Puzzle-based critical thinking motivation strategies, gender and cognitive style on students’ practices towards environment-related concepts in biology

Adesina, Abiodun E.¹*, Adegoke Adebare I.² and Ogundiiwin, Oluyemi A.³

¹General Studies Education, School of Education, Emmanuel Alayande College of Education, Oyo, Oyo State, Nigeria.
²Department of Integrated Science, College of Education, Lanlate, Oyo State, Nigeria.
³Teacher Education Department, Faculty of Education, University of Ibadan, Ibadan. Nigeria.

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It is necessary to carry out a study using critical thinking motivational strategy 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’ environmental education practices. Literature did not indicate that a study that employed any mode of critical thinking strategy in teaching Environmental Education concepts in biology. This study, therefore, examined the effects of Puzzle-Based Learning (PBL), Cognitive style and Gender on student’s practices in selected environment-related concepts in biology. The pretest-posttest control group quasi-experimental design was adopted. Four hundred and fifty one SS2 students from six purposively selected senior secondary. The schools were randomly assigned to experimental (PBL) and control (MCS) groups and the treatment lasted 14 weeks. Five instruments were used: Instructional Guides for teachers, Students’ Environmental Practices Scale (r=0.82), Cognitive Style Test (r=0.81) and Assessment Sheet for evaluating research assistants. Two null hypotheses were tested at 0.05 alpha level. Data were analysed using ANCOVA Treatment had significant main effect on students’ environmental practices (F(2,438) = 363.48; p<0.05). PBL (x̄ =59.18) performed better than MCS (x̄ =48.33). Interaction effect of cognitive style and gender on students’ environmental practices was significant (F(1,438) = 6.03; p<0.05). Female analytical students had the highest mean score (x̄ =58.75) while the male analytical students (x̄ =56.51) had the least. Puzzle-based learning strategy improved students’ practices in environment-related concepts in biology taking into consideration cognitive style and gender of the students.

Key words: Puzzle-based learning, cognitive style, gender and environment-related concepts in biology.

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 (Oduwayne, 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 due to poisoning of 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 print 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 drainage 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 and 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 (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 (Puzzle-Based learning) on student’s practices towards Environmental Education concepts in Biology.

Kendall et al. (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 and 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 and 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 (Oduwayne, 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 (Morribend (2004); Chukwuka (2005); 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 seek to evaluate Puzzle-Based learning will have on student’s practices 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 practices towards Environmental concept in biology.

**Statement of the problem**

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’ environmental education practices. Literature did not indicate that a study that employed any mode of critical thinking strategies in teaching Environmental Education concepts in biology that will expose students to a higher thinking order to improve their performance in the Senior Secondary school certificate as well as promoting in them right environmental practices for sustainable development and positive environmental attitude has been carried out in Nigeria.

This study, therefore investigated Puzzle-based critical thinking motivation strategies on students’ practices towards Environmental Education concepts in Biology. It also examined the moderating effect of gender of the students and their cognitive styles on students’ practices towards Environmental concept in Biology.

**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 interaction effect of Cognitive style and gender on students’ environmental practices

**METHODOLOGY**

This study adopts pretest, posttest, control group, quasi-experimental design. It examined possible effects of Puzzle-Based learning, gender and cognitive style on students’ practices on selected environmental concepts in biology.

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 six 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. 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

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.

**RESEARCH INSTRUMENTS**

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

i. Students Environmental Practices Scale (SEPS)
ii. Cognitive Style Test (CST)
iii. Teachers Instructional Guide (TIG on Puzzle-Based learning on Environmental Concepts in Biology (TIGPB)
iv. Teachers Instructional Guide (TIG) on Modified Conventional Method on Environmental Concepts in Biology (TIGCM)

**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.
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 strategy (Puzzle-Based learning) and Conventional strategy. These were used during the training period for the experimental and control groups.

Teacher’s 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.

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: 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 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.

Training of research assistants

Training was done step by step through the explanation on the teaching guides.
Puzzle-Based learning and Modified Conventional strategies.

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 on Students Environmental Practices Scale.(SEPS) and 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.

