

Full Length Research Paper

The effect of concept mapping- guided discovery integrated teaching approach on Chemistry students' achievement and retention

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This study investigates the effects of Concept Mapping-Guided Discovery Integrated Teaching Approach on the achievement and retention of chemistry students. The sample comprised 162 Senior Secondary two (SS 2) students drawn from two Science Schools in Nasarawa State, Central Nigeria with equivalent mean scores of 9.68 and 9.49 in their pre-test. Five instruments were developed, validated and used by the investigator for the study; they are namely; Chemistry Achievement Pre-Test (CAPE), Chemistry Achievement Post-Test (CAPO), Chemistry Achievement Retention Test (CART), Lesson Plans for the Control Group (LPCG) and the Lesson Plan for the Experimental Group (LPEG). Pre-test / post-test control group design was employed. Results of the Scheffe's test for multiple comparisons revealed that boys in the experimental group performed better than girls in the experimental group. The results of the t-test analysis of the retention test showed that the mean score of the experimental group was significantly better than that of the control group ($p < 0.05$). It is strongly recommended that chemistry teachers should be encouraged to adopt this method for teaching difficult concepts.

Key words: Integrated teaching approach, concept mapping- guided discovery, achievement, retention, scheffe's test.

INTRODUCTION

Chemistry is an important science subject taught at the secondary school level which has been posing a great threat to many students because of its nature. These are complexities due to its peculiar nomenclature, structures of compounds, series of chemical reactions/mechanism involved, chemical equations and the calculation associated with some topics/concepts. Some concepts are also abstract in nature thereby making their comprehension relatively difficult when compared with some other non-science concepts (Fatokun, 2006).

Different methods have been used in teaching Chemistry over the years at the secondary schools level but the effectiveness of any of these methods as measured by the performances of the students involved has not been really encouraging (Burns, 1999; Okebukola, 2005).

Results of students' performance in Chemistry for the past few years in Nigeria as obtained from the West African Examination Council (WAEC) Chief Examiner's report also revealed a decline and high failure rate.

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(About 38.17% of students passed at credit level in 2004, 36.43% passed at credit level in 2005, 40.36% passed in 2006 while less than 26% passed in 2009. The WAEC and National Examination Council (NECO) results released for chemistry in 2010 was also very poor with less than 22 % passes at credit level in both examinations) and nose-dived to below 20% in the recent years.

The question that comes to mind is this: "Is Chemistry really a difficult subject to teach and learn?" The burden of evidence revealed that most concepts in chemistry are indeed difficult to learn by most students (Johnstone and Otis, 2006). Around 1960, there were quite radical changes in emphasis in school chemistry education, with subsequent changes in many university courses. Considerable research was undertaken to explore the learning problems that students were experiencing. The common underlying trend became apparent as it relates to the way humans process new information. The secondary school knowledge of chemistry is often characterized by lack of coherence. Instead of having a well structured and integrated domain-specific knowledge structures, students consider the different concepts as isolated elements of knowledge. Most students do not possess a well founded basic framework in which newly acquired concepts can be integrated (Fatokun, 2012). This lack of integration is suspected to be the basis of students' difficulties concerning concept formation and application of acquired knowledge in exercises and practical work (Brandt et al 2001).

Okebukola (2005) itemized almost the entire concepts in the senior secondary school Chemistry syllabus as areas commonly found difficult to teach by graduate teachers. These concepts include nuclear chemistry, organic chemistry, rate of chemical reactions, chemical equilibrium, redox reactions and electrolysis. Fatokun (2006) therefore expressed that in order to surmount the student and teacher related problems afore listed, the onus therefore lies on the Chemistry teacher to have a good grasp of the subject matter and knows the appropriate means of communicating this, in order to be proficient in his pedagogical challenges. Olayiwola (2001) equally noted that the resourcefulness and effectiveness of the chemistry teacher is paramount in overcoming the so called 'difficult barriers' since he plays the major role in the implementation of the curriculum contents. Hence his effectiveness in the discharge of this duty determines the quality of products from school and invariably the level of development of the nation.

