COMPARATIVE EFFECTS OF CONCEPT MAPPING AND SIMULATION-GAME TEACHING STRATEGIES ON STUDENTS' INTEREST IN ENVIRONMENTAL CONCEPTS IN CHEMISTRY

[1]Okonkwo Ifeoma G.A &[1*]Samuel Naomi N. C.
Department of Science Education, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria
ig.okonkwo@unizik.edu.ng, *nkc.samuel@unizik.edu.ng
08037189552; 08036443567

Abstract
The study investigated the comparative effects of concept mapping and simulation-game teaching strategies on students' interest in environmental concepts in chemistry. The quasi-experimental, pre-test, post-test, non-equivalent control group design was adopted. The sample comprised of four hundred and sixty-seven (467) SS2 chemistry students randomly drawn from four (4) single-sex schools. The instrument for data collection was Environmental Concepts Inventory (ECII), while six research questions and six null hypotheses guided the study. Three intact classes were assigned to concept mapping, simulation-game and lecture method groups. Means, standard deviations were used to answer the research questions, while ANCOVA and Multiple Classification Analysis (MCA) using the Scheffe's test were used to test the null hypotheses at 0.05 level of significance. Results revealed that the simulation-game teaching strategy was more efficient in enhancing students' interest than the concept-mapping strategy. Gender was found to be insignificant. Based on the findings, some recommendations were made.

Keywords: Concept mapping, stimulation-game, teaching strategies, environmental concepts, chemistry

Introduction

The emergence of modern scientific and technological activities, rapid industrialization and population explosion all geared towards economic growth, combating hunger and provision for other basic human needs has led to a drastic transformation of environmental situation. These activities have put so much pressure on the natural environment that the rate at which they are causing environmental degradation is far outrunning the environmental self-capacity to regenerate, and this has resulted in serious environmental problems world over. Asaju&Arome (2015) identified the problem of pollution and solid waste among others as major causes of environmental degradation in Nigeria. Some of these wastes are toxic, flammable, and non-biodegradable while others are more of a nuisance than a danger to man. Solid wastes are common sights in residential zones, schools, market areas, motor parks, along the streets and numerous other locations where wastes are generated. Further compounding the problem is the unavailability

and or poor implementation of regulated or bye laws on population and solid waste management and as a result of this lapse, indiscriminate dumping of waste became the order of the day. Consequently backyards, gutters, roadsides, drainages and in fact any available open space automatically gets converted into unauthorized dumpsite (Osuafor, 2014). This ugly scenario has lots of adverse health and economic implications.

The dumping of toxic waste by unknown persons in Koko, Delta State was the wake-up call on the government on the need for environmental protection and resulted in the 'birth of a child of circumstance'-FEPA-Federal Environmental Protection Agency (now Federal Ministry of Environment) established in 1988 (Eguabor, 2005). Other intervention measures introduced by government towards tackling environmental problems include the infusion of environmental education (EE) topics into primary, secondary and adult education curricular by Nigerian Educational Research and Development Council (NERDC). It has been reported that the teaching of the infused EE topics aimed at addressing the environmental problems has not been vigorously and purposefully implemented. It does appear that the infusion of EE concepts into school curriculum seem not to be achieving the desired objectives (Eguabor, 2005, Osuafor, 2014, Osuafor&Samuel 2015; and Adekola &Fischbacher-Smith, 2017). This is a matter of great concern because the environmental problems continue to increase in complexity. Since Education is an essential tool to effect change in the current destructive relationship between human beings and the environment, the onus lies in the school process to encourage and bring about this change. In the school system, the teacher has a pivotal role to play.
Chemistry as an academic discipline in Nigeria secondary schools is one of the subjects into which environmental concepts have been infused. The EE concepts are examined alongside the core chemistry concepts in the same examination such as West African Examination Council (WAEC) and National Examination Council (NECO). Unfortunately, despite the undisputable relevance of chemistry to vocational and allied disciplines needed for national, scientific, technological and economic development, indices from these examination bodies have shown consistent trend of low enrolment and poor achievement of students in these examinations. On investigating the cause of this ugly trend, researchers (Nja, 2020; Akpu, 2020; Ojukwu, 2016; and Okeke, 2011) reported that lack of qualified teachers, ill-equipped laboratories and inappropriate teaching strategies were some of the factors responsible for the recorded poor achievement and declining interest of students in the subject with inappropriate teaching strategies as the major cause. However, while these studies examined achievement, interest and retention in other core areas of chemistry, the EE aspects of the chemistry syllabus has not been examined for conceptual difficulties and /or poor achievement and interest to students in these examinations.