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 aides 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. The Posttests was administered on Students Environmental Practices Scale.(SEPS)

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. Graphs were used to explain the significant interaction effects.

RESULTS

The results were interpreted at the 0.05 level of significance

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

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

Table 3 revealed students in the Puzzle-Based learning treatment group (X̄ = 59.183) while students in the Modified Conventional strategy group had the least adjusted mean environmental practices score (X̄ = 48.326). The grand mean being 57.512.

H0 2: There is no significant interaction effect of cognitive style and gender on students’ environmental practices

Table 1 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 2 was rejected.

The major contribution to the significant interaction effects comes from the categories of female Analytical students (Mean= 58.750) while the least came from Male
Table 1. Table of specification for SEPS.

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

Cronbach alpha measure after trial testing gave 0.82.

Table 2. Summary of ANCOVA of post-test practices by treatment, cognitive style and gender.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type II sum of squares</th>
<th>Df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial eta squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrected model</td>
<td>25972.465*</td>
<td>12</td>
<td>2164.374</td>
<td>79.674</td>
<td>.000</td>
<td>.686</td>
</tr>
<tr>
<td>Intercept</td>
<td>8119.007</td>
<td>1</td>
<td>8119.007</td>
<td>298.872</td>
<td>.000</td>
<td>.406</td>
</tr>
<tr>
<td>Pre-environmental-practices-scale</td>
<td>1863.824</td>
<td>1</td>
<td>1863.924</td>
<td>68.614</td>
<td>.000</td>
<td>.135</td>
</tr>
<tr>
<td>Treatment</td>
<td>19748.129</td>
<td>1</td>
<td>19748.129</td>
<td>363.478</td>
<td>.000*</td>
<td>.135</td>
</tr>
<tr>
<td>Cognitive-style* gender</td>
<td>163.820</td>
<td>1</td>
<td>163.820</td>
<td>6.030</td>
<td>.014*</td>
<td>.014</td>
</tr>
<tr>
<td>Error</td>
<td>11898</td>
<td>438</td>
<td>27.165</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1518142.000</td>
<td>451</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corrected total</td>
<td>37870.949</td>
<td>450</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Table 3. Estimated marginal means of posttest practices score by treatment and control group. Grand mean= 57.512.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Mean</th>
<th>Std error</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower bound</td>
<td>Upper bound</td>
<td></td>
</tr>
<tr>
<td>Puzzle</td>
<td>59.183</td>
<td>0.466</td>
<td>58.268</td>
</tr>
<tr>
<td>Conventional</td>
<td>48.326</td>
<td>0.414</td>
<td>47.512</td>
</tr>
</tbody>
</table>

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). Grand mean =57.615

**DISCUSSION**

There were significant differences in the effect of treatment on environmental practices of the students exposed to Puzzle-Based learning. This finding shows that Puzzle-Based learning) enhanced students’ practices over and above the Modified Conventional strategy. This result suggests that the Puzzle-Based learning effectively impacted the environmental practices of learners exposed to it than those exposed to Conventional strategies. These may be attributed to the nature of the 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.
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.

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 result revealed that the interaction effects of cognitive style and gender was significant on students' environmental practices. Although various studies have revealed positive relationship between environmental knowledge and attitude (Ajiboye and Ajitoni, 2008; Ajiboye and Silo, 2008; Olagunju, 2002), and that environmental practices depend largely on acquisition and manipulation of environmental skills which are not gender biased (which is at variance with the result of the study).

This finding corroborates the work of Giancarlo and 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 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 (That is 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 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 for effective learning.

The study also revealed that there is need to incorporate in our educational system the Puzzle-Based learning as strategies that could help in providing environmental necessary practices needed to solve various environmental problems prevalent in our surroundings.

**RECOMMENDATIONS**

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

Puzzle-Based learning strategy 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 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. Teachers should take cognizance of cognitive style of students in mediating learning and to impart 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 Strategy to inculcate in both male and female students of different cognitive styles the right environmental practice 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 practices towards environment.

Teaching strategies such as Puzzle-Based learning that reduce the gender difference in environmental 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.

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 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 Puzzle-Based learning strategies in learning environmental concepts, their Practices towards environmental pollution will improved. Also, these strategy 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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