Ausubel's learning theory (Ausubel, 1968) suggests that hierarchical structures should be used in promoting understanding and recall. Ausubel and Novak worked extensively on cognitive structuring. Novak and his co-worker have developed the idea of concept maps as an exemplary learning/teaching strategy (Novak, 1981). Many other studies have also shown the utility of such

maps in diagnosing and in promoting meaningful learning since hierarchical organization have economic representation of important ideas and the relationship among them. It also facilitates the retrieval processes if it is properly adapted to the task domain. Bruner (1983, 1991) takes a different approach to learning. To Bruner learning is a process of discovery. This begins with problem-solving, a process analogous to teaching someone how to swim by throwing him into a deep pool of water. The assumption is that the learner will learn the necessary skills because he needs them to survive from drowning. This often requires an internal re-organization or "cognitive restructuring" of previously known ideas in order to accommodate the new experience. These two learning theories form the basic framework upon which this current study hung. Researchers have also shown that students understand and perform better when different teaching methods are blended or integrated together to enhance learning (Sisovic and Bojovic, 2000).

Oloyede and Adeoye (2009) carried out a study which compared the relative effectiveness of Guided Discovery and Concept Mapping teaching strategies on senior secondary school students' achievement in chemistry in Nigeria. Their result revealed that there is no significant difference in the mean score of students due to the method exposed to (either Guided Discovery or Concept Mapping).

From the studies conducted by Sisovic and Bojovic (2000) in Yugoslavia, the use of concept maps in combination with demonstration experiment for teaching chemistry was illustrated. At elaborate and systematic sessions, concept maps were combined with demonstration experiments to enable students apply their knowledge of concepts and their interrelations, as well as to formulate theoretical explanations for the observed changes they viewed or experienced.

The impact of concept mapping and visualization on the learning of secondary school chemistry students in Belgium was conducted by Brandt et al. (2001). The researchers sought to find the effect of concept mapping and visualization on students' learning by comparing the two approaches. There were 88 students involved in the study and they were divided into two equal groups. The findings revealed that there was a significant positive effect of extra attention to visualization on the learning achievement of students.

In this study, Concept Mapping and Guided discovery were combined to form the integrated approach which was investigated. Specifically, the effect of the approach on students' achievement and retention towards difficult chemical concepts was determined.

Research questions

The following research questions were raised for this study:

1 What is the effect of Concept Mapping-Guided Discovery Integrated Approach on students' achievement in chemistry?

2 Do boys and girls perform equally well when taught electrochemistry using Concept Mapping-Guided Discovery Integrated Approach?

3 Which group of students retains chemical concepts better when exposed to Concept Mapping-Guided Discovery Integrated Approach and Demonstration method?

Hypotheses

The following null hypotheses were formulated and tested:

H_{01} : There is no significant difference in the achievement of students exposed to Concept Mapping-Guided Discovery Integrated Approach and those taught using Demonstration Method.

H_{02} : There is no significant difference in the performance of boys and girls exposed to Concept Mapping-Guided Discovery Integrated Approach and those taught using Demonstration Method.

H_{03} : There is no significant difference in the level of chemical concept retained by students exposed to Concept Mapping – Guided Discovery Integrated Approach and those taught with Demonstration method.

METHODOLOGY

Population

All SS2 chemistry students in all the science secondary schools in Nasarawa State constituted the population for the study. There were 986 SS2 students in the entire population.

Sample

Stratified random sampling technique was employed to select a science school from each of the three educational zones in the state. Pre-test was conducted in the three selected schools in order to establish equivalence. GSSS Karu and GSSS Nasarawa-Eggon eventually participated in the study because of the equivalence of their pre-test mean scores which were 9.68 and 9.49 respectively. The t-test analyses showed that the groups were equivalent at 0.05 level of significance. The 162 sampled students were assigned to experimental and control group in each of the two schools.

Research design

Pretest-Posttest Control –Group Design was employed for the study.

Instruments: Five instruments were used for this study; they were developed by the investigator and validated by experts. They are namely;

Chemistry Achievement Pre-Test (CAPE): This was made up of 20 multiple choice objective test items which were selected from past UTME and SSCE questions on *Electrolysis, Redox reaction*

and Electrochemistry (selected topics for the study). The test items selected were distributed among the six intellectual levels of Bloom's taxonomy in the cognitive domain. The reliability index obtained for the achievement test using Kuder-Richardson method (KR-21) was 0.70.

Chemistry Achievement Post-Test: This consisted of 20 multiple choice objective test items and it was similar in content with the pretest. They were also drafted from past UTME and SSCE objective questions. The reliability index obtained for the achievement test using Kuder-Richardson method (KR-21) was 0.72. Equivalence of CATE and CAPO was established through t –test and the result revealed that there is no significant difference between CAPO and CAPE at 0.05 level of significance.