The environmental problems that necessitated these infusions and teaching of EE concepts in chemistry as well as other subjects has continued to aggravate in alarming and complex proportions and on daily basis. It therefore became necessary to investigate the students' interest in environmental concepts in chemistry. Over ten years after NERDC came up with the infusion for the attainment of the objectives of EE such as (i) awareness (ii) knowledge (iii) attitude (iv) skill (v) evaluation ability and (vi) participation in solving present environmental problems and preventing new ones (UNESCO-UNEP 1986), the objectives according to Adekola et al 2017, Asaju&Arome, 2015 Osuafor & Samuel, 2015 and Osuafor, 2014) are very far from being achieved, judging from the fact that the attitude of the Nigerian citizens in particular towards the environment have not changed one bit. This is not unexpected when it has been reported (Adekola, 2017; Ajai &Arome 2015; Osuafor & Samuel, 2015 and Osuafor, 2011) that the infused EE concepts are not being properly taught in schools with the seriousness they deserve. It can be deduced therefore that one major challenge facing the chemistry teacher is the exploration and adoption of teaching strategies that will be able to reverse this trend of poor achievement in both core and infused EE concepts in chemistry. Nja (2020); Ezike (2018); Ojukwu (2016) and Okeke, (2011) have reported that activity oriented and problem-based teaching strategies which involve the active participation of the students are more efficient in motivating and enhancing students' interest much more than the conventional lecture method currently dominating chemistry classroom instructions. Concept mapping, field trips, simulation-game/ role play are some of the strategies described by UNESCO/UNEP (1998) as being of high potential value to the science teacher and quite essential to the teaching of science for EE.

Concept mapping as defined by Novak (1990) are diagrams indicating inter-relationship among concepts as representation of meanings or ideational framework specific to a domain of knowledge. It is a meta-cognitive tool developed by Novak and a team of researchers from the Cornell University in 1972 (Okonkwo &Nwagbo 2014). Initially, the concept mapping strategy was first developed as a research tool to represent learners' prior, relevant knowledge and later as a tool to enhance meaningful learning. The development of the strategy was based on Ausubel's assimilation theory which is based on the principle that the single most important factor influencing learning is what the learner already knows (prior knowledge). The fundamental idea in Ausubel's cognitive theory is that learning takes place by assimilation of new concepts and prepositions into existing concepts and prepositional structures or framework held by the learner. The knowledge structure already held by the learner according to Caniglia (2019) is also referred to as the individual's cognitive structure. Students while constructing concept maps adopt an active, deep questioning approach to the subject matter and such active, self-engaging transformational interaction with learning material enhances learning in general.

A simulation as defined by encyclopedia of Education is an operating model reproduction or imitation of physical or social phenomena consisting of a set of interrelated factors or variables which function in essentially the same manner as the actual or hypothetical system. It is a concentration of imitation learning experience specifically designed to represent real-life activities by providing the learner with the essential elements to model real-life activity. A simulation is a form of experimental learning and may take a number of forms; they may contain elements of game, a role play or activity that acts as a metaphor. The goal of simulations is not to win but to acquire knowledge. Simulation is a role-playing which involve people adopting roles in a mock-up of a situation; there need not to be a winner rather a changed condition or situation to be achieved by participants (Ajai,2013; Akinsola & Animashun 2007). Both game and simulation share some common features such as in the use of tactics and strategies from the participants' initiative, their ability to provide drill and practical applications where students learn in a play-way. The boundary between game and simulation is so superficial that often times the two approaches are used interchangeably; while some writers prefer to combine the two terms 'simulation-game' to represent instructional games generally. This approach was adopted in this study in which simulation-game would be regarded as a structured imitation of reality which makes use of role play and game elements to stimulate real situations for problem solving.

