



Critical Thinking Motivation Strategies as Innovative Classroom Practices for Sustainable Environmental Development in South Western Nigeria

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Abstract. Developing countries such as Nigeria started experiencing serious and complex environmental problems in the 1980s. Some of these problems include: over-population, pollution, unchecked industrialization, abuse of natural resources, flooding, erosion, solid waste disposal, desertification and drought. Thus, research in science education has continued to seek for more effective ways of teaching science in order to ensure environmental sustainability. Therefore, this study examined critical thinking motivation strategies as innovative classroom practices for sustainable environmental development in Southwestern Nigeria. The study adopted pretest-posttest control group quasi-experimental design. Four hundred and fifty one (451) SS2 students from six purposively selected senior secondary schools in southwestern Nigeria were used for the study. The schools were randomly assigned to critical thinking motivation strategies (Pre-theoretic Intuition Quiz and Puzzle Based Learning) and control. Instruments used included: Instructional Guides for Teachers; Students' Environmental Practices Scale ($r=0.82$), and Assessment Sheet for Evaluating Research Assistants. Two null hypotheses were tested at 0.05 level of

significance. Data collected were analysed using ANCOVA and Scheffe post hoc test. Treatment 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 Control ($\bar{x} = 48.33$). Pre-theoretic intuition quiz and Puzzle-based learning strategies improved students' practices towards sustainable environmental development in Southwestern Nigeria. Based on the findings, the study recommended that Pre-Theoretic Intuition Quiz and Puzzle-Based learning strategies should be adopted as viable strategies for the study of environmental pollution and conservation of natural resources.

Keywords: Pre-theoretic intuition quiz, Puzzle-based learning, sustainable environmental development, Southwestern Nigeria

1. 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 9th of July, 2011 including that of Ibadan on 26th 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.

It has also been observed by researchers like Olagunju, (2002) and Youssef (2004) that the foundations of pre-adult behaviour are formed during childhood and this govern behaviour throughout adult life. At Secondary school level, it is necessary to develop the right environmental knowledge that will improve achievement in environmental concepts including the right attitude and practices for maintaining and promoting sustainable environment.

The National Policy on Education (2013) 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).

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' 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 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 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. 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, cover. 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. age 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).

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 practices toward the environment are formed during childhood and that these practices 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 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.

It has been suggested that 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).To this end, good environmental practices is necessary because environmental degradation, if not checked, can have great impact on natural resources, human health and ecosystems with adverse consequences for the present and future generations of Nigerians (Oduwaye,2009).

Researchers have come up with different findings on the effect of gender on learning outcomes. While some found no significant differences based on gender (Chukwuka (2005). They individually reported that males perform better than their female counterparts in science subjects. Aremu (2005) also reported significant effect of gender on learning outcomes in favour of the male students.

2. Statement of the Problem

The prevailing poor environmental practices for sustainable development suggests that critical thinking is necessary to approach these environmental problem encounter in our environment 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 thought that can ascertain its effect on sustainable environmental development in the country..

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 promote in them right environmental practices for sustainable development in Nigeria.

This study examine critical thinking motivation strategies as innovative classroom practices for sustainable environmental development in southwestern Nigeria It also examined the moderating effect of gender of the students on environmental practices for sustainable development in Nigeria.

3. Hypotheses

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

H₀₁: There is no significant main effect of treatment on students' Environmental practices

H₀₂: There is no significant main effect of gender on students' Environmental practices.

4. Theoretical Framework

Constructivist, as a learning theory, the roots of which can be found in the works of Piaget and Vygotsky, can be traced back to decades, while the actual application of the theory is relatively new (Richardson, 2003). Research shows that good pedagogical practices are more likely when including a constructivist approach as compared to a mere traditional approach to education (DiEnno & Hilton (2005); Muller, Sharma & Reimann, 2006). Constructivist teaching methods are based on constructivist learning theory. Along with John Dewey, Jean Piaget (1954) researched childhood development and education. Their theories are now encompassed in the broader movement of progressive education. . Most of these methods rely on some form of guided discovery where the teacher avoids most direct instruction and attempts to lead the student through questions and activities to discover, discuss, appreciate and verbalize the new knowledge. Constructivist learning theory asserts that knowledge is constructed from a base of prior knowledge. Children are not a

blank slate and knowledge cannot be imparted without the child making sense of it according to his or her current conceptions. Therefore children learn best when they are allowed to construct a personal understanding based on experiencing things and reflecting on those experiences.

The implication of cognitive constructivism, according to Kato & 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.

