PROBLEM-SOLVING AND CONCEPT MAPPING STRATEGIES AS DETERMINANTS OF STUDENTS' ACHIEVEMENT IN SOME ENVIRONMENTAL CONCEPTS IN CHEMISTRY

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Abstract

The study investigated the relative effects of problem-solving and concept mapping strategies on students' achievement of some environmental concepts in senior secondary school chemistry. The study also sought to know the moderating effects of students' gender and verbal ability on students' achievement in environmental concepts. The study adopted pre-test, post-test quasi-experimental design. The population was made up of all senior secondary school three (SS III) students in the three senatorial districts of Ekiti State. The sample consisted of 164 students of which 89 were males and 75 were females.Two instruments were used in the study. These were Environmental Education Achievement Test (EEAT) (r=0.80) and Verbal Ability Test (VAT), (r=0.89). Data were analysed using ANCOVA and t-test. The results revealed that there is a significant difference in the post test scores of subjects exposed to problem-solving, concept mapping and conventional strategies. The study also showed that there is a significant difference in the achievement scores of male and female subjects exposed to the treatments. It was also depicted that subjects of high verbal ability performed better than those of low verbal ability when exposed to problem-solving and concept mapping strategies. On the basis of these, it is therefore recommended that chemistry teachers should adopt the problem-solving and concept mapping strategies in the teaching of environmental aspects of chemistry to their students.

Keywords: problem-solving, concept mapping, strategies, environmental concepts, gender, verbal ability.

1. Introduction

Many countries of the world and individuals are expressing worries about the rapid deteriorating state of the environment as a result of neglect, ignorance and hazardous socio-cultural practices. Serious concern with environmental issues in Nigeria is a relatively recent event while global concern about the environment has been growing for several decades in developed parts of the world as a result of the perceived impact of rapid sociological, technical and scientific advancement. However, the awareness of environmental problems has also been gaining ground within developing countries as manifested in their attempt at reducing poverty and disease which are themselves forms of environmental degradation. Almost all human activities pose serious threats to the environment, the most important of which are the use of pesticides and herbicides, the disposal of solid wastes, air pollution, water pollution, radiation and radioactive substances and over population (Adekunle, 2005). The European Union (EU) countries agreed to reduce greenhouse gas emission by 20% from 1990 levels by the year 2020 and to make renewable sources of energy, such as solar and wind power account for 20% of overall EU energy consumption by 2020.

However, in Nigeria, the non-governmental organizations have been the moving spirit behind most of the environmental awareness programme and conservation projects. Despite the combined efforts of various non-governmental organizations, the environmental degradation still persists. The dangers associated with environmental problems in Nigeria have been identified as management, unethical practices and over population (NEST, 1991). Based on these reasons, the environmental problems have become a priority on the world's political agenda starting form 1990's. There have been concerned efforts in Nigeria to integrate environmental education into core curriculum of the education system. This came into fruition via the National Conservation Foundation and Ministry of Education that drew up a National Conservation Education Strategy which adopted Environmental Education as a module for the new citizenship curriculum for secondary schools. In Nigeria formal school system, environmental education is taught as apart of other subjects such as Integrated Science, Chemistry, Physics, Biology, etc. The Nigerian Educational Research and Development Council (NERDC) has made spirited efforts to infuse environmental education concepts in many subjects in the Junior and Senior Secondary School Curricula (Okebukola, Akpan and Ogunsola-Bandele, 1977). The school subjects listed above, most especially Chemistry are themselves characteristically problem-solving; and as such can be approached with instructional strategies that give opportunity for analysis, inference drawing and drawing

of rational conclusion. To this effect, the instructional strategies such as problem-solving and concept mapping are likely to be very appropriate to address this issue.

