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Effects of Cooperative and Concept Mapping Strategies on Students Achievement in Chemistry in Selected Secondary Schools, Rivers State

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ABSTRACT
The study investigated the effects of cooperative and concept mapping instructional strategies on student's achievement in chemistry. It adopted an experimental design. Through random sampling, sample sizes of 280 SS2 chemistry students were selected from six secondary schools in six Local Government Areas of Rivers State. The students were placed into two experimental groups and a control group. Experimental group I was taught with cooperative teaching method, experimental group 2 was admonished with concept mapping technique and the control group was treated with lecture method. The research instrument was a teacher made Hydrocarbon Chemistry Achievement Test (HCCAT). The instrument was pilot tested and analyzed using Pearson Product Moment Correlation and a reliability coefficient of 0.85 was obtained. Two research questions and two hypotheses guided the study. Mean, percentage and standard deviation were used in analyzing the research questions while analysis of variance (ANOVA) was used to test hypotheses at 0.05 level of significance. Results obtained show that there is a significant difference in academic achievement of students taught with cooperative and concept mapping strategies in respect to gender, location and retention. The male students had better performance in their respective categories. Based on the results, it was concluded that Cooperative Instructional Strategy (CIS) and Concept Mapping Instructional Strategy (CMIS) are effective instructional methods for teaching. Hence, the study recommended the use of both strategies in teaching chemistry in secondary schools.
Keywords: Cooperative Learning, Concept Mapping, Achievement

INTRODUCTION

It is an established fact that science and technology are veritable tools for progress and development of nations. Apparently, science and technology education cannot strive without using appropriate instructional strategy. Akpan (2008) stated that nations at the forefront of modern development are those that have invested huge resources over considerable time in the establishment and nurturing of a stable well supported science and technology education. Science and technology for sustainable development are most needed in this modern era because they are parameters for classifying nations as developed and developing. This calls for effective science and technology education. Ukwungu (2005) blamed students' poor performance in sciences on the teachers and their teaching strategies. He observed that teachers have refused to adopt change in behavior of the students which has made students develop negative attitude towards learning generally.

In the light of this, science educators are steadily for a more appropriate strategy to teach chemical concepts in order to bring about the expected change and objectives of chemistry education. Aluko (2008) condemned the use of teacher-centered strategy in science teaching. He opined that scientists are

recognized by the amount of scientific rigors they undergo rather than the amount of information gathered into their brain. Hence, the investigation into cooperative and concept mapping strategies in chemistry classes is very necessary because learning patterns describe what goes on in the learners and the learning materials. Chemistry, a natural science is a very important subject due to specialized language, mathematical and abstract conceptual nature as well as the amount of content to be covered by student. Francisco, Nicoll and Trautmann (2005) stated that the prevailing teaching practices do not actively involve students in the learning process and that seems to deprive them from taking charge of their learning. Therefore, the chemistry teacher should adopt strategies that would enable the students to understand and apply whatever concept that are being taught to their ever-changing environment.

Studies have shown that students exhibit very poor science skills (Igboegwu 2006); hence, students' achievements in science subjects are usually below expectation at the Senior Secondary Certificate Examination (Ifeakor 2006; Udo, 2008). Researchers have made several efforts towards designing techniques and methods for more effective teaching of science subjects. A number of techniques and methods for diverse situations in the classroom have been suggested. The need to inculcate in the learner creative abilities, improve their self-esteem, eliminate difficulties while learning and make them active participants in the classroom has given rise to tremendous interest by researchers towards developing teaching methods that can capture the above stated qualities. Some innovative teaching methods that are better than the conventional lecture method in acquisition of scientific knowledge include guided inquiry, constructivist based learning (Ibe, 2013), problem solving, demonstration, cooperative learning and concept mapping. All these methods rely on the various form of teacher – student activities. However, some are more activity oriented than others. These activities in science as contained in the federal republic of Nigeria (FRN 2004) which states that one of the goals of science education is to give the child opportunities for developing manipulative skills that will enable the child to function effectively in the society within the limits of the child's ability. Therefore, effective teaching must involve hands-on-activities during instruction. It is necessary to apply strategies that will employ approaches capable of enhancing better academic achievement of students in the science subjects such as the cooperative learning and concept mapping methods in which students actively control their learning process.

