbooks. It would also be a guide for Environmental education, teaching aids, teachers' manual, project guide and practical guide.

1.6 OPERATIONAL DEFINITION OF TERMS

Cognitive Styles: refers to a psychological disposition, which shows how an individual is inclined to think, learn and process information. It could be classified as Analytical and Non Analytical.

Critical Thinking Motivation strategies: are active learning strategies that engage students in the intentional application of rational, higher order thinking skills. It comprises of Pre-Theoretic Intuitions Quiz and Puzzles-Based learning strategies.

Environment:- This is the outer physical and biological system in which man and other organisms live.

Environmental Achievement:- The idea and facts that individuals have about the environment or the influence or impact of human action on the environment. This will be determined from the scores of students in an Environmental achievement test.

Environmental Attitude:- This is the feeling that a person has on environmental issues. This will be determined by using the scores obtained in Environmental Attitude scale.

Environment-related Concept in Biology:- This refers to the concept pollution and conservation Techniques as in SSCE biology.

Environmental Practices: The behaviors of the Secondary school students towards Environmental pollution and conservation techniques; individually and collectively. This will be determined by using Environmental Education Practice questionnaire.

Gender: refers to sexes which could be male or female.

Learning Outcomes:- These are scores derived from tests such as Environmental achievement Test, Environmental attitude and Environmental practice questionnaires.

Pre-Theoretic Intuitions Quiz- is an instructional strategy that Involves getting students interested in a topic in which an instructor gives a quiz aimed at getting students to both identify and to assess their own views on a concept thereby correcting the misconceptions on the concept in order to allow new information to be learnt.

Puzzle-Based learning – is a strategy that involves the useful means of investigating out students' intuitions on a given concept and makes them struggle towards a solution. By forcing the students to work it out without some authority's solution, you increase the likelihood that they will be able to critically assess theories when they are presented later.

CHAPTER TWO

Literature Review

2.0 Introduction

The Review of Literature is in the following order:

2.1 Theoretical Framework

2.1.1 Constructivism

2.1.1.1 Cognitive Constructivism and Critical Thinking Motivation Strategies (The Pre-Theoretic Intuition Quiz and Puzzle-Based learning.

2.1.1.2 Piaget's Theory of Cognitive Development

2.1.2 Skills related to critical thinking

2.1.3 The Principles governing Pre-theoretic Intuition Quiz Strategy

2.1.4 Lang & Evans [2006] Model of Pre theoretic intuition quiz instruction.

2.1.5. Conceptual Model of Puzzle-Based learning.

2.2 Conceptual Framework

2.2.1 Environmental issues: Past and Present

2.2.1.1 Environmental Challenges and Efforts to combat them

2.2.2 Active Learning and Strategies in each category

2.2.3 Pre-theoretic Intuition Quiz Strategy

2.2.4 Puzzle-Based learning Strategy

2.2.5 Conventional Strategy

2.2.6 Environmental Achievement

2.2.7 Environmental Attitude

2.2.8 Environmental Practices

2.3 Empirical Studies

2.3.1 Instructional strategies and Learning Outcomes in Environmental Education.

2.3.2 The Pre-Theoretic Intuitions Quiz and learning Outcomes.

2.3.3 The Puzzle-Based learning and learning Outcomes

2.1 Theoretical Framework

2.1.1 Constructivism

Constructivism, as a learning theory, the roots of which can be found in the works of Paiget (1954),& Glasersfeld, 1989) can be traced back to decades, while the actual application of the theory is relatively new (Richardson, 2003). Active learning strategies obtain their roots from Constructivism. Research shows that good pedagogical practices are more likely when including a constructivist approach as compared to a mere traditional approach to education (Azzarito & Ennis 2003; DiEnno, Hilton & Fall (2005); Muller, Sharma & Reimann, 2006). Three dimensions of constructivism have been identified from the works of several educationists of constructivist persuasion. The most revolutionary of the three being radical constructivism which holds that while knowledge is constructed from experience, that which is constructed is not, in any way, an accurate representation of the external world of realities (Glasserfeld, 1989),other two main schools of thought in

Constructivist learning theory is social constructivism and psychological (cognitive) constructivism (Richardson, 2003). Cognitive constructivists believe that learners construct knowledge individually; that learning is acquired when a learner evaluates new information based on prior experience and that knowledge is the result of "accurate internalization and reconstruction of external reality" (Wang, 2008). Social constructivists, on the other hand, believe that knowledge is the outcome of collaborative construction in a socio-economic context mediated by discourse; and that learning is fostered through interactive processes of information sharing, negotiation, and discussion (Richardson, 2003; Wang, 2008).

Constructivism is basically a theory -- based on observation and scientific study -- about how people learn. It says that people construct their own understanding and knowledge of the world, through experiencing things and

reflecting on those experiences. When we encounter something new, we have to reconcile it with our previous ideas and experience, maybe changing what we believe, or maybe discarding the new information as irrelevant. In any case, we are active creators of our own knowledge. To do this, we must ask questions, explore, and assess what we know In the classroom, the constructivist view of learning can point towards a number of different teaching practices. In the most general sense, it usually means encouraging students to use active techniques (experiments, real-world problem solving) to create more knowledge and then to reflect on and talk about what they are doing and how their understanding is changing. The teacher makes sure she understands the students' preexisting conceptions, and guides the activity to address them and then build on them. The theory is based on two assumptions: (1) That learning is by nature, an active endeavor and (2) That different people learn in different ways (Meyers and Jones 1993).

Constructivist teachers encourage students to constantly assess how the activity is helping them gain understanding. By questioning themselves and their strategies, students in the constructivist classroom ideally become "expert learners." This gives them ever-broadening tools to keep learning. With a well-planned classroom environment, the students learn HOW TO LEARN. Constructivism transforms the student from a passive recipient of information to an active participant in the learning process. Always guided by the teacher, students construct their knowledge actively rather than just mechanically ingesting knowledge from the teacher or the textbook.

Constructivism is also often misconstrued as a learning theory that compels students to "reinvent the wheel." In fact, constructivism taps into and triggers the student's innate curiosity about the world and how things work. Students do not reinvent the wheel but, rather, attempt to understand how it turns, how it functions. They become engaged by applying their existing knowledge and

real-world experience, learning to hypothesize, testing their theories, and ultimately drawing conclusions from their findings.

2.1.1.1 Cognitive Constructivism in relation to The Pre Theoretic Intuition Quiz and Puzzles-Based learning.

Cognitive Constructivism is applicable to The Pre Theoretic Intuition Quiz and Puzzle-Based strategies. Cognitive Constructivism is the concept that learners actively construct their own knowledge and meaning from their experiences. Knowledge is deemed fluid and in a constant state of change, therefore, student's ability to construct viable knowledge and to adapt and be flexible is highly paramount. The implication of cognitive constructivism, according to Kato and Kammi (2001) is that the child becomes very autonomous and docile, refusing to be governed by reward and punishment. The Pre Theoretic Intuition Quiz and Puzzle-Based learning obtain their roots from this theory. Confucius' pedagogical methods also supported this view in which teacher poses questions, cites passages from the classics, or uses apt analogies, and waits for his students to come to their own understanding.

The origins of The Pre Theoretic Intuition Quiz and Puzzles can be traced to the early philosophies of Plato and Aristotle. Plato believed that we learn about the world in two different ways. We get useful information through our senses, like sight and touch. But we reach truth by using a higher thinking ability, which he called reason. Plato said that our senses give us imperfect knowledge, because they tell us about specific objects. But our reason gives us truth, or perfect knowledge, because it tells us about ideas. Both Plato and Aristotle believed that as humans develop, there are qualitative changes in their ability to think logically about experiences. The importance of critical thinking was also evident in the beginning of the modern era of education in the writings of Dewey (1909/1997), who described the ability to think critically as a way to find meaning

in the world in which we live, but the processes by which learning occur, cognitive adaptation and social mediation are believed to be continuous or remain the same throughout the life. At the heart of constructivist philosophy is the belief that knowledge is not given but gained through real experiences that have purpose and meaning to the learner, and the exchange of perspectives about the experience with others (Piaget, 1954).

An emphasis is now being placed on the ability to understand and use information, not just merely to possess it but to improve their achievements, attitude and practices towards environmental education (Igboko and Ibeneme, 2006). Almost unanimously, educators believe the development of critical thinking ability should be a primary goal of education (Pithers & Soden, 2000).

Questions lead to understanding. Many students typically have no questions. They might sit in silence with their minds inactive as well. Sometimes the questions students have tend to be shallow and nebulous which might demonstrate that they are not thinking through the content they are expected to be learning. If we, as educators, want students to think, we must stimulate and cultivate thinking with questions (Paul, 1990).

By engaging students in The Pre Theoretic Intuition Quiz and variety of questioning that relates to the idea or content being studied, students develop and apply critical thinking skills. It has also been discovered that children's sense of reality is based on their interactions with the environment and material in it (Piaget, 1954), that is why the use of puzzle-Based learning in which materials and objects from the children's environment enable them to recognize, verify and store experiences for later use. While the importance of acquisition and recall of basic knowledge remains important, the development of Pre Theoretic Intuition Quiz and Puzzle-Based learning have emerged as equally important and the strategies find balance to facilitate the acquisition of basic knowledge in order to develop and nurture critical thinking in education which is important in the acquisition of

great achievement including right attitude and practices towards environmental education.

2.1. 1.2 Piaget's Theory of Cognitive Development

The most well-known and influential theory of cognitive development is that of Swiss psychologist Jean Piaget (1896–1980). He envisioned a child's knowledge as composed of schemas, basic units of knowledge used to organize past experiences and serve as a basis for understanding new ones. Schemas are continually being modified by two complementary processes that Piaget termed assimilation and accommodation. Assimilation refers to the process of taking in new information by incorporating it into an existing schema. In other words, people assimilate new experiences by relating them to things they already know. On the other hand, accommodation is what happens when the schema itself changes to accommodate new knowledge. According to Piaget, cognitive development involves an ongoing attempt to achieve a balance between assimilation and accommodation that he termed equilibration. Jean Piaget's theory of child development. His distinction between assimilation and accommodation as mechanisms of learning affords the child the "teachable moments".

The final stage of intellectual development begins early in adolescence. While in the stage of concrete operations, a child can only classify, count, and put into series the various objects and events that such a child perceives. Adolescence in the stage of formal operation can "operate with the operations" (Piaget 1954). A child's concrete thought operations occur in response to real situations. Adolescence can consider general laws, and his/her thoughts concern what is hypothetically possible as well as what is real. He/ She formulate rules and engage in a great deal of self- instruction, although he/ she do not state his/her

rules or instructions overtly. Adolescents' extensive use of convert speech is related to the many advances made in cognitive functions during adolescence.

The adolescent can reason deductively, making hypothesis about problem solutions and keeping in mind many variables all at once. He/she is capable of scientific reasoning and of logic in verbal argument. Moreover, at this stage, he/she reflects about, evaluates and criticizes the logic and quality of his/her own thinking. An adolescent's dependence on the perception or manipulation of concrete objects is reduced; he/she needs no longer to confine his /her attention to the immediate situation. He/she can consider hypothesis which may or may not be true, and consider what would follow if they were true. He/she can follow the form of an argument while disregarding its concrete contents. It is from this last characteristic that formal operations get their name.

The Adolescents in this research context are the senior secondary students that will serve as the participant. An average student in the Senior secondary schools in Nigeria according to Ojo, (2008) must be between the ages 15 and 19 years. By the time a child is 15, he has become an adolescent who is able to use logical operations and formal logic in an adult manner in solving problems.

The adolescent's ability to think scientifically is clearly noticed when Puzzle-Based learning is applied particularly when intuition is combined with puzzle in classes where adolescents (in the state of formal operations by Piaget, 1982)discover solutions to problems little by little, by combining the various possibilities logical and determine the effectiveness of each. An adolescent reasons scientifically, forming hypothesis and testing them in reality or in thought. He/she can speculate and these speculations are governed by logical rules.

Piaget's work has enjoyed great popularity for several decades. It is applicable to the Pre Theoretic Intuition Quiz strategy in which intuition guides the adolescent in order to reach the critical stage in their intellectual development which is clearly noticed and in the field of teacher education, particularly at the

secondary school level, it has assumed the role of “pedagogic orthodoxy” (Smith & Anderson, 1986).

2.1.2 Skills Related To Critical Thinking

Across subject areas and levels, educational research has identified several discrete skills related to an overall ability for critical thinking. These are:

- Finding analogies and other kinds of relationships between pieces of information
- Determining the relevance and validity of information that could be used for structuring and solving problems
- Finding and evaluating solutions or alternative ways of treating problems

Just as there are similarities among the definitions of critical thinking across subject areas and levels, there are several generally recognized "hallmarks" of teaching for critical thinking (see, for example, Beyer, 1985; Costa, 1985).

These include :

- Promoting interaction among students as they learn: - Learning in a group setting often helps each member achieve more.
- Asking open-ended questions that do not assume the "one right answer": - Critical thinking is often exemplified best when the problems are inherently ill-defined and do not have a "right" answer. Open-ended questions also encourage students to think and respond creatively, without fear of giving the "wrong" answer.
- Allowing sufficient time for students to reflect on the questions asked or problems posed: - Critical thinking seldom involves snap judgments; therefore, posing questions and allowing adequate time before soliciting

responses helps students understand that they are expected to deliberate and to ponder, and that the immediate response is not always the best response.

- Teaching for transfer: - The skills for critical thinking should "travel well." They generally will do so only if teachers provide opportunities for students to see how a newly acquired skill can apply to other situations and to the student's own experience.

2.1.3 The Principles governing Pre-theoretic Intuition Quiz Strategy

The principles governing Pre-theoretic Intuition Quiz Strategy identified by proponents Odom and Barrow, 1995 and Hestenes, 2006 include the following;

1. An instructor attracts student's attention and activates their background knowledge through the First-tier lower cognitive level quiz thereby reviewing prerequisite knowledge or skills. The feedback should be carefully considered to find out the sub-concept that seem to be abstract, confusing and mixed up.
2. Teacher asks second-tier quiz items, which are upper cognitive level questions utilized to activate students thinking before answering the questions. The feedback from student quiz makes it easier to identify students' misconceptions on the sub-concept and to determine whether those misconceptions could be corrected.
3. Tiers of questions based on the distinction between student knowledge of outcome and mechanism provide an additional source of information for instructors. They also assess student knowledge of the subject matter in a pre- post-lecture comparison.
4. Students move on to study a body of content knowledge that follows in learning sequence.

The Pre-theoretic Intuition Quiz employed two-tiered items. According to Odom and Barrow, 1995 the First-tier items ask 'what happens when . . .?'

(Which students often know); while second-tier items ask 'why does this happen?' (Which students often don't know). Upper level questioning is utilized to activate students thinking. Without upper level questioning, students would not be prompted to think about or use material presented.

For every question posed by an instructor, feedback is possible from the student. According to Lozano 2001and Hestenes, 2006 : Answering questions may show the instructor that the student remembers the answer to a question or problem, but answering upper level questions show that students are actively thinking. The progression of students in the course may be evident in types of questions they ask, and if a student responds to upper level questions, it is evident that he or she is thinking and assimilating information.

Since questioning is an integral part of teaching that can assist students in applying their knowledge, educators should know how to use questioning strategies effectively. Lower level questioning does not promote critical thinking because students rely mainly on recall of information. A simple recall of information does not enhance students' understanding of the information in a meaningful way. Higher level questioning obtained in the Pre-theoretic Intuition Quiz facilitates the development of critical thinking because it is aimed at higher cognitive levels, which involves application, analysis, synthesis and evaluation. Educators should take advantage of stimulating questions in the Pre-theoretic Intuition Quiz help create meaningful active learning instead of just prompting the simple recall of knowledge from students. An approach is illustrated by the Biological Concepts Instrument (BCI) by Klymkowsky, Underwood, & Garvin-Doxas,(2010) which is a 24-item, multiple-choice, research-based instrument (available on-line) designed to reveal students' (and teachers') understanding of foundational ideas within the (primarily) molecular biological arena. The Biological Concepts Instrument (BCI) by Klymkowsky, Underwood, & Garvin-Doxas, 2010 will be utilized in this research.

2.1.4. Lang & Evans [2006] Model of Pre theoretic intuition quiz instruction.

Lang & Evans [2006] Model of Pre theoretic intuition quiz instruction. Introduced teaching strategies and models governed by logical rules are designed to capacitate deep understanding and thinking in teaching science and engineering. Teaching models introduced in this study are widely in use at Estonian Centre for Science and Engineering Pedagogy, in the study process of teaching technical and science teachers in the subject of Science and Engineering Pedagogy. These teaching models are not substitutes for basic teaching skills, it cannot take the place of qualities a good teacher must have, and the different forms of knowledge but provide enough flexibility to allow teachers to use their own creativity. This model uses teachers question and explanation combined with student practice and feedback and is student-centered.

According to Lang & Evans [2006] implementing a lesson using this Model of Pre theoretic intuition quiz instruction has four phases.

- **Introduction and review:** attract students attention and activate their background knowledge through questions that review prerequisite knowledge or skills;
- **Presentation**: explain and illustrate the concept being taught using pre theoretic intuition quiz;
- **Guided practice:** help students try out new content as the teacher carefully monitors their progress and provides necessary support and feedback;
- **Independent practice:** students practice the new concept or skill on their own first in class, later on a homework assignment.

According to Eggen & Kauchak,(2006) using the Model involves Identifying prerequisite knowledge or prior knowledge which provides "hooks" for new learning, allowing connect new information with what they already understand. The key to effective assessment with this model is to ensure that students learn content at a meaningful level. This requires that students work actively with examples and concepts, linking them to the abstraction being taught.

2.1.5 Conceptual Model of Puzzle-Based learning

Meaningful learning requires teachers to change their role from sage to guide, from giver to collaborator, from instructor to instigator". Since students learn from thinking about what they are doing, the teacher's role becomes one who stimulates and supports activities that engage learners in critical thinking.

Student's sense of reality is based on their interactions with the environment and material in it (Piaget, 1954). Using puzzles that represent materials and objects from the children's environment enable them recognize, verify and store experiences for later use. This statement is supported by the work of Zmaczynski (2002) who developed a puzzle apparatus for the study of Chemistry and its history based upon the equilateral triangular model of the periodic table of the chemical elements. This puzzle has a triangular shaped base and it is shaped and sized in order to accommodate rhombohedra shaped pieces that fit into the base and form an overall triangular shape. This successfully completed puzzle has each piece reflecting a chemical element in its correct place in the periodic chart .Zmaczynski (2002) concluded that the puzzle had enable students to recognize, verify and store chemical formula experiences for later use in chemical equations.

Maldonado (2005) proposed a conceptual framework for developing and evaluating puzzle in Science Education. The framework is based largely in part, upon research, development in cognitive science and developmental

theories and utilization. It is this model for development, evaluation and research that will be adopted for this study. The framework could be implemented with any number of theories. The framework is based upon the tasks facing any puzzle developer, evaluator or user. The components of the model are explained thus:

Conceptual Framework for Developing and Evaluating Puzzles

(The Basic Version)

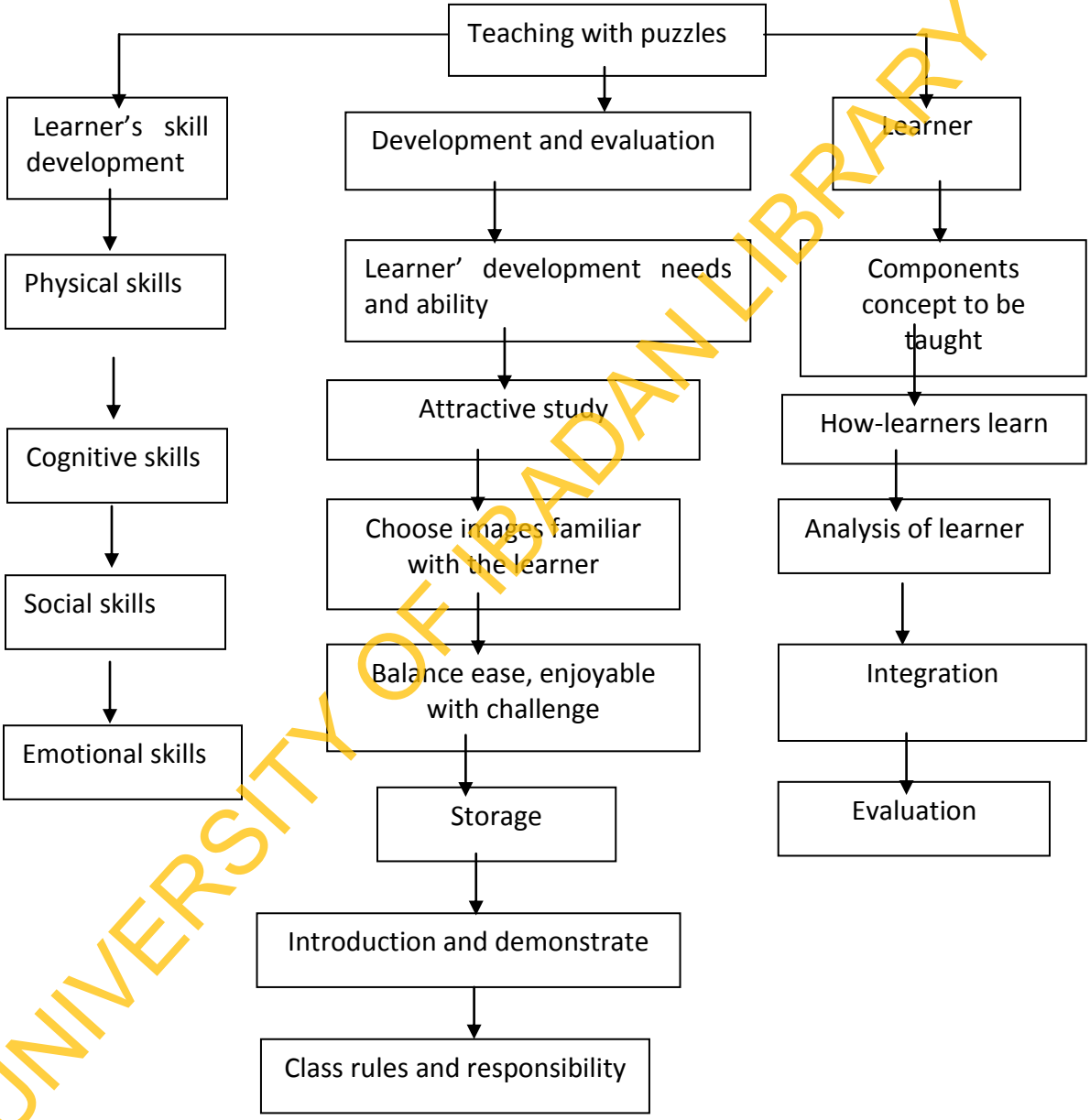


Figure 2.1: Model for Development, Using and Evaluating Puzzles for Teaching
Source: Maldonado (2005). Puzzles: A pathetically neglected, commonly available resource. Young children 51 (4)

Learners' Skills Development

Puzzle, can enhance nearly all areas of learner's development, notably the followings.

- Physical skills: -As learner's grasps, hold, and fit puzzle pieces, they develop eye-hand coordination and .fine-motor dexterity.
- Cognitive skills: *By* piecing or joining together words, learners- gain experience in solving problem. Puzzle - solving experiences help learner to learn science concepts and principles, such as sorting, classifying, comparing- and sets relationships.
- Social skills: When solving puzzle with friends, learner learns how to negotiate with others, control their own actions and learn various critical thinking problem – solving techniques. Watching others solving puzzles helps learner discover new puzzle - solving strategies and encourage them to share their own. Guiding, supporting and encouraging in the process of a puzzle's completion helps learner develop leadership skills.
- Emotional skills: Puzzle solving is fun and engaging. At the end of a puzzle solving activity, learners feel pleased with themselves. They gain confidence in their ability as problem solvers and feel willing to try new puzzles or other challenging activities.
- Choose puzzles that are appropriate to each learner's developmental ability and needs.

This means choose puzzles that are appropriate to learners age and. development, that is, from simple to complex. Observe and work with learners to provide puzzles that fit various individual needs. By careful observation, you can provide for a range or developmental abilities, with puzzles ranging in type and theme.

- Choose puzzles that are attractive.

Table puzzles must be able to withstand repeated use by learner. Puzzles must also be attractive and appealing to learners. The basic requirements are clarity of image and simplicity. Puzzles that are familiar, attractive and aesthetically beautiful invite the learner to engage in the activity.

- Choose puzzles that are familiar to learners:

Familiarity and identification with subjects reassuring as well as interesting to learners. When learners can recognize the subject of a puzzle they can easily evaluate and recognize their success. Learner's sense of reality is based on their interactions with the environment and the materials in it (Piaget 1954). Using puzzles that represent materials and objects from the learner's environment enable them to recognize, verify and store experiences for later use.

- Choose puzzles that balance ease, joy with challenge, Ideally, some classroom puzzles will be fairly easy for learners to put together, and some puzzle will offer a challenge. Select an enjoyable puzzle. Keep in mind that learner need to feel a sense of making and accomplishment to become autonomous in their actions and, eventually in their thinking. Guide learners in their most beneficial use of puzzle through routine and responsibilities.

- Store puzzles in one area.

You can create a library that changes with curriculum themes, such as Ecology, community and so on. The most important thing is that puzzles should be stored for future use.

- Maintain quality:

Regularly check puzzle for damage, encourage learners to report missing puzzle. Nothing frustrates a learner more than to find that the final piece needed to complete a puzzle is missing. It breaks the sense of completion and

continuity of the puzzle - solving activity. Learner need to know that the material they are using is of value to the teacher as well to them.

The teacher might appoint a "puzzle patrol" to assist in this daily task. Repair and replace any missing puzzle pieces.

- Introduce and demonstrate new puzzle:

When you bring a new puzzle to the attention of a class, you help endorse the materials uniqueness. Never take puzzle for granted. The goal of puzzle-solving is not presenting or testing concepts but rather, involving learners in the puzzle-solving activity. With puzzles, the solving is the activity; it is the engagement of the learner's body and mind with the material. Working on a puzzle with a learner requires minimum language. The learner brings language to the puzzle-solving process and you take clues from the learner's action and speech.

- Development of class rules and responsibilities

Puzzles help learners develop a sense of responsibility for attention to the materials they work with. You can set up simple and clear guidelines for selecting, using and returning puzzle thus:

Make sure you have a clear and clean workspace, e.g. the table.

Check the puzzle to see if the picture is complete: Are all the pieces in the frame?

If a piece is missing, check the table, and nearby area.

If you cannot find the missing piece, bring the puzzle to the teacher (Don't leave an incomplete puzzle in the classroom)

When working on a table where someone else: is working on a. puzzle, keep pieces separated by working on another table.

Return puzzle to its place, which may be the puzzle rack or a shell.

Components of concepts to be taught:

The analysis of each sub-concept, to be taught, and objectives for each concept to be well stated in accordance with the guidelines given in the curriculum. Here the concepts and objectives are in accordance with the guidelines of WASSCE syllabus.

How Learner Learn:

The learning theories upon which these puzzle are based are constructivism and Piaget human cognitive developmental theory of learning. These have been well discussed in theoretical framework in chapter two.

Analysis of learners:

Each sub-concept should be carefully considered to find out similarities and differences that could confuse learners in learning the concepts that seem to be abstract, confusing and mixed up would be identified. These include Air, water and land pollution including conservation techniques.

These misconceptions will be taken into consideration in selecting the puzzle. The most misunderstood concepts would be used more often in the puzzle so as to ensure practice that would lead to better learning and understanding.

Integration:

The concepts and sub-concepts should be incorporated into the selected puzzle. All the sub-concepts would be integrated into the structure of the selected puzzle. Some will be modified to suit classroom situation. All the sub-concepts to be taught will be integrated into the selected puzzles (Environmental puzzle). The integration alien's terms are practice on sub-concepts which learners found abstract and confusing.

Evaluation:

The puzzle developed must be tested in order to determine their effectiveness, using different categories of learners. The outcome of the try-out study will be useful in making decision on:

a. duration for learners to complete puzzle

b. class arrangement, chairs, tables, to facilitate easy – access to puzzle.

c. how easily the learner could think critically to answer the question based on the conceptual framework, environmental puzzles will be selected and use for the research.

2.2 Conceptual Frame work

2.2.1 Environmental issues: Past and Present

Ten deadliest natural disasters of the past century is shown in table 2.1

Table 2.1 Ten Deadliest Natural Disasters of the Past Century

Rank	Maximum death toll	Event*	Location	Date
1	234,000	1920 Haiyuan earthquakes	China	December 1920
2	142,000	1923 Great Kanto earthquake	Japan	September 1923
3	257,000–436,000	1931 China floods	China	November 1931
4	120,000	1948 Ashgabat earthquake	Turkmenistan	October 1948
5	300,000–500,000	1970 Bhola cyclone	East Pakistan (now Bangladesh)	November 1970
6	242,419–779,000	1976 Tangshan earthquake	China	July 1976
7	138,000	1991 Bangladesh cyclone	Bangladesh	April 1991
8	230,000 - 310,000	2004 Indian Ocean Tsunami	Indonesia	December 2004
9	138,000+	2008 Cyclone Nargis	Myanmar	May 2008
10	316,000	2010 Haiti earthquake	Haiti	January 2010

* Does not include industrial or technological accidents.

Some of the major natural disasters that have caused havoc of high magnitudes in the different parts of the world in the recent time are highlighted in Table 2.2

Table 2.2 Major Natural Disasters in Recent Time

s/n	Year	Date	Country/Continents	Type	Death toll
1	2003	a)	Europe	Heat wave	35,000
		b) 26 Dec.	Iran	Bam Earthquake	31,000-43,000
2	2004	26 Dec.	Asia – India Ocean	Earthquake under water - tsunami	275,000
3	2005	a) Aug.	USA – Katrina	Florida Atlantic	1,836
		b) 8 Oct.	Asia – Pakistan Kashmir	Hurricane Mississippi Earthquake	80,000 3 million-homeless
		c) 1 Oct.	Guatemala, El-Salvador S/Eastern Mexico etc.	Stan Hurricane	1,598
4	2008	a) 3 May	BurmenMynaman	Cyclone Natgis	146,000
		b) 12 May	China-Great Skhuan	Great Sichuan Earthquake	70,000 17,921 missing bodies
5	2009		Flu – Globally	Swine flu	11,800
6	2010	a) Jan 12	Haiti	Earthquake	230,000 3 million affected 300,000 injured
		b) July 26	Pakistan	Flood	1/5 land underwater 2 million affected 2,000 dead

(Wikipedia, the free Encyclopedia, 2010).

Others include:

- In November 2009, record-breaking amounts of rain were dumped on Cumbria, England and Cork, Ireland, causing minor floods in Cork and major floods in Cumbria. During the floods, waters reached a UK record 8 ft deep in Cockermouth, Cumbria.

- In June 2009, minor flooding hit parts of Sheffield City Centre in Sheffield, England. Waters reached only about half a foot deep as the River Don broke its banks, but considerable damage was still caused.
- The 2008 Indian floods affected several states in India between July 2008 and September 2008 during an unusually wet monsoon season. The floods caused severe damage, and killed an estimated 2404 people.
- The 2007 Africa Floods was one of the worst and most destructive floods in recorded history on the continent of Africa with 14 countries affected.
- Between late May 2007 and early August 2007, severe 2007 United Kingdom floods hit most of the United Kingdom, with the most affected area in the country being Yorkshire. The city of Sheffield (in Yorkshire) was the worst affected city in the country, a months worth of rain fell on the city in just 18 hours on 25 June 2007, bursting the banks of the River Don in that city. There were also fears that the Ulley Reservoir in Sheffield would fail, if it did it would have killed hundreds. 6 people were killed across the country.
- The 2007 Hunter Floods inundated large areas of the cities of Maitland and Newcastle in Australia in June 2007, claimed 11 lives and forced the evacuation of 4,000 people in Central Maitland.
- Peninsular Malaysia, Sumatra, and Sabah suffered floods between December 2006 and January 2007. It killed hundreds and forced 100,000 people to be evacuated in Johor alone. Floods hit the country's capital Jakarta in January 2007, killing 80. It was the worst flood in Malaysia for over 100 years.

- Ethiopia saw one of its worst floods ever in August 2006.
- The Mid-Atlantic States flood of 2006 in the eastern United States is considered to be the worst in that region since the flooding caused by Hurricane David in 1979.
- Korea (both North Korea and South Korea) saw one of its worst floods ever in May 2006.
- In November 2005, in the Indian states of Tamil Nadu and Andhra Pradesh, many villages were isolated due to heavy rains caused by low-pressure areas in the Bay of Bengal.
- Record rain across eastern Europe in August 2005 caused very severe flooding.
- 80% of New Orleans, Louisiana, USA was flooded due to the failure of several levees in August 2005 during Hurricane Katrina. 1,076 people also died because of the hurricane.
- Flooding in Mumbai, India, in July 2005 left over 700 dead. Some areas went under 5 m of water.
- One of Canada's most devastating floods occurred in southern Alberta in June 2005. The flooding affected many major metropolitan areas including Calgary. 4 deaths resulted from the three-week flood.
- In January 2005, flooding on the rivers Eden, Kent, Derwent, Greta and Cocker as well as others in Cumbria, England, flooded about 2,000 properties and caused in excess of £250 million of damage. It was the worst flood in the history of the region of Cumbria (but it was beaten by the Cumbria flooding of November 2009).
- The Boscastle flood, 2004 on the 16 August in the village of Boscastle, Cornwall, United Kingdom, caused much damage to buildings in the Valency river valley. Further flooding took place in surrounding valleys, and in the town of Camelford.

- In 2002, the 2002 Glasgow floods hit Glasgow, Scotland, causing severe damage.
- In 2002, the 2002 European floods hit Central Europe, causing major damage.
- In June 2001, floods from Tropical Storm Allison killed over 30 people in the Houston, Texas, area.
- The 2000 Mozambique flood, caused by heavy rains followed by a cyclone, covered much of the country for three weeks, killing thousands, leaving the country devastated for years afterwards.

Major Natural Disasters in most recent time(2010s)include:

- in June 2011 flooding in China affected more than 4.8 million people, with 100,000 evacuated and 54 reported dead.
- 2011 Brazil floods of January are considered the worst in the country's history. As of Jan. 18, the floods have taken about 700 lives and 14,000 people are homeless mainly due to landslides.
- The 2010-2011 Queensland floods are some of the worst the country of Australia has ever seen.
- The November 2010 Colombia floods and associated landslides killed 138 persons. 1.3 million were left homeless.
- In November 2010, many areas of Cornwall, UK, were struck by floods. The worst hit area was the town of Par.
- On August 4, 2010 at 9:25 am EST a major thunderstorm producing large hail and winds in excess of 60 mph (97 km/h) advanced at the leading edge of a cold front moving across the American Midwest, causing a flash flood that struck Louisville, Kentucky and portions of the surrounding Kentuckiana region.

- On July 26, 2010, heavy monsoon rains flooded most of Pakistan in the 2010 Pakistan floods.
- In May 2010 until August 2010 flooding in China affected more than 230 million people - with 15.2 million people evacuated and thousands dead.
- In May 2010, Poland's Prime Minister Donald Tusk informs the Sejm that ongoing flooding is "the worst natural disaster in the nation's history".
- In Nigeria,2012, flood killed 363, destroyed N2.6tn property – NEMA

All the information listed above was obtained from (Wikipedia, the free Encyclopedia, 2013).

The 2012 rainy season in Nigeria has been worse than earlier years, and heavy rains at the end of August and the beginning of September led to serious floods in most parts of the country. The Nigerian authorities contained the initial excess run-off through contingency measures, but during the last week of September water reservoirs have overflown and authorities were obliged to open dams to relive pressure in both Nigeria and neighboring Cameroon and Niger, leading to destroyed river banks and infrastructure, loss of property and livestock and flash floods in many areas. By 29th of September, the floods had affected 134,371 people, displaced 64,473, injured 202 and killed 148. By the end of October, more than 7.7 million people had been affected by the floods, and more than 2.1 had registered as IDPs. 363 people were reported dead; almost 600,000 houses had been damaged or destroyed. Out of Nigeria's 36 states, 32 have been affected by the floods. A final comprehensive assessment losses of 2.6 trillion Naira was recorded

2.2.1.1 Environmental Challenges and Efforts to combat them

Environmental challenges grow in complexity, intensity and severity as a result of increasing ecological disturbance. The air around many cities in the

developing countries of the world are laden with dangerous chemicals arising from industrial activities while vast lands have been devastated by indiscriminate dumping of refuse and sewage disposal; pesticides applied on agricultural lands are also endangering the lives of human and other organisms. All these and other chemical, biological and physical environmental degradation often cause a lot of harm to the populace.

Environmental deterioration which has grown to their present state of near uncontrollable stage dates back to the 1890's when a Swedish Chemist, Svante Arrhenius alerted the people around that burning fossil fuel and clear standing forests used for various developmental purposes had released an unusual amount of Carbon IV oxide into the atmosphere resulting in the increased warming of the climate. Consequently, Americans constitute less than 5% of the world's population, but produce roughly 25% of the world's carbon (IV) oxide, and generate approximately 30% of world's waste, China has overtaken the United States as the world's biggest producer of carbon (IV) oxide (Guardian. uk, 2007). About 400 million metric tons of hazardous wastes are generated each year.(Microsoft Encarta 2009). The United States alone produces about 250 million metric tons. Studies conducted by David, Michael, and Caroline (2010) have estimated that the number of people killed annually in the United States of America because of pollution and ecological disturbance could be over 50,000.

David, Michael, and Caroline (2010) also indicated that 656,000 people die prematurely each year in China because of air pollution. In India, air pollution is believed to cause 527,700 fatalities a year according to the National Academy of Science (2005). Overview of main health effects of pollution on humans from some common types of pollution in World Resources Institute (2008 Monthly Update) indicates that adverse air quality can kill many organisms including humans. Lorenz (2007) also indicates that ozone pollution can cause respiratory disease, cardiovascular disease, throat inflammation, chest pain, and congestion.

According to Guardian. uk, 2007, water pollution causes approximately 14,000 deaths per day, mostly due to contamination of drinking water by untreated sewage in developing countries. An estimated 700 million Indians have no access to a proper toilet, and 1,000 Indian children die of diarrhea sickness every day. Nearly 500 million Chinese lack access to safe drinking water.

Natural disasters are primarily caused as a result of environmental degradation which tends to have become part of the world's daily experiences as it accounts for the destruction of millions of lives and property worth billions of dollars. Stan Hurricane that occurred in Guatemala, El-Savador and Mexico recorded lowest death toll of 1,598 including the flood in Pakistan that recorded highest death toll of 2million(Wikipedia,2010). Details are presented in chapter two in conceptual framework.

In Africa, recent disasters experienced according to Wikipedia,2010 include:

- The 2009 West Africa floods that affected close to 1 million people across 12 countries, and caused the deaths of at least 193 people.
- The 2009 Angola, Namibia and Zambia floods affected some 445,000 people across 3 countries and resulted in the deaths of at least 131 people.
- The 2008 Benin floods that affected 150,000 people in Benin.
- The 2008 Namibia floods that affected 250,000 people, killing 42.
- The 2007 Mozambican flood that affected 121,000 people and resulted in 29-40 deaths.
- The 2007 African floods that hit over 14 countries in Africa, affecting 2.5 million people and 250 deaths.
- Ethiopia's worst floods in August 2006.

- The 2000 Mozambique flood, caused by heavy rains followed by a cyclone, covered much of the country for three weeks, killing thousands, leaving the country devastated for years afterwards.

Developing countries such as Nigeria in 1980 started experiencing serious and complex environmental problems which include over-population, pollution, unchecked industrialization, over-use of natural resources, flooding, erosion, solid waste disposal problem, desertification and drought (Ajitoni, 2009). The biosphere on which all organisms depend for survival are deteriorating rapidly as a result of the activities of human beings (Gbamanja, 2001).The Ogunpa flood disaster that occurred in Ibadan in 1980 due to the incident of the dumping of waste on streams, ditches, rivers brought environmental degradation into limelight, while concerted efforts about the prevention of environmental problem started in 1988 following the unfortunate incident of the dumping of toxic hazardous wastes at Koko Port in the Delta State of Nigeria (Oduwaye, 2009). The worst that had happened to Nigeria was in 2012, thousands of lives were lost in the country through environmental degradation.

Other large- scale industries with a high profile pollution load are raw material- oriented industries located in the countryside such as cement and paper manufacturing. Other sources of these environmental problems are from flaring other oil and gas related activities. Natural gas associated with crude oil has been flared in the Niger Delta region of Nigeria for more than four decades. Statistics on crude oil production indicated that about 70 percent of the total gas associated with crude oil was flared in obvious disregard for the country's 1979 Gas Injection Legislation (Atoyebi, 2000). The flaring of gases by oil companies in Nigeria accounted for more than

half of the estimated 96.513 million metric tons of carbon (IV) oxide emissions from industrial sources in Nigeria in 1992 (Jaiyeoba, 2002).

Though there are no adequately articulated data on the level of economic and human losses from the devastating effects of environmental disasters in Nigeria there are evidences that virtually all the thirty six States of the country including Abuja, the Federal Capital Territory is being ravaged by one or more forms of degradation problems or the other.

In order to tackle these devastating environmental problems, successive governments in Nigeria have made series of efforts towards protecting its environment through;

(1) establishment of one percent Ecological Disaster Fund for combating natural disasters.

(2) involvement of Presidency in tree planting campaigns

(3) adoption of a National Conservation Strategy for Nigeria in 1988.

(4) launch of National Policy on Environment in 1989.

(5) annual organization of workshops and seminars to mark the World Environmental Day every 5th June.

(6) internationally sponsored training programmes on Environmental Education (EE) for Nigerians.

(7) establishment of National Parks, forest reserve and wetland sanctuaries.

(8) formation of School Conservation clubs

(9) establishment of Natural Co-ordinating Committee on EE (N.C.C.E.E) with secretariat at NERDC (a parastatal of Federal Ministry of Education).

(10) establishment of EE units in Ministries of Education

(11) promulgation of decrees and legislations on Environmental matters such as;

(a) Environmental Sanitation Decree 1 of 1984

(b) Endangered Species Decree No. 11 of 1985

(c) The Factory Decree No 16 of 1987.

(d) Harmful Waste Decree No. 42 of 1988

(e) Federal Environmental Protection Agency (FEPA) Decree 58 of 1988

(f) Natural Resources Conservation Decree 50 of 1989.

(g) Land Use Act cap. 202 LFN 1990

(h) The Environmental Impact Assessment (EIA) Decree 86 of 1992 etc.

In addition to the afore-mentioned Federal Government efforts in solving environmental problems and in the development of EE in Nigeria, the development of EE publications as a mass literacy tool is being pursued by some bodies in Nigeria. Some of those in circulation include;

(i) Toitoise (NCF, Lagos) for primary and secondary school pupils

(ii) EEU News (College of Education, Ekiadolor) for general readership.

(iii) Teacher's Guide to conservation clubs (NCF, Lagos).