Researchers (Caniglia, 2019; Vlachopoulos&Makri 2017; Obeka, 2007; Akinsola and Animashun, 2007) reported that the simulation-game strategy may be effective for teaching complex and real-world situations which changes as the students are involved in the activity. Similarly, Ajai, (2013) and Cañas (2003) reported that in the course of constructing concept maps, learners adopt an active, deep and questioning approach to the subject matter, and that such active self-engaging transformational interaction with learning material may enhance learning in general. From these reports, it may be that concept mapping and or simulation-game teaching strategy or both will effectively enhance students' interest in environmental concepts in chemistry. Therefore, this study investigated the comparative efficacies of these two activities- oriented teaching strategies in enhancing students' interest. All the studies reviewed compared each of these strategies separately with the conventional lecture method.

Interest of students in chemistry may be influenced by gender. Gender has been reported to be among the factors interacting with interest and achievement of students in Chemistry and other sciences (Ajai &Ogbeba 2017; Anderson 2017, Owojaiye & Zuya 2016). In the meantime, research findings on how gender actually influences achievement and interest remains inconclusive. Anderson (2017), Owojaiye et al (2016); Okonkwo & Nwagbo (2014),and Obeka, (2007) reported that males have higher achievement and interest in Chemistry than females, and this was attributed to sex-role stereotyping, masculine image of science and female

socialization process. On the contrary, Ojukwu (2016) reported influence of gender in favor of females, while Ajai and Ogbeba (2017) and Danmole and Femi-Adeoye, (2004) found no significant influence of gender on achievement and interest of students in Chemistry but opined that the achievement and interest of both male and female can be influenced by teaching and learning styles. On this premise this study contributed to the on-going debate by investigating the influence of gender on the interest of students in environmental concepts in Chemistry.

Purpose of the study

The purpose of the study was to determine the comparative effect of concept mapping and simulation-game teaching strategies on the interest of students in environmental concepts in chemistry. Specifically, the study.

1. determined whether there is any significant difference in the interest mean scores of students in Environmental Concepts Interest Inventory (ECII) due to teaching strategy.
2. determined whether there is any significant difference in the interest mean scores of male and female students in ECII after treatment.

Research Questions

The study was guided by the following research questions

1. What is the difference in the interest mean scores of students in ECII due to teaching strategy?
2. What is the difference in the interest mean scores of male and female students in ECII due to teaching strategy?

Hypotheses

The following null hypotheses were tested at $p<0.05$.

1. There is no significant difference in the interest mean scores of students in ECII due to teaching strategy.
2. There is no significant difference in the interest mean scores of male and female students in ECII due to teaching strategy.

Research method

The study employed the quasi-experimental, pre-test, post-test, non-randomized control group design. The population consisted of all senior secondary class two (SS2) students who offered chemistry in all the 50 public secondary schools in Nnewi Education Zone (NEZ) of Anambra state Nigeria. The sample comprised of four hundred and Sixty-seven (467) Senior Secondary Two (SS2) chemistry students drawn through purposive and multi-stage stratified random sampling technique from four (4) single-sex (2 male and 2 female) schools. Single sex schools were used to avoid interferences between boys and girls as gender was a variable in the study.

Environmental Concepts Interest Inventory (ECII) was the instrument used for the study. The ECII is a 28-item, 4-point response options scale developed by the researchers based on the following environmental concepts in chemistry namely: pollution (a) Air pollution, ozone/ozone layer depletion, green-house effect, acid rain (b) water pollution (c) land pollution: solid wastes. The research instrument was face-validated by two experts in the Department of Science Education of Nnamdi Azikiwe University Awka, Nigeria. The construct validity of the ECII was determined using Factor-Analysis. The Factor Analysis which adopted Principal Component Analysis method yielded eight factors. The 28 items of the ECII loaded above .35 in only one factor and were therefore factorially pure. Furthermore, its reliability coefficient was 0.94 obtained using Cronbach-alpha.

Three teaching strategies employed in the study were; concept mapping (E_1), simulation-game (E_2) as experimental groups and the lecture method (C) as control.

Experimental Procedure

The actual teaching was done by the regular chemistry teachers in the selected schools. They were briefed by the researchers for four days during which they were adequately exposed to the concepts and strategies involved in the study. A pre-test was administered to three intact classes after they had been randomly assigned to groups (E_1E_2, and C) in each of the sampled schools a day before the commencement of the treatment. In concept mapping-group E_1, the teacher began the lesson with a brief explanation of what concept mapping is and how it is constructed using concept maps constructed by the researchers. Thereafter, the students were instructed to construct their own concept maps as the lesson proceeds and also after the lesson under the teacher's supervision.