Chemistry Achievement Retention-Test (CART): This also consisted of 20 items structured objective test which was the same as the post test but the only difference was the serial rearrangement of the test items.

Lesson Plans for the Control Group (LPCG): These comprise five lesson plans on the selected topic for the study. It was to be used for teaching the control group using demonstration method for five consecutive weeks. The objectives for all the lessons in the Control group are the same as those of the Experimental group.

Lesson Plan for the Experimental Group (LPEG): These were sets of instructional guides designed only for the experimental group. There were five lesson guides on the selected topics for the study which was taught for five consecutive weeks. The experimental group used the integrated approach which is the combination of Concept Mapping and Guided Discovery approach (concept map together with sets of questions outlined to be answered and some activities to be carried out at different stages of each topic) that was appropriately blended together.

Procedure

The CAPE was first administered and used to determine the initial knowledge of the students on the selected topics and to select equivalent groups which participated in the study. For five weeks, the Experimental Group was taught electrochemistry using Concept Mapping-Guided Discovery Integrated Approach while the Control Group was taught the same set of topics using Demonstration Method. The Post Test was conducted immediately after the teaching and was used to determine the effectiveness of the two methods of teaching but particularly the effect of the treatment on the experimental group. Four weeks later, retention test (CART) which was to determine the amount of content material retained by the students after conducting the post test was administered.

RESULTS AND DISCUSSION

The result of the study is stated below; SPSS was used to obtain the data for all the statistical testing of the hypotheses.

Hypothesis 1

H_{01} : There is no significant difference in the achievement of students exposed to Concept Mapping-

Table 1. Means and standard deviations of post test scores for experimental and control groups in the schools.

School	Group	No. of students	Range of Scores	Mean Score	Std. Deviation	Std. Error
GSS KARU (School 1)	Experimental	40	12	13.80	3.08	0.49
	Control	40	6	11.45	1.45	0.23
GSS Nasarawa Eggon (School 2)	Experimental	40	7	14.75	1.81	0.29
	Control	42	9	9.25	1.86	0.29

Table 2a. Results of ANOVA of Post-Test Mean Scores for school 1.

School 1	Sum of squares	Df	Mean square	F-cal	F-crit	Decision
Between Groups	24.660	9	2.740	1.436	1.350	Significant
Within Groups	57.240	30	1.908			
Total	81.900	39				

Decision: Since $F_{\text{calculated}}$ is greater than the F_{critical} , we reject H_{01} .

Table 2b. Results of ANOVA of Post-Test Mean Scores for school 2.

School 2	Sum of Squares	Df	Mean Square	F-cal	F-crit	Decision
Between Groups	22.29	9	2.78	1.461	1.350	Significant
Within Groups	57.240	30	1.908			
Total	81.900	39				

Decision: Since $F_{\text{calculated}}$ is greater than the F_{critical} , we reject H_{01} .

Guided Discovery Integrated Approach and those taught using Demonstration Method.

From Tables 1 and 2, mean score of the groups are shown and used to answer the first research question. It is indicated from above that the experimental groups had higher means than the control group which implies that the Concept Mapping-Guided Discovery approach enhances achievement in Chemistry learning.

Using both F and t tests respectively, Tables 3 and 4 show that there is a significant difference at 5% level of confidence in the achievements of students in the control and experimental group. Those taught with Concept Mapping-Guided Discovery Integrated Approach achieve more than those taught with Demonstration method

Hypothesis 2

H_{02} : There is no significant difference in the performance of boys and girls when taught with Concept Mapping-Guided Discovery Integrated

Approach and those taught with Demonstration method.

Hence there is a significant difference in the performance of boys and girls when taught with Concept Mapping-Guided Discovery Integrated Approach and those taught with Demonstration Method.

Hypothesis 3

H_{03} : There is no significant difference in the level of chemical concepts retained by students exposed to Concept Mapping-Guided Discovery Integrated Approach and those taught with Demonstration method. Table 5 clearly shows that the experimental group had higher mean scores and better retention rate than those in the control group.

Since the calculated t-value is greater than the critical t-value, we reject the H_{03} . Hence there is a significant difference in the level of retention of chemical materials by students taught using the Concept Mapping-Guided Discovery Integrated Approach and those taught with the Demonstrated Method.