(iv) NCF Newsline (NCF, Lagos) – for general readership

(v) EE strategies series (STAN)

Furthermore, series of efforts and recommendations were made to improve the Nigerian educational system and to enrich EE in order to solve Nigerian environmental problems. These include;

(1) Interdisciplinary and holistic approach as in the teaching of EE concepts.

(2) Integration of Science – Technology Society (STS) based instructions (STAN Proceedings 2001-2012).

(3) EE as indoor and outdoor activities (Olagunju, 2002).

(4) Environmental knowledge and attitudinal change curricula and programmes (STAN EE Workshop Series 2001-2012).

Internationally, the last three decades have witnessed the birth of several initiatives concerned with the protection of the natural environment. These efforts include the launch in 1970 of the Man and the Biosphere (MAB)

programme at the 16th session of the general conference of UNESCO and at the world conservation conferences, (UNEP, FAO and IUCN). The need to protect the environment in times of conflict was also stressed in various United Nations and bilateral agreements, including resolution 2603A (XXIV) of the General Assembly. So far, efforts geared towards sustaining the environment had also included enactment and enforcement of laws and awareness through activities such as environmental sanitation.

In fact, all the countries of the world are also affected by the rate of depletion of the environment, which called for a Climate Change Conference in Copenhagen in December 2009 during which ways of addressing the problems were deliberated upon. Earlier, there has been a call to the need for sustaining the environment by bodies/organisations such as UNESCO, UNAIDS, WORLD BANK, etc which brought about the introduction of environmental concepts such as pollution, conservation, natural resources, family planning, ecology, health, etc into the school curriculum. The incident had also led to the establishment of the Federal Environmental Protection Agency (FEPA) through Decree No 58 of 1988 as amended by Decree 59 of 1992. In 1989, FEPA formulated a National Policy on Environment with an overall goal of achieving sustainable development.

In spite of all these efforts, our environment is continuously being degraded on a high scale (Chukwuka, 2006) because of the recent flood disaster that occurred in Lagos on 9th of July, 2011,including that of Apete flooding that claimed hundreds of lives in Ibadan on 26th of August, 2011 that led to further degradation of the environment. In Ebonyi State, Nigeria, a family of eight died due to suffocation from fumes of electric generator on July 9, 2012.

It has become incessant occurrence that loss of lives and properties must accompany long period of rainfall especially in the first half of 2012. This occurrence is due to the negative attitude and the practices of dumping refuse into streams, ditches, rivers and building of houses and structures on drainages and

waterways. This necessitates the need for Nigerians to understand the nature and magnitude of these environmental problems.

2.2.2 Active Learning and Strategies in each category

Active learning is a process whereby students engage in higher-order thinking tasks such as analysis, synthesis, and evaluation.(Paulson and Faust, 2009).. It is, in short, anything that students do in a classroom other than merely passively listening to an instructor's lecture.

Learning is an active process that requires *thinking*. Every time we learn a new idea, we are actively constructing our mental representations of the idea in apersonally meaningful form. The new idea interacts with your old ideas, as you try to combine the new and old into a coherent system of ideas. Some of the most effective teaching methods are designed to stimulate thinking, to replace boring passivity with exciting activity. Strategies of active learning are those activities which an instructor incorporates into the classroom to foster active learning, Strategies in each category is shown in table 2.3.

Table 2.3: Categories of Active Learning and Strategies in each category

Exercise for Individual Students							
The "One Minute Paper"	Muddiest (or clearest) Points	Affective Responses	Daily Journal	Reading Quiz	Clarification pauses		
Questions and answers the "Socratic Method"							
Wait Time	Student summary of another student's Answer	The fish Bowl	Quiz/Test questions				
Finger signals	Flash cards	Quotations					
Critical Thinking Motivators							
The pre-theoretical intuitions quiz	Puzzles/Paradoxes						
Share/Pair							
Discussion	Note Comparison/Sharing	Evaluation of Another Student's Work					
Cooperative Groups in Class	Active review sessions	Work at the Blackboard	Concept Mapping	Visual Lists	Jigsaw Group Projects	Role Playing	Panel discussion

Source:Paulson and Faust, (2009).

An overview of active learning listed above includes:

Exercises for Individual Students: Because these techniques are aimed at individual students, they can very easily be used without interrupting the flow of the class. These exercises are particularly useful in providing the instructor with feedback concerning student understanding and retention of material. Some (Affective response and Daily journal) are especially designed to encourage students' exploration of their own attitudes and values. Many (especially Daily Journal, Reading Quiz, Clarification Pauses and Response to a demonstration or other teacher centered activity) are designed to increase retention of material presented in lectures and texts. The following strategies are involved:

The "One Minute Paper" - This is a highly effective technique for checking student progress, both in understanding the material and in reacting to course material. Ask students to take out a blank sheet of paper, pose a question (either specific or open-ended), and give them one (or perhaps two - but not many more) minute(s) to respond

Muddiest (or Clearest) Point - This is a variation on the one-minute paper, though you may wish to give students a slightly longer time period to answer the question. Here you ask (at the end of a class period, or at a natural break in the presentation), "What was the "muddiest point" in today's lecture?" or, perhaps, you might be more specific, asking, for example: "What (if anything) do you find unclear about the concept of 'personal identity' ('inertia', 'natural selection', etc.)?".

Affective Response - Again, this is similar to the above exercises, but here you are asking students to report their reactions to some facet of the course material - i.e., to provide an emotional or evaluative response to the material. Obviously, this approach is limited to those subject areas in which such questions are appropriate (one should not, for instance, inquire into students' affective responses to vertebrate taxonomy).

Daily Journal - This combines the advantages of the above three techniques, and allows for more in-depth discussion of or reaction to course material. You may set aside class time for students to complete their journal entries, or assign this as homework. The only disadvantage to this approach is that the feedback will not be as "instant" as with the one-minute paper (and other assignments which you collect the day of the relevant lecture). But with this approach (particularly if entries are assigned for homework), you may ask more complex questions.

Reading Quiz - Clearly, this is one way to coerce students to read assigned material. Active learning depends upon students coming to class prepared. The reading quiz can also be used as an effective measure of student comprehension of the readings (so that you may gauge their level of sophistication as readers). Further, by asking the same sorts of questions on several reading quizzes, you will give students guidance as to what to look for when reading assigned text.

Clarification Pauses - This is a simple technique aimed at fostering "active listening". Throughout a lecture, particularly after stating an important point or defining a key concept, stop, let it sink in, and then (after waiting a bit!) ask if anyone needs to have it clarified. You can also circulate around the room during these pauses to look at student notes, answer questions, etc. Students who would never ask a question in front of the whole class will ask questions during a clarification pause as you move about the room.

Response to a demonstration or other teacher centered activity - The students are asked to write a paragraph that begins with: I was surprised that ... I learned that ... I wonder about ... This allows the students to reflect on what they actually got out of the teachers' presentation. It also helps students realize that the activity was designed for more than just entertainment.

Questions and Answers: While most of us use questions as a way of prodding students and instantly testing comprehension, there are simple ways of tweaking our questioning techniques which increase student involvement and comprehension. Though some of the techniques listed here are "obvious", we will proceed on the principle that the obvious sometimes bears repeating (a useful pedagogical principle, to be sure!). The following strategies are involved:

The "Socratic Method" **:** Taking its namesake from the most famous gadfly in history, this technique in its original format involved instructors "testing" student knowledge (of reading assignments, lectures, or perhaps applications of course material to a wider context) by asking questions during the course of a lecture. Typically, the instructor chooses a particular student, presents her with a question, and expects an answer forthwith; if the "chosen" student cannot answer the question presented, the instructor chooses another (and another) until the desired answer is received.

Wait Time - Rather than choosing the student who will answer the question presented, this variation has the instructor WAITING before calling on someone to answer it. The wait time will generally be short (15 seconds or so) - but it may seem interminable in the classroom. It is important to insist that no one raise his hand (or shout out the answer) before you give the OK, in order to discourage the typical scenario in which the five students in the front row all immediately volunteer to answer the question, and everyone else sighs in relief. Waiting forces every student to think about the question, rather than passively relying on those students who are fastest out of the gate to answer every question. When the wait time is up, the instructor asks for volunteers or randomly picks a student to answer the question. Once students are in the habit of waiting after questions are asked, more will get involved in the process.

Student Summary of Another Student's Answer - In order to promote active listening, after one student has volunteered an answer to your question, ask another student to summarize the first student's response. Many students hear little of what their classmates have to say, waiting instead for the instructor to either correct or repeat the answer. Having students summarize or repeat each others' contributions to the course both fosters active participation by all students and promotes the idea that learning is a shared enterprise. Given the possibility of being asked to repeat classmates' comments, most students will listen more attentively to each other.

The Fish Bowl - Students are given index cards, and asked to write down one question concerning the course material. They should be directed to ask a question of clarification regarding some aspect of the material which they do not fully understand; or, perhaps you may allow questions concerning the application of course material to practical contexts. At the end of the class period (or, at the beginning of the next class meeting if the question is assigned for homework), students deposit their questions in a fish bowl. The instructor then draws several questions out of the bowl and answers them for the class or asks the class to answer them.

Quiz/Test Questions - Here students are asked to become actively involved in creating quizzes and tests by constructing some (or all) of the questions for the exams. This exercise may be assigned for homework and it evaluated (perhaps for extra credit points). In asking students to think up exam questions, we encourage them to think more deeply about the course material and to explore major themes, comparison of views presented, applications, and other higher-order thinking skills. Once suggested questions are collected, the instructor may use them as the basis of review sessions, and/or to model the most effective questions.

Immediate Feedback: These techniques are designed to give the instructor some indication of student understanding of the material presented during the lecture itself. These activities provide formative assessment rather than summative assessment of student understanding, Formative assessment is evaluation of the class as a whole in order to provide information for the benefit of the students and the instructor, but the information is not used as part of the course grade; summative assessment is any evaluation of student performance which becomes part of the course grade. For each feedback method, the instructor stops at appropriate points to give quick tests of the material; in this way, she can adjust the lecture mid-course, slowing down to spend more time on the concepts students are having difficulty with or moving more quickly to applications of concepts of which students have a good understanding. The following strategies are involved:

Finger Signals - This method provides instructors with a means of testing student comprehension without the waiting period or the grading time required for written quizzes. Students are asked questions and instructed to signal their answers by holding up the appropriate number of fingers immediately in front of their torsos (this makes it impossible for students to "copy", thus committing them to answer each question on their own). For example, the instructor might say "one finger for 'yes', two for 'no'.

Flash Cards - A variation of the Finger Signals approach, this method tests students' comprehension through their response to flash cards held by the instructor. This is particularly useful in disciplines which utilize models or other visual stimuli, such as chemistry, physics or biology. For example, the instructor might flash the diagram of a chemical compound and ask "Does this compound react with H_2O?". This can be combined with finger signals.

Quotations - This is a particularly useful method of testing student understanding when they are learning to read texts and identify an author's viewpoint and arguments. After students have read a representative advocate of each of several opposing theories or schools of thought, and the relevant concepts have been defined and discussed in class, put on the overhead projector a quotation by an author whom they have not read in the assigned materials, and ask them to figure out what position that person advocates. In addition to testing comprehension of the material presented in lecture, this exercise develops critical thinking and analysis skills. This would be very useful, for example, in discussing the various aspects of evolutionary theory.

Critical Thinking Motivators: Sometimes it is helpful to get students involved in discussion of or thinking about course material either before any theory is presented in lecture or after several conflicting theories have been presented. The idea in the first case is to generate data or questions prior to mapping out the theoretical landscape; in the second case, the students learn to assess the relative merits of several approaches. The following strategies are involved:

The Pre-Theoretic Intuitions Quiz - Students often dutifully record everything the instructor says during a lecture and then ask at the end of the day or the course "what use is any of this?", or "what good will philosophy [organic chemistry, etc.] do for us?". To avoid such questions, and to get students interested in a topic before lectures begin, an instructor can give a quiz aimed at getting students to both identify and to assess their own views. An example of this is a long "True or False" questionnaire designed to start students thinking about moral theory (to be administered on the first or second day of an introductory ethics course), which includes statements such as "There are really no correct answers to moral questions" and "Whatever a society holds to be morally right is in fact morally right". After students have responded to the questions individually, have them

compare answers and discuss the ones on which they disagree. This technique may also be used to assess student knowledge of the subject matter in a pre-/post-lecture comparison. The well-known "Force Concept Inventory" developed by Hestenes to measure understanding of force and motion is another good example of this.

Puzzles/Paradoxes - One of the most useful means of ferreting out students' intuitions on a given topic is to present them with a paradox or a puzzle involving the concept(s) at issue, and to have them struggle towards a solution. By forcing the students to "work it out" without some authority's solution, you increase the likelihood that they will be able to critically assess theories when they are presented later..

Share/Pair: Grouping students in pairs allows many of the advantages of group work students have the opportunity to state their own views, to hear from others, to hone their argumentative skills, and so forth without the administrative "costs" of group work (time spent assigning people to groups, class time used just for "getting in groups", and so on). Further, pairs make it virtually impossible for students to avoid participating thus making each person accountable. The following strategies are involved:

Discussion - Students are asked to pair off and to respond to a question either in turn or as a pair. This can easily be combined with other techniques such as those under "Questions and Answers" or "Critical Thinking Motivators" above. For example, after students have responded to statements, such as "Whatever a society holds to be morally right is in fact morally right" with 'true' or 'false', they can be asked to compare answers to a limited number of questions and to discuss the statements on which they differed. In science classes students can be asked to explain some experimental data that supports a theory just discussed by the lecturer. Generally, this works best when students are given explicit directions,

such as "Tell each other why you chose the answer you did". ***Note Comparison/Sharing*** - One reason that some students perform poorly in classes is that they often do not have good note-taking skills. That is, while they might listen attentively, students do not always know what to write down, or they may have gaps in their notes which will leave them bewildered when they go back to the notes to study or to write a paper. One way to avoid some of these pitfalls and to have students' model good note-taking is to have them occasionally compare notes. The instructor might stop lecturing immediately after covering a crucial concept and have students read each others' notes, filling in the gaps in their own note-taking. This is especially useful in introductory courses or in courses designed for non-majors or special admissions students. Once students see the value of supplementing their own note-taking with others', they are likely to continue the practice outside of class time.

Evaluation of Another Student's Work - Students are asked to complete an individual homework assignment or short paper. On the day the assignment is due, students submit one copy to the instructor to be graded and one copy to their partner. These may be assigned that day, or students may be assigned partners to work with throughout the term. Each student then takes their partner's work and depending on the nature of the assignment gives critical feedback, standardizes or assesses the arguments, corrects mistakes in problem-solving or grammar, and so forth. This is a particularly effective way to improve student writing.

Cooperative Learning Exercises: For more complex projects, where many heads are better than one or two, you may want to have students work in groups of three or more. As the term "cooperative learning" suggests, students working in groups will help each other to learn. Generally, it is better to form heterogeneous groups (with regard to gender, ethnicity, and academic performance), particularly

when the groups will be working together over time or on complex projects; however, some of these techniques work well with spontaneously formed groups. Cooperative groups encourage discussion of problem solving techniques ("Should we try this?", etc.), and avoid the embarrassment of students who have not yet mastered all of the skills required. The following strategies are involved:

Cooperative Groups in Class - Pose a question to be worked on in each cooperative group and then circulate around the room answering questions, asking further questions, keeping the groups on task, and so forth. After an appropriate time for group discussion, students are asked to share their discussion points with the rest of the class. (The ensuing discussion can be guided according to the "Questions and Answers" techniques outlined above.).

Active Review Sessions - In the traditional class review session the students ask questions and the instructor answers them. Students spend their time copying down answers rather than thinking about the material. In an active review session the instructor posses questions and the students work on them in groups. Then students are asked to show their solutions to the whole group and discuss any differences among solutions proposed.

Work at the Blackboard - In many problem solving courses (e.g., logic or critical thinking), instructors tend to review homework or teach problem solving techniques by solving the problems themselves. Because students learn more by doing, rather than watching, this is probably not the optimal scenario. Rather than illustrating problem solving, have students work out the problems themselves, by asking them to go to the blackboard in small groups to solve problems. If there is insufficient blackboard space, students can still work out problems as a group, using paper and pencil or computers if appropriate software is available.

Concept Mapping - A concept map is a way of illustrating the connections that exist between terms or concepts covered in course material; students construct concept maps by connecting individual terms by lines which indicate the relationship between each set of connected terms. Most of the terms in a concept map have multiple connections. Developing a concept map requires the students to identify and organize information and to establish meaningful relationships between the pieces of information.

Visual Lists - Here students are asked to make a list--on paper or on the blackboard; by working in groups, students typically can generate more comprehensive lists than they might if working alone. This method is particularly effective when students are asked to compare views or to list pros and cons of a position

Jigsaw Group Projects - In jigsaw projects, each member of a group is asked to complete some discrete part of an assignment; when every member has completed his assigned task, the pieces can be joined together to form a finished project. When each student has completed his research, the group then reforms to complete a comprehensive report. In a chemistry course each student group could research a different form of power generation (nuclear, fossil fuel, hydroelectric, etc.). Then the groups are reformed so that each group has an expert in one form of power generation. They then tackle the difficult problem of how much emphasis should be placed on each method.

Role Playing - Here students are asked to "act out" a part. In doing so, they get a better idea of the concepts and theories being discussed. Role-playing exercises can range from the simple (e.g., "What would you do if a Nazi came to your door, and you were hiding a Jewish family in the attic?") to the complex. Complex role playing might take the form of a play (depending on time and resources

Panel Discussions - Panel discussions are especially useful when students are asked to give class presentations or reports as a way of including the entire class in the presentation. Student groups are assigned a topic to research and asked to prepare presentations (note that this may readily be combined with the jigsaw method outlined above). Each panelist is then expected to make a very short presentation, before the floor is opened to questions from "the audience". The key to success is to choose topics carefully and to give students sufficient direction to ensure that they are well-prepared for their presentations. You might also want to prepare the "audience", by assigning them various roles.

Debates - formal debates provide an efficient structure for class presentations when the subject matter easily divides into opposing views or 'Pro'/'Con' considerations. Students are assigned to debate teams, given a position to defend, and then asked to present arguments in support of their position on the presentation day. The opposing team should be given an opportunity to rebut the argument(s) and, time permitting, the original presenters asked to respond to the rebuttal. This format is particularly useful in developing argumentation skills (in addition to teaching content).

Games- Many will scoff at the idea that one would literally play games in a university setting, but occasionally there is no better instructional tool. In particular, there are some concepts or theories which are more easily illustrated than discussed and in these cases, a well-conceived game may convey the idea more readily. For example, when students are introduced to the concepts of "laws of nature" and "the scientific method", it is hard to convey through lectures the nature of scientific work and the fallibility of inductive hypotheses. Instead, students play a couple rounds of the Induction Game, in which playing cards are turned up and either added to a running series or discarded according to the

dealer's pre-conceived "law of nature". Students are asked to "discover" the natural law, by formulating and testing hypotheses as the game proceeds.

In the past several years, an increasing number of national reports indicate a growing concern over the effectiveness of higher education teaching practices and the decreased science(and math) performance of U.S. students relative to other industrialized countries (Project Kaleidoscope, 2006). A variety of national stakeholders, including business and educational leaders, politicians ,parents, and public agencies, have called for long-term transformation of the K–20 educational system to produce graduates who are well trained in science, can engage intelligently in global issues that require local action, and in general are better able to solve problems and think critically. Specifically, business leaders are calling for graduates who possess advanced analysis and communication skills, for instructional methods that improve lifelong learning, and ultimately for an educational system that builds a nation of innovative and effective thinkers (Association of American Colleges and Universities, [AACU] 2005).

Education leaders are similarly calling for institutions of higher education to produce graduates who think critically, communicate effectively, and who employ lifelong learning skills to address important scientific and civic issues (AACU,2005).

Many college faculties consider critical thinking to be one of the most important indicators of student learning quality. In its 2005 national report, the AACU indicated that 93% of higher education faculty perceived analytical and critical thinking to be an essential learning outcome (AACU, 2005) whereas 87%of undergraduate students indicated that college experiences contributed to their ability to think analytically and creatively. This same AACU report showed that only 6% of undergraduate seniors demonstrated critical thinking proficiency based on Educational Testing Services standardized assessments from 2003 to 2004.During the same time frame, data from the ACT Collegiate Assessment of

Academic Proficiency test showed a similar trend, with undergraduates improving their critical thinking from fresh-students to senior students. Thus, it appears a discrepancy exists between faculty expectations of critical thinking and students' ability to perceive and demonstrate critical thinking proficiency using standardized assessments (AACU, 2005).

Teaching that supports the development of critical thinking skills has become a cornerstone of nearly every major educational objective since the Department of Education released its six goals for the nation's schools in 1990. In particular, goal three of the National Goals for Education stated that more students should be able to reason, solve problems, and apply knowledge. Goal six specifically stated that college graduates must be able to think critically. Since 1990, American education has tried—with some success—to make a fundamental shift from traditional teacher-focused instruction to more student-centered constructivist learning that encourages discovery, reflection, and in general is thought to improve student critical thinking skill. National science organizations have supported this trend with recommendations to improve the advanced thinking skills that support scientific literacy (National Academy of Science , 2005).

More recent reports describe the need for improved biological literacy as well as international competitiveness (Bybee and Fuchs, 2006;Klymkowsky, 2006). Despite the collective call for enhanced problem solving and critical thinking, educators, researchers, and policymakers are discovering a lack of evidence in existing literature for methods that measurably improve critical thinking skills (Tsui, 1998, 2002). As more reports call for improvedK–20 student performance, it is essential that research-supported teaching and learning practices be used to better help students develop the cognitive skills that underlie effective science learning (Malcom, Abdallah, Chubin, & Grogan, 2005; Bybee and Fuchs, 2006).

Prior research on critical thinking indicates that students' behavioral dispositions do not change in the short term (Giancarlo and Facione, 2001), but cognitive skills can be developed over a relatively short period of time . In their longitudinal study of behavioral disposition toward critical thinking, Giancarlo and Facione (2001) discovered that undergraduate critical thinking disposition changed significantly after two years. Specifically, significant changes in student tendency to seek truth and confidence in thinking critically occurred during the junior and senior years. Also, females tended to be more open-minded and have more mature judgment than males (Giancarlo and Facione, 2001). Although additional studies are necessary to confirm results from the Giancarlo study, existing research seems to indicate that changes in undergraduate critical thinking disposition are measured in years, not weeks.

2.2.3 Pre-Theoretic Intuition Quiz Strategy

Pre-Theoretic Intuitions Quiz strategy? What is it all about? Students often dutifully record everything the instructor says during a lecture and then ask at the end of the day or the course "what use is any of this?", or "what good will the course do for us?". To avoid such questions, and to get students interested in a topic before lectures begin, The Pre-Theoretic Intuitions Quiz strategy may be used by an instructor to ask questions (Pre-Theoretic Intuitions quiz) in order to excite feedback aimed at getting students to both identify and assess their own views on a concept thereby correcting the misconceptions on the concept in order to allow new information to be learnt. In many fields, “common sense” can lead students astray. Before stepping into a classroom, students have formed hypotheses and theories based on observations and experience, but what seems to make sense based on casual observation may be, in fact, false. These misconceptions can be worse than complete ignorance, as the misconceptions have to be corrected in order for new information to be learned. In fact, most of the

time, students simply modify their existing understanding to accommodate the new concepts rather than internalizing the correct knowledge, leading to a mash-up of correct vocabulary mixed with partially correct theories (Hestenes, 2006).

An example of The Pre-Theoretic Intuitions Quiz is a long "True or False" questionnaire designed to start students thinking about moral theory (to be administered on the first or second day of an introductory ethics course), which includes statements such as "There are really no correct answers to moral questions" and "Whatever a society holds to be morally right is in fact morally right". After students have responded to the questions individually, have them compare answers in pairs or small groups and discuss the ones on which they disagree. This technique may also be used to assess student knowledge of the subject matter in a pre-/post-lecture comparison.

The Pre-Theoretic Intuitions Quiz sometimes called Concept inventories have been developed in Physics (Hestenes and Halloun, 1995Thornton and Sokoloff,1998, Ding, Chabay, Sherwood & Beichner, 2006), Statistics, (Allen,2006),Chemistry,(Wright,1998),Astronomy(Hake,1998),Basic-biology (D'Avanzo,2008),(D'Avanzo, Anderson, Griffith, Merrill, 2010),Natural selection(Nehm&Schonfeld, 2008 and 2010)Genetics(D'Avanzo,2008), Engineering.(Klymkowsky, Underwood, & Garvin-Doxas, 2010) and Geosciences(Nehm & Schonfeld ,2008 and 2010)

The first concept inventory in biology developed by Odom and Barrow, 1995, to evaluate understanding of diffusion and osmosis is a good example of Pre-Theoretic Intuitions Quiz. This concept inventory not only used misconceptions as distractors, but also employed two-tiered items. First-tier items ask 'what happens when . . .?' (Which students often know); second-tier items ask 'why does this happen?' (Which students often don't know). Tiers of questions based on the distinction between student knowledge of outcome and mechanism

provide an additional source of information for instructors. The ultimate goal is to identify student misconceptions and to determine whether those misconceptions are corrected. The result is an indication of how well students understand the overall concepts, as opposed to how they respond to specific questions.

One way to address these misconceptions is by administering a Concept Inventory assessment. A concept inventory utilized in The Pre-Theoretic Intuitions Quiz is a multiple choice test that forces students to choose between the correct concepts and common sense alternatives (Hestenes, 2006). The inventory is administered at the beginning of a course to get a baseline level of student understanding, and again at the end of a course. In addition, there are non-multiple choice conceptual instruments, such as the essay-based approach suggested by Wright, 1998 and the essay and oral exams used by Nehm and Schonfeld (2008& 2010). The difference between the scores represents the students' change from misconception to accurate and deep understanding of the concepts.

A different type of conceptual assessment has been created by the "Thinking like a Biologist research group" at Michigan State University. To date, they have created approximately 80 items exploring students' understanding of matter and energy, organized into Diagnostic Question Clusters that are available for download. These items are valuable for engaging students in collaborative problem-solving activities in class. Another approach is illustrated by the Biological Concepts Instrument (BCI) by Klymkowsky, Underwood, & Garvin-Doxas, 2010 which is a 24-item, multiple-choice, research-based instrument (available on-line) designed to reveal students' (and teachers') understanding of foundational ideas within the (primarily) molecular biological arena. The Biological Concepts Instrument (BCI) by Klymkowsky, et al, 2010 will be Adapted specifically in this research.

2.2.4 Puzzle-Based Learning Strategy

While there are many environmental education materials available that include critical thinking skill development, Powell and Wells (2002) stated that there are several materials that provide for both structure and variety of activities and experiences. Examples of materials with many activities include Aquatic Project Wild, Project Wild, Project Learning Tree, Class, Science-Technology-Society: Preparing for Tomorrow's World, and SuperSaver Investigator. These activities are found in United States of America. An activity manual produced by ERIC/SMEAC described by Howe and Disinger, 2000. The manual also includes examples of activities that one can design in relation to various environmental topics and problems. The activities provide a variety of effective instructional procedures (debates, simulations, critical analyses of materials and presentations, case studies), and focus on specific or combinations of critical thinking skills. There are other wide ranges of innovative tools that can be effectively used and applied in the teaching/learning of Environmental concepts in Biology in our schools which will improve teaching/learning, motivate and make the contents relevant to students. One of such is puzzle-based instructional strategy.

The Oxford Advanced Learner's Dictionary 6th Edition (2006) conceptualized puzzles as games that requires careful thinking in order to solve a problem or answer a question. According to Kendall et al, (2008) Puzzle is a problem or enigma that challenges ingenuity and a problem that seeks solution. Puzzle as resources for teaching and learning are of different types. They include: Assembly puzzles, interlocking puzzles, disassembly puzzles, disentanglement puzzles, construction puzzles, 3 dimensional puzzles, 2 dimensional puzzles, cross word puzzles and Puzzle-Based learning. These different categories of puzzles can be adopted and adapted for the teaching and learning of selected topics in Secondary school science subjects. Gardner, (1994) on the use of puzzles in teaching and learning process identifies some essential

features of educational puzzles, this is also supported by Bora (2003) and Kendall et al (2008) These are:

1. Generality: Educational puzzles should explain some universal problems solving principles. This is of key importance. Most people agree that problem solving can only be learned by solving problems; however, this activity may be supported by strategies provided by an instructor.
2. Simplicity: Educational puzzles should be easy to state and easy to remember. This is important because easy-to-remember puzzles increase the chancesof getting the solution to the problem.
3. Eureka Factors: A puzzle should be interesting because problem-solvers use intuition to start their quest for the solution and this approach usually leads them astray. Eventually Eureka Moment is reached when the correct path to solving the puzzle is recognized. The Eureka moment is accompanied by a sense of relief. The frustration that was felt during the process dissipates, and the problem-solver may feel a sense of reward at his/her cleverness for eventually solving the puzzle.
4. Entertainment: Educational puzzle entertains otherwise the user may loose interest easily

2.2.5 Conventional Strategy

According to National Teachers Institute (2011), the approach to teaching in Nigeria is teacher – centered which implies that teacher does all the talking, and the learners do all the listening. Learners expected that the materials and method of instruction should be easily transferable to the real world. It was noted that the traditional or the conventional instructional method is characterized by;

i. Unspecified or vague objectives
ii. Emphasis on instructor behavior rather than students' behaviour
iii. Use of lectures to provide critical information
iv. A constant instruction – set pace for all students

v. Evaluation which is infrequent over large sections of materials, and for the purpose of assigning elative standing rather than for remediation.

vi. Delayed feedback to students about his performance

vii. Ministerial responses of students to the instructional materials

viii. Few faculty or students or teacher to students interaction and observed that one of the major problems militating against effective teaching of secondary school subject in Nigeria is the method of teaching or package adopted by the teachers.

2.2.6 Environmental Achievement

Environmental education should form an integral part of formal education at all levels, from the pre-primary to the tertiary level, as a means of providing the necessary cognitive, affective and psychomotor needed by the Nigerian populace in tackling the various environmental problems facing the world today (Chukwuka 2006). According to Ojo (2008), teaching Environmental Education in our schools should deviate from the traditional teacher-centered method to activity methods that encourage participation and group work (Ahove,1999). It is assumed that if people are knowledgeable about their environment, the associated problems, subsequent solutions and motivated for actions, the situation would eventually change for the benefit of both present and future generations (Olagunju,2002). Emphasis on the knowledge of the effects of air, land and water pollution including conservation of environmental resources through the use of adequate teaching strategies to teach these important environmental concepts will bring about great achievement in Biology as well as improved quality of living.

2.2.7 Environmental Attitude

The development of environmental attitude is very essential for all citizens and professions to advance towards sustainable development. The task of education, training and information is to relay the environmental consequences of decisions and right solution modes for everyone, (Ogunbiyi, 2005).

One of the important aims of environmental education is to develop a world population that is aware of, and concerned about the environment and its associated problems and which has the knowledge, skills, attitudes, motivations and commitment to work individually and collectively toward solution of current problems and the prevention of new ones (UNESCO, 1997). Attitude should aim at developing a set of basic values regarding human nature. Interactions of living things and environment shows that all life should be respected and that all living things have right to existence, this will help in changing people's attitude positively towards the environment (Adara, 1993).

The policy affecting attitudes should take due account of the multi-disciplinary and intersectional issues which influence, or are influenced by environmental-related considerations such as pollution, conservation of natural resources, housing, sanitation, physical environment, waste treatment disposal, protection from and prevention of traffic and home accidents and work hazards etc. It is therefore very important that the general public, an individual, organizations and government should be re-oriented on their attitudes toward the environment, if the present need for sustainable development is to be achieved. Ajewole(2002) stated that Environmental Education is expected to provide learners with information / facts or skills and attitudes to help preserve the environments. To support this, Olagunju (2002) asserted that if children are made to participate in environmental activities, it will have a positive impact on their attitudes and value thereby facilitating changes in their behavior and this similar influence can be exerted on their peer groups and members of the community. Therefore, all these attributes should be introduced into secondary schools Biology and the curriculum in order to develop positive environmental attitude among the secondary school students.

2.2.8 Environmental Practices

The actual environmental practices of the people are a necessary factor towards attainment of a clean and healthy environment. Noibi (1993) reported daily experiences in Nigeria had revealed very poor environmental practices. It is also assumed that beliefs and misconceptions, which young people had, tend to stick to them for a long period later in life. Students enter secondary schools between ages 11 and 14years and leave between the ages 16 and 19years (Ojo,2008). Secondary school students belong to one of the most sensitive groups of population who may be initiated, involved and prepared for understanding and tackling the environment problem to the extent possible. They are usually receptive and strongly motivated and capable of assimilating an environmental education that is value-oriented, community-oriented and concerned with human well-being. Hence, Environmental Practices should be geared towards sustainable use of the natural resources for both the present and future generations.

2.3 Empirical Studies

2.3.1 Instructional Strategies and Learning Outcomes in Environmental Education

Presently, several strategies have been recommended for imparting environmental education learning outcomes by environmental educators (Olagunju, 2002; Ajewole, 2002). These include problem solving, concept mapping (Ige,2001), values clarification (chukwuka,2005) and enter educate(Abiona,2008). Some of the methods have been proved to enhance students' acquisition of environmental ethics such as problem-solving (Ajewole, 2002) and Enter-educate (Chukwuka, 2006). For instance, Abiona (2008) found values clarification and enter-educate strategies to be more effective than conventional method in teaching sewage disposal and water treatment. Also, Chukwuka, (2006) found values clarification and problem solving strategies more

effective than lecture methods in teaching environmental concepts to secondary school student. These studies and related ones focused on secondary school students learning outcomes but not on Critical thinking skills on senior secondary school students learning outcomes. Moreover, cognitive styles of the students are not dealt with in the previous researches therefore, there is need for instructional strategies that give more freedom to learners in which they will be able to make use of their intuition and find information on their own. One of such strategies is Critical thinking motivation Instructional strategies found in Pre theoretic intuition quiz and Puzzle-Based learning.

Researchers had worked on factors affecting students' learning outcomes in science and science related subjects at the different levels of the educational system. Prominent among the factors identified are the methods of instruction (Iroegbu, 1998). Amoo and Rahman (2004) identified the need to encourage teachers to acquire the use of instructional strategies that could build positive attitudes in science learners. Different researchers have reported the positive effect of instructional strategies on students' towards environmental education. These include Olatundun (2009) in Social studies, Olagunju (2002) and Ige (2001) in Biology .

Studies have predominantly reported poor environmental practices among Nigerians including indiscriminate refuse disposal poor drainage caused by construction of road/houses, poor waste management among others. A study carried out by Abiona, (2008) among residents of two local government area in Oyo state reveals that the predominant method of waste disposal is open dumpsites on the streets, markets, schools, around homes and even hospitals. This also tends to be a reflection of peoples poor environment knowledge and attitude. Olagunju (2002) earlier findings reveal a positive relationship between environmental knowledge and attitude of a target population. Invariably, as Ojo (2008) asserts people's level of ignorance affects the environment and determines the extent of harm they will do to environment. None of these studies focused on

the teaching of environmental education concepts using the higher thinking order skills in secondary schools. This is a gap which this study set to fill. The present study aimed at investigating the efficacy of The Pre-Theoretic Intuitions Quiz and Puzzle-Based Learning strategies in eliciting positive attitude in secondary schools students in environmental education.

2.3.2 The Pre-Theoretic Intuitions Quiz and Students' Learning Outcomes

The Pre-Theoretic Intuitions Quiz involves getting students interested in a topic before lectures begin; an instructor can give a quiz aimed at getting students to both identify and to assess their own views. There are really no correct answers to moral questions and whatever a society holds to be morally right is in fact morally right. After students have responded to the questions individually, they compare answers in pairs or small groups and discuss the ones on which they disagree. This technique may also be used to assess student knowledge of the subject matter in a pre-/post-lecture comparison. Paul (1985) points out that thinking is not driven by answers but by questions. The driving forces in the thinking process are the questions. When a student needs to think through an idea or issue or to rethink anything, questions must be asked to stimulate thought. When answers are given, sometimes thinking stops completely. When an answer generates another question then thought continues. Balogun (2002) noted that subjects must be taught in a way that will accustom learners to thinking themselves, to listening to the ideas of others, and to making decisions according to what seems to be the most sensible things to do.

In their research, Hand and Prain, (2002) using Pre-Theoretic Intuitions quiz and course instructor as variables found that these strategies significantly affected critical thinking performance, with Pre-Theoretic Intuition quiz having the largest effect on critical thinking gains of achievement. Further analysis of the writing group showed that the largest gains in critical thinking occurred during the first few weeks of the term, with graduated improvement during the remainder

of the term. A comparison of average critical thinking performance on initial essays achievement and revised essays showed that thinking skills improvement was greater on initial essays (53%) than on final essays (33%). Collectively, the results of this study indicated that students who experienced writing in general education biology achievement significantly improved their critical thinking skills.

2.3.3 The Puzzle-Based Learning and Students' Learning Outcomes

A classroom that offers an array of learning experience increases the likelihood of success for more students (Orlich, Harder, Callahan, Trevisan, Brown, 2010). Studies involving multi-sensory teaching experiences show students achieve more in learning than when taught with a single approach, whether it is a visual or an auditory approach. Multi-sensory instruction or a combination of approaches appears to create the optimal learning setting, even for students with disabilities (Maal, 2004). The variety in formats for students to demonstrate their learning has the potential to improve student interest, increase student interaction, and extend classroom learning (Orlich et al, 2010). This educational tool contributes to the creation of a powerful learning environment by allowing students to be active participants and take more responsibility in their own learning.

Puzzle-based learning is a new teaching and learning strategy that is focused on the development of problem solving skills (ACM,2006). One of the most useful means of ferreting out students' intuition on a giving topic is to present them with a paradox or puzzle involving the concept and to have them struggle towards a solution.

Puzzles-based instructional strategy gives a Multi-sensory instruction which combines the use of Intuition and Puzzle to create the optimal setting identified by Maal, 2004. The puzzle-based learning approach aims to encourage science students to think about how they frame and solve problems not encountered at the end of some textbook chapters (Nicholas, 2009), the goal is to

enhance student critical thinking and their problem solving skills. ACM. According to ACM, (2006) and Fisher (2001), most of the students never learn how to think about solving problems throughout their education period, they are faced with the problem of applying the material from each chapter to solve few problems provided at the end of each chapter. They concluded that it is not surprising that students are not well prepared for framing and addressing real work with instruction from textbooks because many educators are interested in teaching thinking skills rather than teaching independent thinking or independent problem solving.

Scotts (2006) emphasized that teaching with puzzle gives detail explanation on puzzles made of wood or very heavy cardboard help young children aged 1-8yrs learn motor skills and hand-eye coordination as they fit the pieces of puzzles together; logic puzzles are used to teach logical thinking skills, deductive and inductive reasoning, spatial concepts, motor coordination and planning of advance gambits. Physical puzzles are especially good for tactile learners who often cannot absorb traditional educational methods.

Experts have identified the importance and usefulness of puzzles in teaching and learning processes. Evidence has also shown that puzzles-based instructional strategies in teaching and learning of science education in Korea Universities improved understanding of abstract concepts and develop problem-solving abilities in students (Anany and Mary 2002). Kendall, et al, (2008) also remark that puzzle-solving is an active type of learning as it engages students with materials more than passive type of review does. They further stressed that the use of puzzles make learning more exciting and easily takes place in learners, thereby leading to the achievement of desired learning outcomes.

Research studies according to Idowu and Ige, (2007) shows that the use of puzzles in teaching and learning in Nigeria schools have been scored very low because they are often used as entertainment and relaxation rather than puzzles especially in teaching concept that are abstract in nature. Research carried out to

demonstrate the effectiveness of Puzzle-Based Learning according to Serj, (2002) notes that Puzzle-Based is significantly better when compared with conventional method in developing Problem-solving skills in Junior secondary school mathematics.

In spite of the seeming effectiveness of Puzzle-Based, some studies have shown limitations of this strategy, Hill, (2003) as well as Ross and Huang (2001), in their different studies confirmed that Puzzle-Based is not always effective in teaching operating system concept in computer studies. Obstfeld, Maurice & Kenneth (2001) had identified some of these limitations which include: lack of required skills or creative imagination by teachers for adapting, adopting and creating puzzles; financial constraint; time constraint and scarcity of relevant textbooks may not motivate enterprising and resourceful teachers toward using puzzles as instructional supplement. This inconsistency therefore indicates that studies on the effectiveness of Puzzle-Based in the classroom are inconclusive.

The present study seeks to investigate the effects of The Pre-Theoretic Intuitions Quiz and Puzzles-Based learning will have on student's achievement, attitude and practices towards Environmental Education concepts in Biology. It will also seek to examine whether gender of the students and their cognitive style as moderating variables will have any effect on the students learning outcomes in Environmental concept in biology.

2.3.4 Modified Conventional Strategy and Students' Learning Outcomes

This is the oldest method of teaching used in most Nigerian schools. It is a traditional 'talk-chalk strategy. The teacher "gives out" the facts to the students and the students in turn listen and digest the knowledge (Osokoya, 2002).

There are reasons listed by Adesoji, (2004) which make teachers refuse to change their conventional teaching style:

(a) Lack of infrastructural facilities

(b) Overloaded curriculum

(c) Lack of training programmes/workshops and

(d) Lack of skill in handling difficult concepts identified by Olagunju, 2002

This study considered the use of Critical Thinking Motivation strategies (Pre-Theoretic Intuition Quiz and Puzzle-Based learning) which have been found to help students take charge of their learning (meta-cognition) and so become independent learners.

2.3.5 Cognitive Styles and Students' Learning Outcomes.

The manner in which students receive and process information has been found to be affected by their cognitive styles (Ige, 2001, Awolola, 2009). Cognitive style refers to the individuals' orientation toward processing data, which is not immutable but modifiable through educative experiences.

A review of research conducted by Ige, (2001) into concept mapping and problem-solving teaching strategies as determinants of achievement of student in secondary school ecology (on environmental concept in biology). The result reveals an interaction of teaching strategy and cognitive style. It was discovered that analytic student in the problem-solving strategies and the control group performed better than non analytic students, while the non analytic students in the combined strategies (problem solving and concept mapping) and concept mapping strategies group performed better than their analytic counterpart. This trend as

explained by Ige (2001) is due to the nature of the teaching strategies which may tend to encourage to different degrees, students of different cognitive styles.

The result of the study conducted by Ogundiwin, (2006) revealed that there was significant main effect of cognitive style on students' attitude towards environmental pollution. The result also revealed that subjects that falls into analytical group obtained higher post test mean scores than their non-analytical counterparts. This could be explained by the fact that analytical group deals more with procedure and increased facility with science processes which is in accordance with the work of Ige (2001). Analytical group also enables students to isolate relevant information in questions that contains both relevant and irrelevant data as recorded in questionnaires which require the use of implicit information. Moreover, in the work of Awolola (2009) it was confirmed that the autonomy and self directness in analytic style promote their performance in attitude scores over non analytic counterparts.

The attitude has been found to have positive correlation with environmental practices. The actual environmental practices of the people are a necessary factor towards attainment of a clean and healthy environment. Noibi (1993), citing the earliest studies that reported strong positive correlation between knowledge and attitude concluded that one's level of ignorance different degrees of orientation to the environment determines the extent to harm (practice), he will do to the environment.