Brandy and Tsay (2010) defined cooperative learning as a method of organizing classroom activities into academic and social learning experiences. Cooperative learning is an instructional strategy in which students of different levels of ability use a variety of learning activities to improve their understanding of a subject. It implies the principle of effective group work, appropriate directives and demonstrations by the teacher, high quantity and quality of students' activities (laboratory work, discussion, analysis of a given material beyond text group presentation). Cooperative learning is a teaching strategy in which small groups, each with students of various ability levels, gender and ethnic groups use a variety of structured learning of a subject. Each member of a group is responsible not only for learning what is taught but also for helping group mates learn (Johnson and Johnson 2000 and Okebukola, 2002). Cooperative learning is an active pedagogy that links with other innovations and it is a group based learning which inherently supports a discovery based approach to learning. Cooperative learning is also an interactive classroom instruction that helps students to learn from each other, work on difficult or complex projects, communicate and develop critical thinking skills.

Olayode and Adeoye (2009) citing Inomiese (1997) defined a concept as a generalized pattern from a particular relevant experience. The word concept is central to Ausubel (1968) assimilation theory for meaningful learning and Deese (1965) association memory theory cited in Barbra and Sasa (2005). In concept mapping, relationship between one concept and the other are represented through structurally organized words and ideas that are represented graphically in hierarchical order. Hence, concept maps are tools intended for engaging learners in relating new ideas to what they already know. Concept mapping teaching lessons involves class discussion, practical demonstration and concept mapping activities which are placed in hierarchical order. During such lessons, the relationships between concepts are concretely established as such lesson proceeds either from general to specific ideas or from specific to general ideas. Concept mapping provides a framework for designing and sequencing concepts in graphs and helps both

teachers and students to generate, connect and relate ideas usually which allows one to gain an overview of a domain of knowledge.

According to Annie, Howard and Stoker (2002), academic achievement is defined as the level of actual accomplishment or proficiency one has in an academic area as opposed to one's potential. Bossaerrt (2011) also defined academic achievement as an educational goal that is achieved by a student, teacher or institution over a period. Therefore, academic achievement deals with the level of student's achievement within a specified period. It is measured through examinations or continuous assessment tests. This could be carried out by administering a teacher-made test. Thus, it helps us to ascertain if learning has taken place or not.

Statement of the Problem

There has been a general outcry in most of our Secondary Schools from both students and teachers of chemistry on ways of overcoming the difficulties in the subject. Students complain that the subject has formulas and structures which its nomenclatures do not follow a regular and specific pattern. They also claim that the calculations in the subject are so much with limited time to master them before writing their examinations. To make the situation worse, majority of the students say that the chemistry teachers do not know how to teach the subject.

On the part of the teachers, they claim that most of the students lack the interest to learn. It is obvious that teachers and students are involved in the teaching-learning process every week with the same unchanged story line 'difficult subject'. The issue is the efficacy of the teaching methods used by teachers. It has been noted that teachers continue to use the traditional method instead of activity-oriented strategies on the students. The traditional method is not student centered and activity-oriented as required by the nature of science and its use may be the cause of students' poor academic achievement in chemistry.

In order to address these issues, it is therefore, important to study the impacts of innovative teaching strategies such as cooperative learning and concept mapping on students' achievement in chemistry.

Purpose of the Study

This study aimed at investigating the effects of cooperative and concept mapping instructional strategies on academic achievement in chemistry in selected secondary schools, Rivers State. Specifically, the study sought to:

1. determine the achievement of chemistry students in hydrocarbon chemistry when exposed to cooperative and concept mapping strategies.
2. examine if there is any significant difference between the mean scores achievement of male and female students when taught hydrocarbon chemistry with cooperative and concept mapping strategies.

Research Questions

The following research questions were raised to guide the study:

1. What are the mean scores of chemistry students taught with cooperative instructional strategy and those taught with concept mapping instructional strategy on the chemistry of hydrocarbons?
2. What are the mean scores of male and female students taught with cooperative instructional strategy and those taught with concept mapping strategy on the chemistry of hydrocarbons?