In group E_2-simulation-game, the students were taught conventionally prior to the game exercise. Pre-game hand-outs/role cards were given to the students in advance to get prepared for their roles and procure the necessary materials needed for the game. In the treatment, the students were divided into groups according to their roles and after a brief introductory lesson, the simulation-game exercise took off. There was a debriefing session at the end of the game. It is a general discussion highlighting important points in the exercise. During this time, the experiences of the participants were sought, the views of the teacher were passed on to the participants and effects of co-operation and conflicts resulting from the learning experience were harmonized. In the control group C, the lecture method only was used.

The teaching lasted for five weeks. Post-tests were administered to all the groups in each school a day after the completion of treatment. The pre-test and post-test scores were analyzed using mean and standard deviation scores to answer the research questions while ANCOVA, and Multiple Classification Analysis (MCA) using Scheffe's test were used for testing the hypotheses at 0.05 level of significance.

Results

Results are presented according to research questions and the hypotheses.

Research question 1 sought information on the comparative effects of teaching strategies (concept mapping, simulation-game and lecture) on the interest mean scores of students. Data for answering research question 1 is presented in table 1.

Table 1: Mean Effects of Three Teaching Strategies on Students' Interest in Chemistry

Treatment	Pre-test			Post-test		Mean
Group	N	$\bar{X}$	SD	$\bar{X}$	SD	gain
Concept mapping (E_1)	157	1.67	.72	3.19	.44	1.52
Simulation-game (E_2)	154	1.71	.71	3.37	.52	1.66
Lecture method (C)	156	1.71	.72	1.90	.44	0.19

Data on the table above shows that the Simulation-Game Teaching Strategy (SGTS) had the highest mean gain of 1.66 followed by concept mapping (CMTS) with 1.52 and then control group (CLM) with 0.19. This implies that E_2-simulation-game strategy had the greatest influence on students' interest than concept mapping strategy. Both concept mapping and simulation-game recorded higher interest mean gains than the lecture method. In order to make a decision on students' interest based on the different teaching strategies, hypotheses 1 which stated that there is no significant difference in the interest mean scores of students due to teaching strategy was tested at 0.05 level of probability as presented in Table 2

Table 2: Analysis of Covariance (ANCOVA) of Students' Interest Mean Scores x Teaching Strategies x Gender x School Location

Source	**Sum of Squares**	**d*f***	**Mean squares**	**F**	**Sig.**	**Decision**
Corrected model	209.2269	12	17.435	84.230	.000	
Intercept	503.225	1	503.223	2.431E3	.000	
Pre ECII	.950	1	.950	4.588	.003	
Methods	201.9422	2	100.971	487.789	.000	S
Gender	.002	1	.442	2.935	.107	Ns
Method and gender	.328	2	.464	2.623	.104	Ns
Error	93 .977	454	.207			
Total	4011.110	466				
Corrected total	303.202					

=Significant at p<0.05

Data on table 2 shows that teaching strategy as main effect is significant on students' interest. This is shown by the calculated f-value of 487.789 which is significant at .000 level. To determine the direction of the observed significant differences, a multiple comparison analysis was conducted using Scheffe's test and the result is presented in Table 3 below.

Table 3: Results of Multiple Comparisons Analysis of Students' Interest Scores x Teaching Strategies Using Scheffe's Test

(i)Teaching Strategy	(j)Teaching Strategy	Mean Differences (i-j)	Std Error	sig	Decision
Concept mapping	Simulation-game	-18354*	.05322	.003	S
	Lecture method	1.2910	.05305	.000	S
Simulation-game	Concept mapping	-18354*	.05322	.003	S
	Lecture method	1.47464	.05330	.000	S
Lecture method	Concept mapping	-1.29110*	.05305	.000	S
	Simulation-game	-1.47464*	.05330	.000	S

Results of the Scheffe's post-hoc pair wise MCA show that significant difference existed between concept mapping E_1 and simulation-game E_2. Significant difference also exists between groups (E_1& E_2) and the control group C. Therefore the simulation-game strategy is significantly more efficient than the concept mapping in promoting students' interest in chemistry while both strategies are significantly superior to lecture method in enhancing students' interest.

