

**PRE-THEORETIC INTUITION QUIZ, PUZZLE-BASED CRITICAL THINKING MOTIVATION STRATEGIES, GENDER AND COGNITIVE STYLES ON STUDENTS' ATTITUDE TOWARDS SELECTED ENVIRONMENTAL CONCEPTS IN BIOLOGY**

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**Oluyemi, Akinleye Ogundiwin**

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Department of Teacher Education  
University of Ibadan, Ibadan, Oyo State, Nigeria.  
E-mail: [yemiogundiwin@yahoo.com](mailto:yemiogundiwin@yahoo.com)

**ABSTRACT**

Attempts at modifying people's environmental attitude need to be directed to students in the formal education sector because the foundations of pre-adult attitude toward the environment are formed during childhood, this outcome govern behaviour throughout adult life. This study, determined Pre-theoretic intuition quiz, Puzzle-based critical thinking motivation strategies, gender and cognitive style as predictors of students' attitude toward environmental 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 and control groups and the study lasted sixteen weeks. Six instruments used for data collection were: Teachers Instructional Guides for teachers using the two treatments and control group; Students Environmental Attitude Scale. ( $r = 0.81$ ), Cognitive Style Test (test-retest  $r = 0.81$ ) and Assessment Sheet for the research assistants. Four null hypotheses were tested at 0.05 level of significance. Data collected were analyzed using Analysis of Covariance (ANCOVA) and graphs. There was significant main effect of treatment on students' environmental attitude ( $F_{(2,450)} = 287.32$ ;  $p < 0.05$ ), Pre-Theoretic Intuition Quiz had the highest practices scores enhanced attitude scores ( $\bar{x} = 64.34$ ) than Puzzle-Based learning ( $\bar{x} = 57.81$ ) and Modified Conventional group ( $\bar{x} = 48.97$ ). There was significant interaction effect of cognitive style and sex on students' environmental attitude scores ( $F_{(1,450)} = 6.61$ ;  $p < 0.05$ ). Pre-theoretic intuition quiz and Puzzle-based learning strategies are effective in improving students' attitude toward a sustainable environmental development, taking into cognizance the cognitive style and gender of students.

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**Introduction**

Environmental challenges grow in complexity, intensity and severity as a result of increasing ecological disturbance. The air around is laden with dangerous chemicals arising from industrial activities. Vast lands have been devastated by indiscriminate dumping of refuse, sewage disposal including application of pesticides on agricultural lands.

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). This 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.

The establishment of the Federal Environmental Protection Agency (FEPA) did not help the situation because of the recent flood disaster that occurred in Lagos on 9<sup>th</sup> of July, 2011 including that of Ibadan on 26<sup>th</sup> of August, 2011 that led to further degradation to the environment. In Ebonyi state, Nigeria, a family of eight died through poisonous gas released from electricity generating set was reported on July 9, 2012 and in Ibadan, loss of life and property after long periods of heavy rainfall that occurred in the first half of 2012 have been reported in prints and electronic media. These occurrence are due to the negative attitude and the practices of releasing carbon monoxide from exhaust of electricity generating set, dumping refuse into streams, ditches, rivers and building of houses and structures along drainages and waterways necessitate the need for our environment to be safe and allows all living things to have good access to air and water that maintain as well as promote good health (Moronkola, 2003).

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 environmental resources must be emphasized in environmental education. Adegbile (2002) was of the opinion that teachers who wish to impact the knowledge including magnitude of these environmental problems must employ metacognitive (ability to monitor, use and control thinking skills) teaching strategies.

The National Policy on Education (2004) makes it compulsory for all students to offer at least a science subject at the senior secondary school. Biology is the most preferred subject and chosen by many science and non science students (Abubakar, 2001). Many Environmental Education concepts such as ecology, pollution, conservation techniques and population are found in Biology of the West African Senior Secondary Certificate Examination /National Examination Council/ Senior Secondary Certificate Examination syllabuses.

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, attitude including practices towards environmental concept in Biology (Ige, 2001), Nwozu, (2003) and Olagunju (2002). It is therefore necessary to consider the effects of critical motivation strategies (Pre-Theoretic Intuitions Quiz and Puzzle-Based learning) on student's achievement, attitude and practices towards Environmental Education concepts in Biology

The Pre-Theoretic Intuitions Quiz strategy may be used by an instructor to ask questions in order to elicit 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. The strategy has not occurred on any regular basis in most middle, junior high, and senior high schools due to lack of teacher knowledge, lack of materials, class size and competing demands such as emphasis of tests, coverage of textbook content, and required academic content (Kirschner, Sweller & Clark, 2006).