Hypotheses

The following null hypotheses were postulated and tested at 0.05 level of significance:

Ho_1: There is no significant difference in the mean scores of students taught chemistry using cooperative instructional strategy and those taught with concept mapping strategy.

Ho_2: There is no significant difference in the mean scores achievement of male and female students taught with cooperative instructional strategy and those taught with concept mapping strategy.

Conceptual and Theoretical Framework

The dynamics of teaching is a crucial factor on how students learn. Teachers establish the pattern of general conduct during a lesson while the students establish certain types of behavior to coincide with the pattern. This combined instructional pattern and students' participations lead to a specific classroom environment characterized by specific classroom environment characterized by specific interaction

patterns. Interaction patterns provide what goes on in the teaching – learning process between the teacher, the learner and the learning materials. Olatoye, Aderogba and Aanu (2011), noted that the extent of learning that occurs during instruction depends to large extent on the magnitude and mode of interaction between the learner, the learning materials and learning environment. Okoli (2006) noted that it provides a learning environment in which students discuss the material, share ideas, listen and consider ideas or others and clarify their thinking through verbal interaction with each other. Proper interaction between teacher and students improves scientific literacy.

The work of Bilgin (2006) serves a major conceptual structure of the study expressed in the theory of motivation that performance is a function of an individual's level of arousal and anxiety. Morgan (2005) uses individual differences and motivational point of view and suggested that it is that reward distribution that motivates individuals to behave cooperatively, competitively or individually. He further pointed out that teachers should know how to organize their classes in large groups, small groups or individualized instruction. These decisions are based on teachers' intention, the subject matter, students' characteristics and the learning atmosphere the teacher wishes to create for either cooperative arrangement or competitive arrangement which will be beneficial for the students 'cognitive development.

Signer (2005) defined cooperative instructional strategy as a methodology that employs a variety of teaching activities to improve students understanding of a subject by using a structured approach which involves a series of steps requiring students to create, analyze and apply concepts. In cooperative teaching, both the individual and the social setting are active dynamics in the learning process as students attempt to initiate real life learning. This combination of team work and individual accountability enables students to work towards acquiring both knowledge and social skill. Cooperative teaching is an instructional strategy which allows students to work together in small heterogeneous groups of four to six members helping one another to accomplish assigned tasks. Heterogeneity can be achieved by combining students of different sexes, ages, religions, talents, abilities, interest and backgrounds so that students can get beyond their initial stereotypes in order to accomplish a common goal. Each individual team member is responsible for learning the material and also for helping the other members of the team to learn.

The structure of science comprises of elements such as concepts and principles. These elements provide the most meaningful units for learning through integration and synthesis of facts and meaningful personal experiences. Wikipedia (2012) stated that obviously concepts have some kind of structure. Hence, chemical concepts tend to stand for one kind generalization or another.

(a) Those that provide a generic name for a class of chemical objects etc. or

(b) Phenomena or processes that have common features such as electronegativity/electro positivity, covalency/electrovalency, efflorescence, deliquescence, hygroscopy etc.

It is necessary to understand the science concepts for any meaningful scientific literacy to be achieved. Udo (2008) stated that effective and meaningful teaching and learning of abstract scientific concepts require active students' involvement in the teaching-learning process through meaningful and relevant hands-on-activities. Therefore, the task of science teachers is to structure students learning using concept mapping strategy so as to ensure that specific aspects of concepts and principles are meaningfully learnt and internalized.

Concepts are essential to the development of scientific knowledge. For instance, it will be difficult to imagine chemistry without concepts like atoms, molecules, elements, compounds or hydrocarbons. Concepts help to integrate apparently unrelated observation and phenomena into viable hypotheses and theories which are the basic ingredients of science and technology. Concept map is a graphical tool for organizing and representing knowledge.

Udeani (1993) outlined the steps involved in concept mapping as follows:

(i) Select an item for mapping: This could be an important text, passage, laboratory background materials.

(ii) Choose and underline keywords or phrases, include objects and events in the list.