Problem-solving is an investigative approach in which learners are given problems to solve. This approach encourages participatory learning with the teacher as catalyst and team member (Adekunle, 2005). It also encourages participatory topics to be introduced in the context of learners' environmental problems and process of solving them. Problem-solving involves methods like brainstorming, case study, role play, research and discussion (UNESCO, UNEP 1986). Problem solving involves taking series of actions in the process of an investigation that seeks to bridge the gap between a problem state and anticipated goals (Arstan, 2010). Also, Yewande (2000) asserted that problem solving is a channel of using information and reasoning to overcome obstacle. In another vein, concept maps are diagrams indicating interrelationship among concepts as representation of meanings of or ideational frameworks specific to a domain of knowledge (Novalk, 1990).

Concept maps help students visualize various connections between words of phrased and a main idea. Various types of concept maps exist some are hierarchical while others connect information without categorizing ideas. Most concept maps comprise of words of phrases surrounded by a circle or square that connect to one another and ultimately back to the main idea through graphic lines. According to Hyerle, (1996), these lines help students to negotiate meaning as the read and make the meaningful connections between the main idea and other information. Lovitt and Horton (1994) asserted that concept maps have been shown to support struggling readers by building off of students prior knowledge and asking them to reflect on their understanding while reading. The maps can be applied to any subject matter at any level within the subject.

It is the view of the researcher that inculcating the concept of environmental education into the students through the above stated strategies would go a long way in fulfilling the outlined objectives of UNESCO, UNEP (1986) which include awareness, knowledge, skill participation and evaluation. All these objectives are encompassed in the cognitive and psychomotor domains of learning.

1.1 Statement of the Problem

The importance of environmental education in the survival of individuals in particular and the nation in general, cannot be over-emphasized. We cannot lose sight of the fact that there is day-to-day degradation of our environment through the ignorant actions and inactions of people which eventually bring disaster to the society at large. It is on the basis of this that

the study investigated the relative effects of problem-solving and concept mapping strategies on students achievement of some environmental concepts in senior secondary school chemistry. The concepts include pollution, greenhouse effect, conservation and waste management. The study also sought to know the moderating effects of students' gender and verbal ability on achievement in environmental concepts.

Based on the stated problem, the study attempts to provide answers to the following questions:

1. To what extent would problem solving and concept mapping strategies enhance the learning of environmental concepts in Senior Secondary School Chemistry?
2. Which of the independent variables (problem solving, concept mapping and conventional strategies) would have the most significant effect on students' achievement in the environmental concepts in Chemistry?
3. Would there be difference in the learning outcomes of male and female students exposed to the treatment?
4. Would there be difference in the achievement scores of students of high and low abilities exposed to the treatments?

1.2 Hypothesis

The following hypothesis were formulated and tested at .05 level of significance.

H01: There is no significant difference in the mean post-test achievement scores of subjects exposed to the two groups and control.

H02: There is no significant difference in the main effects of the strategies on the students' learning outcomes in the environmental concepts.

H03: There is no significant difference in the mean post-test achievement scores of male and female subjects in the two treatment groups and control.

H04: There is no significant difference in the post-test achievement scores of subjects of high and low verbal abilities exposed to the treatments.

1.3 Significance

The findings of this study would showcase the competence of the problem-solving and concept mapping strategies in aiding students acquisition of environmental knowledge and skills that would enable them deal with all aspects of environmental issues. The findings would also help to review the status of environmental education in Nigeria, with a bid to

infusing more environmental concepts in senior secondary school Chemistry curriculum. Furthermore, the findings would also provide a leadway for the Environmental Education (EE) specialists, chemistry teachers, curriculum planners and organizations concerned with the implementation of EE programme in Nigeria, in order to identify best practices that could enhance the teaching-learning process of environmental concepts across school curriculum

Not only these, the findings would also increase the awareness in the minds of Nigerian populace about environmental issues and how to handle them effectively.