The habitual pattern identified by Wareing (1981) in his research Cognitive styles and Developing Scientific Attitude confirmed that Cognitive style significantly affect students attitude, this in turn will affect individual knowledge and practices towards environment (Olagunju, 2002). It was observed that rural dwellers who are predominantly peasant farmers, fishers, hunters, petty traders and cattle rears are still engaged in their practice of indiscriminate bush – burning, over-grazing, over-cropping, over-fishing and pollution of water bodies, cutting down of bushes and trees for hunting thereby causing extinction of some plant and

animal species. These people according to (Mabawonku, 2001) relate these practices to the fact that the environmental resources are meant to go back to the soil because they were made from soil.

There are few studies on strategies with significant level of improved Environmental Knowledge, Attitude and Practices of Nigerians. This is an indication that a lot still needs to be done to empower the people for more Environmental friendly habits and sustainable use of environmental resources. . On this, Arnold, Cohen,, & Warner,(2009) opined that those instructional strategies that are capable of bringing about attitudinal changes in the learners as regards creating environmental practices in the course of interacting with their environment such as Pre-Theoretic Intuition Quiz and Puzzle-Based learning should be constantly utilized in the classroom.

2.3.6 Gender and Students' Learning Outcomes

Researchers have shown strong relationship between environmental knowledge, attitude and practices. Such knowledge creates the right attitude and improved practices which help in elimination of environmental wastes, (Mansaray and Ajiboye, 1997). A consideration for practical solutions for the conservation of all environmental resources in a sustainable manner will be of national interest because the majority of Nigerians will benefit from an improved environment (Ajiboye & Olatundun, 2010). In Ahove's (2007) study, the students were generally reported to have favourable attitude toward sustainable development of the environment the females had higher mean score than their male counterpart. However the males are significantly better than the female in terms of environmental practices.

It has been found that many women will be more concerned about the environment than men especially about purity of air, spill and water because of its obvious impact on the young. Among women farmers, the hazards of applying agricultural pesticides and consequent exposure to toxic pesticides vary.

According to World Health Organization, many of the victims that suffered acute or chronic poisoning following exposure to agricultural pesticides are women (Bora, 2003). These women who came into direct contact with those chemicals during work in the fields or through contaminated food and water supplies are usually at greater risk of sickness and death than their male counterparts..

According to Mabawonku, (2001) these women comprise more than half of the agricultural work force in Nigeria and are less likely to be supplied with protective equipment. She concluded that exposure of women to pollution often makes them more susceptible to abortion and foetal damage and call for quick and more effective information about managing and sustaining the environment to be packaged and disseminated to more women, especially at grassroots.

It has also been confirmed that Girls seemed to be shy in mathematics and science classes, perhaps because these subjects require more hands-on work and logical thinking, in contrast to the critical thinking involved in subjects like language arts. According to Gurian, Stevens, & King, 2008: "testosterone, the primary architect of the male brain, is believed to create more and denser neural connections in the right hemisphere of the male brain, resulting in males' having increased resources for spatial reasoning, mental manipulation of the objects, gross motor skills, spatial-mathematical reasoning, and abstract spatial reasoning" .

Solomon (2004) in his study of gender differences and students achievement in secondary school Biology, found out that boys performed better than girls in all schools taken as a group and a single sex school as shown by their mean score (52.2 for boys and 49.8 for girls). In the same light, Ebere (2006) reported in his study of Breaking Gender barrier on Achievement in STME, using hands-on-Mind-on-science, that students (boys and girls) who were exposed to science process based learning activity oriented learning, utilizing students manipulation of materials, yielded a more effective learning irrespective of gender than other students.

Consequently, One of the aims of the environmental education is "developing a world population that is aware of and concerned about the environment for both male and female populace and its associated problems and which has the knowledge, practices, attitude, motivations and committee to work individually and collectively towards solving current problems and the prevention of new ones. Moreover, various studies have revealed positive relationship between environmental knowledge, environmental attitude and environmental practices (Olagunju, 2002), and that environmental practices depend largely on acquisition and manipulation of environmental skills which is not gender biased. Herein lays the need to effect a change in attitude or in behaviour of both male and female students towards the environment through exposure to adequate environmental practices in Biology.

Moreover, Bora (2003) informed that active participation by students is a key component of environmental practices and common goal of severe learning and citizenship education.

Research on thinking skills indicates that students' behavioral dispositions do not change in the short term (Giancarlo et al, 2001), but cognitive skills can be developed over a relatively short period of time. In their longitudinal study of behavioral disposition toward critical thinking, Giancarlo et al (2001) discovered that undergraduate thinking disposition changed significantly after two years. Specifically, significant changes in student tendency to seek truth and confidence in thinking occurred during the junior and senior years. Also, females tended to be more open-minded and have more mature judgment than males (Giancarlo et al, 2001). Although additional studies are necessary to confirm results from this study, existing research seems to indicate that changes in undergraduate critical thinking disposition are measured in years, not weeks.

From this there is need to test the effects Pre-Theoretic Intuition Quiz and Puzzle-Based learning on senior secondary school students' learning outcomes in Biology using gender and cognitive style as moderating variables.

2.4 Appraisal of Reviewed Literature

The review of literature in the area of the study has shown that there have been several attempts made by some individuals and government towards tackling the serious environmental pollution facing the world today. Environmental awareness, metacognition and attitude have been identified as solutions to this environmental degradation. In view of the above assertion, appraisals of some instructional strategies currently used by secondary school biology teachers were examined. The review of literature showed that teachers in Nigeria commonly used Conventional lecture method in teaching their students. This method has been considered unfit, undemocratic and teacher-centered, which will not allow critical thinking and collaborative skills needed for the attainment of the Environmental Education Objective. Research evidences have shown that many of the teachers are either not aware of or are not receptive to the new teaching methodologies like Pre-Theoretic Intuition Quiz and Puzzle-Based learning. The need to introduce these activity-based instructional strategies was highlighted. The review also shows that a considerable number of studies have been carried out on some instructional strategies; there has not been much improvement in achievement, attitude and practices in environment-related concepts.

Furthermore, the review stated the need to use these new teaching methodologies: Pre-Theoretic Intuition Quiz and Puzzle-Based learning to enhance students' environmental achievement, attitudes and practices which are essential in environmental education learning outcomes. The review also examined students' Cognitive styles and Gender with their learning outcomes. Therefore, the present study will include gender and cognitive style as moderating variables to be investigated.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

This study adopted a pretest, posttest, control group, quasi-experimental design. It examined possible effects of the Pre-Theoretic Intuition Quiz and Puzzle-Based learning Critical thinking motivational strategies, gender and cognitive style on students' achievement, attitude and practices on selected environment-related concepts in biology.

Diagrammatically the design is represented below

0_1	X_1	0_2	E_1
0_3	X_2	0_4	E_2
0_5	X_3	0_6	E_3

` Where, 01, 0_3, 0_5, represent the pre-test for both experimental and control group respectively. 0_2, 0_4, 0_6 represent the post-test for the experimental and control groups respectively.

X_1 represents the treatment for experimental group E_1-Pre-theoretic Intuition Quiz.

X_2 represents the treatment for experimental group E_2- Puzzle-Based learning.

X_3 represents the treatment for control group E_3–Modified Conventional method

A 3 X 2 X 2 factorial matrix was adopted with instructional strategy as treatment at three levels, gender at two levels (male and female) and cognitive style at two levels (analytical and non analytical).

The factorial matrix is represented in table 3.1.

Table 3.1: Schematic Representation of the Matrix

Treatment/strategies	**Gender**	**Cognitive style**	
		Analytical	Non-analytical
Pre-Theoretic Intuition Quiz E_1	Male		
	Female		
Puzzle-Based learning E_2	Male		
	Female		
Modified Conventional Method E_3	Male		
	Female		

3.2 Variables of the Study

(1) **Independent Variable:** This is the instructional strategy, which forms the treatment that varies at three levels.

i. Pre-theoretic Intuition Quiz Strategy

ii. Puzzle-Based learning. Strategy

iii. Modified Conventional method Strategy

(2) **Moderating Variables:** There are two moderating variables in the study.

i. Cognitive styles (analytical and non analytical)

ii. Gender of students (male and female)

(3) **Dependent Variables:** These are students' learning outcomes

i. Environmental achievement

ii. Environmental attitude

iii Environmental practices

3.3 Sample Selection

3.3.1. Selection of Participants

Four hundred and fifty one Senior Secondary two (SS II) biology students (189 male and 262 females) participated in the study. The subjects were from nine intact classes used for the study. Nine purposively selected co-educational secondary schools in Ibadan North, Ibadan North East and Akinyele local government Areas of Oyo State.

The choice of SSII biology students was made because they have been exposed to introductory aspects of pollution and conservation techniques as environmental concepts in junior secondary school basic science and SSI biology which act, as pre-requisites for the study of the chosen concepts. The students were likely to be more receptive to the teaching strategy as they were not under

the pressure of preparing for external examination. The teaching of the concepts was also appropriate to the scheme of work at this stage of their spiral curriculum. The selection of schools was based on the following criteria:

- Co-educational schools.
- Availability of experienced biology teachers with at least three years teaching experience.
- Evidence of SSII students of the schools not to have been exposed to the concepts of the study.
- Evidence of SSII students of the schools having been exposed to pre-requisite concepts necessary for the understanding of the concepts of the study in their Junior Secondary Schools.
- Willingness of the required members of staff to participate in the study

3.3.2 Selection of Environmental Education Concepts for the Study

Ajiboye (1997) observed that modern research in the field of curriculum has shown that concepts can be the basis for the development of curriculum and that concept utilization facilitates learning. The two concepts of study were: Pollution and Conservation Techniques. For this study they were subdivided into sub-concepts.

(i) Air pollution (ii) water pollution (iii) land pollution (iv) conservation techniques. The selection of these concepts was based on Senior School Certificate Examinations Biology syllabus.

3.4 Research Instruments

Eight instruments constructed by the researcher were used in this study to collect data.

i. Students' Environmental Achievement Test (SEAT).

ii. Students' Environmental Attitude Scale (SEAS).

iii. Students' Environmental Practices Scale.(SEPS).

iv. Cognitive Style Test (CST).

iv. (v) Teachers' Instructional Guide (TIG) on Pre-Theoretic Intuition Quiz Strategy (TIGPT)

(vi) Teachers' Instructional Guide (TIG) on Puzzle-Based Strategy (TIGPB)

(vi) Teachers' Instructional Guide (TIG) on Modified Conventional Strategy (TIGCM)

(viii) Evaluation Sheet for Assessing Teachers' Performance on the use of the Strategies (ESAT) on:

(a) Pre-theoretic Intuition Quiz Strategy

(b) Puzzle-Based Learning Strategy

(c) Modified Conventional Strategy

3.4.1 Students' Environmental Achievement Test (SEAT)

This instrument was adapted from Biological Concepts Instrument (BCI) type of conceptual assessment created by the "Thinking like a Biologist research group" at Michigan State University. The multiple test items, research-based instrument (available on-line) developed by Klymkowsky, Underwood, & Garvin-Doxas, (2010), was specifically adapted to measure the students' level of achievement in environmental pollution and conservation in Biology. The instrument is made up of two sections.

Section A - This consisted of the personal data of the subjects containing their gender, name of school, etc

Section B – This consisted of 20 multiple test items of Air, water and land pollution including the conservation techniques. Students will be required to pick the option in line with their views on each item. All questions are in objective form with alternatives A to D. Students are to pick the correct answer out of the alternatives provided. The table of specification for the development of the test is in the Table 3.2. The table is in accordance with Okpala and Onocha (1995) in which the six levels of Bloom taxonomy is reduced to three levels; this is done in this research to show the thinking skills that the research is based upon.

Table 3.2: Table of Specification on (SEAT)

Cognitive Level Content	**Remembering (Knowledge Recall) 30%**	**Understanding (Comprehension and Application) 35%**	**Thinking (Analysis, Synthesis and Evaluation) 35%**	**Total 100%**
Air Pollution	(1) 18,	(3) ,8,11, 19	(2) 9,16	6
Water pollution	(2) 1, 14	(2) 2,12,	(1) 20	5
Land pollution	(1) 6	(2) 3,	(1) 10,13	4
Conservation techniques	(2) 4,7	(1) 15	(2) 5, 17	5
Total	6	7	7	20

In the 1950s, Bloom found that most of the test questions developed to assess students' learning required them only to think at the lowest level of learning, the recall of information (Hobgood, Thibault and Walbert, 2005). Today, a considerable amount of attention is given to students' abilities to think critically about what they do. These thinking resources will help foster thinking skills that lead to greater comprehension for all students using the original and revised Bloom's Taxonomy (Anderson, et.al, 2001).

3.4.1.1 Validation of SEAT

This instrument was subjected to face and content validity by giving copies to experts in education, educational evaluation and science education with bias in Biology and Environmental Education. These experts were asked to determine its suitability for the target population in terms of clarity, breath and language. Out of the initial 40 items prepared, only 35 items survived scrutiny. The average difficulty and discriminating indices were determined after the instrument was trial tested on a sample of 30 students in a separate school. The difficulty and discriminating indices range from 0.40 and 0.60 and only 20 items survived scrutiny. The reliability coefficient of 0.80 was obtained using Kuder Richardson (KR.20).

3.4.2 Students' Environmental Attitude Scale (SEAS)

SEAS aimed at investigating or testing the affective domain of the students particularly their attitude towards environmental pollution and conservation techniques in their development of sense of responsibility in providing urgent solutions in the immediate environment of the subjects.

Section A – Consisted of the personal data of the respondents in terms of gender, location of the school etc.

Section B – This section would assess students' attitudes towards the environment. It consisted of 20 items covering the four environmental pollution concepts in biology (to be taught during the treatment period). The items contained equal numbers of positive and negative items reflecting certain attitudinal disposition to environmental pollution and conservation techniques. The items were placed on a 4-point likert type ordinal scale ranging from Strongly Agree (SA), Agree (A) Disagree (D) and Strongly Disagree (SD). The table of specification of SEAS is presented in Table 3.3.

Table 3.3:Table of Specification on SEAS

S/N	Concepts/Topics	(+) Positive	(-) Negative	Total No
1	Air pollution	(3) 3, 4,5	(2) 1, 2	5
2	Water pollution	(2) 6, 7	(3) 8, 9, 10	5
3	Land pollution	(3)11, 12, 15	(2) 13, 14	5
4	Conservation techniques	(2) 18, 19	(3)16, 17, 20	5
	Total	10	10	20

The scoring of SEAS was as follows**:**

Strongly Agree (SA) - 4 marks

Agree (A) - 3 marks

Disagree (DA) – 2 marks

Strongly Disagree (SD) – 1 mark

The above goes for positively worded statement while the reverse was used for negatively worded statements i.e.

Strongly Disagree (SD) - 4 marks

Disagree (DA) – 3 marks

Agree (A) – 2 marks

Strongly Disagree (SD) – 1mark.

3.4.2.1 Validation of SEAS

The face validity of SEAS was done by showing the items to four science educators with bias in biology to determine their suitability in terms of language of presentation, clarity of ideas and class level, length and relevance or applicability to the study. The initial draft containing 45 items were reduced to 20 in the final draft by the experts. Cronbach Alpha reliability co-efficient of 0.81was obtained when the SEAS instrument was trial-tested on a sample of 30 students in a separate school.

3.4.3 Student Environmental Practice Scale (SEPS)

This instrument was adapted from Oladapo (2011) participatants environmental education programme for market men and women. It was modified by considering the educational and maturity level of secondary students, it was found to suit the measurement of practices of senior secondary school students towards environmental pollution and conservation techniques. The instrument was divided into two parts.

Part A: This is made up of the data of the participants such as name of School of the participants, the class and sex.

Part B: This section has 20 items with statements that assess the Participants' practices on environmental pollution and conservation techniques.

Table 3.4:Table of Specification on SEPS

S/N	Concepts/Topics	(+) Positive	(-) Negative	Total No
1	Air pollution	(1) 3, 4,5	(2) 1, 2	5
2	Water pollution	(2) 6, 7	(3) 8, 9, 10	5
3	Land pollution	(3)11, 12, 15	(2) 13, 14	5
4	Conservation techniques	(2) 18, 19	(3)16, 17, 20	5
	Total	10	10	20

The scoring of SEPS is as follows**:**

Very Often (VO) - 4 marks

Often (O)- 3 marks

Seldom (S) – 2 marks

Never (N) – 1 mark

The above goes for positively worded statement while the reverse was used for negatively worded statements i.e.

Very Often (VO) - 1 mark

Often (O)- 2 marks

Seldom (S) –3 marks

Never (N) – 4 marks

3.4.3.1 Validation of SEPS

The instrument was also given to colleagues, in related disciplines as well as professionals in the field of Environmental Education. Their comments, criticisms and suggestions were used to expunge, and add some items when necessary. The final drafts were administered to senior secondary school students at Adekile Goodwill Grammar School in Ibadan. Cronbach alpha measure was used to determine the reliability after trial testing. An index of 0.82 was obtained.

3.4.4 Cognitive Style Test (CST)

This instrument was in line with that of Awolola 2009, hence, it was adapted in this study. The CST consists of twenty cards numbered 1 to 20. Each card contains three pictures in black and white, two of which could have one thing or the other in common or could go together in some ways. The CST was used to classify the students into 'analytic' and 'non-analytic' styles on the basis of their statements regarding the way they perceive the pictures. The students were asked to respond to each set of three pictures by noting how any two of the three pictures in the set go together or are related in any way. The statements made by the students regarding the way they perceived the pictures and classified any two together could be categorized into three thus:

- Analytic Descriptive (AD);
- Categorical Inferential (CI) and;
- Relational Contextual (RC)

3.4.4.1 Analytic Descriptive Responses

Students placed together objects based on their shared or common characteristics, which are directly discernible. Example, in a card containing a

Wristwatch, a man and a ruler, participants here place together wristwatch and man because "they have leathered material on".

3.4.4.2 Categorical Inferential Responses

Participants placed together objects on the basis of super ordinate features, which are not directly discernible (abstract), but are inferred. Example, participants here placed a wristwatch and ruler together because "they are for measurement".

3.4.4.3 Relational Contextual Responses

Participants here placed together objects or events on the basis of features establishing a relational link between them. The two stimuli or objects here are independent conceptionally; rather each derives meaning from the other. Hence, this style is sometimes called global or holistic or contextual mode of categorization. Example, participants here placed together "the man and the ruler" or "the man and the wristwatch" on the ground that, "the man can measure distances with ruler or "know the time with wristwatch".

In this study, analytic style participants were those who scored above the median on Analytic Descriptive (AD) and Categorical Inferential (CI) responses and below the median on Relational Contextual (RC) responses. Non-analytic style participants were those who scored above the median on Relational Contextual (RC) responses and below the median on Analytic Descriptive (AD) and Categorical Inferential (CI) responses.

Table 3.5 Table of Specification for CST

S/N	Content Area	Responses	Number of Items
1.	Analytic Descriptive Responses	Placing objects of common characteristics together	7
2.	Categorical Inferential Responses	Placing objects together on the basis of super ordinate features which are not directly discernable but are inferred	6
3.	Relational Contextual Responses	Placing objects/events together on the basis of features establishing a relational link between them.	7
	TOTAL		20

Source: Afuwape (2002).and Awolola (2009)

3.4.4.4 Validation of Cognitive Style Test (CST)

The face validity of CST was done by showing the booklet of 20 cards which contain pictures of items to experts in educational psychology, educational technology and other technically untrained observers to determine their suitability. Pearson Product Moment Correlation Coefficient for different responses showed stability coefficient obtained. Onyejiaku (1980) had estimated the reliability estimates of items in the CST to range from 0.62 to 0.76. Afuwape (2002) also trial tested the CST using 137 JS III students in four secondary schools in Lagos, Awolola (2009) also trial tested it, The trial test results showed no ambiguities in the instrument with test- retest reliability value of 0.84 was obtained.

For the present study the CST was trial tested twice (separated by four weeks to allow consistency of feedback expected from the students and in order to further ensure its validity and reliability) using 30 SS II students of the field-testing school at Adekile Goodwill Grammar School Ibadan,. A test-retest reliability value of 0.81 was obtained.

3.4.5 Teachers' Instructional Guides (TIG)

These are teaching guides prepared by the researcher for the teachers on Critical Thinking Motivation Strategies (Pre-Theoretic Intuition Quiz and Puzzle-Based learning) and Conventional strategy. These were used during the training period for the experimental and control groups respectively.

3.4.5.1 Teachers' Instructional Guide on Pre-Theoretic Intuition Quiz Strategy (TIGPT)

Steps involved in Teachers' Instruction Guide on Pre-theoretic intuition quiz in environmental pollution (TIGPT)

Introduction attracts student's attention and activates their background knowledge through the first tier lower level quiz that reviews prerequisite knowledge or skills.

Presentation involves:

-Teacher asks second-tier higher level quiz to activate students thinking before answering the questions.

-Students think independently between four to six seconds before answering the questions.

-More second-tier upper cognitive level quiz asked generate additional source of information based on answers provided by the students to the quiz.

Evaluation involves:

-Teacher clarifies students view on the concept by assessing students for more critical analysis by allowing students to try out the new concept or skill in class.

-Homework or assignment given for more assessment of the skills developed.

TIGPT was given to two University lecturers in Teacher Education Department to reconstruct some of the guide. The recommendations given were used to reconstruct the guide and the inter-rater reliability was then estimated using Scott' π. The inter-rater reliability index obtained was 0.76.

3.4.5.2 Teachers' Instructional Guide on Puzzle-Based Learning Strategy (TIGPB)

This is a teaching strategy designed to break down the concept environmental pollution into sub-topics such as air pollution, water pollution, and land pollution including the conservation techniques.

The puzzle clues and the key used in this research were adapted from www.TheTeachercorner.net, this is a crossword puzzle that can be made with papers or heavy cardboard, it is beneficial in that it teaches vocabulary, critical thinking skills, spellings and correct misconceptions in some concepts. In this stimulus instrument, the teacher introduces and demonstrates new puzzle. The steps include:

Introduction involves

- Attraction of students' attention and activates their background knowledge.

Presentation involves:

Students identify the key words and sub-concepts using environmental puzzles clues.

- More question posed with the aid of the environmental puzzle clues generate additional source of information based on answers provided by the students
- Teacher clarifying students view on the concept using the environmental puzzle as basis for clarification.

Evaluation involves:

- Assessing students for more critical analysis on the content using the environmental puzzle clues in order to help students to practice individually and develop a deep understanding of the topics they study and improve their thinking abilities.

- Teacher gives homework or assignment for more assessment of the skills developed.

Conceptual framework for developing and evaluating puzzle in Science Education according to Maldonado (2005) was utilized. TIGPB was given to experienced Biology teachers in senior Secondary School and University lecturers in Department of Teacher Education and Science unit to examine its content and face validity. The recommendations given were used to reconstruct the guide. The recommendations given were used to reconstruct the guide and the inter-rater reliability was then estimated using Scott' π. The inter-rater reliability index obtained was 0.74.

3.4.5.3 Teacher's Instructional Guide on Modified Conventional Strategy (TIGCS)

Steps involved in conventional strategy in environmental pollution including the conservation techniques.

The main features of the guide are general information which consist of subject, topic, the procedure, the teacher, general objective, contents for each week and specific treatment package for each week. The instructional guide was given to two senior secondary school Biology teachers for review and all their suggestions were incorporated in the guide The recommendations given were used to reconstruct the guide and the inter-rater reliability was then estimated using Scott' π. The inter-rater reliability index obtained was 0.72.

3.4.6 Evaluation Sheet for Assessing Teachers' Performance on the use of the Strategies (ESAT)

This is the guidelines for evaluating performance of the trained teachers on the effective use of these strategies

(1) Pre-Theoretic Intuition Quiz Strategy (ESATPT).

(2) Puzzle-Based learning Strategy (ESATPB).

(3) Modified Conventional Strategy (ESATMC).

This is a rating scale that is made up of two sections

Section A – This consisted of the personal data of the trained teacher containing name, school, period, class taught, date and the summary of the concept discussed in the class.

Section B - This consisted of items to be evaluated. The items were placed on a 5-point likert type rating scale ranging from Very Good (VG), Good (G) Average (AV) Poor (P) and Very Poor (VP).

The scoring of ESAT is as follows**:**

Very Good (VG)- 5marks

Good (G), - 4 marks

Average (AV)- 3 marks

Poor (P) – 2 marks

Very Poor (VP).– 1 mark

3.4.6.1 Validation of ESAT

The instrument was trial tested to ensure its reliability. For the purpose of validation, expert's attention was drawn to ascertain the appropriateness of the concepts and methods to the target population. The observations and comments of these experts were taken into consideration while preparing the final draft.

3.5 Research Procedure

The first week was used for visitation to schools used for the study.

The next two (2) weeks for training of research assistants

One (1) week for scrutiny of research assistants used.

One (1) week for pretest (Administration of SEAS, SEAT and SEPS)

Eight (8) weeks for treatment using the trained research assistants on the listed strategies. These took place simultaneously in all the schools selected.

One (1) week Post-Test (Administration of SEAS, SEAT and SEPS)

This makes a total of fourteen (14) weeks.

3.5.1 Training of Research Assistants.

Training was done step by step through the explanation on the teaching guides : Pre-theoretic Intuition Quiz Strategy, Puzzle-Based learning Strategy and Modified Conventional strategy.

3.5.2 Administration of Pretest.

All the 451 students (SSII) in all the nine representative schools used for the experimental and control groups were given pretest on all the evaluative instruments. The pre-test lasted for one week as follows: The Students Environmental Attitude Scale (SEAS) was given first, followed by Students Environmental Achievement Test (SEAT), Students Environmental Practices Scale.(SEPS) and Cognitive Style Test **(**CST) in that order.

3.5.3 Treatment Procedure

The treatments were carried out on all the SSII students in all the nine representative schools on the experimental and control groups. During this period, students were taught various aspects of the environmental concepts (air, water, land pollution and conservation of natural resources by the research assistants using the three strategies.

3.5.3.1 Pre-Theoretic Intuition Quiz Strategy

Pre-Theoretic Intuition Quiz Strategy steps include;

Step 1: Research assistants attract students' attention and activates their background knowledge through First-tier lower level questions posed thereby recalling facts and knowledge or skills previously taught. It also increases the number of students offering responses; the number of responses from less capable students and positive interaction between students

Step 2: Research assistants help students to think by asking second-tier higher level questions to improve the quality of response from student. The quiz should

prompt and probe to seek clarification and identify student misconceptions thereby correcting these misconceptions.

Step 3: Students try out new content through more second tiers higher level question. Students are allowed to think independently between four and six seconds about questions that have been posed in order to formulate their own ideas and provide additional source of information as Research assistants carefully monitors their progress by asking sequence questions in a way that extends thinking; listen very carefully to student answers in order to ask the right question.

Step 4: Research assistants allow students to practice the new concept or skill on their own through, later on, a homework or assignment. The result should indicate how well students understand the sub-concept, as opposed to how they respond to specific questions.

The students were taken through the four lessons of forty minutes duration each and this lasted for eight weeks

3.5.3.2 Puzzle-Based Strategy

Puzzle-Based Strategy steps include;

Step 1: Research assistants should **i**ntroduce each sub-concept (Air, water and land pollution including conservation techniques) through questions posed thereby reviewing prerequisite knowledge or skills. This often involves close-ended questions.

Step 2: Research assistants involve students in the identification of all the sub-concepts to be taught which will be integrated into the selected puzzles (Environmental puzzles). The integration of alien's term is practice on sub-concepts which learners found abstract and confusing.

Step 3: Research assistants engage students' thinking with the aid of environmental puzzle to present each key word or sub-concept. Student has one to three minutes opportunity to express his or her key word while research assistant and students listen not just to look for the answer expected but also to

alert them to unusual or innovative answers not expected which could highlight misconceptions that need correction.

Step 4: Research assistants should allow students to develop the skills by practicing individually with the aid of environmental puzzle on a homework /assignment.

The students were taken through the four lessons of forty minutes duration each and this lasted for eight weeks.

3.5.3.3 Modified Conventional strategy steps include;

Modified Conventional strategy steps include;

Step 1: The teacher introduces the lesson by asking questions based on their previous knowledge

Step 2: Teacher presents instructional aids and discusses the content of the lesson.

Step 3: Teacher directs students to write the blackboard summary in their note books.

Step 4: Teacher evaluates the lesson by asking students some questions in class, later on homework/ assignment.

The students were taken through the four lessons of forty minutes duration each and this lasted for eight weeks.

3.5.4 Administration of Posttest

All the SSII students in the nine sampled schools used for the experimental and control groups were given Posttests on all the evaluative instruments. The Posttests were as follows: Students' Environmental Attitude Scale (SEAS) followed by Students' Environmental Achievement Test (SEAT) and Students' Environmental Practices Scale. (SEPS) were administered.

3.6 Procedure for Data Analysis

Analysis of data collected in relation to this study was done using Descriptive Statistics (mean, standard deviation) including Bar charts to explain

the mean distribution of the various groups (Treatment, gender and cognitive styles),

The data was also analyzed using inferential statistics of Analysis of Covariance (ANCOVA) of the posttest scores, with the pretest scores as covariates. Multiple classification analysis (Sidak Approach) was used to determine estimated marginal means of different groups. Scheffe post hoc test was used where significant main effects were obtained. Line graphs were used to explain the significant interaction effects.

CHAPTER FOUR

INTERPRETATION OF RESULTS

4.0 Introduction

The focus of this study is to investigate the effects of pre-theoretic intuition quiz and puzzle-based critical thinking motivation strategies on students learning outcomes in selected environment-related concepts in biology.

. This chapter presents the results of the findings and discussion of the data gathered during the course of the research.

4.1 Descriptive Statistics.

4.1.1 Descriptive Statistics Associated with Treatment

Table 4.1: Summary of Descriptive Statistics Associated with Treatment

	Achievement Scores			**Attitude scores**			**Practice scores**		
	PTI	PBS	MCS	PTI	PBS	MCS	PTI	PBS	MCS
No of cases	145	140	166	145	140	166	145	140	166
Pre-test mean	11.13	10.77	8.67	53.77	52.59	55.17	54.27	53.44	55. 95
Pre-test S.D	2.92	3.99	3.28	7.11	7.68	7.36	7.05	7.34	7.18
Posttest mean	14.30	12.61	8.23	64.34	57.81	46.97	65.34	59.18	48.33
Posttest S.D	4.17	4.54	5.00	2.01	2.16	2.39	1.99	2.15	2. 42
Mean Gain	3.17	1.84	-.44	10.57	5,22	-9.20	11.07	5.74	-7.62

- PTI - Pre-Theoretic Intuition Quiz
- PBS - Puzzle-Based learning
- MCS - Modified Conventional strategy.
- S.D- Standard deviation

Table 4.1 displays the descriptive statistics of the students' achievement, attitude and practices scores. The post test scores improved for Pre-Theoretic Intuition Quiz in achievement, attitude and practices scores 3.17, 10.57 and 11.07 respectively. Puzzle-Based learning post test scores shows improvement with 1.84, 5.22 and 5.74 respectively. In case of Modified conventional strategy, the posttest scores do not improve in achievement, attitude and practices scores. The mean gain in descending order is;

Pre-theoretic Intuition Quiz had higher mean gain than Puzzle-Based learning while Puzzle-Based learning had higher mean than Modified Conventional Strategy.

Figures 4.1, 4.2 and 4.3 displayed the bar charts showing the magnitude of descriptive statistics of the students' achievement, attitude and practices scores associated with treatment as presented earlier in Table 4.1.

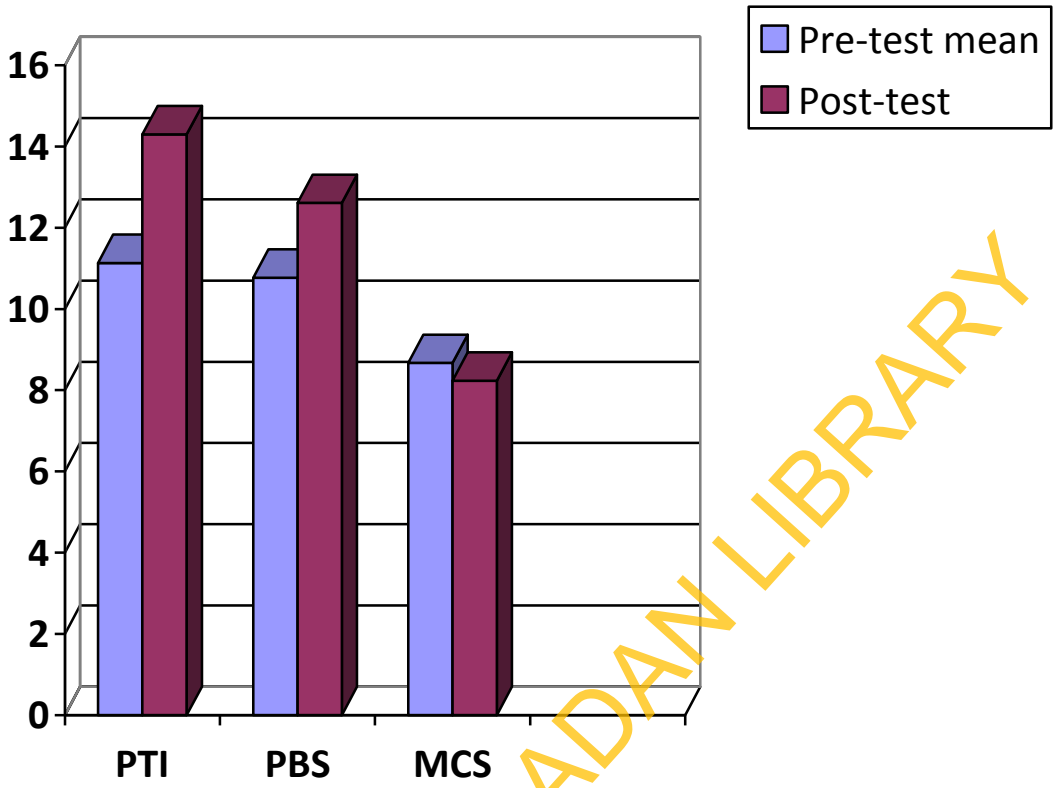


Fig 4.1: Bar chart showing descriptive statistics associated with treatment on achievement mean scores.

- PTI - Pre-Theoretic Intuition Quiz
- PBS - Puzzle-Based learning
- MCS - Modified Conventional strategy.

Figure 4.1 revealed the bar chart showing descriptive statistics associated with treatment on achievement mean scores.

The posttest scores improved for Pre-Theoretic Intuition Quiz in achievement scores by 3.17. (Pretest mean =11.13, Posttest mean = 14.30), Puzzle-Based learning posttest scores show improvement with 1.84 (Pretest mean = 10.77 .Post-Test mean = 12.61). In case of Modified conventional strategy, the posttest scores do not improve in achievement.(Pretest mean = 8.67, Posttest mean = 8.23). The mean gain in descending order was;

Pre-theoretic Intuition Quiz had higher mean gain than Puzzle-Based learning, while Puzzle-Based learning had higher mean gain than Modified Conventional Strategy.

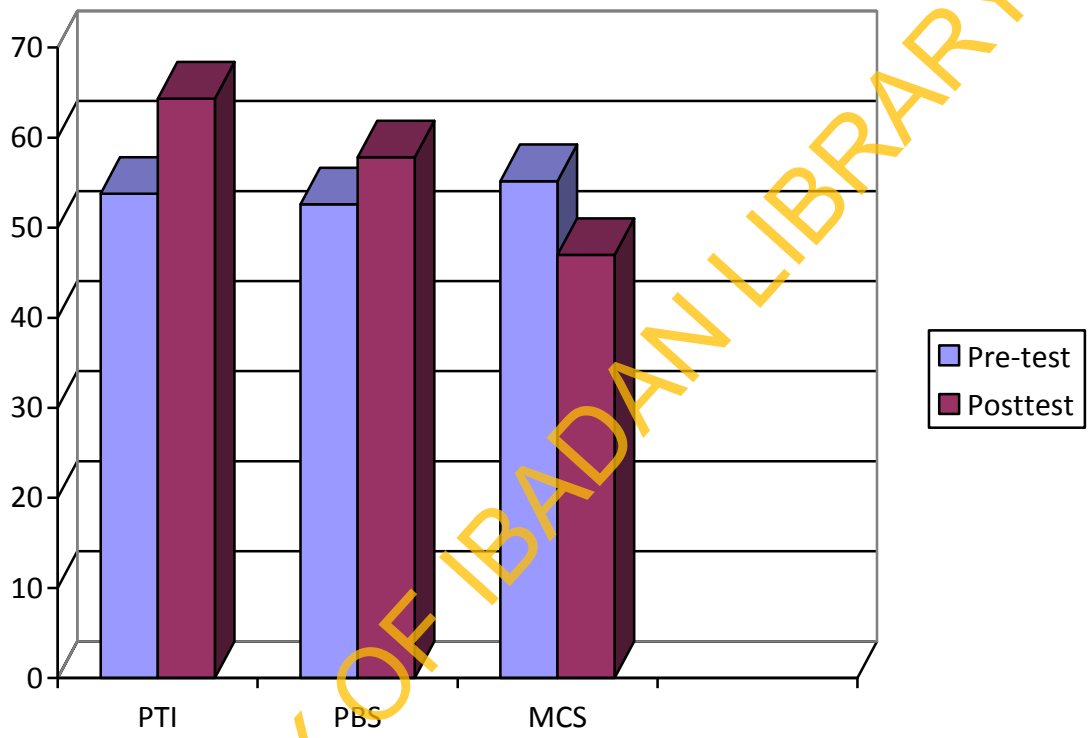


Fig 4.2: Bar chart showing Descriptive Statistics Associated with Treatment on attitude mean scores.

- PTI - Pre-Theoretic Intuition Quiz
- PBS - Puzzle-Based learning
- MCS - Modified Conventional strategy.

Figure 4.2 revealed the bar chart showing descriptive statistics associated with treatment on attitude mean scores.

The posttest scores improved for Pre-Theoretic Intuition Quiz in attitude scores by10.57.(Pretest mean =53.77 , Posttest mean = 64.34). Puzzle-Based learning posttest scores shows improvement with 5.22. (Pretest mean =52.59, Posttest mean =57.81). In case of Modified conventional strategy, the post test scores do not

improve in attitude scores.(Pretest mean =55.17 , Posttest mean = 46.97). The mean gain in descending order was; Pre-theoretic Intuition Quiz had higher mean gain than Puzzle-Based learning while Puzzle-Based learning had higher mean gain than Modified Conventional Strategy.

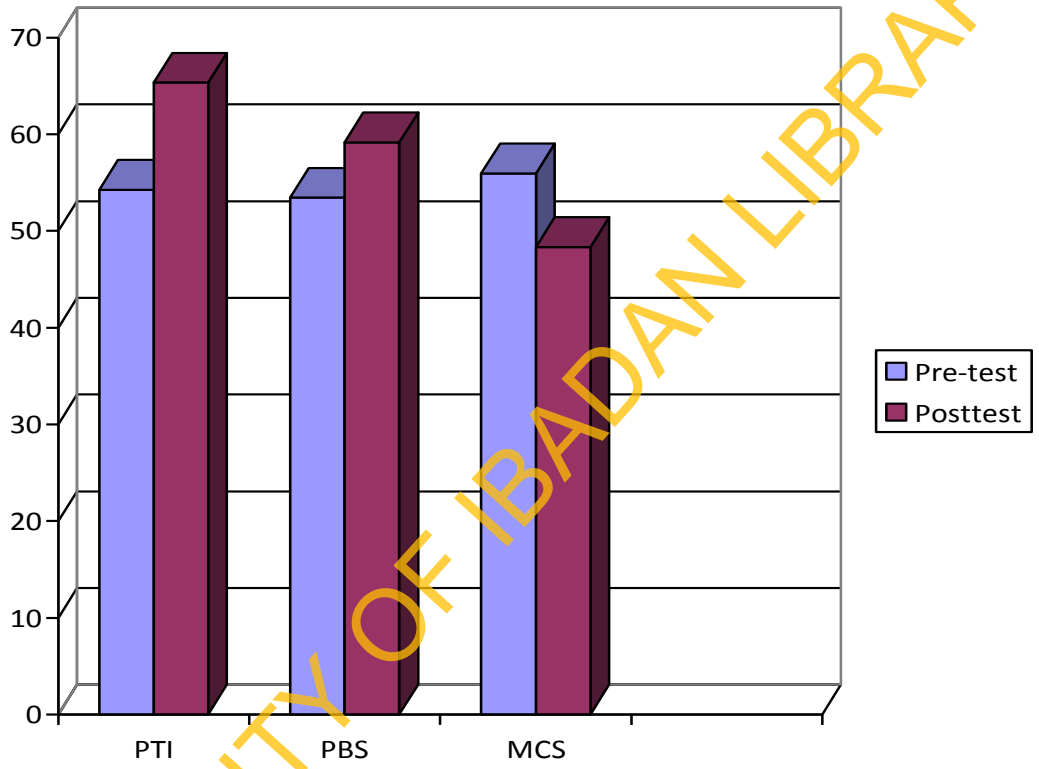


Fig 4.3: Bar chart showing descriptive statistics associated with treatment on Practices mean scores.

- PTI - Pre-Theoretic Institution Quiz
- PBS - Puzzle-Based learning
- MCS - Modified Conventional strategy.

Figure 4.3 revealed the bar chart showing descriptive statistics associated with treatment on Practices mean scores.

The post test scores improved for Pre-Theoretic Intuition Quiz in practices scores by 11.07.(Pretest mean =54.27 , Posttest mean = 65.34) and Puzzle-Based learning post test scores shows improvement with 5.74.(Pretest mean =53.44 , Posttest mean = 59.18). In case of Modified conventional strategy, the post test scores do not improve in practices scores.(Pretest mean =55.95 , Posttest mean =48.33). The mean gain in descending order was; Pre-theoretic Intuition Quiz had the highest mean gain followed by Puzzle-Based learning while Modified Conventional Strategy had the least mean gain.

4.1.2. Descriptive Statistics Associated with Gender

Table 4.2: Summary of Descriptive Statistics Associated with Gender

	Achievement Scores		**Attitude scores**		**Practice scores**	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
No of cases	189	262	189	262	189	262
Pre-test mean	9.40	8.76	60. 46	59.65	59.68	58.13
Pre-test S.D	.15	.01	.10	.06	.20	.06
Posttest mean	11.63	11.79	56.57	57.51	57. 15	58.08
Posttest S.D	4.95	6.29	2.38	3.03	2.38	3.03
Mean Gain	2.23	3.03	-3.89	-2.14	-2. 53	-.05

Table 4.2 displays the descriptive statistics of the students' achievement, attitude and practices scores with gender. . The mean gain in descending order was; female students had higher mean gain than male students

Figures 4.4, 4.5 and 4.6 displayed the bar charts showing the magnitude of descriptive statistics of the students' achievement, attitude and practices scores associated with gender as presented in Table 4.2.