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

An approach illustrated by the Biological Concepts Instrument (BCI) by Klymkowsky *et al.*, (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 was adapted specifically in this research.

Kendall, Parks & Spencer (2008) 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 Education which include Classroom resources, Arts and craft,, introducing new ideas, illustrating strategies, physical manipulation, public event, skill testing, problem posing and original research. Evidence abounds that Puzzle-based instructional strategy in teaching and learning of science education in Korean Universities improved understanding of abstract concepts and develop problem-solving abilities in students (Anany & Mary 2002).According to Kendall *et al.*, (2008), Puzzle-based learning engages students with materials more than passive review and its use made learning more exciting thereby leading to the achievement of desired learning outcomes.

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. Olagunju (2002) supported this view when asserting that any strategy in Environmental Education 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.

Researchers have come up with different findings on the effect of gender on learning outcomes while some found no significant differences based on gender (Morribend (2004), Chukwuka (2005) and Ogunleye (2002), Raimi, (2003). They individually reported that males perform better than their female counterparts in science subjects. Okeke (2001) and Aremu (2005) also reported significant effect of gender on learning outcomes in favour of the male students.

It has also been suggested that student's cognitive styles 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.

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

### **Statement of the Problem**

A number of studies have been carried out using instructional studies to address students' attitude in Biology. However, it is necessary to carry out a study using critical thinking motivational strategies where students will be equipped with the instructional materials they needed for thinking activities as they engage in critical thinking to ascertain its effect on students' attitude. Literature did not indicate that a study that employed two modes of critical thinking strategies in teaching Environmental Education concepts in biology that will expose students to a higher thinking order to promoting in them sustainable development and positive environmental attitude has been carried out in Nigeria.

This study, therefore investigated the effects of pre-theoretic intuition quiz and puzzle-based critical thinking motivation strategies on students' attitude towards Environmental Education concepts in Biology. It also examined the moderating effect of gender of the students and their cognitive styles on learning outcomes in Environmental concept in Biology.

### **Hypotheses**

The following null hypotheses will be tested at 0.05 level of significance.

H<sub>01</sub>: There is no significant main effect of treatment on students' environmental attitude

H<sub>02</sub>: There is no significant main effect of cognitive style on students' environmental attitude.

H<sub>03</sub>: There is no significant main effect of gender on students' environmental attitude

H0<sub>4</sub>: There is no significant interaction effect of cognitive style and gender on students' Environmental attitude

### **Methodology**

This study adopts pretest, posttest, control group, quasi-experimental design. It examined possible effects of the Pre-Theoretic Intuition Quiz and Puzzle-Based learning, gender and cognitive style on students' attitude toward selected environmental concepts in biology.

A 3 X 2 X 2 factorial matrix will be 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).

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

### **Research Instruments**

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

- i. Students Environmental Attitude Scale (SEAS)
- ii. Cognitive Style Test (CST)
- iii. Teachers Instructional Guide (TIG) on Pre-theoretic Intuition Quiz on Environmental Concepts in Biology (TIGPT)
- iv. Teachers Instructional Guide (TIG on Puzzle-Based learning on Environmental Concepts in Biology (TIGPB)
- v. Teachers Instructional Guide (TIG) on Modified Conventional Method on Environmental Concepts in Biology (TIGCM)
- vi. Evaluation Sheet for Assessing Teachers Performance on the use of the Strategies (ESAT) on Pre-theoretic Intuition Quiz in Environmental Concepts in Biology, Puzzle-Based learning in Environmental Concepts in Biology .and Modified Conventional Strategy in Environmental Concepts in Biology.

### **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.

**Table 1: Table of Specification for 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         |
|     | <b>Total</b>            | <b>10</b>      | <b>10</b>      | <b>20</b> |

The initial draft containing 45 items were reduced to 20 in the final draft by the experts Cronbach Alpha reliability co-efficient of 0.81 was obtained.

**Cognitive Style Test (CST)**

This instrument was in line with that of Sigel’s cognitive style Test (1967). The revised edition by Awolola (2009) 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 ‘analytical’ and ‘non-analytical’ styles on the basis of their statements regarding the way they perceive the pictures.

**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.

**Teachers Instructional Guide on Pre-Theoretic Intuition Quiz Strategy in Environmental Concept (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.