(iii) Rank the list of concepts from the most abstract and inclusive to the most concrete and specific.

(iv) Cluster the concepts according to two criteria that function at a similar level of abstraction and concepts that interrelate closely.

(v) Arrange the concepts as a two dimensional array analogous to a road map. Each concept is in effect a potential destination for understanding. Its route is defined by other concepts in the neighboring territory.

(vi) Link related concepts with lines and label each line in propositional or prepositional form.

A well constructed and completed concept map shows the clear relationship between various sets of concepts and this basic relationship is well communicated to other persons.

This study is anchored on the cognitive development theory as being mast applicable for cooperative learning. Its emphasis is on the acquisition of critical thinking which is the whole essence of science through clarification of concepts and ideas by ways of discussion and debate. Concept mapping on the other hand, is mainly based on the constructivist learning theory of Piaget (1967) and Ausubel (1968). Ausubel was concerned about how information can be made more meaningful so that it can be better understood and used. The theory addresses the issue of meaningful learning and stresses the value of prior knowledge in students learning and linking of new information to existing schemes as a necessary requirement for meaningful learning. According to Ausubel, meaningful learning takes place when learners integrate new information into the existing knowledge structures. It occurs where there is appropriate link between prior knowledge and new learning task. Meaningful learning is therefore the formation of variable relationships among ideas, concepts and information.

RESEARCH METHODS

Research Design and Procedure

The study adopted a pre-test, post-test, control group quasi experimental design. Intact classes were used which prompted the design. The study was conducted in six co-educational public schools, one from each Local Government Area of Rivers State, Nigeria. Senior Secondary 2 (SS2) students formed the sample of the study because the topics taught were selected from their curriculum. 280 subjects comprising 166 males and 144 females were randomly selected. The six selected senior schools were grouped into urban located and rural located types. These school types is their intact classes were randomly assigned experimental groups and control groups. Four intact classes were used for the experimental groups (two each for cooperative learning and concept mapping) and two for the control group.

The instrument for data collection was Hydrocarbon Chemistry Achievement Test (HCCAT). HCCAT contained 40 multiple choice objective questions. The topics covered were meaning of hydrocarbons, classification of hydrocarbons, isomerism and nomenclature of compounds. The HCCAT was face validated by experts in science education as well as measurement and evaluation and content validated using a test-blue print. 20 students each from community secondary school, Umungasi and Army Day Secondary School, Ekeakpara, all in Abia State were trial tested with the instrument. The schools were outside the study area. A reliability coefficient of 0.85 was obtained using Pearson product moment correlation. Students were pre-tested before treatment and the same instrument was administered as post-test after the treatment. The teaching lasting for six weeks. The lesson plan developed by the researcher was followed accordingly. Mean, percentage and standard deviation were used to answer research questions while ANOVA was used to test hypothesis.

Research Question 1: *What are the mean scores of chemistry students taught with cooperative instructional strategy and those taught with concept mapping instructional strategy on the chemistry of hydrocarbons?*

Table 1: Mean Scores of Students Taught with Cooperative Instructional Strategy (CIS) and those Taught with Concept Mapping Instructional Strategy (CMIS) on Hydrocarbon Chemistry

Group	Treatment	N	Pre-test		Post-test		Mean Difference
			$\overline{X}$	S.D	$\overline{Y}$	S.D	
1	CIS	94	26.71	5.18	58.05	10.71	31.34
2	CMIS	93	26.40	5.17	57.65	10.28	31.25
3	LM	93	26.11	5.38	38.84	5.63	12.73

CIS - Cooperative instruction strategy
CMIS - Concept Mapping Instructional Strategy
LM - Lecture method

Table 1 shows 26.71% pretest score for students taught with cooperative instructional strategy (CIS), 26.40% obtained for those taught with concept mapping instructional strategy and 26.11% pretest score for lecture method (LM) tutored group. Their post-test scores include 58.05%, 57.65% and 38.84% respectively. The standard deviation for cooperative, concept mapping and lecture method groups are 5.18, 5.17 and 5.38 (pretest) in that order while that of post-test for the respective groups are 10.71, 10.28 and 5.63. The table also reveals the mean percentage differences of these groups with cooperative instructional group having 31.34% , concept mapping group 31.25% and 12.73% for lecture method category. From the table, it is obvious that the students taught with cooperative instructional strategy performed better than the concept mapping group. The mean achievement score of the experimental groups is higher than those of the control group (31.34 and 31.25 > 12.73).