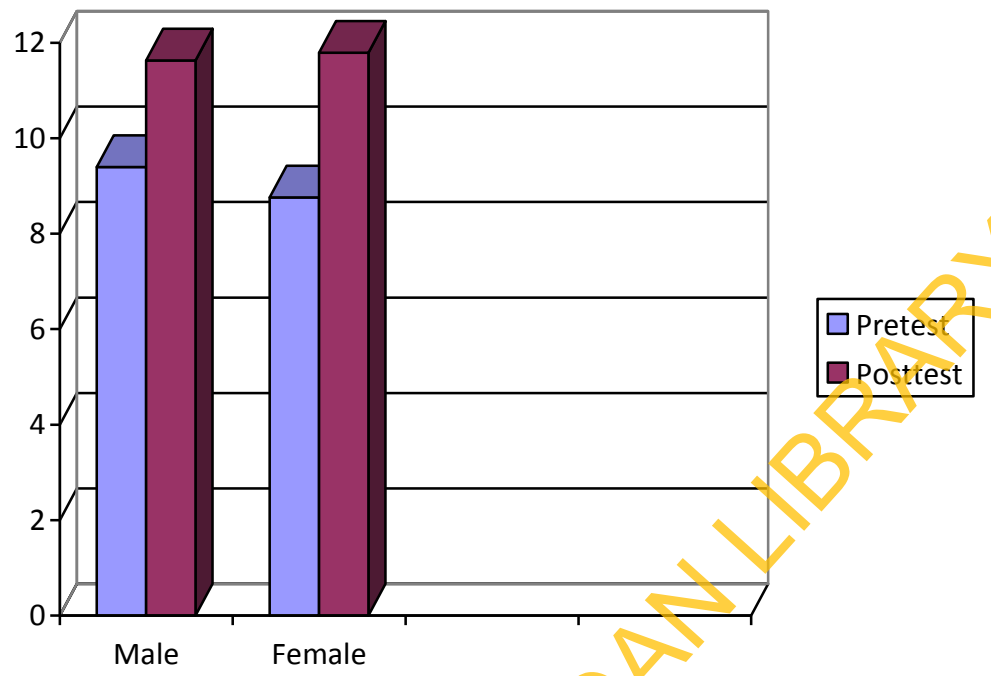


Fig 4.4: Bar chart showing descriptive statistics associated with achievement according to gender

Figure 4.4 revealed bar chart showing descriptive statistics associated with achievement according to gender.

There were improvements in male and female posttest achievement scores 2.23. (Pretest mean = 9.40, Posttest mean =11.63) and 3.03.(Pretest mean =8.76, Posttest mean =11.79) respectively.

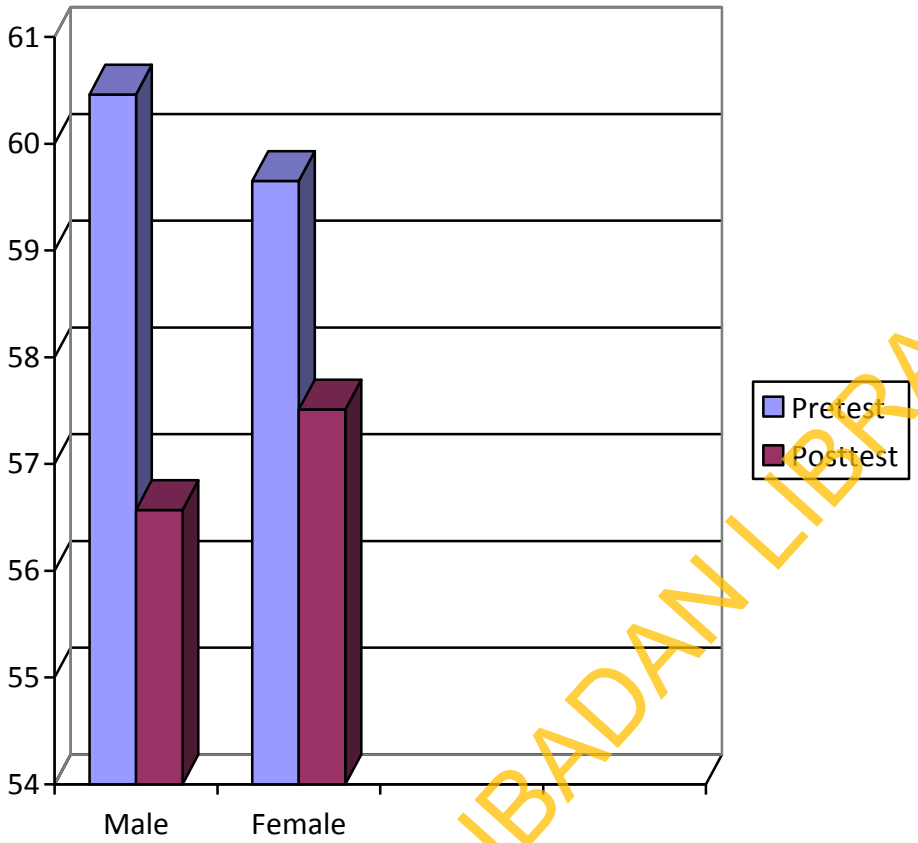


Fig 4.5: Bar chart showing descriptive statistics associated with attitude according to gender

There were no improvements in male and female posttest attitudinal scores -3.89. (Pretest mean =60.46, Posttest mean = 56.57) and -2.14. (Pretest mean =59.65, Posttest mean = 57.15) respectively. The attitude of male and female students to selected environmental concept was insignificant.

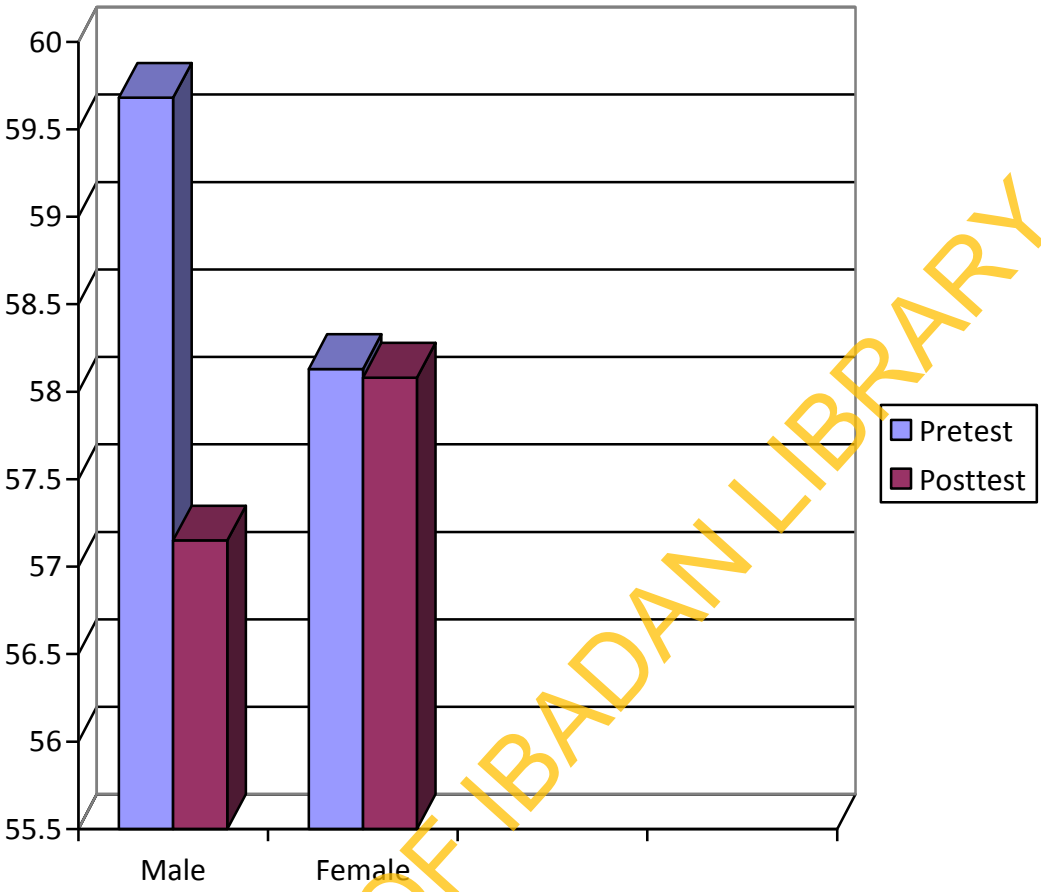


Fig 4.6: Bar chart showing descriptive statistics associated with practices according to gender

Figure 4.6: revealed Bar chart showing descriptive statistics associated with practices according to gender. There were no improvements in male and female practices scores -2. 53. (Pretest mean =59.68, Posttest mean =57.15) and - 0.5. (Pretest mean =58.13, Posttest mean =58.08) respectively There was no gain in mean scores of male students while there was an improvement in mean scores of Female students

4.1.3: Descriptive Statistics Associated with Cognitive Style

Table 4.3: Summary of Descriptive Statistics Associated with Cognitive Style

	Achievement Scores		Attitude scores		Practice scores	
	Analytical	Non Analytical	Analytical	Non Analytical	Analytical	Non Analytical
No of cases	264	187	264	187	264	187
Pre-test mean	9.19	8.86	63. 45	52.88	65.46	54.13
Pre-test S.D	.04	.05	.13	.19	.12	.16
Posttest mean	11.85	11. 57	57.03	57.06	57.63	57.60
Posttest S.D	6.29	4.90	3.03	2.30	3.03	2.29
Mean Gain	2.66	2.71	-6. 42	4.18	-7.83	3. 47

Table 4.3 displays the descriptive statistics of the student's achievement, attitude and practice scores associated with cognitive style. There were improvements in the Mean achievement scores of both analytic (2.66) and non-analytic (2.71) students but the Non analytic students show greater improvement in mean attitudinal scores (4.18) while there was no improvement in the mean attitudinal scores of analytic students (-6.42). The mean practice scores of non- analytic students' show greater improvement (3.47) than that of analytic students (-7.83).

Figures 4.7, 4.8 and 4.9 displayed the bar charts showing the magnitude of descriptive statistics of the students' achievement, attitude and practices scores associated with cognitive style as presented in Table 4.3.

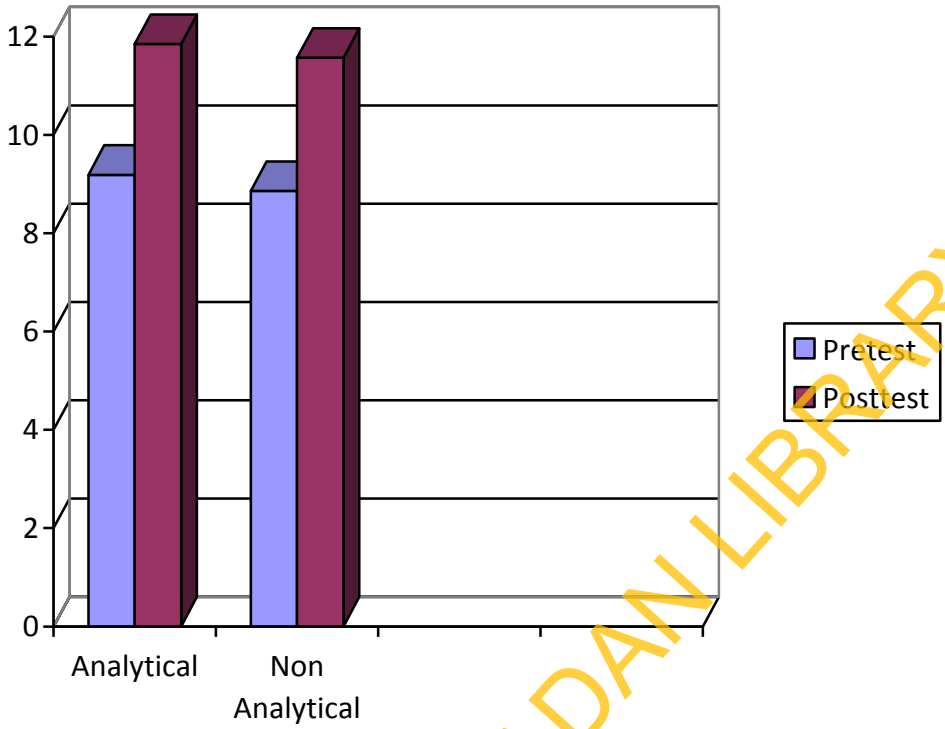


Fig 4.7: Bar chart showing descriptive statistics of achievement associated with cognitive Style

Figure 4.7 revealed the Bar chart showing descriptive statistics of achievement associated with Cognitive Style.

There were improvements in the mean achievement scores of analytic by 2.66. (Pretest mean =9.19, Posttest mean =11.85) and non-analytic students by 2.71 (Pretest mean =8.86, Posttest mean =11.57) .

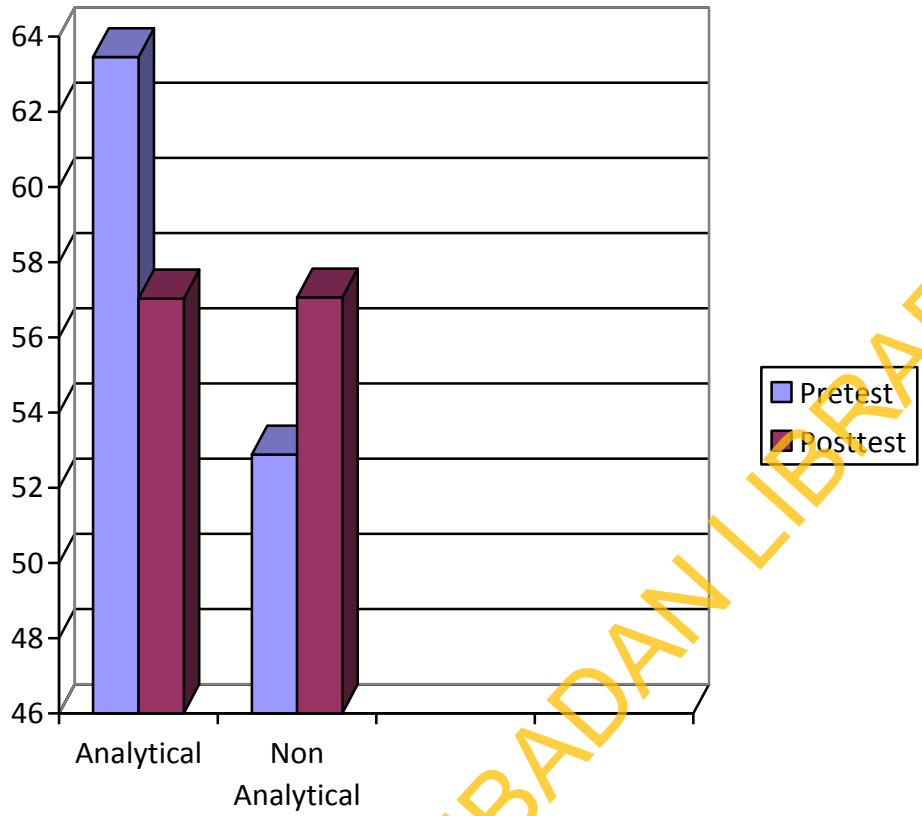


Fig 4.8: Bar chart showing descriptive statistics of attitude associated with cognitive Style

Figure 4.8 revealed the Bar chart showing descriptive statistics of attitude associated with cognitive style.

The Non analytic student shows greater improvement in Mean attitudinal scores by 4.18.(Pretest mean =52.88 , Posttest mean =57.06) while there was no improvement in the Mean attitudinal scores of analytic students by -6.42.(Pretest mean =63.45 , Posttest mean =57.03).

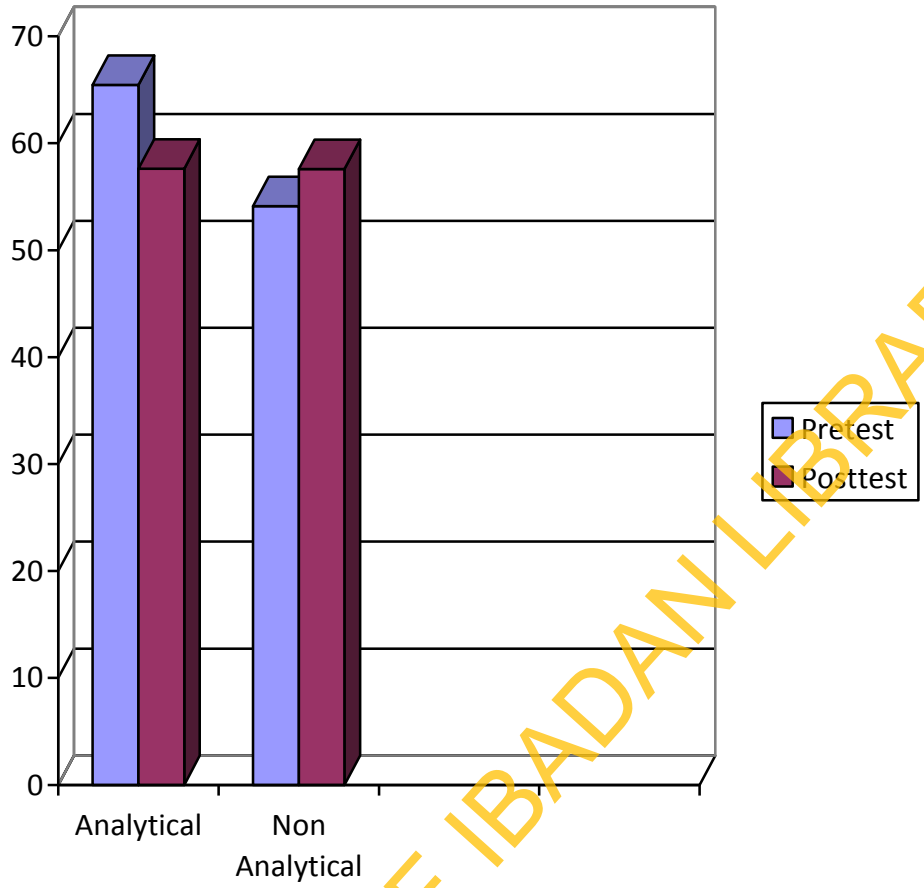


Fig 4.9: Bar chart showing descriptive statistics of practices associated with cognitive style

Figure 4.9 revealed bar chart showing descriptive statistics of practices associated with cognitive style.

The mean practice scores of non-analytic students' show greater improvement by 3.47(Pretest mean =54.13, Posttest mean =57.60) than that of analytic students by -7.83. (Pretest mean =65.46, Posttest mean = 57.63).

4.2. Testing of Hypotheses

Main Impact of Treatment

4.2.1a $H0_1a$: There is no significant main effect of treatment on students' environmental achievement.

Table 4.4 represents the summary of ANCOVA results on subjects' post test achievement scores.

Table 4.4: 3 X 2 X 2 ANCOVA of Post-test Achievement Scores of students by Treatment, Cognitive Style and Gender

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3512.202[a]	12	292.684	46.196	.000	.559
Intercept	4271.069	1	4271.069	674.128	.000	.606
PRE-ENVIRONMENTAL ACHIEVEMENT-TEST	348.605	1	348.605	55.022	.000	.112.
TREATMENT*	2656.177	2	1328.089	209.620	.000*	.489
COGNITIVE-STYLE*	7.162	1	7.162	1.130	.288	.003
GENDER*	2.386	1	2.386	.377	.540	.001
TREATMENT* COGNITIVE-STYLE*	18.207	2	9.103	1.437	.239	.007
TREATMENT* GENDER*	25.295	2	12.648	1.996	.137	.009
COGNITIVE-STYLE* GENDER*	.109	1	.109	.017	.896	.000
TREATMENT* COGNITIVE-STYLE* GENDER*	28.902	2	14.451	2.281	.103	.010
Error	2775.035	438	6.336			
Total	67448.000	451				
Corrected Total	6287.237	450				

R.Squared = .559 (Adjusted R. Squared = .547) *Significant at P<.05

Table 4.4 revealed that treatment had a significant effect on subjects' post-test achievement scores ($F_{(2,438)}$ = 209.620 ;<.05; partial eta squared = .489). The effect size of 48.9% was fair. The hypothesis was therefore rejected. This means that there was a significant difference in the mean achievement scores of subjects exposed to treatment. On the basis of these findings, hypothesis 1a was rejected. To find out the magnitude of the mean scores of the group's performance, Table 4.5 is presented as follows;

Table 4.5: Estimated Marginal Means of Posttest Achievement Scores by Treatment and Control Group

			95% Confidence Interval	
Treatment	Mean	Std Error	Lower Bound	Upper Bound
Pre- theoretic	.14.296	.242	13.820	14.772
Puzzle	12.614	.224	12.174	13.054
Conventional	8.227	..200	7.833	8.621

Table 4.5 revealed that students in the Pre-Theoretic Intuition Quiz treatment group had the highest adjusted posttest mean achievement scores (($\overline{X}$ = 14.296) followed by the Puzzle-Based learning treatment group (($\overline{X}$ = 12.614) while students in the Modified Conventional strategy group had the least adjusted mean achievement scores (($\overline{X}$ = 8.227).

Further, the source of the significant difference obtained in table 4.6 was traced using Scheffe post-hoc test.

Table 4.6: Scheffe Post-hoc tests Analysis of Post-test Achievement Score according to Treatment Group

Treatment	N	Mean	1.Pretheoretic	2. Puzzle	3 Conventional
1Pretheoretic	145	14.296		*	*
2. Puzzle	140	12.614	*		*
3.Conventional	166	8.227	*	*	

*Pairs of group significantly different at P<.05.

The result from post-hoc analysis in Table 4.6 revealed that group 1 (Pre-Theoretic Intuition Quiz) was significantly different from Puzzle-Based learning and Modified Conventional strategy strategies in their achievement scores. Puzzle-Based learning was significantly different from Pre-Theoretic Intuition Quiz and Modified Conventional

strategy in achievement scores, these revealed that the direction of increasing effect of instructional strategy (treatment) on environmental achievement was Modified Conventional strategy not performing better than Puzzle-Based learning, Puzzle-Based learning not performing better than Pre-Theoretic Intuition Quiz.

4.2.1b Ho1b: There is no significant main effect of treatment on students 'Environmental Attitude.

Table 4.7: 3 X 2 X 2 ANCOVA of Post-test Attitude Scores of students by Treatment, Cognitive Style and Gender

Source	Type II Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	24101.394	12	2008.449	73.661	.000	.669
Intercept	7069.451	1	7069.451	259.275	.000	.372
PRE-ENVIRONMENTAL ATTITUDE-SCALE	2056.439	1	2056.439	75.421	.000	.147
TREATMENT*	15668.385	2	7834.193	287.322	.000*	.567
COGNITIVE-STYLE*	.090	1	,090	.003	.954	.000
GENDER*	84.392	1	84.392	3.095	.079	.007
TREATMENT* COGNITIVE-STYLE*	46.969	2	23.485	.861	.423	.004
TREATMENT* GENDER*	88.525	2	44.263	1.623	.198	.007
COGNITIVE-STYLE* GENDER *	180.347	1	180.347	6.614	.010*	.015
TREATMENT* COGNITIVE-STYLE* GENDER*	176.570	2	88.285	3.2238	.040*	.015
Error	11942.624	438	27.266			
Total	1489511.000	451				
Corrected Total	36044.018	450				

R Squared=.669 (Adjusted R Squared = 660) *Significant at P < 0.05

Table 4.7 revealed that there was a significant effect of treatment on students' environmental attitude ($F_{(2,438)}$ = 287.322; P <0.05; partial eta squared = .567). The effect size of 56.7% was fair. On this basis, hypothesis 1b was rejected. This

means that the difference between the environmental attitude score of students exposed to treatment group was significant.

Table 4.8: Estimated Marginal Means of Posttest Attitude Score by Treatment and Control Group

Treatment	Mean	Std Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Pre theoretic	64.344	.502	63.358	65.331
Puzzle	57.808	..463	58.898	58.718
Conventional	48.973	.416	48.152	49.794 -

Table 4.8 revealed that students in the Pre-Theoretic Intuition Quiz treatment group had the highest adjusted posttest mean Attitude scores ($\overline{X}$ = 64.344) followed by the Puzzle-Based learning treatment group ($\overline{X}$ = 57.808) while students in the Modified Conventional strategy group had the least adjusted mean Attitude scores (($\overline{X}$ = 48.973).

Further, the source of the significant difference obtained was traced using Scheffe Post-hoc test in Table 4.9.

Table 4.9: Scheffe Post-hoc tests Analysis of Post-test Attitude Score According to Treatment Group

Treatment	N	Mean	1.Pretheoretic	2. Puzzle	3 Conventional
1Pretheoretic	145	64.344		*	*
2. Puzzle	140	57.808	*		*
3.Conventional	166	48.973	*	*	

*Pairs of group significantly different at P<.05

The result from post-hoc analysis in Table 4.9 revealed that attitude mean scores of students in Pre-Theoretic Intuition Quiz was significantly different better than Puzzle-Based learning while Puzzle-Based learning was significantly better than Modified Conventional strategy) in their mean attitude scores. these revealed that the direction of increasing effect of instructional strategy (treatment) on environmental attitude was Modified Conventional strategy did not perform better than Puzzle-Based learning, while Pre-Theoretic Intuition Quiz performed better than Puzzle-Based learning.

4.2.1c Ho 1c: There is no significant main effect of treatment on students' environmental Practices**.**

Table 4.10: Summary of 3 X 2 X 2 ANCOVA of Post-Test Practices by Treatment, Cognitive Style and Gender

Source	Type II Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	**25972.465[a]**	**12**	**2164.374**	**79.674**	**.000**	**.686**
Intercept	**8119.007**	**1**	**8119.007**	**298.872**	**.000**	**.406**
PRE-ENVIRONMENTAL-PRACTICES-SCALE	**1863.824**	**1**	**1863.924**	**68.614**	**.000**	**.135**
TREATMENT*	**19748.129**	**2.**	**9874.064**	**363.478**	**.000***	**.135**
COGNITIVE-STYLE*	**.083**	**1**	**.083**	**.0003**	**.956**	**.000**
GENDER*	**80.684**	**1**	**80.684**	**2.970**	**.086**	**.007**
TREATMENT* COGNITIVE-STYLE*	**42.067**	**2**	**21.034**	**.774**	**.462**	**.004**
TREATMENT* GENDER	**129.573**	**2**	**64.786**	**2.385**	**.093**	**.011**
COGNITIVE STYLE* GENDER*	**163.820**	**1**	**163.820**	**6.030**	**.014***	**.014**
TREATMENT* COGNITIVE-STYLE* GENDER*	**145.720**	**2**	**72.860**	**2.682**	**.070**	**.012**
Error	**11398**	**438**	**27.165**			
Total	**1518142.000**	**451**				
Corrected Total	**37870.949**	**450**				

R Squared = 686 (Adjusted R Squared = .677) *Significant of P < 0.05.

Table 4.10 revealed that there was significant main effect of treatment on students' environmental practices ($F_{(F_{(2,438)})}$ = 363.478; p < 0.05; partial eta squared = .135). The effect size of 13.5% was fair. Hypothesis 1c was therefore rejected. This implies that there was significant difference in the environmental practices of students exposed to the treatment.

Table 4.11: Estimated Marginal Means of Posttest Practices Score by Treatment and Control Group

Treatment	Mean	Std Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1Pretheoretic	65.337	.502	64.350	66.325
2. Puzzle	59.183	.466	58.268	60.098
3.Conventional	48.326	.414	47.512	49.139

Table 4.11 revealed students in the Pre-Theoretic Intuition Quiz treatment group had the highest adjusted post test mean environmental practices score ($\overline{X}$ = 65.337) followed by the Puzzle-Based learning treatment group ($\overline{X}$ = 59.183) while students in the Modified Conventional strategy group had the least adjusted mean environmental practices score ($\overline{X}$ = 48.326).

Further, the source of the significant difference obtained in Table 4.10 was traced using Scheffe post-hoc test in Table 4.12

Table 4.12: Scheffe Post-hoc tests Analysis of Post-test Practices Scores According to Treatment Group

Treatment	N	Mean	1.Pretheoretic	2. Puzzle	3 Conventional
1Pretheoretic	145	65.337		*	*
2. Puzzle	140	59.183	*		*
3.Conventional	166	48.326	*	*	

*Pairs of group significantly different at P<.05

The result from post-hoc analysis in Table 4.12 shows that group 1 (Pre-Theoretic Intuition Quiz) was significantly different from Puzzle-Based learning and Modified Conventional strategies in their practices score. Puzzle-Based learning was significantly different from Pre-Theoretic Intuition Quiz and Modified Conventional strategy in practices score. These revealed that the direction of increasing effect of instructional strategy (treatment) on environmental practices was :Modified Conventional strategy not performing better than Puzzle-Based learning, while Pre-Theoretic Intuition Quiz performed better than Puzzle-Based learning.

Main effect of Cognitive Style

4.2.2a H02a: There is no significant main effect of cognitive style on students' environmental achievement.

Table 4.4 revealed that cognitive style had no significant effect on the students' achievement ($F_{(1,438)}$) = 1.130; P< .05;. partial eta squared = .003). The effect size of .3% was negligible. Therefore, hypothesis 2a was not rejected.

Table 4.13: Estimated Marginal Means of Posttest Achievement Scores by Cognitive style

Cognitive style	Mean	Std Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Analytical	.11.851	.159	11.539	12.162
Non analytical	11.574	.204	11.173	11.975

From table 4.13 Analytical students had higher Mean = 11.851 while the non-analytical students had a lower mean = 11.574, but the difference was not significant

4.2.2b Ho2b: There is no significant main effect of cognitive style on students' Environmental Attitude.

Table 4.7 revealed that there was no significant effect of cognitive styles of participants on environmental attitude ($F_{(1,438)}$ = .003; p > .05; partial eta squared = .000). Hence hypothesis 2b was not rejected.

Table 4.14.Estimated Marginal Means of Posttest Attitude Scores by Cognitive style

Cognitive style	Mean	Std Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Analytical	.57.026	.334	56.369	57.662
Non analytical	57.058	.434	56.204	57.912

From table 4.14 non-analytical students had higher mean = 57.058 while the analytical students had a lower mean =57.026, but the difference was not significant

4.2.2c Ho 2c: There is no significant main effect of cognitive style on students' Environmental Practices.

Table 4.10 revealed that there was no significant effect of education level on participants' environmental practices ($F_{(1,438)}$ = .003; p > .05; partial eta squared = .000). Hence, hypothesis 2c was not rejected.

Table 4 15: Estimated Marginal Means of Posttest Practices Scores by Cognitive style

Cognitive style	Mean	Std Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Analytical	57.63i.	.333	56.977	58.285
Non analytical	57.600	.435	56.745	56.455

From table 4.15 Analytical students had higher mean =57.631 while the non-analytical students had a lower Mean = 57.600, but the difference was not significant

Main effect of gender

4.2.3a Ho 3a: There is no significant main effect of gender on students' environmental achievement**.**

Table 4.4 revealed that gender had no significant effect on students' achievement in environmental pollution. ($F_{(1,438)}$ = .377; p >0.0; partial eta squared = .001) The effect size of 0.1% was negligible. Therefore, hypothesis 3a was not rejected**.**

Table 4.16: Estimated Marginal Means of Posttest Achievement Scores by Gender

Gender	Mean	Std Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	11.633	.202	11.237	12.030
Female	11.791	.159	11.478	12.105

From table 4.16Female students had higher Mean = 11.791 while the Male students had a lower Mean =11.633, but the difference was not significant

4.2.3b Ho 3b: There is no significant main effect of gender on students' Environmental Attitude.

It was obtained from Table 4.7 that the effect of gender on participants environmental attitude was not significant ($F_{(1,438)} = 3.095$, $p > 0.05$; partial eta squared = .007) The effect size of 0.7% was negligible. Therefore, hypothesis Ho 3b was not rejected.

Table 4.17: Estimated Marginal Means of Posttest Attitude Scores by Gender

Gender	Mean	Std Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	56.571	.420	55.744	57.397
Female	57.513	.331	56.863	58.163

From table 4.17 Female students had higher mean =57.513 while the male students had a lower mean = 56.571, but the difference was not significant

4.2.3c Ho 3c: There is no significant main effect of gender on students' Environmental practice**.**

From Table 4.10, there was no significant effect of gender on participants' environmental practices ($F_{(1,438)} = 2.970$; $p < .05$; partial eta squared = .007) The effect size of 0.7% was negligible.. Hence, hypothesis 3c was not rejected.

Table 4.18: Estimated Marginal Means of Posttest Practices Scores by Gender

Gender	Mean	Std Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	57.154	.421	56.326	57.981
Female	58.077	.330	57.428	58.725

From table 4.18, Female students had higher Mean =58.077 while the Male students had a lower mean = 57.154, but the difference was not significant

Interaction effect of treatment and cognitive style

4.2.4a H04a: There is no significant interaction effect of treatment and cognitive style on students' environmental achievement.

Table 4.4, revealed that the 2-way interaction effect of treatment and cognitive style was not significant on subjects' achievement scores $F_{(2, 438)}$=1. 437; P<.05; partial eta squared = .007 . The effect size of 0.7% was negligible. Therefore, hypothesis 4a was not rejected

4.2.4b H04b: There is no significant interaction effect of treatment and cognitive style on students' attitude towards environmental pollution.

Table 4.7 revealed that the interaction effect of treatment and cognitive style on students' attitude scores was not significant ($F_{(2, 438)} = .861$;P<.05: partial eta

squared = .004) The effect size of 0.4% was negligible. Hence, hypothesis 4b was not rejected.

4.2.4c Ho 4c: There is no significant interaction effect of treatment and cognitive style on students' environmental practices.

Table 4.10 shows that there was no significant interaction effect of treatment and education level on students' environmental practices ($F_{(2, 438)}$ =.462; p > .05;. partial eta squared = 004 The effect size of 0.4% was negligible. This finding necessitated the non-rejection of hypothesis 4c.

Interaction effect of treatment and gender:

4.2.5a H05a: There is no significant interaction effect of treatment and gender on students' environmental achievement.

Table 4.4 revealed that there was no significant 2-way interaction effect of treatment and gender on subjects environmental achievement scores ($F_{(2, 438)}$ = 1.996; P<.05: partial eta squared = .009) The effect size of 0.9% was negligible, on the basis of this finding, hypothesis 5a was not rejected.

4.2.5b H05b: There is no significant interaction effect of treatment and gender on students' environmental attitude**.**

Table 4.7 revealed that there was no significant interaction effect of treatment and gender on students' attitude scores ($F_{(2, 438)}$ = .196; P<.05; partial eta squared = .007) The effect size of 0.7% was negligible. Hence, hypothesis 5b was not rejected.

4.2.5c Ho 5c: There is no significant interaction effect of treatment and gender on students' environmental Practices.

Table 4.10 revealed that there was no significant interaction effect of treatment and gender on students' environment. Practices ($F_{(2, 438)}$ = 1.623, p < .05: partial

eta squared = .011).The effect size of 1.1% was negligible. Hypothesis 5c was hereby not rejected.

Interaction effect of cognitive style and gender

4.2.6a H06a: There is no significant interaction effect of cognitive style and gender on students' environmental achievement.

Table 4.4 revealed that there was no significant interaction effect of cognitive style and gender on students achievement scores ($F_{(1,438)}$ = .017;P<.05; partial eta squared = .000). Hence, hypothesis 6a was not rejected.

4.2.6b H06b: There is no significant interaction effect of cognitive style and gender on students' environmental attitude

Table 4.7 revealed that there was significant interaction effect of cognitive style and gender on students' attitude towards environmental pollution scores ($F_{(1,438))}$ = 6.614;P<.05) partial eta squared = .015.The effect size of 1.5% was fair.

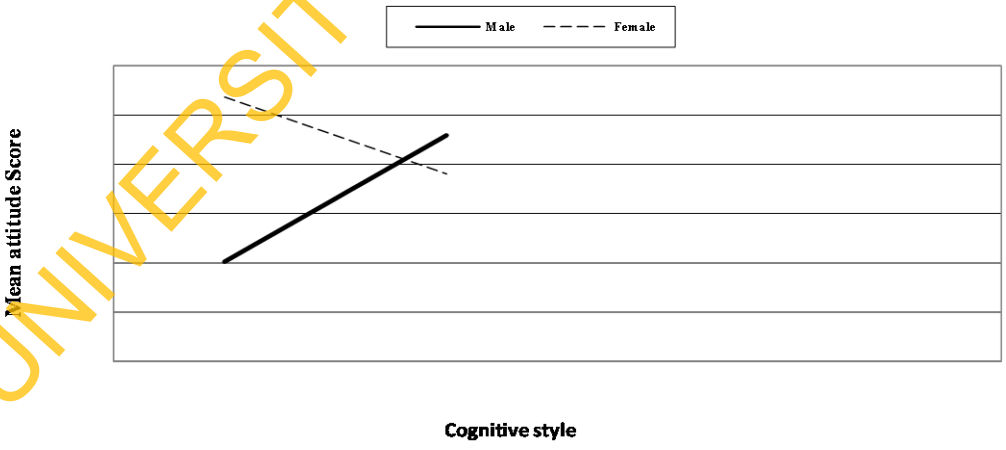


Figure 4.10: Graph showing interaction effect of Posttest attitude by Cognitive Style and Gender

Therefore, hypothesis 6b was rejected.

The graph in Figure 4.10 showed the interaction effect of Posttest attitude by cognitive style and gender. The highest contribution to the significance came from Female Analytical Students (Mean = 58.186) while the least came from Male Analytical Students (Mean = 55.866).The magnitude of contribution in ascending order include Male Analytical (Mean= 55.866) < Female Non Analytical (Mean= 56.841) < Male Non Analytical (Mean= 57.276) < Female Analytical (Mean= 58.186).

This interaction is disordinal. It means both the Gender and Cognitive Style worked together to produce a joint impact on students 'environmental attitude.

4.2.6c H06c: There is no significant interaction effect of cognitive style and gender on students' environmental practices

Table 4.10 revealed that there was significant interaction effect of cognitive style and gender on students' environmental Practices. ($F_{(1,438))} = 6.030; P<.05$; partial eta squared = .014) The effect size of 1.4% was fair. Hence hypothesis 6c was rejected.

.

,

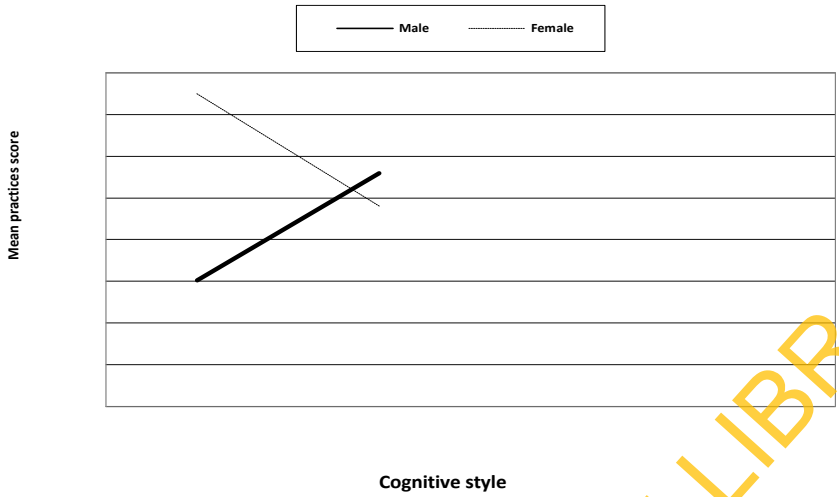


Figure 4.11: Graph showing interaction effect of Posttest Practices by Cognitive Style and Gender

The graph in Figure 4.11 showed the interaction effect of Posttest Practices by cognitive style and gender.

The major contribution to the significant interaction effects came from the categories of female Analytical students (Mean= 58.750) while the least came from Male Analytical students (Mean= 57.796). The magnitude of contribution in ascending order include male Analytical (Mean= 56.512) < female Non analytical (Mean= 57.403) < male Non analytical (Mean= 57.796) < female analytical (Mean= 58.750).

This interaction is disordinal. It means both the Gender and Cognitive Style worked together to produce a joint impact on students' environmental practices.

Interaction effect of treatment, cognitive style and gender

4.2.7a H07a: There is no significant interaction effect of treatment, cognitive style and gender on students' environmental achievement.

From Table 4.4, it was revealed that the 3 way interaction effect of treatment, cognitive style and gender on subjects' achievement scores was not significant ($F_{(2,\ 438)}$ =2.281;P<.05; partial eta squared = .01). The effect size of 1.0% is negligible. Hence, hypothesis 7a was not rejected.

4.2.7b H07b: There is no significant interaction effect of treatment, cognitive style and gender on students 'environmental attitude

From table 4.7, the 3-way interaction effect of treatment, cognitive style and gender on students attitudinal score was significant ($F_{(2,438)}$=3.238;P<.05; partial eta squared = .015) The effect size of 1.5% was fair. Hence, hypothesis 7b was rejected.

The magnitude of contribution to the significance was explained using figure 4.12 and 4.13.

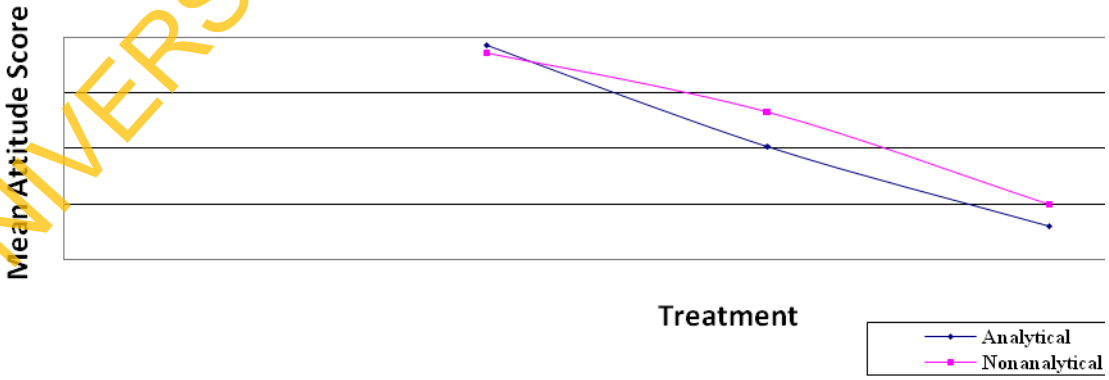


Fig. 4.12: Graph showing interaction effect of Posttest Enviornmental Attitude by Treatment, Cognitive Style and Gender (at Gender=Male)

Figure 4.12 revealed the estimated marginal means of post environmental attitude scores according to treatment and cognitive style (At Gender – male). The highest contribution came from Pre-theoretic Intuition Quiz Analytical Male Students with environmental (Mean = 64.314), while the least contribution came from modified conventional strategy analytical Male (Mean = 48.066). The magnitude of contribution in descending order include Pre-theoretic Intuition Quiz Analytical Male (Mean= 64.314) performing better than Pre-theoretic Intuition Quiz Non Analytical Male (Mean= 63.562) , Pre-theoretic Intuition Quiz Non Analytical Male (Mean= 63.562) performing better than Puzzle- Based Non Analytical Male (Mean= 58.270) , Puzzle- Based Non Analytical Male (Mean= 58.270) performing better than Puzzle- Based Analytical Male (Mean= 55.218) , Puzzle- Based Analytical Male (Mean= 55.218) performing better than Modified Conventional Non Analytical Male (Mean= 49.994), Modified Conventional Non Analytical Male (Mean= 49.994) performing better than Modified Conventional Analytical Male (Mean= 48.066) .This interaction is disordinal. It means both the treatment, gender (male) and cognitive style worked together to produce a joint impact on students' environmental attitude.