### ***Teachers Instructional Guide on Puzzle-Based Learning Strategy in Environment Concept (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](http://www.TheTeachercorner.net). In this stimulus instrument, the teacher introduces and demonstrate 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.

### ***Teacher's Instructional Guide on Modified Conventional Strategy in Environmental Concept (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

### ***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: Pre-theoretic Intuition Quiz (PRESAT), Puzzle-Based learning (PESAT) and Modified Conventional Strategy (MESAT).

### ***Research Procedure for the Study***

The following time schedule will be adopted;

- The first week for visitation to schools to be used for the treatment
- The next two (2) weeks for training of research assistants
- One (1) week for scrutiny of research assistants to ensure that they are ready to do what they are supposed to do. (During demonstration lesson).
- One (1) week for pre-test (Administration of SEAS)
- Eight (8) weeks for treatment using the trained research assistants on the listed strategies. These take place simultaneously in all the schools selected.
- One (1) week Posttest (Administration of SEAS)

This makes a total of fourteen (14) weeks.

### ***Training of Research Assistants***

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

### ***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 followed by Cognitive Style Test (CST) in that order.

### ***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.

### ***Pre-theoretic Intuition Quiz Strategy***

Steps include;

**Step 1:** Research assistants should be able to 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 should be able to 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 should 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

### ***Puzzle-Based Learning Strategy***

Steps include;

**Step 1:** Research assistants should introduce 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 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.

### ***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.

### ***Administration of Posttest***

All the SSII students in the nine representative schools used for the experimental and control groups were given Posttests on all the evaluative instruments. Students Environmental Attitude Scale was administered.

### ***Procedure for Data Analysis***

The data was analyzed using Analysis of Covariance (ANCOVA) of the posttest scores with the pretest scores as the 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. Graphs were used to explain the significant interaction effects.

### **Results**

The results were interpreted at the 0.05 level of significance

**Ho<sub>1</sub>:** There is no significant main effect of treatment on students 'Environmental Attitude.

**Table 2: 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 |                        |     |             |         |       |                     |
| Treatment                        | 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*                 | 180.347                | 1   | 180.347     | 6.614   | .010* | .015                |
| Gender                           |                        |     |             |         |       |                     |
| Treatment*                       |                        |     |             |         |       |                     |
| Cognitive-Style*                 | 176.570                | 2   | 88.285      | 3.2238  | .040* | .015                |
| Gender                           |                        |     |             |         |       |                     |
| 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 2 revealed that there was a significant effect of treatment on students' environmental attitude ( $F_{(2,450)} = 287.322$ ;  $P < 0.05$ ; partial eta squared = .567). The effect size of 56.7% was fair. On this basis, hypothesis 1 was rejected. This means that the difference between the environmental attitude score of students exposed to Pre-Theoretic Intuition Quiz, Puzzle-Based learning and that of control e group was significant.

**Table 3: Estimated Marginal Means of Posttest Attitude Score by Treatment and Control Group**

Grand Mean= 57.042

| 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 3 revealed that students in the Pre-Theoretic Intuition Quiz treatment group had the highest adjusted post test mean Attitude scores ( $\bar{X} = 64.344$ ) followed by the Puzzle-Based learning treatment group ( $\bar{X} = 57.808$ ) while students in the Modified Conventional strategy group had the least adjusted mean Attitude scores ( $\bar{X} = 48.973$ ). The grand mean being 57.042. Further, the source of the significant difference obtained was traced using Scheffe post-hoc test in Table 4.6.

**Table 4: Scheffe Post-hoc Tests Analysis of Post-test Attitude Score According to Treatment Group**

| Treatment      | N   | Mean   | 1.Pretheoretic | 2. Puzzle | 3 Conventional |
|----------------|-----|--------|----------------|-----------|----------------|
| 1 Pretheoretic | 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 revealed that group 1 (Pre-Theoretic Intuition Quiz) is significantly different from group 2 (Puzzle-Based learning) and group 3 (Modified Conventional strategy) in their Attitude scores. Pre-Theoretic Intuition Quiz revealed significant difference from Puzzle-Based learning and Modified Conventional strategies in attitude scores; these revealed that the direction of increasing effect of instructional strategy (treatment) on environmental attitude was Modified Conventional strategy < Puzzle-Based learning < Pre-Theoretic Intuition Quiz.

**H0<sub>2</sub>:** There is no significant main effect of cognitive style on students' Environmental Attitude.

Table 2 revealed that there was no significant effect of education level on participants environmental attitude ( $F_{(1,450)} = .003$ ;  $p > .05$ ; partial eta squared = .000). Hence hypothesis 2b was not rejected.