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 .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, 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 practices towards environmental sustainability.

5. 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 and gender on students' practices on selected environmental concepts in biology.

5.1 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 drawn from nine intact classes used for the study. Random sampling technique was used to select the six purposively selected co-educational secondary schools in Ibadan, Osogbo, Lagos, Akure, Ado Ekiti and Abeokuta in Southwestern Nigeria. The selections of schools are based on the following criteria:

- Evidence of presenting students for SSCE Biology examination for at least ten (10) years co-education schools
- Availability of experienced Biology teachers with at least three years teaching experience
- Evidence of SS II students of the schools having been exposed to basic pre-requisite concepts necessary for the understanding of the concepts of the study accessibility of the school

5.2 Selection of Environmental Education Concepts for the Study

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 Secondary Certificate Education Biology syllabus.

5.3 Research Instruments

Five instruments constructed by the researcher were used in this study to collect data:

- Students Environmental Practices Scale.(SEPS)
- Teachers Instructional Guide (TIG) on Pre-theoretic Intuition Quiz on Environmental Concepts in Biology (TIGPT)
- Teachers Instructional Guide (TIG) on Puzzle-Based learning on Environmental Concepts in Biology (TIGPB)
- Teachers Instructional Guide (TIG) on Modified Conventional Method on Environmental Concepts in Biology (TIGCM)
- 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.

5.4 Student Environmental Practices Scale (SEPS)

The instrument is a property of George Street Research Limited, Edinburgh (2006). It was modified to suit the measurement of practices of senior secondary school students towards environmental pollution and conservation techniques.

Table 1: Table of Specification for SEPS

S/N	Concepts/Topics	(+) Positive	(-) Negative	Total No
1	Air pollution	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

Cronbach alpha measure after trial testing gave 0.82.

5.5 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.

5.6 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.

5.7 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. 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.

5.8 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

5.9 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).

6. Research Procedure for the Study

The following time schedule was 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, SEAT and SEPS)
- 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 SEPS)

This makes a total of fourteen (14) weeks.

6.1 Training of Research Assistants.

7. Results

Ho 1: There is no significant main effect of treatment on students' Environmental Practices.

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

6.2 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 Students Environmental Practices Scale.(SEPS).

6.3 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.

6.4 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. The Posttests was Students Environmental Practices Scale.(SEPS) .

6.5 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.

Table 2: Summary of ANCOVA of Post-Test Practices by Treatment 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
GENDER	80.684	1	80.684	2.970	.086	.007
Error	11898	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 2 revealed that there was significant main effect of treatment on students’ environmental practices ($F_{(2,450)} = 363.478$; $p < 0.05$; 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 3: Estimated Marginal Means of Posttest Practices Score by Treatment and Control Group

Grand Mean= 57.512

Treatment	Mean	Std Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1.Pretheoretic	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 3 revealed students in the Pre-Theoretic Intuition Quiz treatment group had the highest adjusted post test mean environmental practices score ($\bar{X} = 65.337$) followed by the Puzzle-Based learning treatment group ($\bar{X} = 59.183$) while students in the Modified Conventional strategy group had the least adjusted mean environmental practices score ($\bar{X} = 48.326$). The grand mean being 57.512. Further, the source of the significant difference obtained in Table 4.9 was traced using Scheffe post-hoc test in Table 4

Table 4: Scheffe Post-hoc tests Analysis of Post-test Practices Score 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 shows that group 1 (Pre-Theoretic Intuition Quiz) was significantly different from Puzzle-Based learning and Modified Conventional strategy 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 < Puzzle-Based learning < Pre-Theoretic Intuition Quiz.

Ho 2: There is no significant main effect of gender on students’ Environmental practice.

From Table 2, there was no significant effect of gender on participants’ environmental practices ($F_{(1,450)} = 2.970$; $p < .05$; partial eta squared = .007) The effect size of 0.7% was negligible.. Hence, hypothesis 3 was not rejected.

8. Discussion

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), 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.

9. Implications for Findings.

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 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 and necessary practices needed to solve various environmental problems prevalent in our surroundings.

10. 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 the study of environmental pollution and conservation of natural resources as they involve the students in monitoring their learning process. These are viable teaching methods for raising achievement, attitude and necessary

practices 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. for 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 Nigerian youths 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.

11. Conclusion

This study is in line with the work of researchers who believe that strategy learning improves content learning and to develop strategies for resolving environmental problems leading to sustainable development in our country, 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 students' practices towards environmental pollution will improved positively, 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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