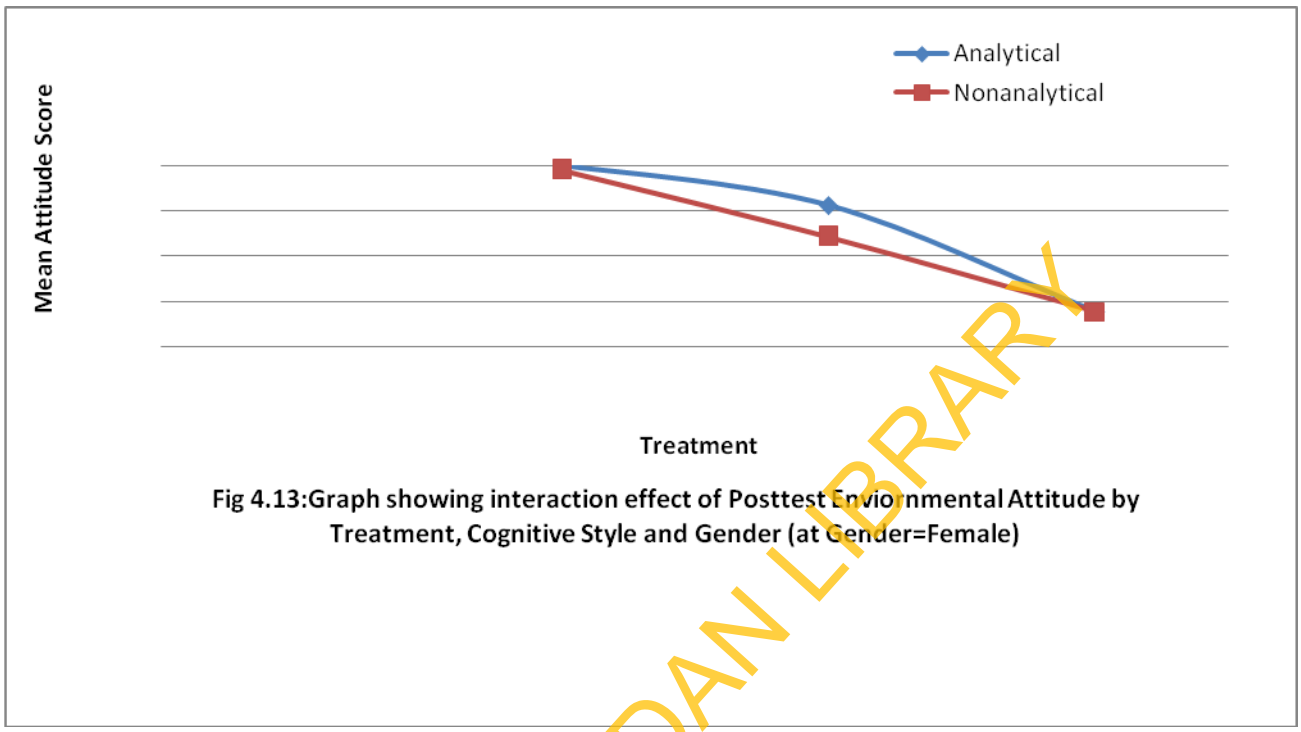


Fig 4.13:Graph showing interaction effect of Posttest Environmental Attitude by Treatment, Cognitive Style and Gender (at Gender=Female)

Figure 4.13 revealed the Estimated Marginal means of post environmental attitude scores according to treatment and cognitive style (At Gender – Female)

The highest contribution came from Pre-theoretic Intuition Quiz Analytical Female Students with environmental Mean = 65.030, while the least contribution came from Modified Conventional Strategy Non Analytical Female (Mean = 48.904). The magnitude of contribution in descending order include Pre-theoretic Intuition Quiz Analytical Female (Mean= 65.030) > Pre-theoretic Intuition Quiz Non Analytical Female (Mean= 64.472) > Puzzle- Based Analytical Female (Mean= 60.598) > Puzzle- Based Non Analytical Female (Mean= 57.145) > Modified Conventional Analytical Female (Mean= 48.929) > Modified Conventional Non Analytical Female (Mean= 48.904). Grand mean = 55.997. This interaction is disordinal. It means both the treatment, Gender (Female) and Cognitive Style worked together to produce a joint impact on students' environmental attitude.

4.2.7c H07c: There is no significant interaction effect of treatment, cognitive style and gender on students' environmental Practices.

From table 4.10, the 3-way interaction effect of treatment, cognitive style and gender on students 'environmental Practices was not significant ($F_{(2, 438)}$=2.682;P<.05; partial eta squared = .012) The effect size of 1.2% was negligible. Therefore, hypothesis 7c was not rejected.

4.3 Discussion

4.3.1 Effect of Treatment on Students Environmental Achievement, Attitude and Practices

There were significant differences in the effect of treatment on environmental achievement, attitudes and practices of the students exposed to Pre-Theoretic Intuition Quiz and Puzzle-Based learning as shown in Table 4.4, 4.7 and 4.10. This finding shows that both strategies Pre-Theoretic Intuition Quiz and Puzzle-Based learning) enhanced students' achievement attitudes and practices over and above the Modified Conventional strategy. This result suggests that the Pre-Theoretic Intuition Quiz effectively impacted the environmental achievement, attitudes and practices of learners exposed to it than those exposed to Puzzle-Based learning and Conventional strategies. These may be attributed to the nature of the Pre-Theoretic Intuition Quiz and Puzzle-Based learning developed and implemented in the course of the study in which the learners were allowed the freedom to engage in various learning activities that enabled them to construct their own knowledge of the concepts selected for the study as they individually or in their groups use their thinking skills to recall facts, observe, collect and group objects and resources in the environment as well as defined, explained and debated on issues. They also evaluated, summarized and drew conclusions on the lessons all by themselves with minimal teacher interference. These real life activities must have enormously influenced and as such impacted their environmental achievement.

Furthermore, the participation of the students in experimental group in activities that led to removal of misconceptions on the concept presented to students in the class involved a lot of critical thinking and evaluation of each other's input. Similarly the variety of ideas and views presented by the groups to the entire class generated a wider scope of information in relation to the concepts learnt as well as improved their spellings on EE concepts.

This finding is related to the findings of research conducted by Tessier (2006), using Pre-Theoretic Intuitions Quiz strategy. It was found that students' achievement scores significantly improved. It was also discovered that Attitudes toward environmental issues also improved tremendously. This finding is supported by Olagunju (2002). which suggested that every strategy for successful education on environmental management should be geared towards a change of the attitude and any strategy that will be successful in his area should aim at developing positive environmental attitude and actions among people, seek to stimulate people's awareness about their behavioural patterns and how best to get involved in pollution management activities and a development of a training programme that goes beyond theory but incorporates practical activities.

Puzzle-based strategy when compared with Modified Conventional Strategy by Anany,(2002) in analysis of algorithms showed that Puzzle-Based strategy was more effective. The findings further shown that there was better improvement in the learning outcomes of the participants treated with Puzzle-Based strategy than their counterparts treated with conventional method in algorithms.

The findings of this study support the research work of Ojo,2009 and Oduwaiye, 2009 that students achievement and attitudes correlated highly. Wlodkowski,(2008) emphasized that using critical thinking motivational strategy for every course will enhance concretely the sense of self-efficacy of learners and make clearly visible the actual work expected of them.

This study also revealed higher environmental practice scores for the learners exposed to the Pre-Theoretic Intuition Quiz and Puzzle-Based learning than those in the Modified Conventional Strategy. This implies that those in the Pre-Theoretic Intuition Quiz and Puzzle-Based learning acquired better environmental practices than their counterparts in the control group. This is likely to be as a result of the nature of the critical thinking and evaluation programme developed and implemented in the study which emphasized active learner participation. This corroborates the findings of UNESCO (1998,2001), UNESCO (2004), Mahanty (2003), WWF (2008), Ngothor, Fincham and Quinn (2004), who reported significantly high environmental practices of adults and adolescent learners exposed to their non-formal participatory EE programmes.

The poor performance of the modified conventional method (control) group in the posttest cognitive achievement mean score when compared with the other treatment groups' mean scores may not be unconnected with the fact that the group was taught with the method that is teacher-centered. Also, it may be as a result of inadequate practice on the part of the students which is an attribute of the conventional method. That is, the conventional method does not seem to involve students with related steps and activities which they need to go through in an attempt to accomplish a given task. Modified conventional method appears to only allow students to listen passively, with little or no interaction with the teacher. Thus the relatively low cognitive achievement in modified conventional lecture method group repeats itself in this study as it was the findings of Chukwuka (2006), Ajitoni (2009), Baron (2000), Olagunju (2002), Mansaray and Ajiboye (1997), Ajiboye (1997). This is because the modified conventional method often subjects the learners to the position of passive recipient of fact handed down to him by the teacher.

4.3.2 Effects of Gender on Students' Environmental Achievement, Attitude and Practices.

The findings appear to provide evidence that there is no significant main effect of gender on students' environmental achievement. That is, gender does not seem to influence the variations in environmental achievement. . These findings revealed that the treatment had about equal effect on both the male and female students. The implication is that the two instructional strategies seem to contain essential elements to enhance both male and female learning outcomes in the classroom. In other words, the two instructional strategies could have given the students equal opportunity regardless of their gender differences. This finding corroborate with the research findings of Ajiboye (1996), Olagunju (1998) and Bora (2003) that gender did not have a significant main effect on students' environmental achievement.

These findings however differ from other gender-related research findings of Mansaray (1985), Okebukola (1992) and Nwaubani (1996) who found significant difference between the male and female subjects with regard to achievement post-test mean scores of the experimental and control groups. The reason for this result might be that the teaching strategies used by the researchers were gender biased thereby favouring one sex than the other.

The reason for the non-significant difference between male and female in the post-test achievement scores could be attributed to the fact that both sexes were given the same opportunity to participate actively in the process of knowledge development and acquisition which are part and parcel of the two strategies. Also the fact that trained teachers of the experimental groups made sure that both male and female students participated actively together in all the stages of the two instructional strategies without discrimination may have accounted for this equal gain in knowledge.

In respect of environmental attitude posttest scores, show that gender has no significant effects on students' environmental attitude scores. The findings of

this study agree with those of Osakwe (1992), Nwaubani (1996), Lawal (1999), Olagunju (1998), and Bora (2003) that gender has no effect on subjects' environmental achievement and attitude. Similarly, in respect of environmental practices posttest scores, show that gender has no significant effects on students' environmental practices scores.The findings of this study agree with that of Ojo (2009)) that gender has no effect on subjects' environmental practices.

4.3.3 Effects of Cognitive Style on students' Environmental achievement, Attitude and Practices.

The findings appear to provide evidence that there is no significant main effect of Cognitive Style on students' environmental achievement, attitude and practices. That is, Cognitive style does not seem to influence the variations in environmental achievement, attitude and practices. Cognitive style or "thinking style" is a term used in cognitive psychology to describe the way individuals think, perceive and remember information. Cognitive style is the information processing habits which represent the learner's typical modes of perceiving, thinking, remembering, and problem solving. Cognitive style refers to a recurring pattern of perpetual and intellectual activity. Cultures provide people with a range of cognitive styles that are appropriate for different cognitive tasks in different context. Student's cognitive styles described different manners in which students perceive and analyze a stimulus configuration. The student's responses to various stimuli in environmental pollution had no significant effect on their achievement, attitude and practices. This study is consistent with the result of other researchers (Adeyemi, 1987, Agina-Obu, 1991; Amunmondion, 2008) but at variance with that of Ige (2001).

4.3.4 Interaction effect of treatment and gender on students' Environmental achievement, Attitude and Practices.

Treatment and students' genders had no significant interaction effect on students' achievement**,** attitude and practices post-test mean scores. This could mean that the treatment is suitable to both sexes with respect to the environmental concepts. It does not vary from male to female. This result agrees with the findings of Adesoji (1999), but disagrees with Ogunleye (2002).

4.3.5 Interaction Effect of Treatment and Cognitive Style on Students' Environmental Achievement, Attitude and Practices.

.There was no significant interaction effect of treatment and cognitive style on students environmental achievement, attitude and practices.

This could mean that the treatment is suitable to both analytic and non-analytic students with respect to the environmental concepts. It does not vary from analytical to non-analytical. Although Pre-theoretic intuition quiz analytical students group had higher posttest mean scores than their non- analytical counterparts but the difference was not significant. This result disagrees with Awofala (2002) that the personal variable of cognitive style interacts with instruction to produce results.

4.3.6 Interaction Effect of Cognitive Style and Gender on Students' Environmental Achievement, Attitude and Practices.

The results in Table 4.4 revealed that there was no significant interaction effect of cognitive style and gender on student's environmental achievement. However, Table 4.7 revealed the interaction effects of cognitive style and gender to be significant on students' environmental attitude. This finding corroborates the work of Adodo (2005) who identified that students attitude in science is directly

related to students cognitive styles. Giancarlo & Facione (2001) discovered that undergraduate thinking disposition changed significantly after two years.

Specifically, significant changes in students' tendency to seek truth and confidence in thinking occurred during the junior and senior years. Also, females tend to be more open-minded and have more mature judgment than males which indicates the characteristics of female analytical cognitive style group. Moreover, the attitude shown by female analytical group in the study as supported in the work of Ige (2001) confirmed that the autonomy and self-directness in analytic style promote their performance in attitude scores over non analytic counterparts.

Figures 4.1 and 4.2 also revealed that students that fall into analytical group obtained higher posttest mean scores in attitude and practices than their non-analytical counterparts. This could be explained by the fact that analytical group deals more with procedure and increased facility with science processes which is in accordance with the work of Ige (2001). It also (i.e. analytical group) enables students isolate relevant information in questions that contains both relevant and irrelevant data as recorded in questionnaires which require the use of implicit information. Furthermore, for future use of the strategies, more efforts should be extended to the foster improvement of the non-analytic students

Table 4.10 revealed that the interaction effects of cognitive style and gender was significant on students' environmental practices. Although Ojo (2009) had revealed in her study the positive relationship between environmental attitude and practices Lovelace (2005) confirmed that the self-directness in Female analytic style promote their performance in practices scores over non-analytic male counterparts. Ajiboye & Ajitoni (2008); Ajiboye & Silo (2008); Olagunju, 2002, confirmed that improved successes recorded in environmental practices in their various researches depend largely on acquisition and manipulation of necessary environmental practical skills by an individual. These attributes are possessed by analytical female students help them "to commit themselves toward working

individually and collectively for a better environment as well as for sustainable life styles (Giancarlo and Facione ,2001)

Non-analytical students (male or female) are likely to learn more effectively under conditions of intrinsic motivations (e.g. self-study) and are influenced less by social reinforcement (Daniel, & Reid, 2000). Individuals vary in predictable ways of cognitive style, that is, they differ in the way in which they gather and process information.

Csikszentmihaly, (1990) propounded the Flow Theory which states that "there is a deep absorption in an activity that is intrinsically enjoyable, as when artists and athletes are focused on their play or performance". Individual in this state perceive their performance to be pleasurable and successful and the activity is perceived as worth doing for its own sake, even if not further goal is reached . Flow theory is based on a symbiotic relationship between challenges and skills needed to meet those challenges.

Csikszentmihalyi (1990) reported that when students described optimal experiences (situations which are highly enjoyable), they often used the term flow. According to Csikszentmihalyi (1990), flow refers to the "spontaneous, seemingly effortless of flow experience of such experiences" a recurring aspect of flow experiences descriptions is the balance between perceived high levels of challenge and high levels of skills- the task is demanding but the enjoyment of the experiences also derives from having the skills necessary to complete the task Non-analytical students(male or female) are likely to learn more effectively when this theory is utilized in any teaching strategy a teacher uses. Researchers agree that students who engaged in this theory learn more, retain more, and enjoy learning activities more than students who are not engaged (Dowson & McInerney, 2001; Hancock & Betts, 2002; Voke, 2002).

4.3.7 Interaction Effect of Treatment, Cognitive Style and Gender on Students' Environmental Achievement, Attitude and Practices.

The results in Table 4.4, 4.7 and 4.10 revealed that the 3-way interaction effect of treatment, cognitive style and gender was not significant on environmental achievement and environmental practices; However, Table 4.4 revealed there was significant interaction effect of treatment, cognitive style and gender on students' environmental attitude. In other words, understanding and utilizing the core principles of critical motivation strategies to inculcate in both male and female students of different cognitive styles the right environmental attitude becomes inevitable. Also, female analytic cognitive style students exposed to pre-theoretic Intuition quiz strategy performed better than male gender based non- analytic in environmental attitude because these group of students were very critical in their thinking and were able to formulate their own ideas and provide additional source of information from their background and this may have enhanced their attitude towards environment (Atoyebi, 2000).

Female analytic cognitive style students as described by Giancarlo and Facione (2001) are the ideal critical thinkers that are habitually inquisitive, well-informed, trustful of reason, open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear about issues, orderly in complex matters, diligent in seeking relevant information, reasonable in the selection of criteria, focused in inquiry, and persistent in seeking results which are as precise as the subject and the circumstances of inquiry permit. Thus, educating good critical thinkers means working toward this ideal. It combines developing Critical thinking skills with nurturing those dispositions which consistently yield useful insights and which are the basis of a rational society to alter people's attitudes toward the environment and help them "to commit themselves toward working individually and collectively for a better environment as well as for sustainable life styles.

According to Eggen & Kauchak, (2006) model identifying prerequisite knowledge or prior knowledge which provides "hooks" for new learning, allowing connect new information with what they already understand. The key to effective assessment with this model is to ensure that students learn content at a meaningful level. This requires that students work actively with examples and concepts, linking them to the abstraction being taught. Using this model can improve environmental practices of non-analytical male students when combined with conventional strategy. The differential environmental achievement, attitude and practices of males and females who have different level of cognitive styles, coupled with the nature and levels of interaction among the two critical thinking motivational strategies indicate a need of considering non-analytical male student to be open-minded, flexible, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments.

John Dewey believes that children are socially active learners who learn by exploring their environment (Eggen and Kenchak, 2006). Dewey (1897) wrote

> *I believe that all education proceed by the participation of the individual in the social consciousness of the race. I believe that the only true education comes through the simulation of the child's powers by the demands of the social situation in which he finds himself, through these demands he is stimulated to act as a member of a unity, to emerge from his original narrowness of action and feeling and to conceive of himself from the standpoint of the welfare of the group to which he belongs.pp.142*

Schools should take the advantage of this mutual curiosity by bringing the outside world into the classroom making it available and accessible for students. He believes that there should be an integration of theory and practice, the cyclic pattern of experience and the conscious application of that learning experience.

Dewey proposed his concept of Critical thinking in his book, How We Think (1910; 1933). He substituted the word "inquiring" for "critical thinking" in

his later work, Logic: The Theory of inquiring (1938). Inquiring, according to Dewey (1933) is the "active, persistent, and careful consideration of any belief of supposed form of knowledge in the light of the grounds that support it and the further conclusion which it intends." Inquiring in this perspective seems to connote something more active and operational than thinking. It refers to the activity engaged in to overcome a situation of doubt to generate knowledge, with provisional and tenuous results, posited in the light of new experience and insight.

Using Dewey proposed concept of Critical thinking combined with Puzzle-based learning or conventional strategies may improve the performances of deficient non-analytical male students to be responsive in their environmental attitude to biology.

Working on the Work Theory by Schlechty (2001) states that "quality work increases students' engagement and results in improved performance. This theory focuses attention on student motivation and the strategies needed to increase the prospect that schools and teachers will be positioned to increase the presence of engaging tasks and activities in the routine life of the school. When students are authentically engaged in meaningful, quality work, the likelihood for them to learn something new and to remember what was learned increases (Hancock & Betts, 2003, Schlechty (2002), supported by the group at Center for Leadership in School Reform (CLSR), theorized that when teachers work on the quality of work they give students, the work will engage more students most of the time. Improve student academic performance will result from increased student participation because students work harder to achieve desired results, this may improve the performances deficient non-analytical male students to be responsive in their environmental attitude to biology.

4.4 Summary of Findings

The findings of this study could be summarized as follows:

1. There was a significant difference in the effect of treatment on environmental achievement, attitudes and practices of the students. This finding suggests that both strategies (Pre-Theoretic Intuition Quiz and Puzzle-Based learning) enhanced students' achievement, attitudes and practices of the students over and above the modified conventional strategy. The order in which the teaching strategies facilitated environmental achievement was Pre-Theoretic Intuition Quiz > Puzzle-Based learning >Modified Conventional strategy.
2. Cognitive style had no significant effect on the students' environmental pollution achievement, attitudes and practices of the students, that is, there was no significant difference in the environmental achievement, attitudes and practices of the students that belong to analytic and non-analytic groups.
3. Gender has no significant effect on the students' environmental pollution achievement, attitudes and practices that is; there was no significant difference in the environmental achievement, attitudes and practices of male and female students.
4. There was no significant interaction effect of treatment and cognitive style on students' environmental achievement, attitude and practices
5. There was no significant interaction effect of treatment and gender on students environmental achievement, attitude and practices.
6. There was a significant interaction effect of cognitive style and gender on students' environmental Attitude as well as Environmental Practices, However, there was no significant interaction effect of cognitive style and gender on students' environmental achievement

7. The 3-way interaction effect of treatment, cognitive style and gender was significant on students' environmental attitude; however, the interaction effect was not significant on environmental achievement and environmental practices.

CHAPTER FIVE

5.0 Summary, Educational Implications, Recommendations and Conclusion

5.1 Summary

This study, examined the effects of pre-theoretic intuition quiz and puzzle-based critical thinking motivation strategies on students' achievement, attitude and practices towards Environment-related concepts in Biology. It also examined the moderating effect of gender of the students and their cognitive styles on learning outcomes in Selected Environment-related concepts in Biology.

The research design used was pretest-posttest control group, quasi-experimental design using a 3x2x2 factorial matrix Eight instruments were used in this study to collect data:

i Students' Environmental Achievement Test (SEAT)

ii Students' Environmental Attitude Scale (SEAS)

iii Students' Environmental Practices Scale.(SEPS)

iv Cognitive Style Test (CST)

v Teachers' Instructional Guide (TIG) on Pre-theoretic Intuition Quiz Strategy on Environment-Related Concepts in Biology (TIGPT)

vi Teachers' Instructional Guide (TIG on Puzzle-Based Learning Strategy on Environment-Related Concepts in Biology (TIGPB)

vii Teachers' Instructional Guide (TIG) on Modified Conventional Strategy on Environment-Related Concepts in Biology (TIGCM)

viii Evaluation Sheet for Assessing Teachers Performance on the use of the Strategies (ESAT) on:-

(a) Pre-theoretic Intuition Quiz Strategy,

(b) Puzzle-Based Learning Strategy.

(c) Modified Conventional Strategy .

Four hundred and fifty one SS2 biology students (189 males and 362 females) from nine intact classes participated in the study. Four biology topics were used for the study. They were. (i) Air pollution (ii) water pollution (iii) land pollution (iv) conservation techniques, the following work schedule was adopted;

The first week was used for visitation to schools used for the study.

The next two (2) weeks for training of research assistants

One (1) week for scrutiny of research assistants used.

One (1) week for pretest (Administration of SEAS, SEAT and SEPS)

Eight (8) weeks for treatment using the trained research assistants on the listed strategies. These took place simultaneously in all the schools selected.

One (1) week Post-Test (Administration of SEAS, SEAT and SEPS)

This makes a total of fourteen (14) weeks.

The data collected were analysed using Analysis of Covariance (ANCOVA), Estimated Marginal Mean (EMM) and Scheffe post-hoc analysis.

The findings of this study revealed:

1. There was a significant difference in the effect of treatment on environmental achievement, attitudes and practices of the students.
2. Cognitive style had no significant effect on the students' environmental pollution achievement, attitudes and practices of the students
3. Gender has no significant effect on the students' environmental pollution achievement, attitudes and practices
4. There was no significant interaction effect of treatment and cognitive style on students environmental achievement, attitude and practices
5. There was no significant interaction effect of treatment and gender on students environmental achievement, attitude and practices.
6. There was no significant interaction effect of cognitive style and gender on students environmental achievement, however, the interaction effect was

significant on students' environmental Attitude as well as Environmental Practices

7. The 3-way interaction effect of treatment, cognitive style and gender was not significant on environmental achievement and environmental practices; however, the interaction effect was significant on students' environmental attitude.

5.2 Educational Implications.

The exposure of the learners to Pre-Theoretic Intuition Quiz and Puzzle-Based learning strategies have been found to positively affects the enhancement of students' environmental achievement, attitudes and Practices. The findings have therefore revealed importance of using teaching strategies that are participatory and learner centered where learners are trained to take control and direct their learning processes for effective learning.

The study also revealed that there is need to incorporate in our educational system the Pre-Theoretic Intuition Quiz and Puzzle-Based learning as strategies that could help in providing environmental cognitive achievement including the right attitudes and necessary practices needed to solve various environmental problems prevalent in our surroundings.

Teachers of biology must endeavour to match teaching strategies with the manner in which students receive and process information. Teachers should take cognizance of cognitive style of students in mediating learning and to impart right attitude and necessary practices toward resolving environmental problems that may arise from time to time in our country for a sustainable development. Understanding and utilizing the core principles of Critical Motivation Strategies to inculcate in both male and female students of different cognitive styles the right environmental attitude becomes inevitable because students will be very critical in their thinking and will be able to formulate their own ideas and provide additional source of information from their background and this may have enhanced their

attitude towards environment. Most of the differences encountered by students in learning could be described in terms of the different manner in which students perceive and analyse for details (analytical), others respond by making a general view of the whole materials (non analytical). It is believed that, for meaningful learning to take place most especially is science education consideration should be given to the cognitive style of individual learners and the relevant instructional strategies.

According to Eggen & Kauchak,(2006) model identifying prerequisite knowledge or prior knowledge which provides "hooks" for new learning, allowing connect new information with what they already understand. The key to effective assessment with this model is to ensure that students learn content at a meaningful level. This requires that students work actively with examples and concepts, linking them to the abstraction being taught. Using this model can improve environmental practices of non-analytical male students when combined with conventional strategy. The differential environmental achievement, attitude and practices of males and females who have different level of cognitive styles, coupled with the nature and levels of interaction among strategies of instruction indicate a need of considering these variables in future instructional arrangements.

John Dewey believes that children are socially active learners who learn by exploring their environment (Eggen and Kenchak, 2006). Schools should take the advantage of this mutual curiosity by bringing the outside world into the classroom making it available and accessible for students. He believes that there should be an integration of theory and practice, the cyclic pattern of experience and the conscious application of that learning experience. Dewey proposed his concept of Critical thinking in his book, How We Think (1910; 1933). He substituted the word "inquiring" for "critical thinking" in his later work, Logic: The Theory of inquiring (1938). Inquiring, according to Dewey (1933) is the "active, persistent, and careful consideration of any belief of supposed form of knowledge in the light of the grounds that support it and the further conclusion

which it intends." Inquiring in this perspective seems to connote something more active and operational than thinking. The theory combined with the two critical thinking motivational strategies taken into cognizance the non-autonomous characteristics of non-analytic male students will go a long way in improving their performance in environmental achievement, attitude and practices.

Maldonado (2005) model as used in this research proposed a conceptual framework for developing and evaluating puzzle in Science Education. The framework is based largely in part, upon research, development in cognitive science and developmental theories and utilization. This model can also be utilized by either male or female students of varying cognitive styles in order to improve both cognitive, affective and psychomotor domains of science education. The importance of this condition becomes more obvious when objective of promoting the level of environmental achievement; attitude and practises encouraging more equitable gender participation in biology are considered. There is therefore a need to intensify the effort of exposing teacher educators to this model of instructional strategies that respect the findings of the present study. It is also important that textbook authors should be aware of this new model of instruction and content organization so that they may reflect them in their writings.

Vygosky's theory of learning is basically on cognitive development. Two processes are involved in cognitive development, namely, the biological and physiological processes. According to him, children's behaviour emerges at the intersection of these two processes. The theory states that biological processes are quantitatively transformed into higher psychological functioning in developmental processes. According to him, all the physical changes are series of transformation, which were brought about by developmental processes. Children's development is as a result of the social and cultural processes. Vygosky also emphasis the social genesis of knowledge. To him every function in the (student's) cultural development appears twice: first, on the social level, and later, on the individual level. This social genesis of knowledge construction is comprised of three primary

assumptions: (a) knowledge and meaning are active creations of socialization; (b) knowledge and meaning are social creations and as such reflect social negotiation and consensus; and (c) knowledge and meaning are constructed for the purposes of social adaptation, discourse, and goal achievement (Doolittle, Hicks, Triplett, Nichols, and Young; 2006). These three assumptions are evident Critical Thinking Motivational strategies.

Vygosky believes that development is as a result of combination of speech and practical activities. His ideas also led to the notion of scaffolding which is a process of helping learners to move from a point of his initial difficulties on a topic, to a point where he received "help" they are able to perform. The theory also states that children are ready to learn a concept when their cognitive structures are able to incorporate some aspects of that concept. For example, different learners who are ready to learn a concept may learn different things about the concept from the same experience. He also conceptualized learning and development as a social and collaborative activity that cannot be "taught" to anyone. Rather, the learner constructs his own understanding in his own mind while the teacher acts as a facilitator just as in the two Critical thinking motivational strategies, which designs appropriate situations and support for learners to learn meaningfully. This includes incorporating classroom activities and providing learners with a sense of critical thinking skills to solve problems relating to environment in their community.

5.3 Recommendations

In the light of the results and discussion, the following recommendations are advanced:

- Pre-theoretic intuition quiz and puzzle-based learning strategies should be adopted as viable strategies for studying environmental pollution and conservation of natural resources as they involve the students in monitoring their learning process. These are viable

teaching strategies for improving achievement, attitude and necessary practices needed by students in selected environmental concept in our secondary schools like ecology, acid rain, ozone layer depletion, greenhouse effect, population, biodiversity.

- Teaching strategies such as pre-theoretic intuition quiz and puzzle-based learning that reduce the gender difference in environmental achievement, its attitudes and necessary practices as recorded in this research could be used as a basis for bringing about a reduction of anxiety in learning for both male and female students.
- Puzzle-based instructional strategy which gives a multi-sensory instruction which combines the use of Intuition and puzzle to create the optimal setting must be embraced by teachers and our curriculum planners as a better strategy compared to the teacher centered conventional strategy.
- Puzzle-based learning approach aims at encouraging science students to think about how they frame and solve problems not encountered at the end of some textbook chapters, hence the goal is to enhance student critical thinking and their problem solving skills, because many educators are interested in teaching thinking skills rather than teaching independent thinking or independent problem solving, they should learn to teach both independent thinking and problem solving.
- Teachers of biology must endeavour to match teaching strategies with the manner in which students receive and process information. Teachers should take cognizance of cognitive style of students in mediating learning and to impart right attitude and necessary practices toward resolving environmental problems that may arise from time to time in our country for a sustainable development. Understanding and utilizing the core principles of Critical

Motivation Strategies to inculcate in both male and female students of different cognitive styles the right environmental attitude becomes inevitable because students will be very critical in their thinking and will be able to formulate their own ideas and provide additional source of information from their background and this may have enhanced their attitude towards environment.

- Teachers should develop activities that will allow active students participation in the teaching and learning of Biology. These are activities in which students concentrate, experience enjoyment and are provided with immediate intrinsic satisfaction that builds a foundation of interest for the future.
- There is need to integrate into the school science various students' activities and materials involved in puzzle-based learning for teaching environmental pollution and conservation of natural resources as well as other concepts in biology. Teachers should authentically engaged students in this meaningful and quality classroom activities which can foster or enhance learning in Biology.
- Finally, there is need to integrate into the school science curriculum, systematic ways in which practicing teachers and would-be teachers can be trained in the use of pre-theoretic intuition quiz not only for teaching environmental pollution and conservation of natural resources in biology, but should be applied to other Biological concepts so as to produce qualified and well groomed students for biological courses in higher institutions.

5.4 Conclusion

This study is in line with the work of researchers who believe that strategy learning by teachers improves content learning of students (Olagunju,2002; Awolola,2009) and to develop strategies for resolving environmental problems leading to sustainable development in our country (Olagunju, 2002), thus as practicing teachers and would-be teachers were trained and became competent in the use of pre-theoretic intuition quiz and puzzle-based learning strategies in learning environmental concepts, their achievement in, attitude and practices towards environmental pollution will improved. Also, these strategies encouraged students to take control of their learning (as they are learner centered strategies) thus making students more critical in their thinking when compared with the traditional conventional teaching method which emphasized teacher activity over pupil involvement.

5.5 Limitations of the Study

Some constraints were encountered in the process of carrying out this study and may therefore limit the generalizability of the results. These constraints are stated as follows:

These include the fact that the present study was conducted in only nine schools in three local government areas of Oyo State (Ibadan North, Ibadan North East and Akinyele). There is therefore need to replicate this study using larger population in Oyo states. Also only four selected environmental education concepts in biology were used for the study.

Cognitive style and gender were the only moderator variables used in the study. It is however possible that many other moderator variables like engagement styles, socio-economic status of students, personality traits, location of the school could put a limitation on the extent to which the result of this study could be generalized. The findings would serve as a basic foundation for future studies in the area of Pre-Theoretic Intuition Quiz and Puzzle-Based learning strategies and

their proper utilization for effective, teaching and learning of biology in our secondary schools.

5.6 Contributions of the Study to Knowledge

This study has contributed to knowledge generally in the following ways:

- Pre-theoretic intuition quiz and puzzle-based learning strategies have been found to be effective in enhancing students' achievement, attitude and practices in environmental concepts in biology as revealed by the findings in the study. This result has provided a basis for curriculum innovation in the training, retraining and in-service programmes of would–be biology teachers and those who are already in the field respectively.
- The provision of enriched learning environment and well designed pre-theoretic intuition quiz and puzzle-based compatible instructional materials as revealed in this study will improve environmental achievement, its attitudes and necessary practices among students in teaching biology.
- pre-theoretic intuition quiz and puzzle-based encourages concept learning and studies have shown that the two strategies exposed students to a higher thinking order needed to recognize assumptions, evaluate controversy, and scrutinize inferences in alleviating the problem of low students' learning outcomes in biology

5.7 Suggestions for Further Studies

The researcher conducted this study only in three local government areas of Oyo State. There is need to replicate this study in other local government areas in more states of Nigeria in order to give room for valid generalization.

. It is hoped that samples may involve higher institutions scholars in which the independent and moderator variables may be applied to test their impact on students' learning outcomes.

It is also suggested that similar studies could be extended to other moderating variables like mental ability, social economic status and subject specialization. Other environmental concepts in biology such as ecology, acid rain, ozone layer depletion, greenhouse effect including other aspects of biology apart from environmental issues could be involved as this will enhance performance of our students in biological sciences.

Selected topics that could be studied include

(1) Variability, heredity and evolution
(2) Structure and physiology of organisms
(3) Cell and its environment
(4) Habitat and Population
(5) Skeletal and supporting system in animals
(6) Transport system in plants and animals
(7) Cellular respiration
(8) Feeding and nutrition in organism
(9) Alimentary system.

These are difficult concepts as indicated by Researchers Olagunju(2002), Ojo (2009) and Oduwaye (2009) including Chief examiners' reports (2002 to 2012).

REFERENCES

Abimbola. I.O 1984: A study to describe and explain the alternative conceptions related to human respiration by Nigerian form four students *Dissertation abstracts international,* 45(5), 1357-A,(No. DA 8414218).

---------1991: A determination of the readability of STAN biology._*Journal of Curriculum and Instruction*, 3(1&2), 15-28.

--------- 2013: The Misunderstood word in science towards a technology of perfect understanding of all. *In 123rd Inaugural lecture of University of Ilorin* (p22-31) Unilorin Press.

Abimbola I.O. & Baba.S 1996: Misconceptions and alternative conceptions in science textbooks: The role of Teachers as filters. *The America Biology Teacher,* 58(1) 14-19.

Abiona, O. F, 2001: Effectiveness of Three Modes of Instructional (Problem Solving, Analogy (Pictorial representation) concept mapping) On Students Environmental Attitudes, knowledge and skills in solid waste disposal. An *Unpublished M.Ed thesis*. *University of Ibadan*, Ibadan.

Abiona O. F. 2008: Effect of three modes of instruction on students environmental knowledge, attitudes and skills in solid wastes and sewage management in Biology. *An unpublished Ph.D thesis University of Ibadan*, Ibadan.

Abubakar .M.M. 2001: The Impact of Information Technology on the Biological Science: *Journal of Science Education 5(1 and 2)p.16-20.*

ACM, A.F.C, 2006. *A model curriculum for K-12 computer science*. Final Report of the ACM K-12 Task Force Curriculum Committee. New York.

Adams W. K. & Wieman C. E., 2010: Development and Validation of Instruments to Measure Learning of Expert-Like Thinking. *International Journal of Science Education, 1-24. First, DOI: 10.1080/09500693.2010.512369.*

Adara, O.A. and Eguabor, V.O. 2004: "Rain Forest Management and Curriculum Issues", in Okebukola, P and Akpan, B.B., eds: *Strategies for Environmental Education: Focus on Rain Forest ;* 43 – 71.

Adegbile, J.A. 2002: Advance Organiser and Secondary School Teacher, Teaching Strategies for Nigerian secondary schools. *Unpublished PhD Thesis, University of Ibadan.*

Adeleke, O.A. 1991: Promoting Population/Family Life Education Concepts through Enter-Educate Approach. A paper presented at the training workshop for lecturers of Alvan Ikoku College of Education Owerri.

Adesoji, F.A 1999: Mock Examination results and students' gender as correlates of performance in the senior secondary school certificate examination in mathematics; *African Journal of Education Research 5, 1; 101-107.*

Adesoji, F.A 2004: Science and Curriculum Development: An unpublished M.Ed. *Unpublished Lecture note, University of Ibadan.*

Adewale, J.G. 2002: Modern Trends in Physics Teaching at the Secondary School Level. In Ayodele, S.O. (2002) *Teaching Strategies for Nigerian Secondary Schools*, Ibadan: Powerhouse Publications.

Adeyemi, M.A. 1987: Effect of Cognitive style and Two Instructional Modes of Students' Achievement in Biology. *An Unpublished PhD Thesis, University of Ibadan.*

Adodo.S .O 2005: Correlates of Students Variables and achievement in Integrated science*; Journal of Educational Research and Development. 1(2) 208-214.*

Adu-Febiri, F. 2002: *Thinking skills in education: ideal and real academic cultures* .CDTL Agency (FEPA) Nigerian Biodiversity (First Draft), FEPA, The Presidency, Abuja, pp1-14.

Afuwape, M. O. 2004: The Effect of Computer-Assisted Instruction on Students' Attitude towards Integrated Science; *Nigeria Journal of Computer Literacy (NJCL) 5. (1) 40 - 51.*

Agina- Obu, T.N. 1991: Cognitive Styles, Problem-solving Paradigm and Achievement in Biology. *An Unpublished PhD Thesis.* University of Ibadan.

Ahove, M. 2007: 'Students' Perception, Attitude and Practical Steps Taken Towards Sustainable Development of the Environment *in Proceedings of the 50th Anniversary Conference of Science Teachers' Association of Nigeria*. 118 – 121.

Ajiboye J.O. 1997: A Self Learning Programme, The Modified Lecture Method and Students' Cognitive and Affective Outcomes in some population Education concepts. *Unpublished Ph.D Thesis,* University of Ibadan, Ibadan.

Ajiboye, J. O.& Olatundun , S. A. 2010: Impact of Some Environmental Education Outdoor Activities on Nigerian Primary School Pupils' Environmental Knowledge. Published in *Applied Environmental Education & Communication. Volume 9, Issue 3 July 2010 , pages 149 – 158.*

Ajiboye, J.O. and Silo, N. 2008: Enhancing Botswana Children's Environmental Knowledge, Attitude and Practices through the School Civic Club; *International Journal of Environmental and Science Education 3(3) 105-114.*

Ajitoni S.O. 2005: Effects of full and quasi participatory learning strategies on senior secondary pupils' environmental knowledge and attitude in Kwara State Nigeria. An unpublished Ph.D Thesis, Department of Teacher Education, University of Ibadan.

Ajitoni, S.O, 2009: The effect of environmental pollution on neighbourhood security in Ibadan, Oyo State, Nigeria A paper delivered at the social studies Association National Conference, Epe Lagos Nigeria.

Ajewole, G.A. 2002: Teaching Terrestrial Habitat in Biology to students in African Secondary Schools for sustainable development. *Proceedings of 43rd annual Conference of science teachers association Nigeria,* Nzewi, Uchenna Ed. Ibadan, HEBN 287-290.

Akpan, E.A 1995: "Socio-cultural and Economic Factors in Environmental Health" in Olaniran, N.S. Akpan, E.A. Ikpeme, EE and Udofia, G.A. (Ed). *Environment and Health,* Lagos: Macmillan Nig. Publishers. Ltd. For NCF pp. 157-174.

Allen, K ., 2006: The Statistics Concept Inventory; Development and Analysis of a Cognitive Assessment Instrument in Statistics. Doctoral dissertation, The University of Oklahoma American Association for the Advancement of Science 1989. Science for All Americans. A Project 2061 Report on Literacy Goals in Science, Mathematics, and Technology, Washington, DC.

Amphiah, J.G. 2002: A cross level study of conception of the nature of gasses held by students within Cape Coast Municipality. *Ghana Journal of Education and Teaching. 1 (2), 19-26.*

Amoo, S.A. and Rahman, M.A. 2004: Secondary School Students' Attitude to Learning of Mathematics in the world of information technology – implication for Mathematics Teachers Preparation in *Science Teachers Association of Nigeria (STAN) proceedings of the 45th Annual Conference* in Akale, M.A.G. Ed. Ibadan: HEBNPLC 175-182.

Aimunmondion, M.C. 2008: Effects of Thought-Flow Knowledge and Shared Reading Instructional Strategies on Senior Secondary School Students'

Achievement in English Reading Comprehension and Summary Writing. An Unpublished Post field Seminar Paper, Department of Teacher Education, University of Ibadan

Anany, L, 2002: *Introduction to the design and analysis of Algorithms*. Boston., Addson Westly, http://www. Carnegie Foundation. Org/classification index asp

Anany, L. and Mary, A.P. 2002: Using Puzzles in teaching algorithms. Proceeding of 23 SIGLSE technical *symposium on computer science education* Antinnati, Kentuky

Aremu, A 2005: Gender implications of the use of Video Drama in Environmental Education in A. Dada, A. Abimbade and O.O. Kolawole eds *Issues in language, Communication and Education.*. 342 – 352.