Research Question 2

What are the mean scores of male and female students taught with cooperative instructional strategy and those taught with concept mapping strategy on the chemistry of hydrocarbons?

Table 2: Mean Scores of Male and Female Students Classified by Instructional Strategies

Group	Treatment	Gender	N	Pre-test		Post-test		Mean Difference
				$\overline{X}$	S.D	$\overline{Y}$	S.D	
1	CIS	Male	56	26.42	6.34	57.92	10.36	31.50
		Female	38	25.66	5.27	54.97	10.89	29.31
2	CMIS	Male	56	26.63	6.36	59.71	8.77	33.08
		Female	37	25.74	5.73	57.76	9.90	32.02
3	LM	Male	56	26.21	4.57	40.00	6.02	13.79
		Female	37	25.13	5.49	39.61	6.24	13.48

Table 2 shows that the male and female mean achievement scores in the experimental groups (31.50 and 29.31) for cooperative instructional strategy (CIS), 33.08 and 32.02 for concept mapping instructional strategy (CMIS) are greater than the mean scores of their counterpart in the control group (13.79 and 13.48). Again, the standard deviations of the pre-test scores for the first experimental group (CIS) are male 6.34 and female 5.27, that of the second experimental group (CMIS) has 6.36 for male, 5.73 for female while the control group gives 4.57 (male) and 5.49 (female). The standard deviations of post-test according to the cooperative concept mapping and lecture method groups for male and female as contained in table 4.2 are 10.36/10.89, 8.77/9.90 and 6.02/6.24 respectively. The table also indicates that the mean scores of the male students in the experimental groups are greater than the mean score of male students in the control group (31.50 and 33.08 > 13.79). However, the male students have better performance than their female counterparts regardless of the strategy adopted.

Ho_1: There is no significant difference in the mean scores of students taught chemistry using cooperative instructional strategy and those taught with concept mapping strategy.

Table 3: Summary of ANOVA on Mean Achievement Scores of Students Classified by Instructional Strategies

Sources of Variance	Sum of Squares	df	Mean Square	F	Level of Significance
Between groups	5873.937	2	2936.969	101.195	0.05
Within groups	7176	276	29		
Total	**13049.937**	**278**	**2965.969**		

Table 3 reveals that at a level of significance less than 0.05, the F-calculated value is 101.195 while the F-critical value at df 276 is 3.84. The null hypothesis is rejected since the F-calculated value is greater than the F-critical value. Hence, there is a significant difference in the mean scores of students taught hydrocarbon chemistry based on cooperative learning strategy and concept mapping strategy.

Ho_2: There is no significant difference in the mean scores achievement of male and female students taught with cooperative instructional strategy and those taught with concept mapping strategy.

Table 4: Summary of ANOVA on Mean Achievement Scores of Male and Female Students Classified by Instructional Strategies

Sources of Variance	Sum of Squares	df	Mean Square	F	Level of Significance
Between groups	534.214	2	267.107	4.023	0.05
Within groups	14739.69	222	66.395		
Total	**15273.904**	**224**	**333.502**		

Table 4 shows that at P < 0.05, the F-calculated is 4.023 while the F-critical value at df 222 is 3,84. The null hypothesis is rejected since the F-calculated value is greater the F-critical value. As such, there is a significant difference in the mean scores achievement of male and female students taught with cooperative instructional strategy and those taught using concept mapping strategy.