2. Theoretical Framework

The target of this study is premised on instructional strategies and environmental education. Therefore, theories that have to do with the characteristics of these entities as they affect learning would be applicable. Since learning of any subject matter depends on the way it is presented to the learner by his or her teacher, the way the learner interacts with the learning experiences presented to him and the environment within which the learning takes place, it is therefore expected that these entities will be affected by variables that have to do with them. These variables include problem-solving, concept mapping, gender and verbal ability, that are considered in this study. The theories of Piaget, Ausubel and Vigotsky would therefore provide theoretical basis for the study. Piaget emphasized the intra-individual process in knowledge construction. The piagetians consider the individual as locus of construction of knowledge. However, Vigotsky focuses on inter-individual construction. The fundamental idea in Ausubel cognitive psychology is that learning takes place by the assimilation of new concepts and propositions into propositional frameworks held by the learners. This knowledge structure as held by a learner is also referred to as the individual's cognitive structure. Out of the necessity to find a better way to represent children's conceptual understanding emerged the idea of representing children's knowledge in the form of a concept map. These three theories consider knowledge as being constructed by an individual alone or in collaboration with others. Problem-solving and Concept mapping therefore, operate within this theoretical frame work.

3. Methodology

The pre-test, post-test quasi-experimental design was used for the study. The research design consists of two experimental groups (1 and 2) and one control group. Subjects in group 1 were exposed to the four selected environmental concepts (pollution, greenhouse effect,

conservation and waste management) using problem solving strategy, while subjects in the experimental group 2 were exposed to the same concepts using concept mapping strategy. The control group was equally exposed to the selected concepts using the conventional method. The score of subjects in Environmental Education Achievement Test (EEAT) were obtained before and after treatment in all the groups.

The study employed a 3x2x2 factorial design.

Table 1: 3x2x2 factorial Matrix

Treatment	Gender	Verbal Ability	
		High	Low
Problem-Solving	Male Female	n_1 n_3	n_2 n_4
Concept-mapping	Male Female	n_5 n_7	n_6 n8
Conventional Method	Male Female	n_9 n_{11}	n_{10} n_{12}

The independent variable in this study is the instructional strategy manipulated at three levels.

1. Problem-solving Strategy
2. Concept-mapping Strategy
3. Conventional strategy

The dependent variable is the learning outcome of the students exposed to environmental concepts measured by EEAT. The intervening variables are

1. Gender at 2 levels: male and female.
2. Verbal Ability at 2 levels: high and low.

The population was made up of all senior secondary school year three (SSS III) students in the three senatorial districts of Ekiti State Nigeria, namely, Ekiti South, Ekiti North and Ekiti Central. It is comprised of sixteen (16) local government areas. Two schools were selected using stratified random sampling technique from each of the senatorial districts.

The following criteria were set for the schools to be selected:

1. the school must be co-educational.

2. the school must have completed Senior Secondary School II Chemistry Scheme of Work.
3. the school must not have taught the concepts for study to the SSS III students.

Two schools each were assigned to experiments 1 and 2, and control groups. From each of the schools, two randomly selected intact SSIII classes were involved in the experiment and control exercises. The sample consisted of 164 students out of which 89 were males and 75 were females.

Two instruments were used in the study. These were

1. Environmental Education Achievement Test (EEAT), (r=0.80)
2. Verbal Ability Test (VAT), (r=0.89)

The EEAT was a 30-item instrument used to assess the level of acquisition of the selected environmental concepts in Chemistry by the students. The VAT was used to classify students into the two ability groups (high and low). It is relevant in the sense that the learning materials to be given to students in experimental groups are textual and ability to read and comprehend is considered a fundamental variable that might affect the results of the study.

Treatment Strategies

Three treatment strategy guides were used in the study. These included

1. Problem-Solving Strategy Teachers' Guide (PSSTG)
2. Concept-Mapping Strategy Teachers' Guide (CMSTG)
3. Conventional Strategy Teachers' Guide (CSTG).

All the Strategy Guides were in the forms of lesson notes based on the selected environmental concepts. Each lesson lasted 40 minutes. The Verbal Ability Test (VAT) was administered to the students. The scores obtained were used to rank students into high and low ability groups. The Environmental Education Achievement Test (EEAT) was also administered to the students as pre-test. The two tests were administered shortly before the treatment. The treatment was carried out for the two experimental groups and control group.