Aremu A. & John A. 2005: Gender implications of the use of video drama in environmental education**.** A book in honour of Caroline A. Okedara. *Dada A.* Akinbade and O.O. Kolawole, Eds. *Issues in language, communication and education.* Ibadan: Constellation books Pg 342-352

Aremu A. and Olasunkanmi I. 2007: Using Sodoku puzzle to enhance logical reasoning. ; *African Journal of Education Research 5, 1; 111-117.*

Arnold, H. E., Cohen, F. G., & Warner, A.2009: Youth and environmental action: perspectives of young environmental leaders on their formative influences. *Journal of environmental education, 40(3), 27-36.*

Association of American Colleges Universities(AACU) 2005: Liberal Education Outcomes: A Preliminary Report on Student Achievement in College, Washington, DC.

Atoyebi I.O., 2000: Overview of Environmental problem in Nigeria National Centre for Economic Management and Administration (NCEMA) . A Paper Presented at the Conference on Environment and Sustainable Development. Ibadan, 17-18 August.

Awofala, A.O.A., 2002: Concept Mapping Problem-Solving Paradigms and Achievement in Secondary School Mathematics. *An Unpublished M.Ed thesis*, University of Ibadan.

Awolola, S.A, 2009: Impact of brain-based instructional strategy on students learning outcomes in senior secondary school mathematics in selected local

government areas in Oyo state, Nigeria. Unpublished Ph.D Thesis, University of Ibadan.

Aworanti, O.A. & Abimbola I.O. 1997: The level of achievement on ecology concepts among Nigerian Final year secondary school students. *Journal of the Science Teachers Association of Nigeria, 32(1&2), 51-58.*

Ayanda O.E 2006: The influence of Teachers Acquisition, Preservation and improvisation of Biological Specimens on Students' Learning outcomes in Selected Secondary Schools in Lagos State. An Unpublished masters Degree, Project, Teacher Education Department, University of Ibadan.

Azzarito, L., & Ennis, C. October, 2003: A Sense of Connection: Toward Social Constructivist Physical Education. *Sport, Education & Society, 8*(2), 179. Retrieved May 10, 2009, from Academic Search Premier database.

Balogun, F. 2002: Application of Philosophy to Secondary School Teaching. In Ayodele, S.O. (2002) eds. *Teaching Strategies in Nigerian Secondary School.* Ibadan: Powerhouse Publication.

Blair, K. Schwartz, D. L., Biswas, G., & Leelawong K. 2007: Pedgogical Agent for Learning and Teaching: Teachable Agents. *Educational Technology, 47(1), 56-61.*

Berg, E. S. 2001: An assessment of community college students' learning styles, choice of instructional delivery method, withdrawal rates, and performance in writing intensive courses. *Dissertation Abstracts International*, 62 (10), 3246A.

Beyer, B.K. 1985: Critical thinking: What is it? *"Social Education,"* 49, 270-276.

Blacksmith Institute - September 2007: The World's most polluted places. *http://www.eurojournals.com/ejsr.htm*.

Bora, B., 2003: Values Education Strategies: Implication for Teaching Environmental Education. Conner Stone *Journal of Values Education* 40 (1) pp. 19-37.

Business-Higher Education Forum, and American Council on Education, 2003: *Building Nation of Learners: The Need for Changes in Teaching and Learning To Meet Global Challenges*, American Educational Research Journal, 29, 663-676.

Burbach, M. E., Matkin, G. S., &Fritz,S. M. 2004: Teaching critical thinking in an introductory leadership course utilizing active learning strategies: A confirmatory study. *College Student Journal,38(3), 482-493.*

Burris, C. C., & Welner, K. G. 2005: November Closing the achievement gap by detracking. *Phi Delta Kappan*, 86(8), 594–598.

Bybee, R. W., & Fuchs, B, 2006: Preparing the 21st century workforce: a new reform in science and technology education. *Journal of. Research in Science. Teaching. 43(4), 349–352*

Cameron, J., Pierce, W. D., Banko, K. M., & Gear, A. (2005). Achievement-based rewards and intrinsic motivation: A test of cognitive mediators. *Journal of Educational Psychology, 97*, 641-655.

Carnevale, A. P, American Society for Training Development ,1990. Workplace Basics: The Essential Skills Employers Want, San Francisco, CA; Jossey-Bass

Chukwuka. C.N. 2005: The effects of moral dilemma and problem-solving strategies on secondary school students' environmental knowledge, problem-solving achievement and attitudes in selected EE concepts in biology. Unpublished PhD Thesis. University of Ibadan.

Costa, A.L. (Ed.) 1985: "Developing minds: A resource book for teaching thinking." Alexandria, VA: *Association for Supervision and Curriculum Development*.

Csikszentmihalyi, M. 1990: *Flow: The Psychology of Optimal Experience* New York: Harper- perennial. 20, 426-443.

Daniel, E, and Reid, N. 2006: Cognitive Factors that can Potentially Affect Pupils Test Performance. Chemistry Education Research and Practice. Online http://www.nst.gov/sba/srs/seind02/10/cos/htm

D'Avanzo. C. 2008. Biology concept inventories: overview, status, and next steps. *Journal of BioScience 58: 1079-85*

D'Avanzo C, Anderson CW, Griffith A, Merrill J. 2010: Thinking like a biologist: Using diagnostic questions to help students reason with biological principles. (17 January 2010*; www.biodqc.org/*)

David, Michael, and Caroline 2010: Air Pollution Effects "Library think quest org/26026 Environmental Problem/air pollution-effects html. Retrieved 2010-08-26.

Ding, L, Chabay, R, Sherwood, B, & Beichner, R 2006: Evaluating an electricity and magnetism assessment tool: Brief Electricity and Magnetism Assessment (BEMA). Physics. Revised. Standardised Physics Edition. Research 2, 17-24.

deGroot, J. I. M., & Steg, L. 2010: Relationships between value orientation, self-determined motivational types and pro-environmental behavioral intentions. *Journal of environmental psychology, 30(4), 368-378.*

Dewey, J (1909/1997): *How we think*. New York: Houghton Mifflin.Wikipeadia

DiEnno, C., & Hilton, S.& Fall,2005: High School Students' Knowledge, Attitudes, and Levels of Enjoyment of an Environmental Education Unit on Nonnative Plants. *Journal of Environmental Education, 37(1), 13-25.* Retrieved May 10, 2009, from Academic Search Premier database.

Dowson, M. & McInerney, D.M. 2001: Psychological parameters of students' social & work avoidance goals: A quantitative investigation. *Journal of Educational psychology, 93, 35-42.*

Ebere, I. 2006. Breaking Gender Barriers on Achievement in STM, Using Hands-on, Minds-on Science: Implication for supply of Resources, *Science Teachers of Association of Nigeria Proceeding, 47th Annual Conference.*

Eggen P.,D., Kauchak D.,P. 2006: *Strategies and Models for Teachers Teaching Content and Thinking Skills*, 5th edition, Pearson Education Inc., 376 p., ISBN0-205-453325

Egu, S.B 2001: The Knowledge and Attitudes of Biology teachers and students toward the conservation of Nigerian environment. An unpublished M.Ed project, University of Ibadan.

Eguabor V.O. 2012: Environmental Education skills acquisition in primary school. In O.Abonyi (ed) STAN 53rd annual Conference Proceeding (pg307- 311) Abuja: HEBN Publishers Plc.

Ennis, R. H., and Weir, E. 1985: The Ennis-Weir Critical Thinking Essay Test, Pacific Grove CA: Midwest Publications. Retrieved Jan. 22, 2008 from http://www.nctq.org/stpy/

Fadoju, A.O. 2001: Combating Staleness and Burn Out among University Athletes in South West Nigeria. *African Journal of Cross-Cultural Psychology and Sport Facilitation (1), 52 59.*

Federal Government of Nigeria (FME) 2004: Nigerian National Policy on Education (Revised) Yaba, Lagos. NERDC Press (ed).

Federal Ministry of Education (FME) 2008: National Curriculum for Senior Secondary School Biology Lagos. Government Press.

Ferguson, L., Angell, T. & Tudor, M. 2001: Better test scores through *Environmental Education? Clearing*, 110, 20-22.

Fisher, A. 2001: *Critical Thinking. An Introduction* Cambridge University Press. 5:3:83-95

Gardener, P.L. 1994: Mathematics attitudes to science. Research in Science Education 25:3:283-295.

Garvin-Doxas & Klymkowsky, 2009: in Wilson CD, Anderson CW, Heidemann M, Merrill JE, Merritt BW, Richmond G, Sibley DF, Parker JM. 2007. *Assessing students' ability to trace matter in dynamic systems in cell biology*. CBE Life Sciences Education 5: 323-331.

Gbamanja S.P.T. 2001: Strategies for Teaching Waste Management to Higher Education Students. (P. Okebukola and B.B. Akpan eds *Strategies for Teaching Waste Management* STAN E.E. Project Series (5). 73-85

Giancarlo, C. A., and Facione, P. A. 2001: A look across four years at the disposition toward critical Gough A. 2002. Mutualism: A different Agenda for Environmental and Science Education. *International Journal of Science Education, 24, 1201-1215.*

Glaserfeld, E.. *Constructivism in education.year=1989*. Oxford England:Pergamon Press. http://eric.ed.gov/PDFS/ED444966.pdf

Gough, D. 2002: Thinking about Thinking. Alexandria, VA: National Association of Barnesville, GA, March, 2002.

Grace, M. & Ratcliffe, M. 2002: The Science and values that young people draw upon to make decisions about biological conservation issues. *International Journal of Science Education, 24, 1157-1169.*

Guardian.co.uk June 19, 2007:China overtakes US as world's biggest CO2 emitter. Guardian Times Newspaper,London 12-17

Gurian, M., Stevens, K., and King, K. 2008: Strategies for Teaching Boys and Girls. San Francisco, CA.: Jossey-Bass. Thinking among undergraduate students. *Journal of General. Education. 50(1), 29-55*.

Hacker, D.J., Dunlosky, J., &Graesser, A.C. 1998: Metacognition in educational theory and practice. Mahwah, NJ: Erlbaum. Koriat, A., & Bjork, R.A. (2005). Illusions of competence in monitoring ones knowledge during study. *Journal of Experimental Psychology, 31, 187-193.*

Hake RR 1998: Interactive-engagement versus traditional methods: a six-thousand-student survey of mechanics test data for introductory physics courses. American Journal of Physics 66: 64-74

Hand, B., and Prain, V. 2002: Teachers implementing writing-to-learn strategies in junior secondary science: a case study. *Science. Education Journal. 86(6), 737–755.*

Hancock, V. & Betts, F. 2002: Back to the future: Preparing learners for academic success in 2004 Learning and Leading with Technology. *International Journal of Science Education, 20(8), 989-999.*

Hawkins.J.M.1995 Oxford Advanced Learners' Dictionary 1995 edition, pg 330, Oxford University Press , Oxford London U.K. ISBN 8-18-962166-9.

Hestenes, D. 2006: Notes for a Modeling Theory of Science, Cognition and Instruction. Retrieved October 1, 2010,from http:// modeling asu.edu/ R &E/ Notes-on- modeling-Theory.pdf.

Hill, J. M. D. 2003: Puzzles and games : addressing different learning styles in teaching operating system concept.ACM Press 182-186.

Holmes, J., and Clizbe, E. 1997: Facing the 21st century. *Business. Education. Forum. 52(1), 33– 35.*

Howe, Robert W. and John F. Disinger, 2000: Environmental Activities for Teaching Critical Thinking. ERIC/SMEAC, Columbus, OH, 2000 (in press).

Idowu, C.B. and Ige A. 2007: Science Teacher's Assessment of puzzle games in the teaching of environment concepts of integrated science *Journal of Science Education vol. 4 No. 1*

Ifamuyiwa, S.A.; and Akinsola, M.K. 2008: Improving Senior Secondary Students' attitude towards Mathematics through self and Cooperative Instructional Strategies. *International Journal of Mathematical Education in Science and Technology. 39, 5:569 – 585;* Retrieved 9th July, 2008 from http://www.informaworld.com.

Igbokoko and Ibeneme O.T, 2006: Effect of some cognitive constructivism instructional Approaches on students Achievement and Retention in the study of Introductory Technology in Nigeria. *Journal of Science Teachers Association of Nigeria Vol.41 No 1 and 2.*

Ige T.A. ,2001: A Concept Mapping and Problem Solving teaching Strategies as Determinates of Achievement in secondary school Ecology: Ibadan. *Journal of Educational Studies Volume 1-(1), May 2001.*

Ikoh M.I 2009: Reforms and Innovation in Accounting Education; *Journal of Teacher Perspective 3 (3).*

Iroegbu.T.O. 1998: Problem Based learning numerical ability and gender and line graphic skills at Senior Secondary Physics in Ibadan. . Unpublished PhD Thesis. University of Ibadan.

Jekayinfa, A.A, Yusuf, M.O., Yahaya, L.A,& Yusuf. A., 2010: An overview of the philosophical, historical, political and socio-economic factors that have

impacted on the development of Universities in Nigeria. In J. Okojie, I. Oloyede, & P.A.I. Obanya (Eds), 50 years of University education in education in Nigeria: Evolution, achievement and Future directions (pp.47-64), Ilorin & Abuja: University of Ilorin & National Universities Commission.

James, T. & Olajide, J. O. 2011: Developing Entrepreneurship Teaching Approach Using "Words and Picture" Games in Integrated Science Classroom. *European Journal of Scientific Research. ISSN 1450-216X Vol. 52 No. 1 (2011), pp70-74 © Eorojournals Publishing, Inc. 2011* .

Jaiyeoba, I.A., 2002: Environment in Africa Atlases: Nigeria. Les Editions J.A., Paris pp.22-123.

JAMB, 2011: Joint Admission and Matriculation Board guidelines for Admission to First Degree Courses in Nigeria Universities and other Awarding Institution 2011/2012 session. http;//www.jambng.com.

Jarman, T, Ruth. L, McChane. P & Billy V 2001: Use the news: A study of secondary teachers use of Newspaper in the science classroom. *Journal of Biological Education, 35(2)69*

Johnson, J.D 2006: The place of information technology in University science teaching in Australia. Uniserve science news,5,5-8.

Kato Y and Kamii C.2001: .Piaget constructivism and childhood education in Japan, Prospects, XXXI(2) 161-173.

Kendalls, G., Parks, A and Spoerer 2008: A Survey of NP – complete puzzles, *International Computer Games Association Journal, 31 (1) pp. 13-84.*

Klymkowsky, Underwood, & Garvin-Doxas, 2010: In D'Avanzo C, Anderson CW, Griffith A, Merrill J. 2010. Thinking like a biologist: Using diagnostic questions to help students reason with biological principles.(17 January 2010

Klymkowsky, M. W. 2006: Can non majors courses lead to biological literacy? Do majors courses do any better? *Cellular. Biology. Education. 4*, 42–44

Knapp, D., & Benton, G.M. 2006: Episodic and semantic memories of a residential environmental education program. Environmental education research, 12(2), 165- 177

Lang H.,R., Evans D.,N. 2006. Models, Strategies and Methods for Effective Teaching, Pearson Education Inc. 509 p., ISBN 0-205-40841-9.

Lauric Williams and Robbert Kessler, 2001: Experimenting with industry pair programming model in the computer Science Classroom. *Journal of Science Education.*

Lawson, A. E. 2001: Using the learning cycle to teach biology concepts and reasoning patterns. *Journal of Biology Education. 35(4), 165–169.*

Leach, J., Driver, R., Scott, P.,& Wood-Robinson, C. 1992: Progression in understanding of ecological concepts by pupils aged 5 to *16*. Leeds, UK: The University of Leeds, Centre for Studies in Science and Mathematics Education.

Levi, L. October, 2000:. Gender equity in mathematics education. Teaching Children Mathematics, 2, 101-105.

Liras, A 2004: Teaching and learning the biological sciences and biological education. *Journal of Biological Education 28(3, 147-150)*

Lozano, R. 2001: Needs, practices and recommendations of active learning for today's radiation therapy student. *Radiologic Science Education.* 2001; 6(1): 17-28.

Lorenz Eric S. 2007: Pennsylvania State University Potential Health Effects of Pesticides. *water health connection.org*

Lovelace, M. 2005: Meta-analysis of experimental research based on the Dunn and Dunn Conversation between Psychology and Anthropology. *Ethos*, 36, 1-28 Critique.

Lundy, L. K., Irani, T. A., Ricketts, J.C., Eubanks, E. E., Rudd, R.D., & Gallo-Meagher, M. 2002: December.: *A mixed-methods study of undergraduate dispositions toward thinking critically about biotechnology*. Paper presented at the National Agricultural Education Research Conference, Las Vegas, NV.

Maal, N. 2004: *Learning via multisensory engagement.* Association Management. Washington, D.C.: American Society of Association Executives.

Mabawonku .I ,2001: Educating Women for Environmental Development in Nigeria: The Role of Information Agents and NGOs. *Ibadan Journal of Education Studies Volume 1 (1): 197 – 212.*

Mahanty, B. 2003. Doing it and Telling it. *Connect 28 (1, 2).*

Malcom, S. M., Abdallah, J., Chubin, D. E., and Grogan, K. 2005: A System of Solutions: Every School, Every Student, Washington, DC: American Association for the Advancement of Science.

Maldonado .M.2005: Model for Development, Using and Evaluating Puzzles for Teachin Puzzles: A pathetically neglected, commonly available resource children 51 (4) .

Mansaray A. and Ajiboye J.O. 1997: Environmental Education and Nigeria Students' knowledge, Attitude and Practices (KAP): Implications for Curriculum Development. *International Journal of Environmental Education and Information 16 (3) pp. 317 – 327.*

Mcaughtry N, 2005: Elaborating Pedagogical content knowledge :What it means to know students and Think about Teachers and Teaching: Theory and Practice. *International Journal of Environmental Education and Information*11(4), 379-395.

Meinhardt, P. L, 2009: Overview of Waterborne Disease Trends] MD, MPH, MA, Author. Retrieved on April 16, 2009

Merriam-Webster 2010 Pollution: Definition from the Merriam-Webster Online Dictionary webster.com. 2010-08-13 Retrieved 2010-08-26.

Meyers, C. and Jones, T.B. 1993: Promoting active learning. Strategies for the college classroom. San Francisco: Jossey-Bass, 1993.

Morribend, B 2004: Gender and Academic ability as Determinant of Students' affective and Cognitive Achievement in Environmental Education. *Journal of Environmental Value Education 98 (2) pp.10-25.*

Muller, D., Sharma, M., & Reimann, P. 2008: Raising cognitive load with linear multimedia to promote conceptual change. *Science Education, 92(2), 278-296.* Retrieved May 10, 2009, from Academic Search Premier database.

National Academy of Sciences, National Academy of Engineering, Institute of Medicine 2005: Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future, Washington, DC: Committee on Prospering in the Global Economy of the 21st Century.

National Teachers' Institute, 2011. Manual for the Re-training of Junior Secondary School Teachers Basic Science & Technology:Millenium Development Goals (MDGs) Project. September 2011. NTI Press. ISBN 978-35416-4-1.

Nicholas Falker, 2010: Puzzle-based Learning for engineering and Computer science. The LEEE *Computer Society.*

Ndioho.O.F.2007: Effect of Constructivist based Instructional model on senior secondary students achievement in Biology. In U. Nzewi (ed), *Science Teachers Association of Nigeria*, 50th Annual Conference Proceedings (pp98-101) Sokoto; Heinemann Educational Books.

Nehm R &Schonfeld I. S 2008: Measuring knowledge of natural selection: A comparison of the C.I.N.S., an open-response instrument, and an oral interview. *Journal of Research in Science Teaching, 45, 1131-1160.*

---------- 2010: The future of natural selection knowledge measurement: A reply to Anderson et al. (2010). *Journal of Research in Science Teaching, 47, 358-362.*

Nigeria Educational Research and Development Council (NERDC), 2009: *Senior Secondary Education Curriculum: Biology for Senior Secondary Schools* 1-3, Abuja: NERDC.

Ngotho, M. Fincham R. & Quinn N. 2004: Government, Business and Public: The Role of EE in Creating Sustainable Urban Places. *EE Research* 10(3) August P. 318-319.

Njoku, Z.C. 2004: Fostering the Application of Science Education Research findings in Nigerian Classrooms: Strategies and Need for Teachers' Professional Development. *45th Annual Conference Proceedings of Science Teachers Association of Nigeria*,, 217 – 222.

Noddings, N., November 1995: Teaching themes of caring. *Education Digest, 61*(3), 24–28.

Noibi Y 1993: Training and Education for Conservation and Sustainable Development**.** National Conference of E.E Proceedings NCF/WWF, 26-37.

Nwosu, A.A. 2003: Constructivism as an Innovative Model For Science Teaching: Importance and Extent of use in Secondary Schools; *Journal of Science Teachers Association of Nigeria, 38(1 and 2).*

----------, 2006: Biology Education for New Millennium. Science, Technology and Mathematics Education in Nigeria, in Busari (Ed), 42nd Annual Conference Proceedings of STAN.

Obioma, G. 2006: Resources for Science, Mathematics and Technology (STM) Education in the Context of Education Reforms in Nigeria Proceedings of *47th Annual Conference of Science Teachers Association of Nigeria, Nzewi, U. Ed. 3 – 7.*

----------2007: In Preface for National Curriculum for schools, NERDC Press.. Nigeria Proceedings of *47th Annual Conference of Science Teachers Association of Nigeria, Nzewi, U. Ed. 3 – 7.*

Obstfeld, Mauric and Kenneth Rogoff. 2001. The six major puzzles in International Macroeconomics. Is there a common Cause? In Ben S. Bernanke and Kenneth Rogoff, eds NBER *Macroeconomics* Annual 2002 Cambridge, MA:MII Press pp 339-390.

Odom AL, Barrow LH 1995: Development and application of a two-tier diagnostic test measuring college biology students' understanding of diffusion osmosis after a course of instruction*; Journal of Research In Science Teaching 32: 45-61.*

Oduwaiye, J.O. 2009: Impact of Computer-Assisted and Programmed Instructions on Pre-service Teachers Learning Outcomes in some Environmental Education Concept in Biology. unpublished doctoral thesis to the faculty of Education, University of Ibadan, Nigeria.

Office of Educational Research Improvement 1991: Striving for excellence: The National Education Goals, Washington, DC.

Ogueri, A.C. 2004: The need for environmental education in secondary education level in Nigeria: Problems and challenges. Retrieved 28/01/2010 from http://rudar/ruc.dk/bitstream/1800/331/1/the_Need_for.pdf

Ogunboyede M.O. 2011: Effects of Teachers Variables on the academic achievement of secondary schools students in South-West Nigeria. Akungba *Journal of Research in Education 1. (1) 163- 178*

Ogundiwin, O., A. 2006: Effectiveness of Analogy, Field Trip and Group Project Method On Students Learning Outcomes in Environmental Concept in Biology. An Unpublished M.Ed thesis. University of Ibadan.

Ogunleye, B.O. 2002: Evaluation of the Environmental Aspect of the Senior Secondary School Chemistry Curriculum in Ibadan, Nigeria. Unpublished Ph.D Thesis. University of Ibadan, Ibadan.

Ogunkola, B. J. 2000: Instructor - Experiences Students' Locus of Control and Infinite Entry Behaviour as Measure of Students Achievement on and Attitude Toward Biology. An Unpublished Ph.D. Thesis.University of Ibadan, Ibadan.

Ojo T. A. 2008: Impact of Video CD and Audio Cassette Instructions on Students Learning Outcomes in some Environmental Education Concept in Biology. Unpublished doctoral thesis to the faculty of Education, University of Ibadan, Nigeria.

Okebukola, P.O.A. 2001: Our Environmental our Density. A paper delivered at the distinguished lecture series of Adeniran Ogunsanya College of Education (AOCOED).

Okebukola.P, Akpan Ben, Ahove. A, Kola Olusanya and OgunsolaBandele, 1997: Six strategies as potentially effective for teaching some selected environmental concepts in biology: STAN. *45th Annual Conference Proceedings of Science Teachers Association of Nigeria*,, 210 – 212

Okeke, E.A.C. 2001: Women in Science, Technology and Mathematics Education in Nigeria, in Busari (Ed), 42nd Annual Conference Proceedings of STAN.

Okpala, N.P and Onocha, C.O. 1995: Students Factor as Correlates of Achievement in Physics. Physics Education. *A Journal of British Institute of Physics. 6 pp. 261-265.*

Oladapo S.O, 2011: Effects of a participatory environmental Education programme on market men and Women's knowledge attitudes and practices. In waste management in Oyo state, Nigeria. A Post Field Seminar Paper Presented at Department of Teacher Education, Faculty of Education University of Ibadan.

Oladele, F.K. 1991: A Science Technology Society Curriculum Model and Students Scientific World view and Learning Outcomes in Biology. Unpublished Ph.D. Thesis University of Ibadan.

Oladokun, T. 2001: The Relative Effectiveness of Concept Mapping, Analogy and Problem-solving Strategies on Students Learning outcomes in some Environmental Concept in Biology. Unpublished M.Ed Thesis University of Ibadan, Ibadan.

Olagunju A.M 2002: Environment Education for sustainable Development in Nigeria. Implication for Biological. Conference Proceeding of STAN on difficult concepts in STM Abeokuta.

Olagunju A.M. & Abiona O.F.2004: Effectiveness of Three Modes of instruction on Nigerian Biology Students Environmental Knowledge and Attitudes to Solid Wastes Disposal for Sustainable Development. A paper published, for presentation with published Abstract for CASTME international and CASTME Europe Conference in Nicosia, Cyprus. (15th- 18th April, 2004).

Olatoye, R. A. & Adekoya Y. M. 2010: Effect of Project-based, Demonstration and Lecture Teaching Strategies on Senior Secondary Students' Achievement in an Aspect of Agricultural Science. *International Journal of Education Research and Technology, vol. 1(1) June 2010 19-29.*

Olatundun, O. 2009: Impact of outdoor Educational Activities on Pupils' Environmental Knowledge and Attitude in selected primary schools in Ibadan Nigeria; is an unpublished doctoral thesis to the faculty of Education, University of Ibadan, Nigeria.

Olatunji, M.W. 2005: Misconception and alternative conceptions of biology concepts help by secondary school students and teachers in kwara state. Unpublished Ph.d, thesis, Department of Science Education, University of Ilorin, Ilorin, Nigeria.

Oludipe, B. & OludipeI.D. 2010: Effect of Constructivist-based Teaching Strategy on Academic Performance of Students in Integrated Science at the Junior Secondary School Level. *Educational Research and Reviews Vol 5 (7), pp. 347-353 July 2010.*

Onyejiaku, F.O. 1980: Effects of Cognitive Styles and Instructional Strategies on Academic Performance, An Unpublished Ph.D. Thesis, University of Ibadan, Ibadan, Nigeria.

Oriafor,S.O. 2003: Strategies for Teaching Science, Technology and Mathematics for Learners Gain In K.O. Oloruntegbe (Ed) Strategies for Enhancing the Teaching and Learning of Science, Technology and Mathematics for Learners Gain.

Orlich D.C., Harder R.J., Callahan R.C., Trevisan M.S., Brown A.H. 2010: Teaching Strategies – Guide to Effective Instruction. 9th edition, Wadsworth ENGAGE Learning. 381 p. ISBN-13: 978-1-4390-4566-4

Osokoya M.M. 2002: Modern Trends in the Teaching of Secondary Schools Chemistry – In Ayodele S.O. (ed) *Teaching Strategies for Nigerian Secondary Schools* pp. 213-229.

Paulson ,D.R, and Faust,J.L. 2009: Active Learning for the College Classroom (California State University, Los Angeles) http://www.acrel.org/sdrs/engaged.htm.

Paul, R.W. 1990: Bloom's taxonomy and critical thinking instruction. *Educational Leadership,* 42, 36-39.

Phillips, N, Duke, M. ,2002: The questioning skills clinical teachers and preceptors: A comparative study. *Journal of Advance Nursing. 2001*; 33(4): 523-532. Available at: Academic Search Premier database. Accessed September 12, 2002.

Piaget, J: 1954. The Theory of Stages in cognitive development in Green D, Ford M. and Tamed (Ed) 1971.*Measurement and Piaget.* New York; McGraw till 1 -11.

Pithers, R. T., & Soden, R. 2000: Critical thinking in education: A review. Educational Research, 42(3), 237-249. Richardson, V. (2003). *Constructivist pedagogy. Teachers College Record* 105(9), 1623-1640.

Powell, K and Wells, M 2002: The Effectiveness of three Experimental Teaching Approaches on students science learning in fifth grade public school classrooms. *The Journal of Environmental Education 13 pp.33-38*. Purdue University. April 7, 2008:

Project Kaleidoscope. 2006: *Transforming America's Scientific and Technological Infrastructure: Recommendations for Urgent Action, Washington,* DC: National Science Foundation

Raimi, S.M. 2003: Gender Differences in Acquisition of Practical Skills, Unpublished Paper Presented at the 1st National Conference on Science, Technology and Mathematics Education. School of Science, St. Andrew's College of Education, 17th – 20th, July.

Richardson, V. 2003: Constructivist Pedagogy. *Teachers College Record, 105*(9), 1623-1640. Retrieved May 10, 2009, doi:10.1046/j.1467-9620.2003.00303.x

Rim-Rukeh A. 2007: Environmental Education curriculum for secondary schools in Nigeria: suggestive Approaches for its implementation. *Asaba Journal of Educational Studies* 2(2): 117-121 published by Federal College Education (Technical), Asaba Delta State Nigeria.

Ross J.M, and Huang,O. 2001: Guiding Students thought programming puzzles: value and examples of java games assignment *SIGCSE* Vol 34 NO 4 94-98.

Schlechly, P.C. 2002: Working on the work: An action plan for teacher principals and superintended. San Francisco, Jossey-Bass.

Schlechty, P.C. 2001: Shaking up the school base. http://www.jisc,ac.uk /index.cfm. name = news circular 700

Scott, Kim. 2002: Puzzle Model. Http//www.scottkin.com/thinggames/index

Scott, K. 2006: What is puzzle? Http//www.scottkin.com/thinggames/index

Sellappah, S, Hussey, T, Blackmore, A, & McMurray, A.1998: The use of questioning strategies by clinical teachers. *Journal of Advance Nursing.* 1998; 28(1): 142-149.

Serj.T. 2002. Thinking and Literacy: *Statistical Educational Research Journal* 1 (1) 30- 45.

Sidhu G.K, Fook C.Y, & Kaur.S. 2011: Assessing ESL Teachers trainees content pedagogical, and professional knowledge base. *The assessment Books* 4(2), 3-18.

Smith, E., Anderson, C. 1986: Alternative conceptions of matter cycling in ecosystems. Paper presented at the annual meeting of the National Association for Researching Science Teaching. San Francisco, CA.

Smith MK, Wood WB, Knight JK 2008: The Genetics Concept Assessment: A New Concept Inventory for Gauging Student Understanding of Genetics. *CBE Life Science Education* 7(4): 422-430

Solomon, R.O. 2004: Gender differences and students achievement in Secondary School Biology in Okene Local Government Area of Kogi State. Unpublished M.Ed thesis, University of Ibadan Nigeria

Tessier, J. 2006: Writing assignment in a non major introductory ecology class. *Journal of College of Science. Teaching*. *35*(4), 25–29.

Thornton RK, Sokoloff DR 1998: Assessing student learning of Newton's laws Force and Motion Conceptual Evaluation and Evaluation of Active Learning Laboratory and Lecture Curricula. . *American Journal of Physics* 66: 338-352.

Umoren, G.U. 1991: A Science-Technology Society Paradigm and Cross River State Secondary School Students' Scientific Literary, Problem-Solving and Decision Making. Unpublished Ph.d. Thesis University of Ibadan, Ibadan.

Umozulike, J.C. 1992: Improving the Teaching and Learning of EE Topicthe National Primary Science Core Curriculum. Unpublished M.Ed. Research project, University of Lagos, Lagos.

UNESCO, 2001: Guidelines for the Development of Non-formal Environment Education. *Environmental Education Series 23*. Published by Division of Science Technical and Environmental Education.

UNESCO. 2004: Activity-Based Joyful Learning Approach. *Journal of Indian Education. 77-88.*

U.S. Department of Education, 1990*: National Goals for Education*, Washington, DC.

Voke, H. 2002. Feb. Motivating Students to Learn. ASCD Info brief, 2(28). Retrieved Sept 19, 2002 from *http://www.ascd.org/readingroom/infobrief/200202 Issue28.html*.

Vygostsky, L.S. 1978 Mind in Society .Cambridge, M.A Havard University.

WAEC,2002: *Chief Examiners' Report Nigeria WASSCE,2002 Biology*, pg 136-140

WAEC,2003: *Chief Examiners' Report Nigeria WASSCE,2003 Biology*, pg 130-136

WAEC,2004*: Chief Examiners Report Nigeria WASSCE 2004 Biology*, pg 126-132

WAEC,2005: *Chief Examiners' Report Nigeria WASSCE,2005 Biology*,

WAEC,2007: *Chief Examiners' Report Nigeria WASSCE,2007* Biology,

WAEC,2008*: Chief Examiners' Report Nigeria WASSCE,2008* Biology.

WAEC,2009. *Chief Examiners' Report Nigeria WASSCE,2009* Biology.

WAEC,2010. *Chief Examiners' Report Nigeria WASSCE,2010* Biology.

WAEC,2011. *Chief Examiners' Report Nigeria WASSCE,2011* Biology.

WAEC,2012. *Chief Examiners' Report Nigeria WASSCE,2012* Biology.

World Resources Institute: August 2008: Monthly Update: Air Pollution's Causes, Consequences and Solutions Submitted by Matt Kallman on Wed, 2008-08-20 18:22. http://www.calstatela.edu/dept/chem/chem2/Active/main.htm Retrieved on April 17, 2009

Wang, Q. 2008: A generic model for guiding the integration of ICT into teaching and learning. Innovations in Education & Teaching International, *45*(4), 411-419. Retrieved May 10, 2009, doi:10.1080/14703290802377307.

Wareing, C. 1981: Cognitive Style and Developing Scientific Attitudes in the SCIS Classroom". *Journal of Research in Science Teaching, 18.1:73-77.*

Waxler Adam 2010: Teaching Tips Machine, LLC Classroom Management

Adam Waxler<awaxler@tampabay.rr.com> Wikipedia, 2010 The free Encyclopedia. Wikipaedia, 2012 The free Encyclopeadia.

Wood, W. B. and Gentile, J. M. 2003: Teaching in a Research Context. *Journal of Research in Science Teaching, 17; 1;* 302:1510

Wright J, 1998. Chem. Ed. 75: 986-992.in Beichner, R. Testing student interpretation kinematics graphs, *American . Journal of. Physics., 62, 750-762*.

WWF, 2008. *Education for Sustainable Societies*. WWF – Brazil

Youssef, R 2004. The Effect of Teaching an Environmentally-oriented Science Unit on Students' Attitude and Achievement *Science Education International*, (1)pp.15-17.

Zmaczynski, S.K. 2002: Triangular table: chemistry puzzle and teaching device United States Patent Application *20020072046 Kind Code:A1* Aids Google

APPENDICES

APPENDIX IA

STUDENTS ENVIRONMENTAL ACHIVEMENT TEST (SEAT)

This test is mean to assess the students' intellectual achievement in environmental pollution in Biology.

Fill the test paper as possible by ticking ( ) where appropriate and complete the gap where necessary.

SECTION

Personal information (Biodata)

Name of School:

Sex: Male ( ) Female ( )

Class: SS___

SECTION B

Read the following items and circle (0) the most appropriate response.

1 Water pollution may occur by

(a) Discharge of fresh clean water on water bodies

(b) Deposition of adequate oxygen on water bodies

(c) Discharge of sewage and other wastes on water bodies

(d) Avoidance of spillage when loading tankers

2 Waste may occur in various forms, what form does Sewage exist:

(a) Solid waste

(b) Liquid waste

(c) Gaseous waste

(d) Refined waste

3 How is the effect of land pollutant similar to that of air pollutant?

(a) Air carries land pollutant to exert its effect

(b) The moment the plant are affected by air pollutant through absorptions man invariably gets contaminated after eating from the crop

(c) The insect pest may transmit the pathogen of air pollutant to man

(d) Land and air pollutants are taken in through nasal opening

4 The following are examples of conservation agencies expect

(a) National Electric Power Authority (NEPA)

(b) River Basin Development Authorities

(c) Nigeria Conservation Foundation

(d) Union Bank of Nigeria PLC

5. With the knowledge of water and land pollution what does this tells you about fisheries conservation methods

(a) Water pollution must be avoided to keep the adult fish and fingerlings alive

(b) Water pollutants will increase fingerlings population

(c) Discharge of solid waste into water bodies to supply plankton (fish food)

(d) Game farming must be adopted

6 The following materials are land or soil pollutants expect

(a) Discarded objects

(b) Food waste

(c) Industrial waste of land

(d) Oxygen from atmosphere

7. The burning of rubbish in controlled incinerator is a conservative technique of which resources

(a) Wild life

(b) Land or soil

(c) Fisheries

(d) Forest

8. Smoke and soot as air pollutants pose similar effect on plant and animal life by

(a) Irritating respiratory passages

(b) Elongate the life span

(c) Improve yield of crop

(d) Release of oxygen to atmosphere

9 The expected result in a densely populated area with the presence of air pollutant, if all avenues to protect the environment fails are as follows expect

(a) Increase in mortality rate

(b) Decrease and extinction of weaker organisms

(c) Migration from the polluted area into a conducive environment

(d) Adequate management of resources

10. If refuse dump on land encouraged breeding of pests then its effect on plant and animal life could be any of the following:

(a) Improvement in game forest

(b) Poor crop yield and the community can be poisoned

(c) More energy and time will be needed to kill the pests

(d) More land should be allotted to the community

11. Soot obtained from industrial furnaces and domestic fires that contain carbon particles which settle on vegetation has the following effect on plant and animal life expect

(a) Reduce light received for photosynthesis

(b) May kill the plant

(c) Reduce crop yield

(d) Purifies the surrounding air

12 . Household refuse and organic wastes are pollutants that equally pollute the land or soil at the same time. The similarities stem from

(a) Contamination of streams, decomposition that attracts flies and enters the food chain

(b) Burning of the waste to produce smoke

(c) Bad odour emitted from the waste

(d) Treatment of gases that may contaminate drinking water.

. 13 Choose the most sensible statement

(a) Solid waste deposited on land should be taken seriously in Nigeria

(b) Solid waste deposited on land is no problem in Nigeria

(c) Infection cannot result from improper solid waste disposal

(d) Rural dwellers need not worry about solid waste because they do not produce solid waste.

14 Throwing feaces into streams can lead to:

(a). Waste water treatment

(b). Water pollution

(c). Environmentalsanitation

(d). Erosion

15 How can water conservation techniques be used to control pollution, this is through;

(a). Adequate control and use of ground water.

(b). Research centers should be encouraged on adequate form of recycling water and sewages

(c). Water should not be allowed to spill all over the towns e.g. burst water pipe.

(d). Oil spillage on water bodies to control mosquitoes

16. Ways of assessing the effect of air pollution on the environment are as follows expect

(a) Measure the irritation that air pollutant can cause on eye and nose

(b) Judge the lead poisoning effect on children's intelligence quotient (IQ)

(c) Indicate the rate of which Nitrogen oxides irritate the lungs

(d) The use of lead free fuels

17 By identifying the conservative techniques of land and water resources what does this tells you about land and water pollution

(a) Land and water pollutant have the same source

(b) The moment the land is polluted, the effect is transferred to the water source

(c) Land pollution has nothing to do with water pollution

(d) Land and water pollution has no effect on human life

18 Air pollution is mainly cause by air borne particles which include

(a) Oil spillage

(b) Carbon monoxide

(c) Old cans

(d) Detergents

19 The air pollutant which combines with the haemoglobin in blood and prevents oxygen from combining is termed

(a) Oxides of oxygen

(b) Soot

(c) Smoke

(d) Carbon monoxide

20 If detergents may be used to check oil spillage then detergent is one of the

. (a) control of Land pollution

(b) control of Air pollution

(c) control of Water pollution

(d) control of Soil pollution

APPENDIX IB

ANSWER SHEET

STUDENTS ENVIRONMENTAL ACHIVEMENT TEST (SEAT)

INSTRUCTIONS: Tick the best option from A-D

Personal information (Biodata)
Name of School:
Sex: Male ( ) Female ( )
Class: SS___

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

APPENDIX IIA

STUDENTS' ENVIRONMENTAL ATTITUDE SCALE (SEAS)

INTRODUCTION: This Scale intends to investigate your attitude towards environmental pollution and conservation techniques.

SECTION A

Personal information (Biodata)

Name of school:

Sex: Male ( ) Female ( )

Class: SS___

SECTION B

Mark the correct response as it is applicable to you for each of the items. There are four options ranging from Strongly Agreed (SA) Agree (A) Disagree (DA) to Strongly Disagree (SD).

SA – for the statement you wholly agree with

A – for the statement you slightly agree with

DA – for the statement you slightly disagree with

SD – for the statement you strongly disagree with.

S/N	STATEMENT	SA	S	DA	SD
1	I think it will be difficult to make our illiterate populace understand air pollution.				
2	I think air pollution is only a problem that affects female gender but not everybody.				
3	I feel field investigation of causes of air pollution could help in research work to eradicate air pollution.				
4	I prefer group efforts to be used in combating the causes of air pollution.				
5	I feel the objective report made on previous air pollution effect will serve as unforgettable experience.				
6	It is preferable to visit the source of water before purification				

	method will be applied.				
7	It is interesting and enjoyable to see groups working together to prevent water pollution.				
8	I feel waste water does not constitute nuisance.				
9	I feel soak away constructed near source of water cannot pollute water				
10	It is desirable to kill fish with chemicals				
11	I like to work with people who make discoveries on treatment of solid waste				
12	It is interesting to se boys and girls keeping their environment clean				
13	I prefer having first hand field experience than finding out from experts the causes and effects of land pollution.				
14	I feel that I gain nothing in learning environmental pollution on land since my environment is clean.				
15	I like learning land pollution because of its effect on environment.				
16	I dislike learning conservation techniques because it cannot supply all the answers to our question about useful living.				
17	I feel there could be misconception of conservation ideas hence it may not be necessary.				
18	I will like boys and girls to learn conservation of resources in Biology.				
19	It is enjoyable see groups and corporate bodies participating in conservation of resources.				
20	I hate field work exercise used for conversation of our natural resources.				

APPENDIX IIB

ANSWER SHEET

STUDENTS' ENVIRONMENTAL ATTITUDE SCALE (SEAS)

INSTRUCTIONS: Tick the best option

Personal information (Biodata)

Name of School:

Sex: Male ( ) Female ( )

Class: SS___

S/N	SA	A	DA	SD
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

APPENDIX IIIA

STUDENTS ENVIRONMENT PRACTICES SCALE (SEPS)

INTRODUCTION: This Scale intends to investigate your practice towards environmental pollution and conservation techniques.