**Table 5: Estimated Marginal Means of Posttest Attitude Scores by Cognitive style**

Grand Mean= 57.042

| 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      |

Non analytical students had higher Mean = 57.058 while the analytical students had a lower Mean =57.026, but the difference was not significant.

**H0<sub>3</sub>:** There is no significant main effect of gender on students' Environmental Attitude. It was obtained from Table 4.4 that the effect of gender on participants environmental attitude was not significant ( $F_{(1,450)} = 3.095$ ,  $p > 0.05$ ; partial eta

squared = .007) The effect size of 0.7% was negligible. Therefore, hypothesis Ho 3b was not rejected.

**Table 6: Estimated Marginal Means of Posttest Attitude Scores by Gender**

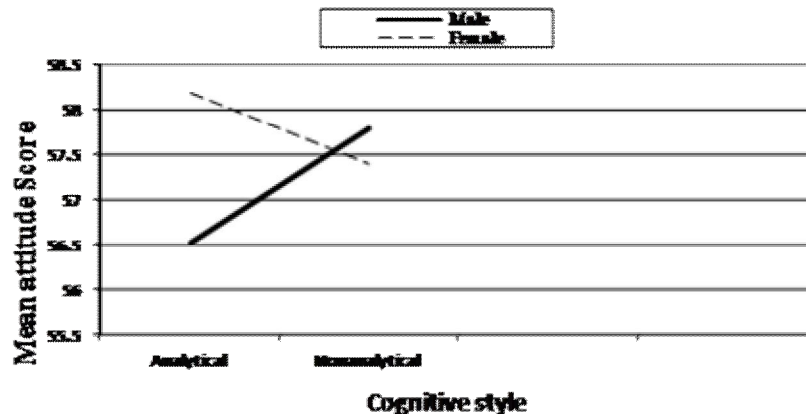
Grand Mean= 57.042

| 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      |

Female students had higher Mean =57.513 while the Male students had a lower Mean = 56.571 , but the difference was not significant

**HO<sub>4</sub>:** There is no significant interaction effect of cognitive style and gender on students' environmental attitude.

Table 2 revealed that there was significant interaction effect of cognitive style and gender on students' attitude towards environmental pollution scores ( $F_{(1,450)} = 6.614; P < .05$ ) partial eta squared = .015. The effect size of 1.5% was fair. Therefore, hypothesis 6b was rejected. Figure 4.1 revealed the graph showing Post-Test attitude by Cognitive Style and gender



**Figure 1: Graph showing interaction effect of Posttest attitude by Cognitive Style and Gender**

The graph in Figure 1 showed the interaction effect of 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). Grand mean = 57.042.

### **Discussion of Results, Implication of Findings and Recommendations**

There was a significant difference in the main effect of treatment on environmental attitudes of the students exposed to Pre-Theoretic Intuition Quiz and Puzzle-Based learning as shown in Table 2. This finding shows that both strategies (Pre-Theoretic Intuition Quiz and Puzzle-Based learning) enhanced students' attitudes over and above the Modified Conventional strategy. This result suggests that the Pre-Theoretic Intuition Quiz effectively impacted the environmental attitudes 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 attitude.

This finding is related to the findings of research conducted by Tessier (2006), using Pre-Theoretic Intuitions Quiz strategy. 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. 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.

Thus; the relatively low attitude 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.

Table 2 revealed the interaction effects of cognitive style and gender were significant on students' environmental attitude. This finding corroborates the work of Giancarlo & Facione (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 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 1 also revealed that students that fall into analytical group obtained higher post test mean scores in attitude 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.

### **Implications for Findings**

The exposure of the learners to pre-theoretic intuition quiz and puzzle-based learning strategies has been found to positively affect the enhancement of students' environmental attitudes. 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 the right attitudes needed to solve various environmental problems prevalent in our surroundings.

### **Recommendations**

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

Pre-Theoretic Intuition Quiz and Puzzle-Based learning strategies should be adapted as viable strategies for study environmental pollution and conservation of natural resources as they involve the students in monitoring their learning process. These are viable teaching methods for raising attitude needed by students in our secondary schools.

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 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.

Teaching strategies such as Pre-Theoretic Intuition Quiz and Puzzle-Based learning that reduce the gender difference in environmental attitudes 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.

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 and Puzzle-Based learning 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.

### **Conclusion**

This study is in line with the work of researchers who believe that strategy learning improves content learning (Palinscar and Brown, 1984) 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 attitude 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.

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