DISCUSSION OF FINDINGS

The discussion of findings is done under sub-headings

1. ***Academic achievement of students exposed to cooperative and concept mapping***

The result in table 4.1 reveals that cooperative instructional group got 58.05% pass, concept mapping tutored group obtained 57.65% pass and the lecture method group 35.84%. The two experimental groups highly outscored the control group. This implies that the instructional strategies adopted in teaching the students hydrocarbon chemistry concepts were effective. This is in agreement with the finding of Olatoye, Aderogba and Aanu (2011) that cooperative learning strategy improved students' achievement in chemistry especially in organic chemistry. The null hypothesis was rejected due to the result of the hypothesis 1 (Table 4.5) which states that there is a significant difference in the mean scores of students taught chemistry of hydrocarbons with cooperative and concept mapping strategies, since the calculated F-ratio at P < 0.55 is greater than the critical value (101.195 > 3.84) at degree of freedom, df 276.

The adoption of cooperative teaching enabled the experimental group 1 students learn among themselves which was not so in the concept mapping group. They share knowledge within the group, capture different student's interest and set out goals for themselves. The concept mapping group on the other hand employed an active process of identifying links between concepts where new knowledge was reconciled, progressively differentiated and well integrated into the previous knowledge already acquired by the students. These enhanced the two experimental groups better understanding of hydrocarbon chemistry. This present result is in line with the findings of Olayede and Adeoye (2009) which compared the effects of guided discovery and concept mapping teaching strategies on senior secondary school students and found out that both instructional strategies improved students' academic achievement equally.

It is revealed in the first result of this study that cooperative and concept mapping strategies are viable tools for enhancing student's achievement in chemistry. This is to say that students will step up performance if teachers will employ some of these activity oriented methods in teaching chemical concepts.

2. ***Academic achievement of male and female students taught with cooperative and concept mapping instructional strategies***.

The result in table 4.2 reveals that cooperative got 57.92% pass by male and female 54.97%, concept mapping got 59.71% by male and 57.76% pass by female while the control group had 40% pass by male and female 38.61% pass. The two experimental groups performed well than the control group. Male students slightly outscored the females in cooperative and concept mapping groups. An ANOVA test of hypothesis 2 in table 4.6 has shown that the F-calculated value is greater the F-critical at df 1,222. Hence, hypothesis was rejected.

This means that there is a significant difference between the mean scores achievement of male and female students based on instructional strategies. This is in conformity with the findings of Okonkwo (2000) and Yusuf (2005) which found that male students achieved better than females. Contrary to this finding is Otor (2013) that female students exposed to concept mapping performed creditably well than their male counterparts in the achievement test. Abdusalam (2010) also reported that gender was not a significant factor in students understanding of some biological concepts using cooperative learning approach. These researchers confirmed that cooperative learning or concept mapping is not gender discriminatory.

There is gender discrimination in the second result as the male students are ahead of the females in terms of performance. To this end, instructional strategies that are result oriented and student centred such as cooperative and concept mapping strategies should be generally adopted during instruction irrespective of gender.

CONCLUSION

Inspite of the efforts and concerns shown to enhance intellectual skill and growth of the students in science, students' achievement in chemistry is not encouraging. One of the causes of this dwindling performance from students is the adoption of inappropriate instructional strategies by chemistry teachers. Activity oriented teaching methods and strategies such as cooperative learning methods and concept mapping should be employed instead of the conventional method. This study also leads empirical support that the exposure of students to both instructional strategies will step up their performance in chemistry. Cooperative and concept mapping strategies facilitated students' academic achievement in hydrocarbon chemistry than the lecture method. In adopting these methods, gender affects students' academic performance in favour of male students. It is also seen that while both cooperative and concept mapping groups had more achievement than the lecture method, concept mapping group is likely to do better.

RECOMMENDATIONS

Based on the findings of the study, it is evident that cooperative and concept mapping instructional strategies are driving tools capable of enhancing academic achievement of students in chemistry. Therefore:

1. Cooperative and concept mapping instructional techniques should not only be incorporated into chemistry syllabus by curriculum designers and developers but also to ensure implementation which will help students to retain and apply learnt concepts in problem-solving situation.
2. Authors should shift attention to student centred activities that will enhance the incorporation of cooperative and concept mapping techniques in teaching and learning chemistry for greater achievement of students in different locations in science.
3. Government at all levels should train and retrain teachers through regular workshops, seminars and symposia on the use of innovative and result oriented techniques such as cooperative and concept mapping, review their salary and pay them promptly for quality delivery of instructions.

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