SECTION A

1. Name of School: -
2. Gender: Male ( ) Female ( ) -

SECTION B

These are some statements' about practices of students towards environmental pollution and conservation techniques. Please mark (X) in the box provided that matches the extent of your Practices with each statement. The letters stands for the following:-

VO - Very Often
O - Often
S - Seldom
N - Never

S/N	How often do you do the following?	VO	O	S	N
1.	Sleeps in a room immediately after spraying insecticides.				
2.	See people smoking along the streets without been cautioned.				
3.	Control Bush burning not to produce smoke that will disturb people.				
4.	Purify the air around by using air purifier like Air fresheners				
5.	Stay away from unpleasant odour in the environment.				
6.	Treat your well/borehole				
7.	Drink water when it is treated.				

8.	Educate fishermen on the danger of continuous fishing on water bodies without permission from the necessary authority.				
9.	Read newspaper articles alerting people on the threats posed on our health by using polluted water				
10.	Allowing people to get away with tapping petroleum products illegally without reporting to the necessary authority concerned.				
11.	Providing dust bin for refuse disposal.				
12.	Sweep a dusty sandy place after wetting the soil.				
13.	Stay very close to heavy heaps of refuse in the environment.				
14.	Pick waste on the floor when I have the time.				
15.	Observing environmental sanitation exercise.				
16.	Digging of holes during extraction without covering the holes after the extraction.				
17.	Leaving people dumping wastes into the drainage systems during rainfall without correcting their actions.				
18.	Educate people on conservation techniques.				
19.	Educate hunters on the danger of poaching.				
20.	Empty my soak away/ septic tank on rivers and streams as a Conservation techniques				

APPENDIX IIIB

ANSWER SHEET

STUDENTS ENVIRONMENT PRACTICES SCALE (SEPS)

INSTRUCTIONS: Tick as appropriate.

1. Name of School: -
2. Age :
3. Gender: Male ( ) Female ( ) -

S/N	Very Often	Often	Seldom	Never
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

APPENDIX IV

COGNITIVE STYLE TEST

Instructions

Call the students one after the other and pass out a sheet of paper and picture booklets to the student and instruct him/her to fill in on the sheet paper answer the following

Name of the Student in full……

Name of School……..

Class……

Sex……(Male of Female)

Age……

Date……

Research Assistant holds up the cognitive style booklet while the students hold another copy and say:

Do not open or turn the copy you are holding until I tell you to do so. Turn over to any card now. Here are a set of cards on which are pictures of many familiar things. As an example, on card number 1 you can see three pictures: the watch has an A under it. The man has a B underneath: and the ruler has a C beneath it. What I want you to do is to pick out two of the three pictures which go together, belong together, or are related in any way, then you state your reasons why you select the two pictures.

When I ask you to go ahead, I want you to mention as many reasons as possible that you can give for objects or pictures that go together, belong together, or related in any way.

Continue giving as many pairs of your reasons, as you can until I tell you to stop (use 75 sec.) do not turn the picture card on which you are working until I tell you to do so. It you finish before I tell you to stop wait for the next signal; to go ahead.

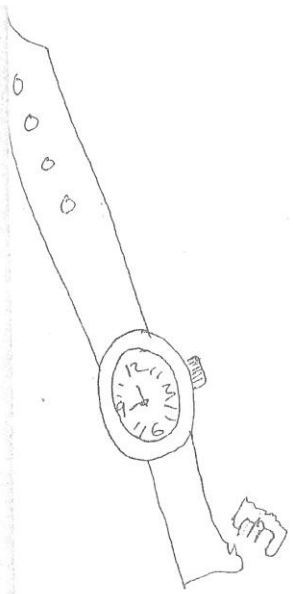
There is no right or wrong answers. We are interested in the different ways children see things. Some you many see many things; some of you only a few. Just do the best you can. Don't worry about pronunciation or diction. If you wish to change your reasons, simply say sorry, I will not score the old reason but score the new point.

RULES

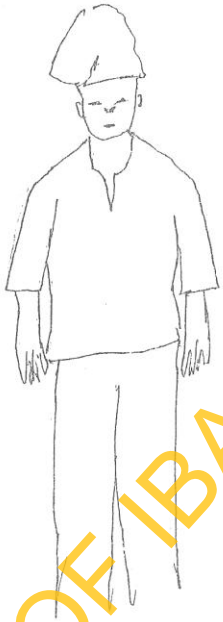
Do not allow the student that has just pass through the test to influence other by sending the student away from the vicinity of testing environment.

Go on for each set thereafter with 75 second intervals.

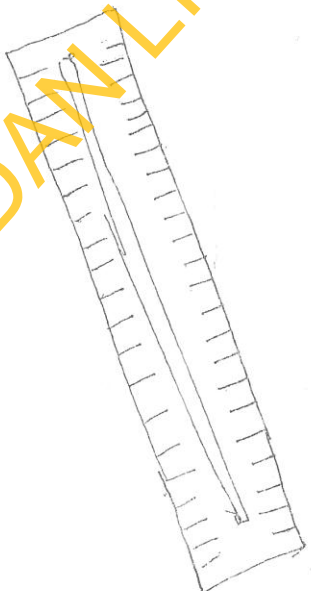
Do not permit the subject to work at their own pace.



WRISTWATCH



MAN

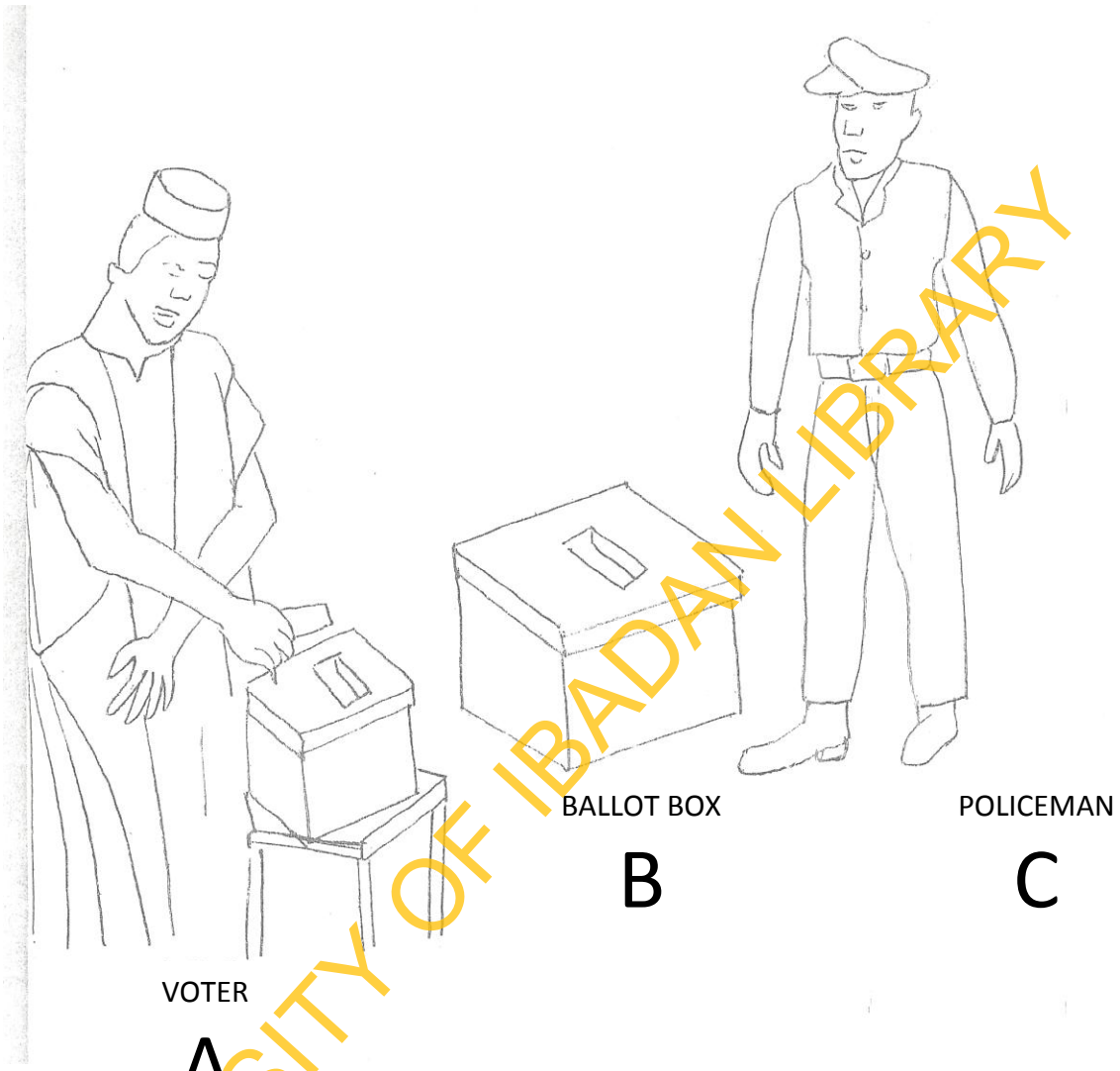


RULER

A

B

C



VOTER

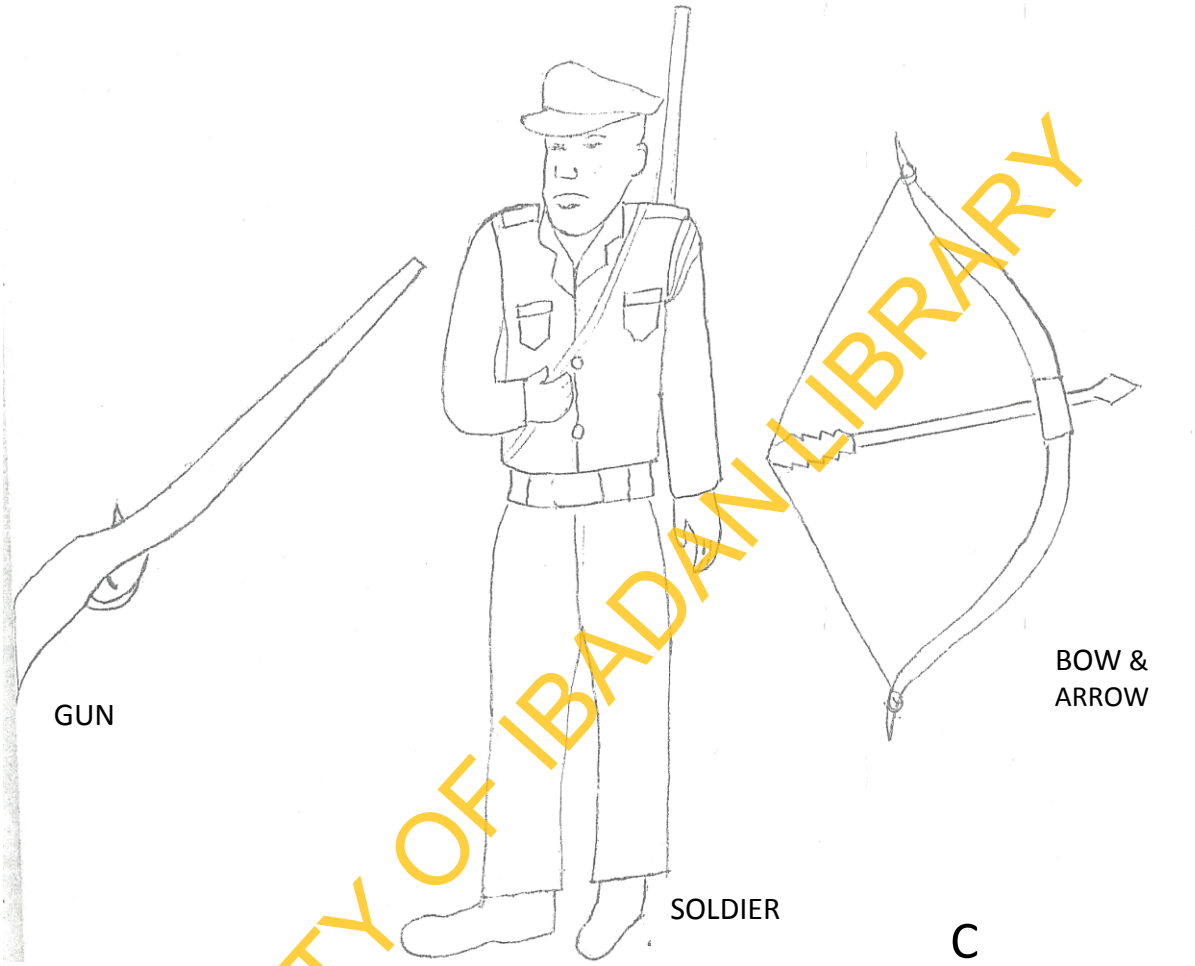
A

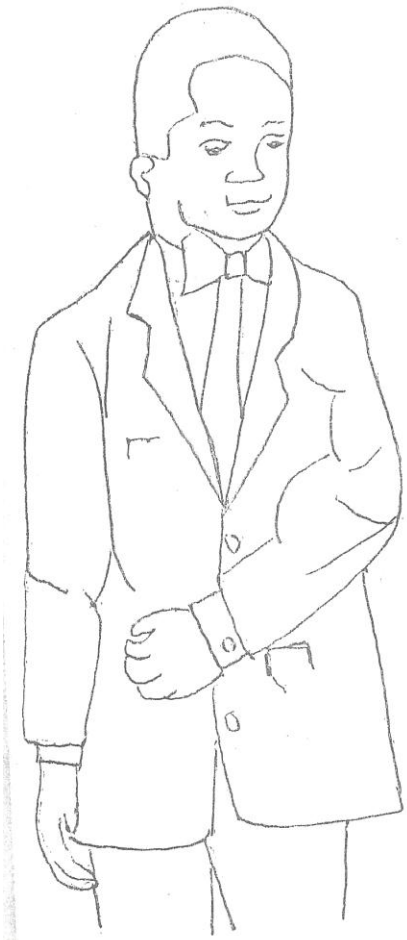
BALLOT BOX

B

POLICEMAN

C



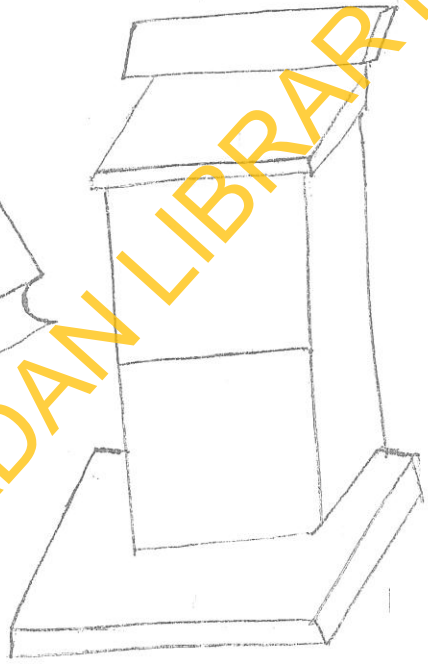


PASTOR

A

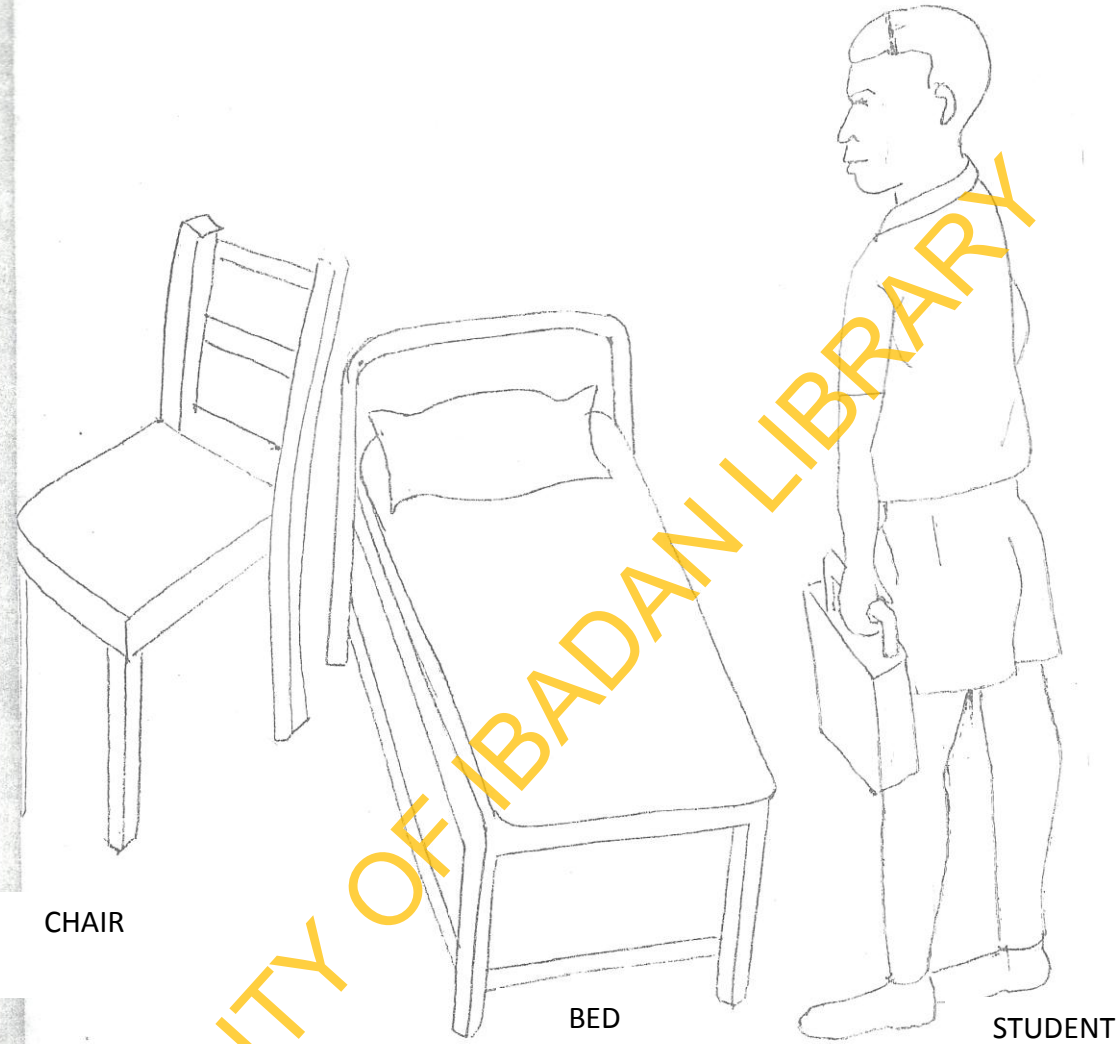
BIBLE

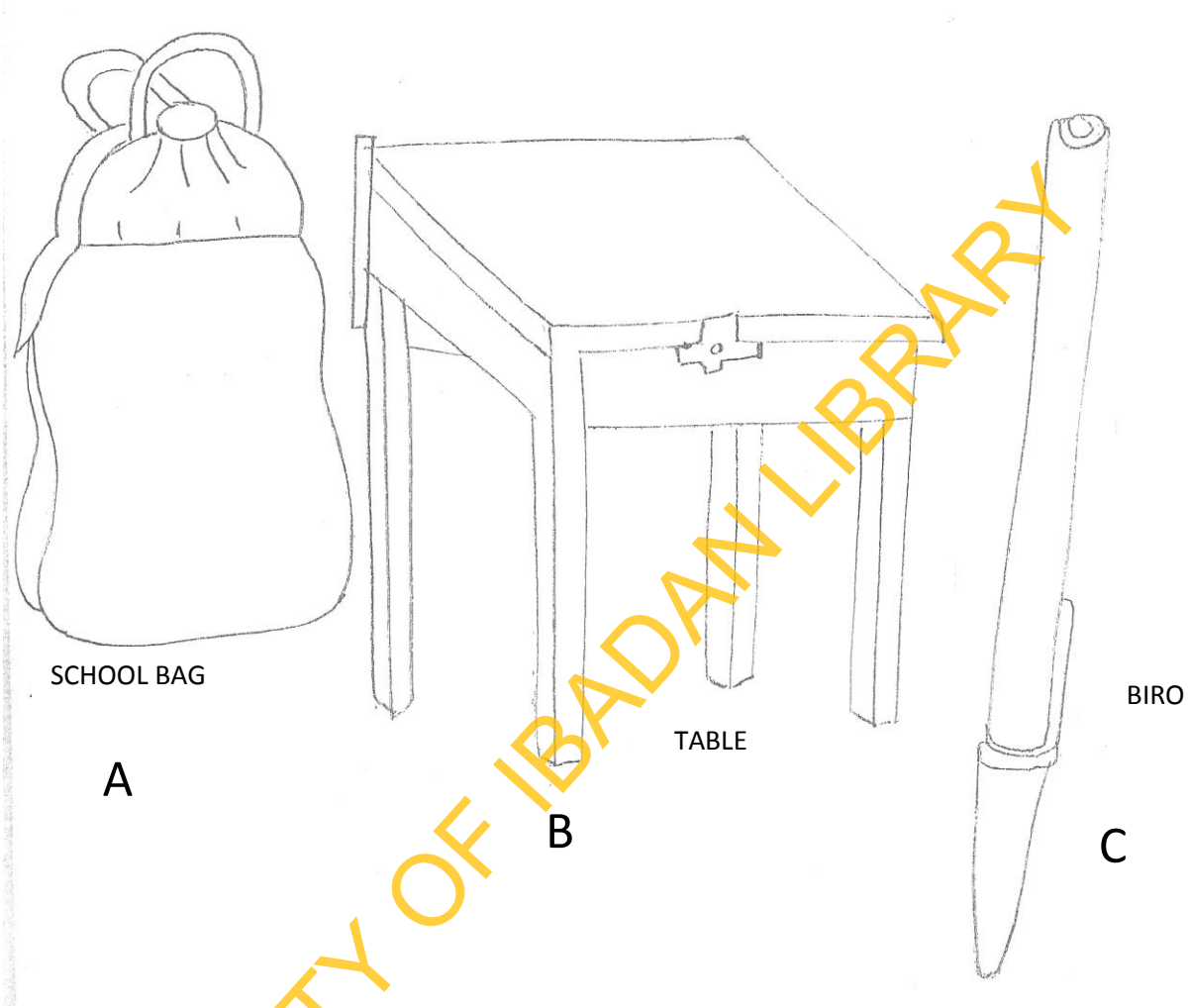
B



PUPILT

C





SCHOOL BAG

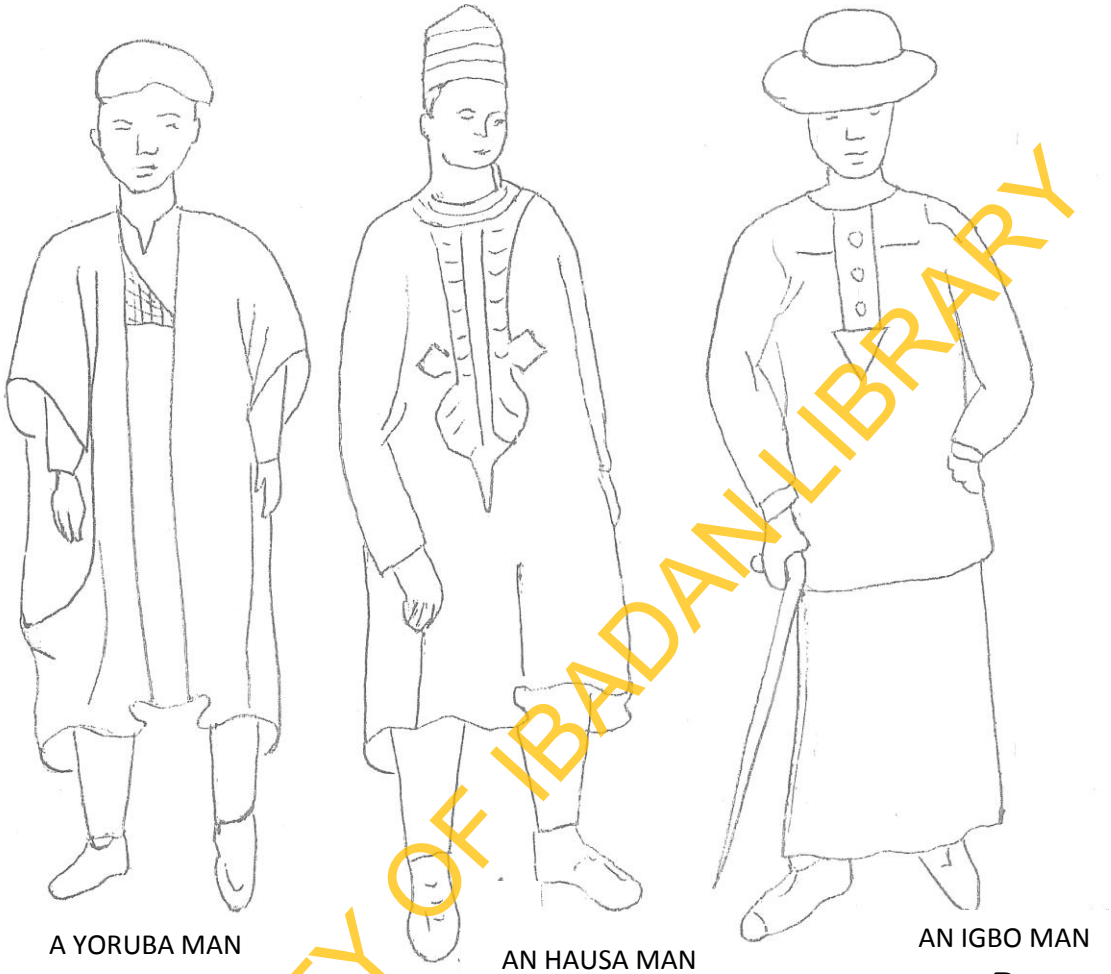
A

TABLE

B

BIRO

C



A YORUBA MAN

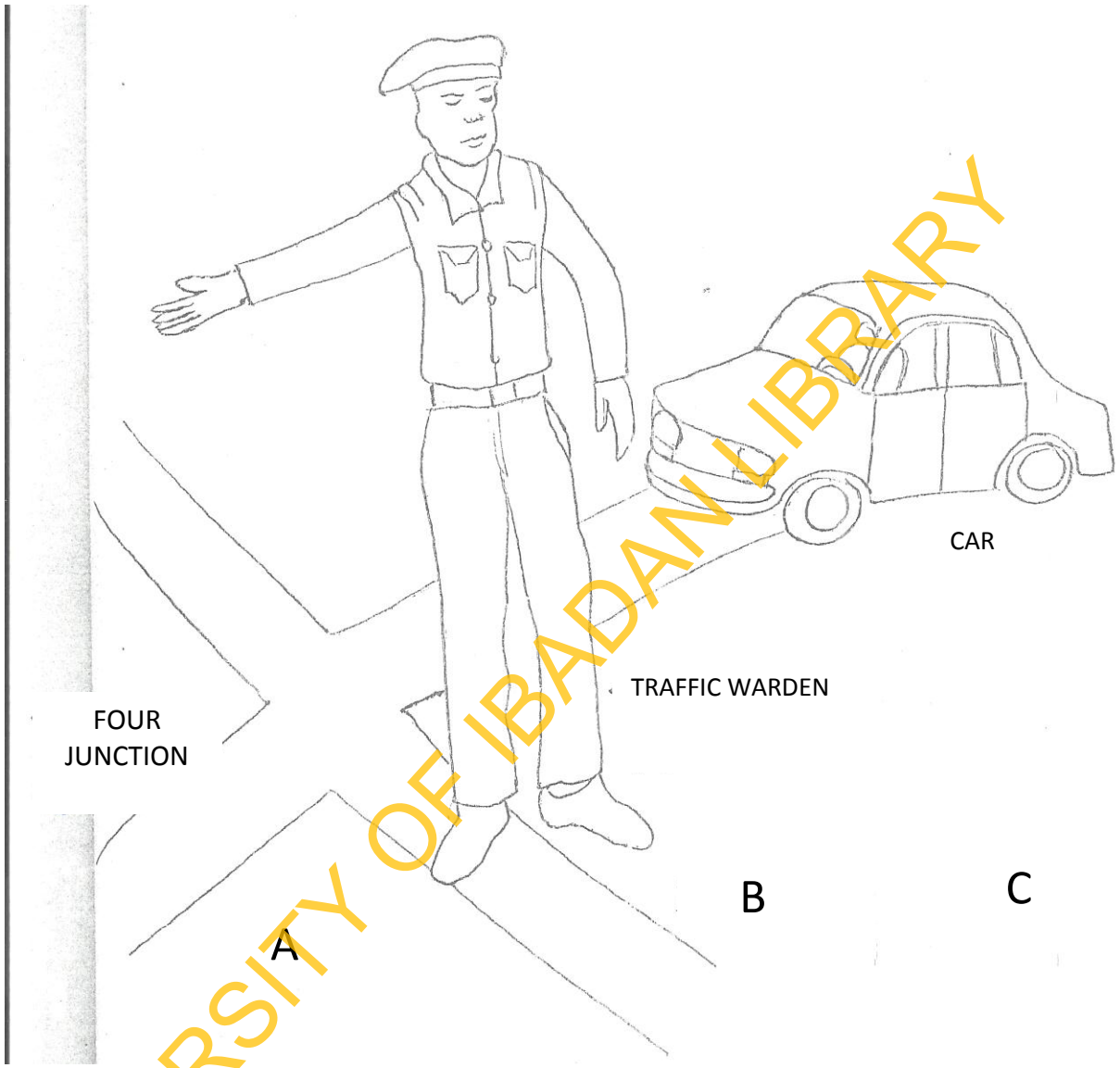
A

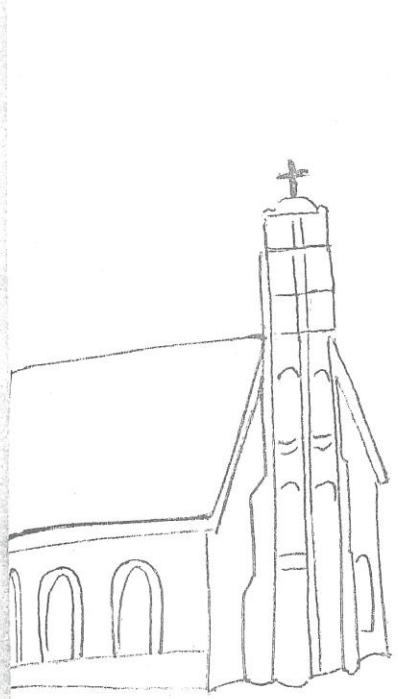
AN HAUSA MAN

B

AN IGBO MAN

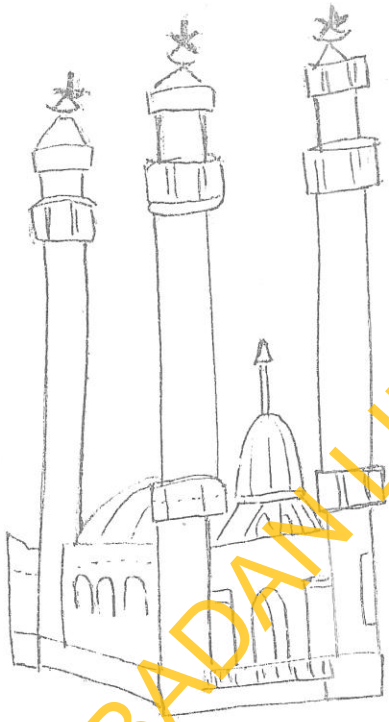
B





CHURCH

A



MOSQUE

B

AN IMMAM

C

GREEN PASTURES

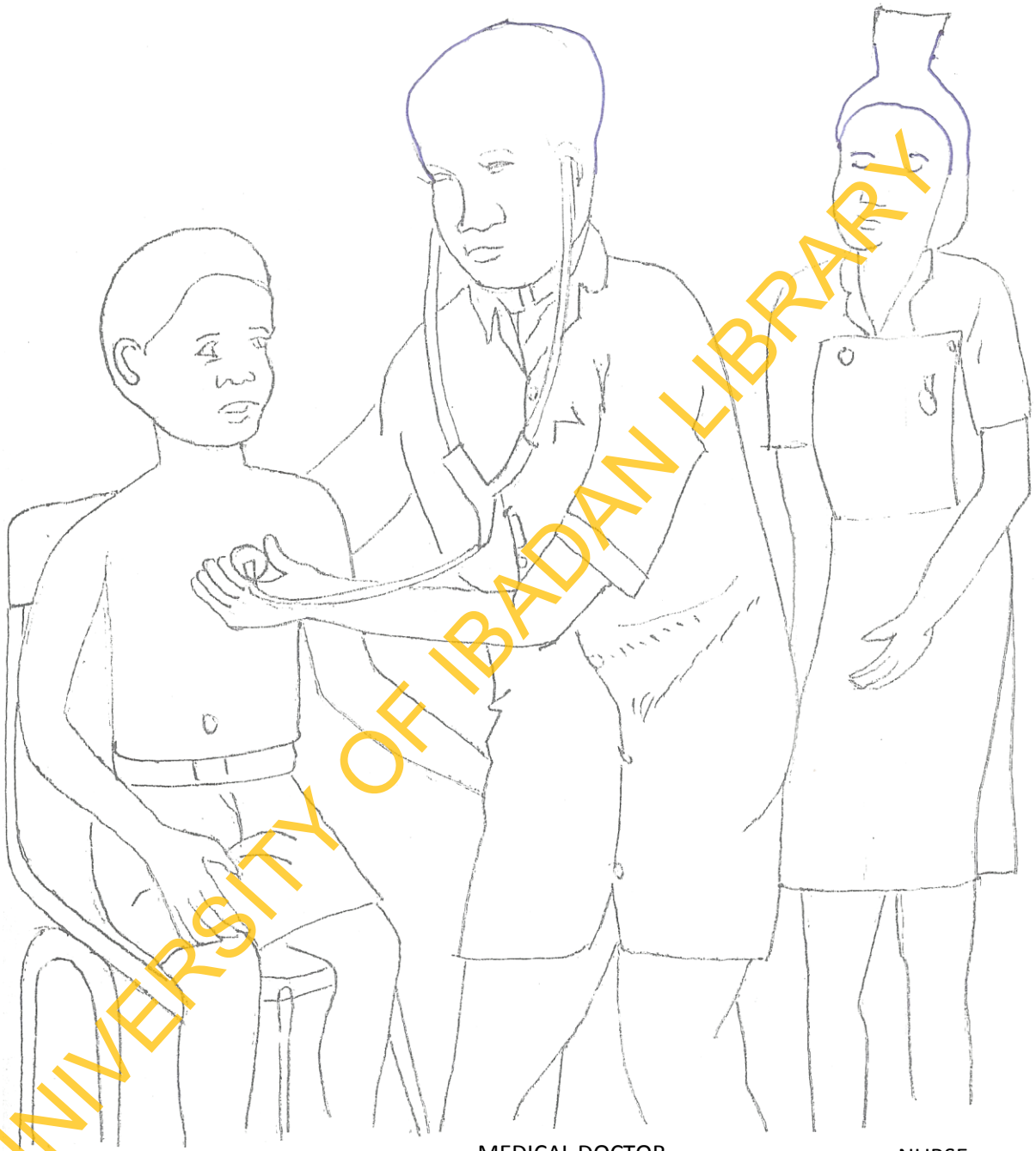
A

FLOWING STREAM

B

FLOCK OF SHEEP

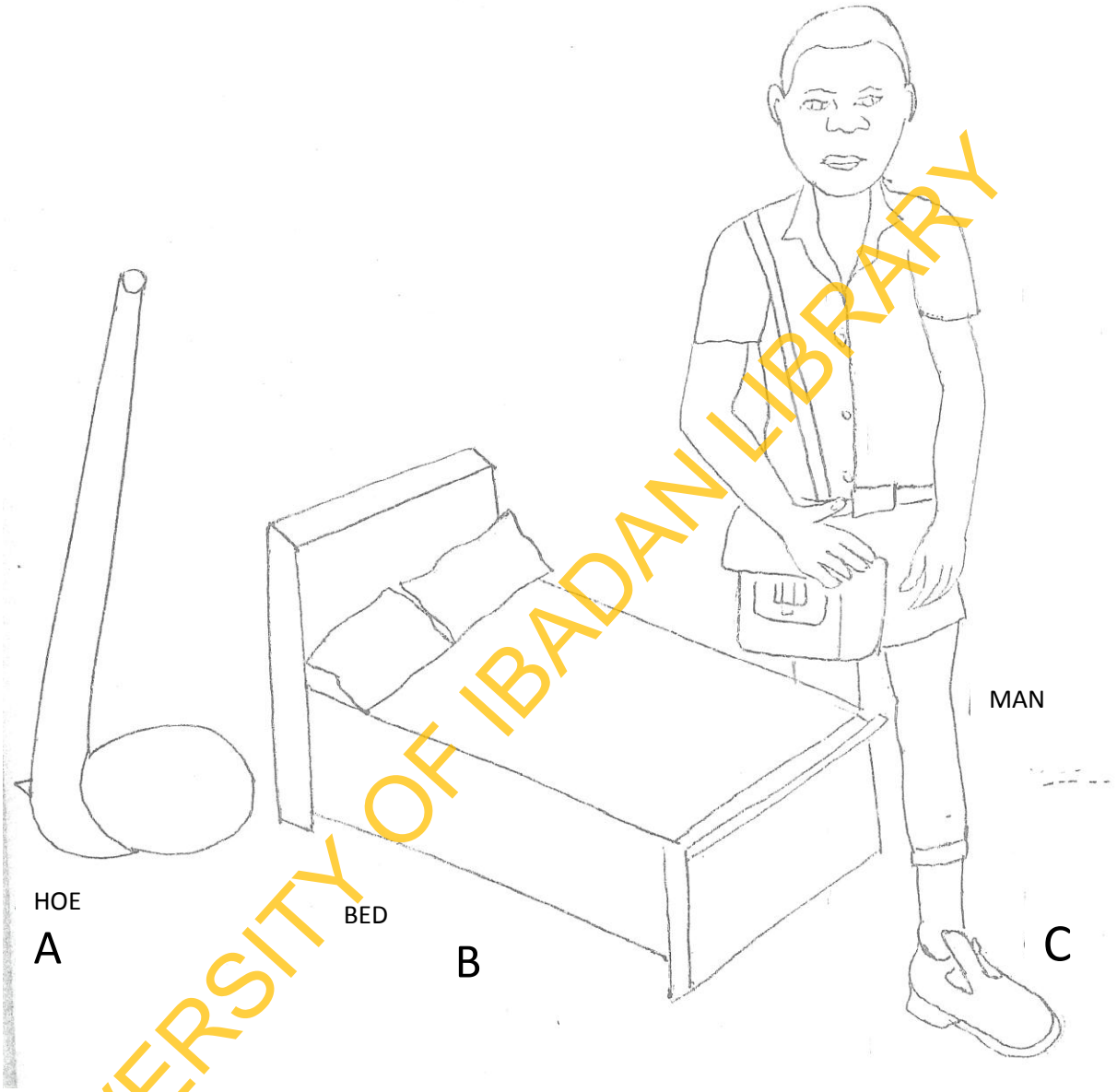
C

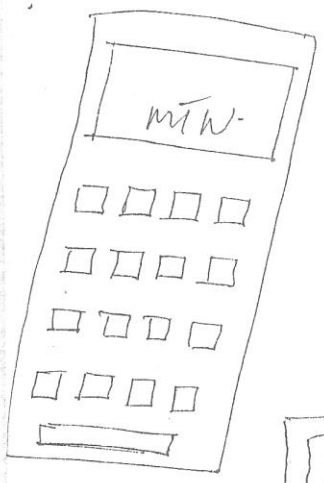


PATIENT
A

MEDICAL DOCTOR
B

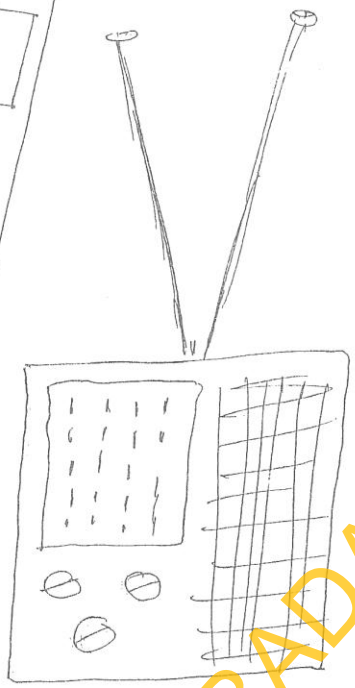
NURSE
C





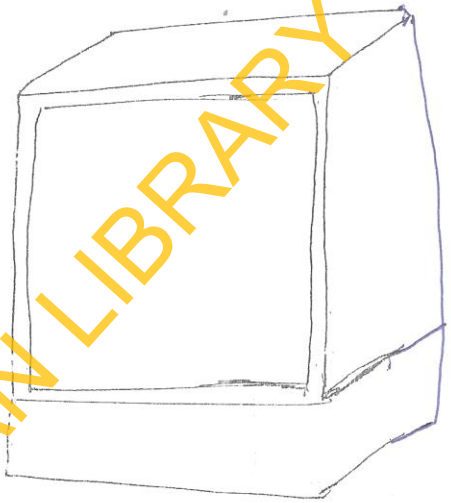
HANDSET

A



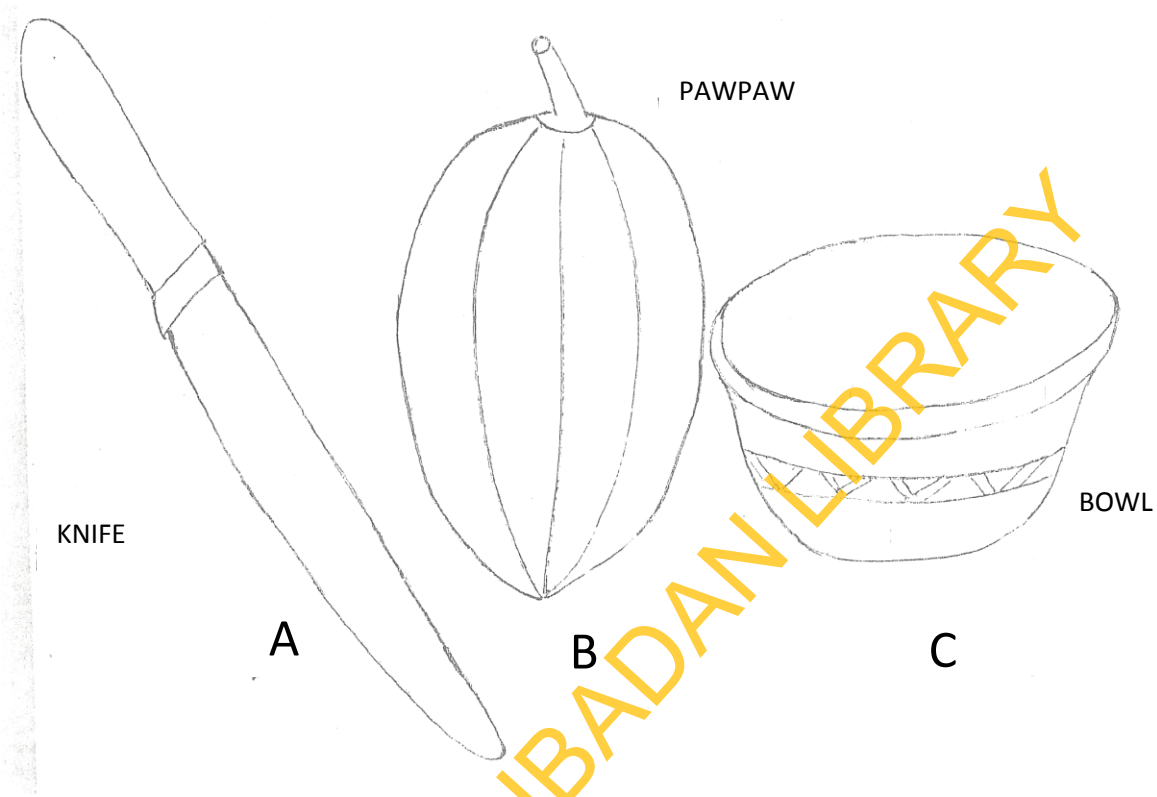
T.V.