Post-test: The (EEAT) was administered again at the end of the treatment sessions.

4. Data Analysis

Data was analysed using Analysis of Covariance (ANCOVA) and t-test

Table 2 presents the summary of results of post-test achievement scores of subjects according to treatment, verbal ability and gender using ANCOVA.

Table 2: Summary of ANCOVA of Post-test achievement scores by Treatment, Verbal Ability and gender

Covariates Pretest	Sum of Square	Df	Mean Square	F	Sig.
	4325.688	1	4325.688	203.422	.000
Mean Effects (combined	704.578	2	351.289	16.52	.000
Treatment	396.496	1	396.496	18.64	.000*
Ability	90.299	1	90.299	4.25	.004
Gender	217.781	1	217.781	10.24	.000*

P<0.05

Table 2 shows that treatment had significant effect on variation in the post-test achievement scores of subjects (F(2,314)=18.64; P<.05). This means that there is a significant difference in the post-test scores of subjects exposed to the Problem-Solving, concept-mapping and Control.

EFFECT OF VERBAL ABILITY ON STUDENTS' ACHIEVEMENT

Verbal ability has a significant effect on the variations in the post test achievement scores of subjects as earlier shown in Table 2(F1,314).=4.25 at P<0.05. This implies that subjects in the two experimental groups and control are significantly different in their post test mean scores. High ability subjects performed better than their low ability counterparts in the two experimental groups and control.

EFFECT OF GENDER ON SUBJECTS' ACHIEVEMENT

As presented in Table 2, the main effect of gender on subjects' post test achievement scores is significant (F(1,314)=10.24); P<0.05. This implies that there is a significant difference between the post test achievement scores of male and female subjects exposed to the two treatments and control.

Table 3: t-test Comparison of male and female subjects' Achievement Scores in each of the two treatment Groups and Control

Treatment	Sex	N	Mean	S.D.	t-value	df	Sig.
Concept Mapping	Male Female	36 31	12.678 10.349	3.415 1.626	1.5031 1.294	32	.003*
Problem-solving	Male	35	10.310	3.587	0.488		

	Female	32	11.621	3.629	0.494	68	.159
Conventional	Male	19	3.28	2.516	0.568		
	Female	15	6.96	2.767	0.616	68	.154

P<0.05

Table 3 reveals that female subjects performed better than their male counterparts in both the Problem-solving and Control groups. (t=0.494) (t=0.616) for problem-solving and conventional method. However, in the Concept mapping, male subjects performed significantly better than their female counterparts (t=1.503; P< 0.05).

5. Findings and Conclusion

From the results obtained, it is revealed that there is a significant difference in the post test scores of subjects exposed to Problem-solving, Concept-mapping and the Conventional strategies. It is also depicted that there is a significant difference in the achievement scores of male and female subjects exposed to the treatments. Here, male subjects in the Concept-mapping performed better than their female counterparts while the female subjects performed better than their male counterparts in both the problem-solving and conventional strategies. Furthermore, the study reveals that subjects of high verbal ability performed better than those of low verbal ability when exposed to Problem-solving and Concept-mapping strategies. It is therefore concluded that in enhancing students achievement in some environmental concepts in chemistry, problem solving and concept mapping instructional strategies are better than conventional strategies. The effectiveness of the strategies as shown in the study is in the order problem solving > concept mapping > conventional.

5.1 Recommendations

The following recommendations are made:

- Teachers should adopt the problem-solving and concept-mapping strategies in the teaching of environmental aspects of chemistry to their students irrespective of gender.
- Teachers should make their lesson student-centered in congruence with the characteristics of the strategies being used to put the knowledge across.
- Problem-solving and Concept-mapping strategies should be used by government and other stakeholders in creating environmental awareness in the minds of the citizens.

- Students of high and low abilities should be identified in the class so as to enable the teachers to use the strategies to improve on the performance of the low ability students.
- The curriculum developers should encourage the Chemistry teachers to make use of the strategies in the teaching of environmental aspects by embedding same in the Chemistry curriculum.

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