Research question 2 sought information on the influence of gender on students' interest in environmental concepts in chemistry. Data used for answering this question is presented in Table 4.

Table 4: Mean and Standard Deviation Scores of Students' Interest by Gender

		Pre-test		Post-test		Mean
Gender	N	$\bar{X}$	SD	$\bar{X}$	SD	Gain
Males	232	1.71	.72	2.77	.73	1.06
Females	235	1.67	.72	2.86	.87	1.19
Total	467	1.69	.72	2.82	.81	1.13

Table 4 shows that females showed higher interest with interest mean gain of 1.19 than the males with a lower interest mean gain of 1.06. To determine if this observed difference is significant, hypotheses 2 was tested at $p<0.05$. Table 2 reveals that

there is no significant difference in the interest of male and female students. This is shown by the calculated f-value of 2.935 which is not significant at 0.107. To this effect, the researchers failed to reject the null hypotheses and concluded that there was no significant difference in the interest mean scores of male and female students.

Discussion of Findings

Result in table 1and 2 show significant main effect of treatment on interest measure. The results indicate that students' interest was greatly improved when they were exposed to the concept mapping and simulation-game teaching strategies when compared with the conventional lecture method. This is consistent with the reports of Nja, (2020); Akpu, 2020; Ojukwu, 2016; Osuafor, 2011 and Longjohn, (2009) that students' interest could be enhanced through activity-oriented instructional strategies. However, results of Scheffe's post-hoc pair wise multiple comparison analysis on the interest mean scores of the three groups as presented in table 3 revealed that comparatively, the simulation-game strategy is significantly more effective than the concept mapping strategy in enhancing students' interest. This could be attributed to the fact that, in simulation-game environment, there seems to be a more engaging interaction by learner, provision of motivating activities which students find enjoyable and consequently learn in a fun-filled play-way which removes aversion, tension and boredom. The superiority of simulation-game in enhancing interest as reported in this study is consistent with Obeka, (2007); Akinsola and Animashun, (2007); Onwukwe,(2010); Ajai, (2013); Vlachopoulos & Makri, (2017) and Caniglia, (2019) who reported that simulation-game teaching strategy motivates students' interest. Both concept mapping and simulation-game create room for tangible thinking because in playing games, and constructing concept maps, thoughts are connected out physically and results are seen. Another possible reason for the superior achievement recorded by the treatment groups in this study is the activity and problem- oriented nature of the two strategies. In both strategies, students' attention was focused on the learning materials as the onus of deciding what to do at each stage of the learning process falls on them.

The results of this study also indicated that gender is not a significant factor in students' interest. This is consistent with the findings of Ajai &Ogbeba, (2017) and Imoko, (2005), who reported that gender has no significant effect on students' interest but at variance with the views of Isa, (2005) and Osuafor (2011) that reported significant influence of gender on students' interest. In this study, the relative effects of concept mapping and simulation games across the students' gender are consistent, implying that they are not sex stereotyped. Therefore, a gender balanced atmosphere accounted for the superiority of the two experimental strategies in enhancing interest over the lecture method.

Summary of Findings

1. Students in the simulation-game teaching strategy (SGTS-E_2) had a statistically significant higher interest mean scores than those in concept mapping (CMTS-E_1) and both treatment strategies were significantly more effective than the lecture method in enhancing interest of students in environmental concepts in chemistry.
2. The difference in the interest mean scores of male and female students was not significant.

Recommendations

1. Science teachers should endeavor to introduce fun and interactive activities that are student-centered in their lessons in order to arouse and motivate students to learn meaningfully to enhance and sustain their interest.
2. Ministries of education at both federal and state levels in conjunction with professional associations like Science Teachers Association of Nigeria (STAN) should organize in-service training in the form of seminars and workshops on a regular basis to keep chemistry teachers abreast of the application of innovative, problem-solving and activity-based teaching strategies like concept mapping and simulation.
3. Examination bodies like the West African Examination Council (WAEC), National Examination Council (NECO) should give the environmental concepts infused in all subjects in the school curricula the importance and prominence they deserve by increasing the number of test items on these environmental concepts.

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