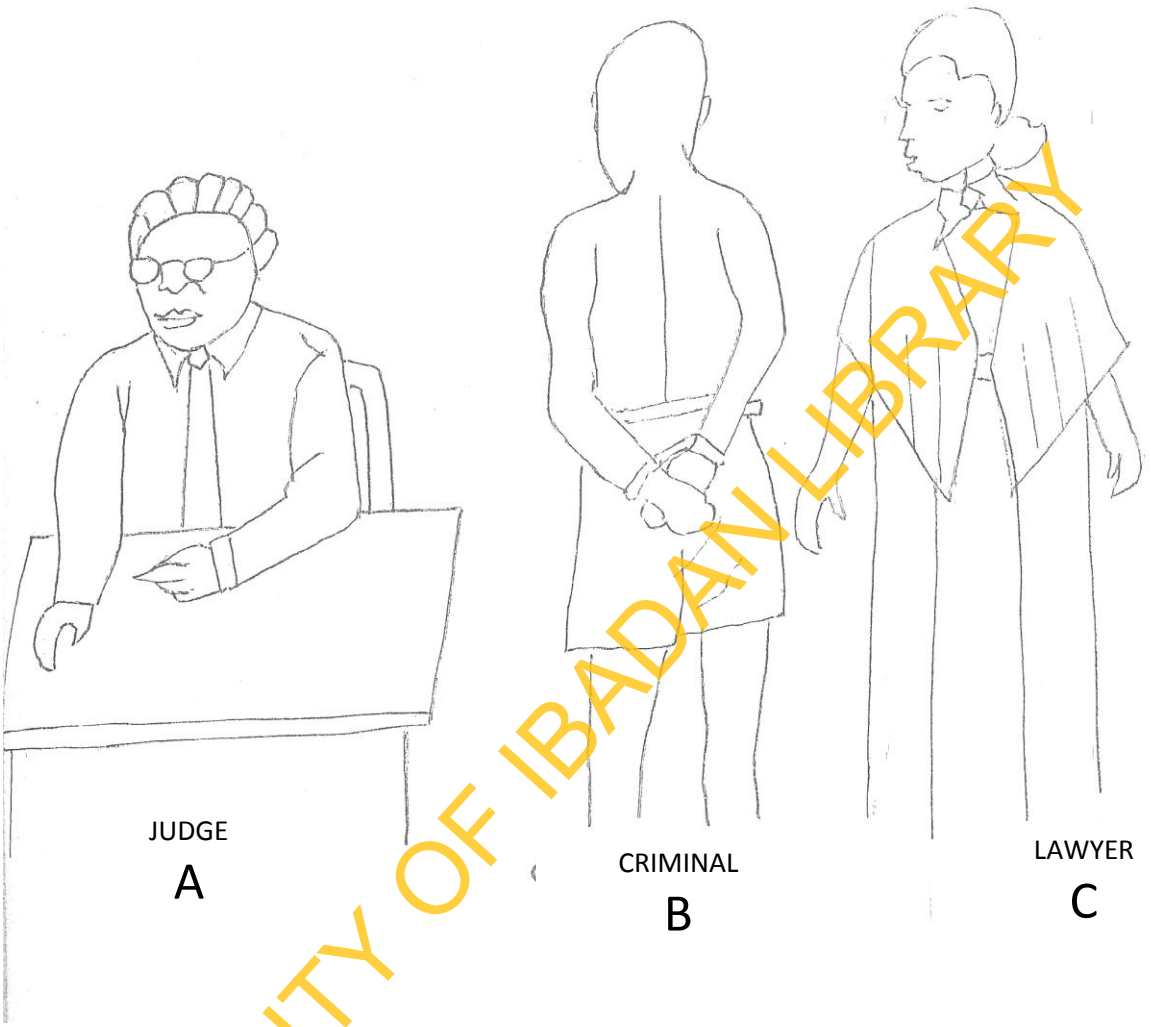
B



RADIO

C





JUDGE

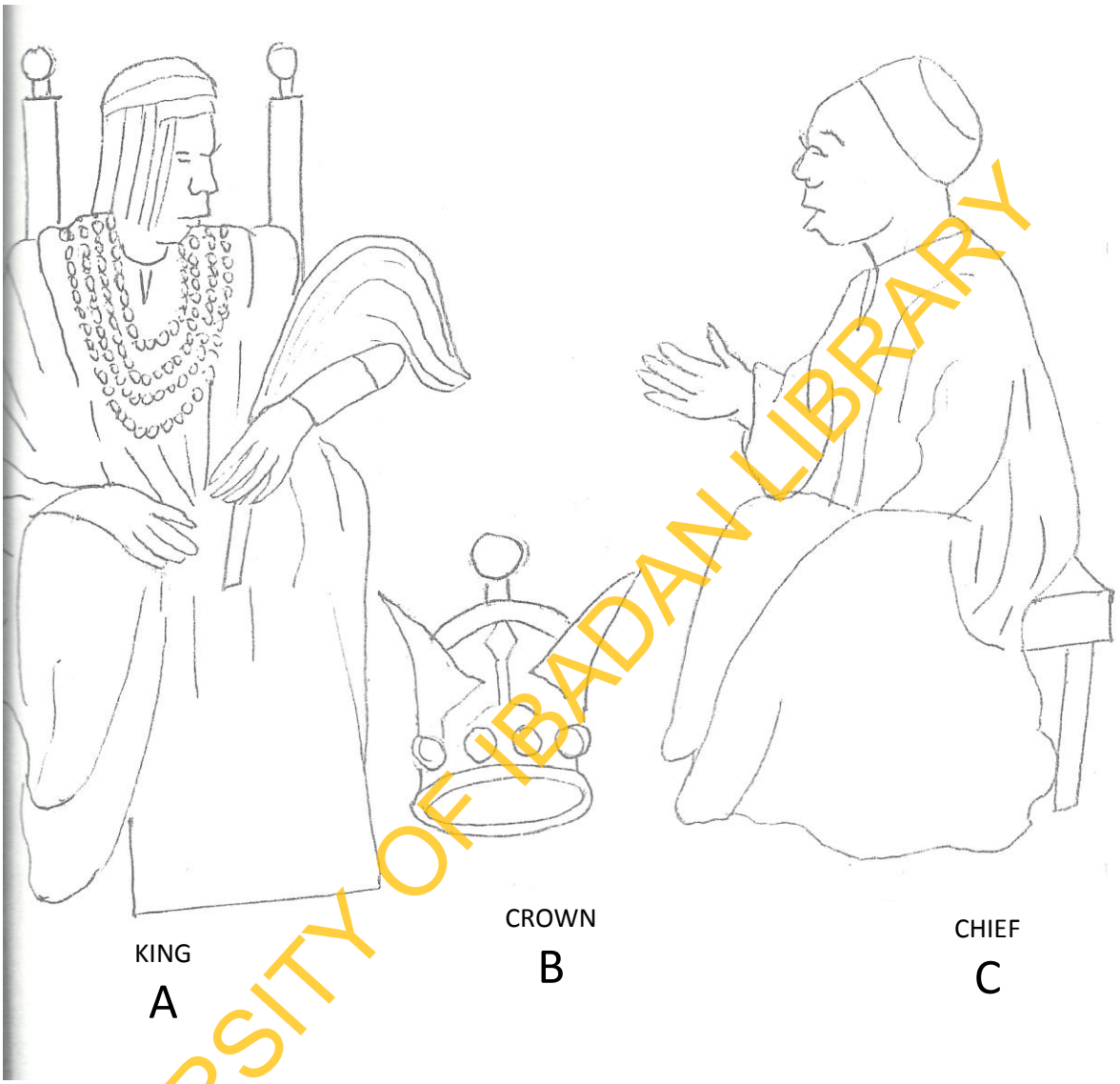
A

CRIMINAL

B

LAWYER

C



KING

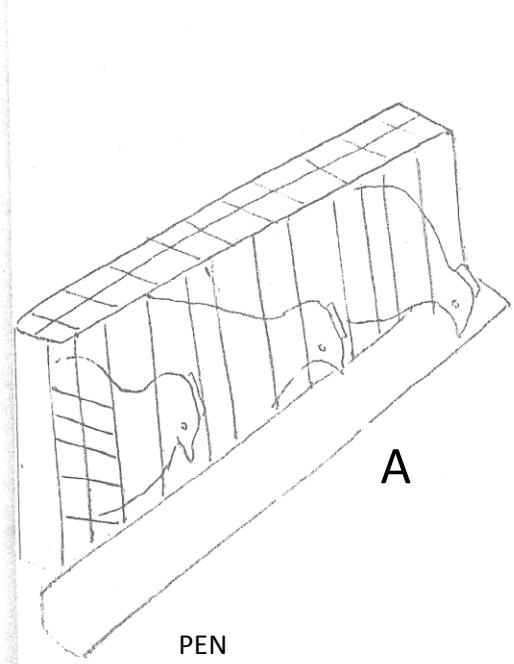
A

CROWN

B

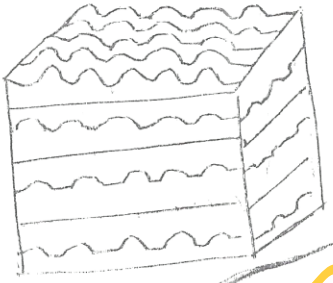
CHIEF

C



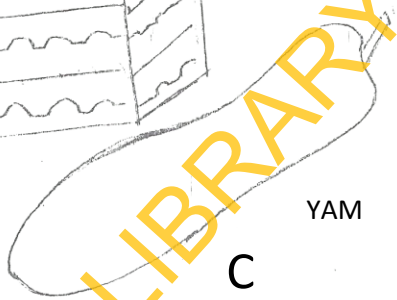
PEN

A



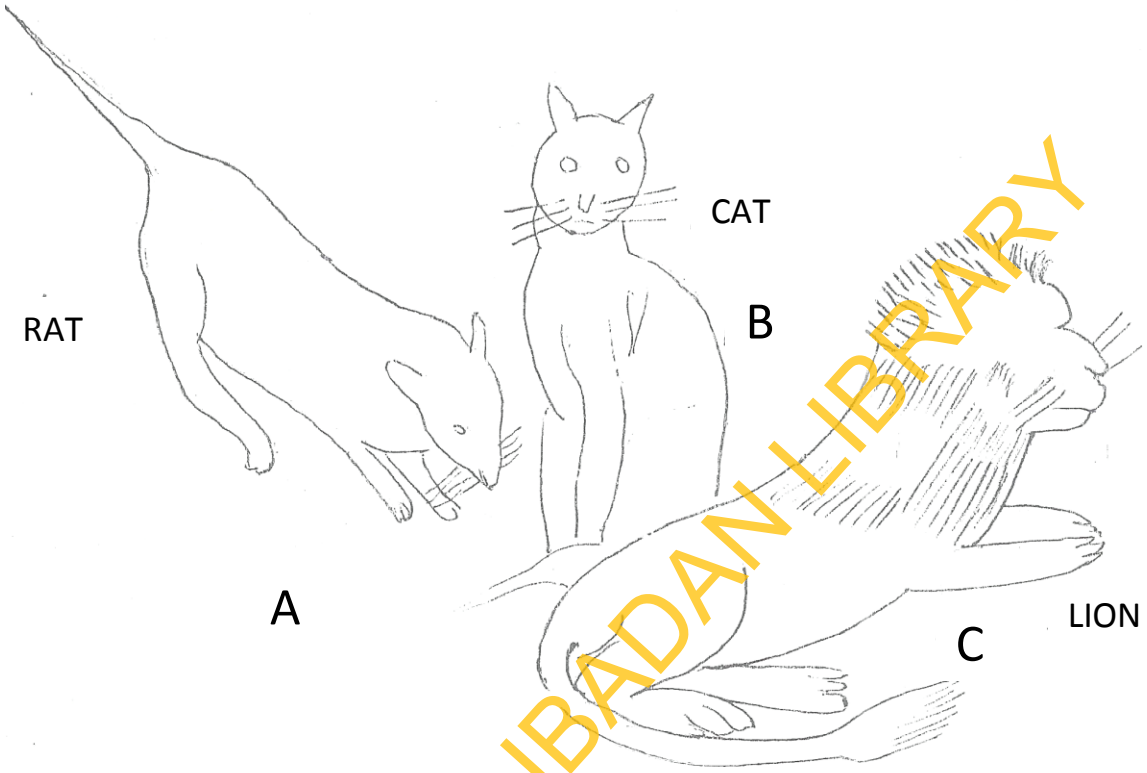
EGG CRATES

B



YAM

C



FUNNEL

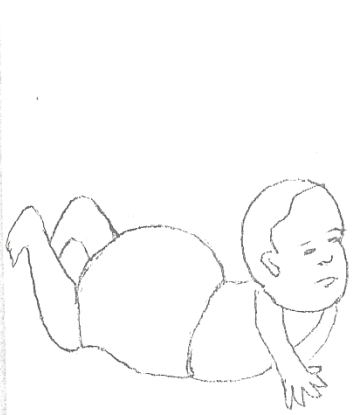
A

KEROSINE GALLON

B

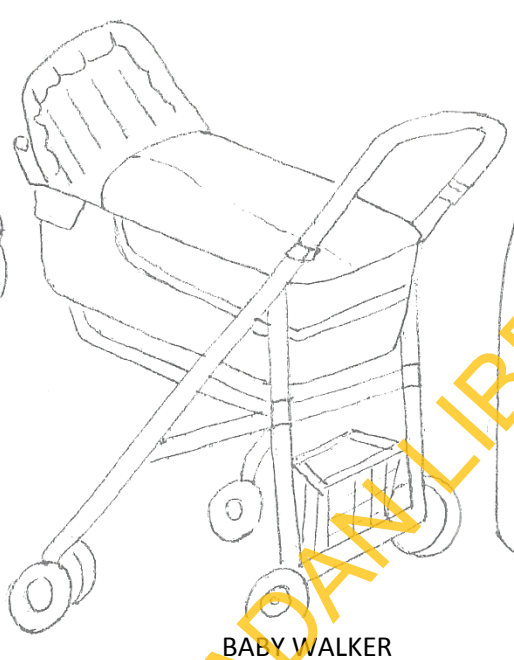
LANTERN

C



BABY

A



BABY WALKER

B

FEEDING BOTTLE

C

APPENDIX V

APPENDIX V A

TEACHER'S INSTRUCTIONAL GUIDE ON PRE-THEORETIC INTUITION QUIZ (TIGPT)

LESSON 1

Topic: Air pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term Air pollution

State the examples of air pollutants

Mention the causes and sources of Air pollution

Previous Knowledge: Students has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of pollution.

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you think can bring about dirt and germs in Air?

(2) What do these dirt and germs do to our bodies?

(3)Is it possible to control these germs and dirt from getting into our bodies? Give reason to support your answer.

The answers to the questions are based on students Intuition. The teacher presents the concept to the students.(20MINUTES)

Presentation:

Step I: The teacher lists the following questions to be discussed and student's responses are expected

What do you know about the process of releasing harmful substances into living environment?

Mention the term used to describe these harmful substances present in the air?

What brings about these harmful substances released into the air.

Mention five sources of these harmful substances released into the air.(20MINUTES)

Step II: Each student responded to the questions individually, by discussing answers to the question with the whole students in the presence of the teacher.(15MINUTES)

Step III: Teacher discusses the ones on which they disagree. (10MINUTES)

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define the term 'Air pollution'

Give examples of Air pollutants

Mention the cause and sources of the following

Air pollutant on living organisms

Smoke

Carbonmonoxide.(15MINUTES)

Assignment: The students are asked to read Effects, prevention and control of Air pollution against next lesson.

LESSON II

Topic: Effects, prevention and control of Air pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

State the effects of air pollutants

Mention the control measures for these Air pollutants.

Mention the preventive measures for these Air pollutants

Previous Knowledge: Students has been taught Air pollution.

Introduction: The following questions are asked based on students' previous knowledge:

Define the term 'Air pollution'

Give examples of Air pollutants

Mention the cause and sources of the following

Air pollutant on living organisms

Smoke

Carbonmonoxide.

The answers to the questions are based on students Intuition. The teacher presents the concept to the students.

Presentation:

Step I: The teacher lists the following questions to be discussed and student's responses are expected

What are the effects of releasing harmful substances into living environment?

How do we control these harmful substances released into the air?

Is it possible to prevent these harmful substances from been released into the air? How will it be possible?

Step II: Each student responded to the questions individually, by discussing answers to the question with the whole students in the presence of the teacher.

Step III: Teacher discusses the ones on which they disagree.

Evaluations: The teacher assesses students' knowledge of the subject matter,

the following question were asked.

State five effects of air pollutants

Mention five control measures for the following Air pollutants

Smoke

And Carbon monoxide.

How do we prevent the occurrence of these substances?

Assignment: The students are asked to read water pollution against next lesson.

LESSON III

Topic: Water pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term Water pollution.

State the examples of Water pollutants.

Mention the causes and sources of Water pollution.

Previous Knowledge: Students has been taught Effects, prevention and control of Air pollution.

Introduction: The following questions are asked based on students' previous knowledge:

State five effects of air pollutants

Mention five control measures for the following Air pollutants

Smoke

And Carbonmonoxide.

How do we prevent the occurrence of these substances?

The answers to the questions are based on students Intuition. The teacher presents the concept to the students..

Presentation:

Step I: Teacher give quiz aim at getting students to both identify and to assess their own views. These questions are

What do you know about the process of releasing harmful substances into water?

Mention the term used to describe these harmful substances present in water?

What brings about these harmful substances released into water?.

Mention five sources of these harmful substances released into the water?.(20MINUTES)

Step II: Each student respond to the questions individually, by discussing the answers to the questions in the presence of other students and teachers.

Step III: - Teacher discusses the ones on which they disagree.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define the term 'Water pollution'

Give examples of Water pollutants

Mention the cause and sources of the following water pollutants on living organisms

Sewage

Detergent

Assignment: The students should read Effects, prevention and control of water pollution against next lesson.

LESSON IV

Topic: Effects, prevention and control of water pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

State the effects of water pollutants

Mention the control measures for these water pollutants.

Mention the preventive measures for these water pollutants.

Previous Knowledge: Students has been taught water pollution

Introduction: The following questions are asked based on students' previous knowledge:

Define the term 'Water pollution'

Give examples of Water pollutants

Mention the cause and sources of the following water pollutants on living organisms

Sewage

Detergent

The answers to the questions are based on students Intuition. The teacher presents the concept to the students..

Presentation:

Step I: Teacher give quiz aim at getting students to both identify and to assess their own views. These questions are

What are the effects of releasing harmful substances into living environment?

How do we control these harmful substances released into the air?

Is it possible to prevent these harmful substances from been released into the air? How will it be possible?

Step II: Each student respond to the questions individually, by discussing the answers to the questions in the presence of other students and teacher.

Step III: - Teacher discusses the ones on which they disagree.

Evaluation: Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

State the effects of water pollutants

Mention the control measures for these water pollutants.

Mention the preventive measures for these water pollutants on living organisms

Sewage

Detergent

Assignment: The students should read Effects, prevention and control of land pollution against next lesson.

LESSON V

Topic: Land pollution

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term land pollution

List some land pollutants

Mention the causes and sources of land pollution

Previous Knowledge: Students has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of pollution.

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you think can bring about dirt and germs on Land?

(2) What do these dirt and germs do to our bodies?

(3)Is it possible to control these germs and dirt from getting into our bodies? Give reason to support your answer.

The answers to the questions are based on students Intuition. The teacher presents the concept to the students.

Presentation:

Step I: Teacher give the following quiz aimed at getting students to both identify and to assess their own views

What do you know about the process of releasing harmful substances on land?

Mention the term used to describe these harmful substances present on land?

What brings about these harmful substances released land?.

Mention five sources of these harmful substances released on land?(20MINUTES)

Step II: Each student respond to the questions individually, by discussing the answers to the questions in the presence of other students and teachers.

Step III: - Teacher discusses the ones on which they disagree.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define the term 'land pollution'

Give examples of land pollutants

Mention the cause and sources of the following

land pollutant on living organisms

Refuse

Old tins

Assignment: The students are asked to read Effects, prevention and control of land pollution against next lesson.

LESSON VI

Topic: Effects, prevention and control of land pollution.

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

State the effects of land pollutants

Mention the control measures for these land pollutants.

Mention the preventive measures for these land pollutants.

Previous Knowledge: Students has been taught land pollution.

Introduction: The following questions are asked based on students' previous knowledge:

Define the term 'land pollution'

Give examples of land pollutants

Mention the cause and sources of the following

land pollutant on living organisms

Refuse

Old tins

The answers to the questions are based on students Intuition. The teacher presents the concept to the students.

Presentation:

Step I: Teacher give quiz aim at getting students to both identify and to assess their own views. These questions are

What are the effects of releasing harmful substances into living environment?

How do we control these harmful substances released into the air?

Is it possible to prevent these harmful substances from been released into the air? How will it be possible?

Step II: Each student respond to the questions individually, by discussing the answers to the questions in the presence of other students and teacher.

Step III: - Teacher discusses the ones on which they disagree.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

State the effects of land pollutants

Mention the control measures for these land pollutants.

Mention the preventive measures for these land pollutants.

Assignment: Students should read Conservation of Natural Resources against next lesson.

LESSON VII

Topic: Conservation of Natural Resources

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define and explain conservation of natural resources

Enumerate method of conservation of natural resources

List importance of conservation

Previous Knowledge: Students has been taught has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of Conservation techniques..

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you understand by Good Environment?

(2) What do you expect to see in a good Environment?

(3)Is it possible to maintain Good Environment? Give reason to support your answer.

The answers to the questions are based on students Intuition. The teacher presents the concept to the students.

Presentation:

Step I: Teacher give the following quiz aimed at getting students to both identify and to assess their own views;

What do you know about the process of preservation of assets provided by nature from which man can draw to satisfy his needs?

Are there any methods of preserving these assets? Then mention any three methods that you know?

What do we gain from these preservation methods?

Step II: Each student respond to the questions individually, by discussing the answers to the questions in the presence of other students and teachers.

Step III: - Teacher discusses the ones on which they disagree.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define and briefly explain conservation of resources

Enumerate the methods and importance of the following conservation technique

Water conservation

Soil conservation

Fisheries conservation

Assignment: Students should read Conservation agencies and problems encountered in conservation.

LESSON VIII

Topic: Conservation agencies and problems encountered in conservation

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Explain conservation agency.

Enumerate five conservation agencies.

List problems of conservation

Previous Knowledge: Students has been taught Conservation and its importance.

Introduction: The following questions are asked based on students' previous knowledge:

Define and briefly explain conservation of resources

Enumerate the methods and importance of the following conservation technique

Water conservation

Soil conservation

Fisheries conservation

Presentation:

Step 1. Teacher gives the following quiz aimed at getting students to both identify and to assess their own views;

What is the general name given to organizations meant for the preservation of assets provided by nature from which man can draw to satisfy his needs? Think and name any three of those organizations.

Do these organizations have challenges? What are the challenges faced by these organizations?

Step II: Each student respond to the questions individually, by discussing the answers to the questions in the presence of other students and teachers.

Step III: - Teacher discusses the ones on which they disagree.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

What is meant by conservation agency?

Enumerate five conservation agencies that you know.

List problems of conservation in Nigeria.

Assignment: Students should read Pathogens against next lesson.

APPENDIX V B

TEACHER'S INSTRUCTIONAL GUIDE ON PUZZLE-BASED LEARNING (TIGPB)

LESSON 1

Topic: Air pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term Air pollution

State the examples of air pollutants

Mention the causes and sources of Air pollution.

Previous Knowledge: Students has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of pollution.

Introduction: The following questions are asked based on students' previous knowledge:

What do you think can bring about dirt and germs in Air?

What do these dirt and germs do to our bodies?

Is it possible to control these germs and dirt from getting into our bodies? Give reason to support your answer.

The answers to the questions are based on students Intuition The teacher presents the concept to the students using the environmental puzzle as guide to identify and explain the key points of the concept.

Presentation:

Step I: The teacher gives the Environmental Puzzle to the students and lists the numbers of clues students should provide word(s).

The following clues in environmental puzzle are listed;

CLUE 4

CLUE 1

CLUE 2

Step II: Each student use their Intuition with the aid of environmental puzzle respond to the questions individually, students explain each corresponding word(s) to the clue giving more examples to buttress their points.

Step III: Teacher discusses the ones on which they disagree using environmental puzzle as a guide and providing more examples where necessary.

Evaluations: The teacher assesses students' knowledge of the subject by asking the following questions;

Define the term 'Air pollution'

Give examples of Air pollutants

Mention the cause and sources of the following

Air pollutant on living organisms

Smoke

Carbonmonoxide.

Assignment: The students are asked to read water pollution against next lesson.

LESSON II

Topic: Effects, prevention and control of Air pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

State the effects of air pollutants

Mention the control measures for these Air pollutants.

Mention the preventive measures for these Air pollutants

Previous Knowledge: Students has been taught Air pollution.

Introduction: The following questions are asked based on students' previous knowledge:

Define the term 'Air pollution'

Give examples of Air pollutants

Mention the cause and sources of the following

Air pollutant on living organisms

Smoke

Carbonmonoxide.

The answers to the questions are based on students Intuition The teacher presents the concept to the students using the environmental puzzle as guide to identify and explain the key points of the concept.

Presentation:

Step I: The teacher gives the Environmental Puzzle to the students and lists the numbers of clues students should provide word(s).

The following clues in environmental puzzle are listed;

CLUE 4

CLUE 5

CLUE 17

Step II: Each student use their Intuition with the aid of environmental puzzle respond to the questions individually, students explain each corresponding word(s) to the clue giving more examples to buttress their points.

Step III: Teacher discusses the ones on which they disagree using environmental puzzle as a guide and providing more examples where necessary.

Evaluations: The teacher assesses students' knowledge of the subject by asking the following questions;.

State five effects of air pollutants

Mention five control measures for the following Air pollutants

Smoke

And Carbonmonoxide.

How do we prevent the occurrence of these substances.

Assignment: The students are asked to read water pollution against next lesson.

LESSON III

Topic: Water pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

. Define the term Water pollution.

State the examples of Water pollutants.

Mention the causes and sources of Water pollution.

Previous Knowledge: Students has been taught Effects, prevention and control of Air pollution.

Introduction: The following questions are asked based on students' previous knowledge:

State five effects of air pollutants

Mention five control measures for the following Air pollutants

Smoke

And Carbonmonoxide.

How do we prevent the occurrence of these substances?

The answers to the questions are based on students Intuition The teacher presents the concept to the students using the environmental puzzle as guide to identify and explain the key points of the concept.

Presentation:

Step I: The teacher gives the Environmental Puzzle to the students and lists the numbers of clues students should provide word(s).

The following clues in environmental puzzle are listed;

CLUE 4

CLUE 10

CLUE 11

Step II: Each student use their Intuition with the aid of environmental puzzle respond to the questions individually, students explain each corresponding word(s) to the clue giving more examples to buttress their points.

Step III: Teacher discusses the ones on which they disagree using environmental puzzle as a guide and providing more examples where necessary

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define the term 'Water pollution'

Give examples of Water pollutants

Mention the cause and sources of the following water pollutants on living organisms

Sewage

Detergent

Assignment: The students should read Effects, prevention and control of water pollution against next lesson.

LESSON IV

Topic: Effects, prevention and control of water pollution.

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

State the effects of water pollutants

Mention the control measures for these water pollutants.

Mention the preventive measures for these water pollutants.

Previous Knowledge: Students has been taught water pollution

Introduction: The following questions are asked based on students' previous knowledge:

Define the term 'Water pollution'

Give examples of Water pollutants

Mention the cause and sources of the following water pollutants on living organisms

Sewage

Detergent

The answers to the questions are based on students Intuition. The teacher presents the concept to the students..

Presentation:

Step I: The teacher gives the Environmental Puzzle to the students and lists the numbers of clues students should provide word(s).

The following clues in environmental puzzle are listed;

CLUE 4

CLUE 8

CLUE 12

Step II: Each student use their Intuition with the aid of environmental puzzle respond to the questions individually, students explain each corresponding word(s) to the clue giving more examples to buttress their points.

Step III: Teacher discusses the ones on which they disagree using environmental puzzle as a guide and providing more examples where necessary

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

State the effects of water pollutants

Mention the control measures for these water pollutants.

Mention the preventive measures for these water pollutants on living organisms

Sewage

Detergent

Assignment: The students should read land pollution against next lesson.

LESSON V

Topic: Land pollution

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term land pollution

List some land pollutants

Mention the causes and sources of land pollution

Previous Knowledge: Students has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of pollution.

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you think can bring about dirt and germs on Land?

(2) What do these dirt and germs do to our bodies?

(3)Is it possible to control these germs and dirt from getting into our bodies? Give reason to support your answer.

The answers to the questions are based on students Intuition. The teacher presents the concept to the students.

Presentation:

Step I: The teacher gives the Environmental Puzzle to the students and lists the numbers of clues students should provide word(s).

The following clues in environmental puzzle are listed;

CLUE 4

CLUE 6

CLUE 7

Step II: Each student use their Intuition with the aid of environmental puzzle respond to the questions individually, students explain each corresponding word(s) to the clue giving more examples to buttress their points.

Step III: Teacher discusses the ones on which they disagree using environmental puzzle as a guide and providing more examples where necessary

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define the term ‘land pollution’

Give examples of land pollutants

Mention the cause and sources of the following

land pollutant on living organisms

Refuse

Old tins

Assignment: The students are asked to read Effects, prevention and control of land pollution against next lesson.

LESSON VI

Topic: Effects, prevention and control of land pollution.

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

State the effects of land pollutants

Mention the control measures for these land pollutants.

Mention the preventive measures for these land pollutants.

Previous Knowledge: Students has been taught land pollution.

Introduction: The following questions are asked based on students’ previous knowledge:

Define the term ‘land pollution’

Give examples of land pollutants

Mention the cause and sources of the following

land pollutant on living organisms

Refuse

Old tins

The answers to the questions are based on students Intuition. The teacher presents the concept to the students.

Presentation:

Step I: The teacher gives the Environmental Puzzle to the students and lists the numbers of clues students should provide word(s).

The following clues in environmental puzzle are listed;

CLUE 4

CLUE 16

CLUE 9

Step II: Each student use their Intuition with the aid of environmental puzzle respond to the questions individually, students explain each corresponding word(s) to the clue giving more examples to buttress their points.

Step III: Teacher discusses the ones on which they disagree using environmental puzzle as a guide and providing more examples where necessary

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked

State the effects of land pollutants

Mention the control measures for these land pollutants.

Mention the preventive measures for these land pollutants.

Assignment: Students should read Conservation of Natural Resources against next lesson.

LESSON VII

Topic: Conservation of Natural Resources

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define and explain conservation of natural resources

Enumerate method of conservation of natural resources

List importance of conservation

Previous Knowledge: Students has been taught has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of Conservation techniques..

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you understand by Good Environment?

(2) What do you expect to see in a good Environment?

(3)Is it possible to maintain Good Environment? Give reason to support your answer.

The answers to the questions are based on students Intuition. The teacher presents the concept to the students.

Presentation:

Step I: The teacher gives the Environmental Puzzle to the students and lists the numbers of clues students should provide word(s).

The following clues in environmental puzzle are listed;

CLUE 13

CLUE 14

CLUE 15

CLUE 18

Step II: Each student use their Intuition with the aid of environmental puzzle respond to the questions individually, students explain each corresponding word(s) to the clue giving more examples to buttress their points.

Step III: Teacher discusses the ones on which they disagree using environmental puzzle as a guide and providing more examples where necessary

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked

Define and briefly explain conservation of resources

Enumerate the methods and importance of the following conservation technique

Water conservation

Soil conservation

Fisheries conservation

Assignment: Students should read Conservation agencies and problems encountered in conservation.

LESSON VIII

Topic: Conservation agencies and problems encountered in conservation

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Explain conservation agency.

Enumerate five conservation agencies.

List problems of conservation

Previous Knowledge: Students has been taught Conservation and its importance.

Introduction: The following questions are asked based on students' previous knowledge:

Define and briefly explain conservation of resources

Enumerate the methods and importance of the following conservation technique

Water conservation

Soil conservation

Fisheries conservation

The answers to the questions are based on students Intuition. The teacher presents the concept to the students.

Presentation:

Step I: The teacher gives the Environmental Puzzle to the students and lists the numbers of clues students should provide word(s).

The following clues in environmental puzzle are listed;

CLUE 15

CLUE 19

CLUE 20

Step II: Each student use their Intuition with the aid of environmental puzzle respond to the questions individually, students explain each corresponding word(s) to the clue giving more examples to buttress their points.

Step III: Teacher discusses the ones on which they disagree using environmental puzzle as a guide and providing more examples where necessary

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

What is meant by conservation agency?

Enumerate five conservation agencies that you know.

List problems of conservation in Nigeria.

Assignment: Students should read Pathogens against next lesson.

APPENDIX VC

TEACHER'S INSTRUCTIONAL GUIDE ON CONVENTIONAL STRATEGY (CONTROL) (TIGCS)

LESSON 1

Topic: Air pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term Air pollution

State the examples of air pollutants

Mention the causes and sources of Air pollution

Previous Knowledge: Students has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of pollution.

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you think can bring about dirt and germs in Air?

(2) What do these dirt and germs do to our bodies?

(3) Is it possible to control these germs and dirt from getting into our bodies? Give reason to support your answer.

Presentation:

Step I: The teacher explains the meaning of pollution and defines Air pollution.

Step II: The teacher states examples of Air pollution

Step III: The teacher explains the sources and causes of Air pollution

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define the term 'Air pollution'

Give examples of Air pollutants

Mention the cause and sources of the following

Air pollutant on living organisms

Smoke

Carbonmonoxide.

Assignment: The students are asked to read Effects, prevention and control of Air pollution against next lesson.

LESSON II

Topic: Effects, prevention and control of Air pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

State the effects of air pollutants

Mention the control measures for these Air pollutants.

Mention the preventive measures for these Air pollutants

Previous Knowledge: Students has been taught Air pollution.

Introduction: The following questions are asked based on students' previous knowledge:

Define the term 'Air pollution'

Give examples of Air pollutants

Mention the cause and sources of the following

Air pollutant on living organisms

Smoke

Carbonmonoxide.

Presentation:

Step I: The teacher explains the process of releasing harmful substances into living environment .

Step II: The teacher lists five effects of these harmful substances released into the air.

Step III; The teacher mention five control and five preventive measures of these harmful substances released into the air.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

State five effects of air pollutants

Mention five control measures for the following Air pollutants

Smoke

And Carbonmonoxide.

How do we prevent the occurrence of these substances?

Assignment: The students are asked to read water pollution against next lesson.

LESSON III

Topic: Water pollution

Time: 80 minutes

References

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term Water pollution.

State the examples of Water pollutants.

Mention the causes and sources of Water pollution.

Previous Knowledge: Students has been taught Effects, prevention and control of Air pollution.

Introduction: The following questions are asked based on students' previous knowledge:

State five effects of air pollutants

Mention five control measures for the following Air pollutants

Smoke

And Carbonmonoxide.

How do we prevent the occurrence of these substances?

Presentation:

Step I: The teacher defines Water pollution and explains it.

Step II: The teacher mention some example of Water pollution and its effect on living organisms.

Step III: The teacher explains the sources and Water pollution and its effects on living organisms.

Evaluations: The teacher assesses students' knowledge of the subject matter,

the following question were asked.

Define the term 'Water pollution'

Give examples of Water pollutants

Mention the cause and sources of the following water pollutants on living organisms

Sewage

Detergent

Assignment: The students should read Effects, prevention and control of water pollution against next lesson.

LESSON IV

Topic: Effects, prevention and control of water pollution

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

State the effects of water pollutants

Mention the control measures for these water pollutants.

Mention the preventive measures for these water pollutants.

Previous Knowledge: Students has been taught water pollution

Introduction: The following questions are asked based on students' previous knowledge:

Define the term 'Water pollution'

Give examples of Water pollutants

Mention the cause and sources of the following water pollutants on living organisms

Sewage

Detergent

Presentation:

Step I: Teacher discusses the process of releasing harmful substances into water including

Step II: Teacher discusses the effects of these harmful substances released into water?

Step II: Teacher discusses five control measures of these harmful substances released water.

Evaluation: Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

State the effects of water pollutants

Mention the control measures for these water pollutants.

Mention the preventive measures for these water pollutants on living organisms

Sewage

Detergent

Assignment: The students should read Effects, prevention and control of land pollution against next lesson.

LESSON V

Topic: Land pollution

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define the term land pollution

List some land pollutants

Mention the causes and sources of land pollution

Previous Knowledge: Students has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of pollution.

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you think can bring about dirt and germs on Land?

(2) What do these dirt and germs do to our bodies?

(3)Is it possible to control these germs and dirt from getting into our bodies? Give reason to support your answer.

Presentation:

Step I: Teacher discusses the process of releasing harmful substances on land.

Step II: Teacher discusses the effects of these harmful substances released on land.

Step II: Teacher discusses five control measures of these harmful substances released on land.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define the term 'land pollution'

Give examples of land pollutants

Mention the cause and sources of the following

land pollutant on living organisms

Refuse

Old tins

Assignment: The students are asked to read Effects, prevention and control of land pollution against next lesson.

LESSON VI

Topic: Effects, prevention and control of land pollution.

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

State the effects of land pollutants

Mention the control measures for these land pollutants.

Mention the preventive measures for these land pollutants.

Previous Knowledge: Students has been taught land pollution.

Introduction: The following questions are asked based on students' previous knowledge:

Define the term 'land pollution'

Give examples of land pollutants

Mention the cause and sources of the following

land pollutant on living organisms

Refuse

Old tins

Presentation:

Step I: The teacher state the effects of land pollutants

Step II: The teacher mention the control measures for these land pollutants.

Step III: The teacher mention the preventive measures for these land pollutants.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

State the effects of land pollutants

Mention the control measures for these land pollutants.

Mention the preventive measures for these land pollutants.

Assignment: Students should read Conservation of Natural Resources against next lesson.

LESSON VII

Topic: Conservation of Natural Resources

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Define and explain conservation of natural resources

Enumerate method of conservation of natural resources

List importance of conservation

Previous Knowledge: Students has been taught has been taught YOU AND YOUR ENVIRONMENT in their junior secondary school which may be helpful in understating the concept of Conservation techniques..

Introduction: The following questions are asked based on students' previous knowledge:

(1) What do you understand by Good Environment?

(2) What do you expect to see in a good Environment?

(3)Is it possible to maintain Good Environment? Give reason to support your answer.

Presentation:

Step I: The teacher defines and explains conservation

Step II: The teacher defines and states the methods of water conservation.

Step III: The teacher also defines and states the methods and importance of wildlife and fisheries conservation.

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

Define and briefly explain conservation of resources

Enumerate the methods and importance of the following conservation technique

Water conservation

Soil conservation

Fisheries conservation

Assignment: Students should read Conservation agencies and problems encountered in conservation.

LESSON VIII

Topic: Conservation agencies and problems encountered in conservation

Time: 80 minutes

Reference Book

Comprehensive Biology by Chris Nweze

Exam Focus Biology for SSCE and JME by Egunyomi, Bob Manuel, Abdullahi and Oyetola.

Instructional Materials: Charts

Behavioural Objectives: At the end of the lesson students should be able to:

Explain conservation agency.

Enumerate five conservation agencies.

List problems of conservation

Previous Knowledge: Students has been taught Conservation and its importance.

Introduction: The following questions are asked based on students' previous knowledge:

Define and briefly explain conservation of resources

Enumerate the methods and importance of the following conservation technique

Water conservation

Soil conservation

Fisheries conservation

Presentation:

Step I: The teacher explains conservation agency.

Step II: The teacher enumerates five conservation agencies.

Step III: The teacher lists the problems of conservation

Evaluations: The teacher assesses students' knowledge of the subject matter, the following question were asked.

What is meant by conservation agency?

Enumerate five conservation agencies that you know.

List problems of conservation in Nigeria.

Assignment: Students should read Pathogens against next lesson.

APPENDIX VIA

EVALUATING SHEET FOR ASSESSING TEACHERS' PERFORMANCE ON THE USE OF PRE-THEORETIC INTUITION QUIZ (ESATPT)

Name of Teacher: ----------
School: ----------
Date: ----------

Guidelines Involved	V. Good 5	Good 4	Average 3	Poor 2	V.Poor 1
Teacher introduction of the lesson whether it is based on students previous Knowledge.					
Teacher's ability to give students the opportunity to answer the questions using their intuition.					
Teacher's ability to give students quiz aimed at getting students to both identify the concept and leading to the behavioural objective.					
Teacher's patience to allow students to present their ideas based on their intuition					
Teacher's clarification of students views on the concept.					
Teacher's assessment for more critical analysis.					
Teacher gives homework or assignment					

APPENDIX VIB
EVALUATING SHEET FOR ASSESSING TEACHERS' PERFORMANCE ON THE USE OF PUZZLE-BASED (ESATPB)

Name of Teacher: ----------
School: ----------
Date: ----------

Guidelines Involved	V. Good 5	Good 4	Average 3	Poor 2	V. Poor 1
Teacher introduction of the lesson whether it is based on students previous Knowledge.					
Teacher's ability to give students the opportunity to answer the questions using their intuition and the Environmental puzzle as guides.					
Teacher's ability to use the clues inside the Environmental puzzle as guides in order to make students to both identify the concept and leading to the behavioural objective.					
Ability of the teacher to make students to respond by allowing students to present their ideas with the aid of the Environmental Puzzle.					
Teacher clarification of students views on the concept using the Environmental puzzle as basis for clarification.					
Teacher's ability to assess students for more critical analysis on the content using the Environmental puzzle.					

APPENDIX VIC:
EVALUATING SHEET FOR ASSESSING TEACHERS' PERFORMANCE ON THE USE OF MODIFIED CONVENTIONAL STRATEGY (ESATMC)

Name of Teacher: ----------
School: ----------
Date: ----------

Guidelines Involved	V. Good 5	Good 4	Average 3	Poor 2	V. Poor 1
Teacher's introduction of the lesson.					
Ability of the Teacher to discuss the content of the concepts.					
Ability of the Teacher to allow students to write the note.					
Teacher's ability to give an overview of the lesson.					
Teacher's oral questions in conformity with the concept.		`			
Teacher conclusion of the lesson.					
Teacher gives homework or assignment.					