Table 3a. Result of t-test Analyses of Post – Test Mean Scores for school 1.

School 1 Groups	No of students	Mean Score	Standard deviation	t-cal	t-crit = $t_{0.05,78}$	Decision
Experimental	40	13.80	3.08	4.68	1.67	Significant
Control	40	11.45	1.45			

Since $t_{\text{calculated}}$ is greater than the t_{crit} , we reject H_{01} .

Table 3b. Result of t-test Analyses of Post – Test Mean Scores for school 2.

School 2 groups	No of students	Mean score	Standard deviation	t-cal	t-crit = $t_{0.05,80}$	Decision
Experimental	40	14.75	1.81	13.57	1.67	Significant
Control	42	9.25	1.86			

Since $t_{\text{calculated}}$ is greater than the t_{crit} , we reject H_{01} .

Table 4 a. Results of Scheffe's Test on Post test Mean Scores for School 1.

School1 Groups	Gender	N	Mean Score	Range of score	Standard deviation	$S_{\text{calculated}}$ -value	S_{critical} -value
Experimental	Male	21	$\bar{x}_1 = 15.14$	10	3.23	31.76	5.70
	Female	19	$\bar{x}_2 = 12.32$	13	2.14		
Control	Male	27	$\bar{x}_3 = 11.82$	13	1.44		
	Female	13	$\bar{x}_4 = 10.69$	11	1.18		

Since $S_{\text{calculated}}$ is greater than the S_{critical} , we reject H_{02} .

Table 4 b. Results of Scheffe's Test on Post test Mean Scores for School 2.

School 2 Groups	Gender	N	Mean Score	Range of score	Standard deviation	$S_{\text{calculated}}$ -value	S_{critical} -value
Experimental	Male	24	$\bar{x}_1 = 15.04$	9	1.78	49.70	5.70
	Female	16	$\bar{x}_2 = 14.31$	7	1.82		
Control	Male	22	$\bar{x}_3 = 8.86$	10	2.14		
	Female	20	$\bar{x}_4 = 9.90$	9	1.41		

Since $S_{\text{calculated}}$ is greater than the S_{critical} , we reject H_{02} .

Table 5. Results of the t-Test analyses for Content Retention by the Experimental and Control Group in Schools 1.

Group	No of students	Range of scores	Mean score	Standard deviation	t-cal	t-crit = $t_{0.05,78}$	Decision
Experimental	40	9	14.87	1.92	4.68	1.67	Significant
Control	40	12	11.45	1.45			

Since $t_{\text{calculated}}$ is greater than the t_{crit} , we reject H_{03} .

CONCLUSION AND IMPLICATION OF THE STUDY

There is remarkable improvement in the achievement of students taught with the Concept Mapping–Guided Discovery Integrated Approach as compared to those taught with demonstration methods.

The effective implementation of the two teaching strategies as a new approach was responsible. Burner asserted that students learn science best through discovery and Cascales et al. (2001) affirmed that concept Mapping should be used mostly in Teaching Chemistry. This is in agreement with Inekwe (2010) who concluded that new and novel teaching strategies often enhance learning and productivity.

It was discovered that a considerable gap still exist between the achievement of boys and girls when taught under the same condition particularly when taught using Concept Mapping – Guided Discovery Integrated Approach with the boys performing better than their female counterparts. There is still a margin between the performance of boys and girls despite all efforts to bridge the gender gap, although there is an appreciable improvement as compared to the past decades. This result supports the outcomes of earlier studies by Olaleye and Ajileye (2004), Oloyede and Adeoye (2009) and Fatokun and Idagboyi (2010). Students exposed to the Integrated Approach retain the knowledge of chemical concepts gained during teaching better than those taught using Demonstration method. This result is consistent with the finding of Oloyede and Adeoye (2009) where they reported and established that both Guided Discovery and Concept Mapping are effective teaching methods when used independently since in the current study, the two teaching methods were blended together, it is expected that students' retention would improve considerably and it did.

The implication of the above is that Concept Mapping – Guided Discovery Integrated Approach is an effective teaching method for learning difficult chemical concept/topics. Chemistry content is better retained when this approach is employed because it adopts problem based learning (an integral part of guided discovery method), that enhances cognitive restructuring and linkage of ideas to existing knowledge structure (Fatokun and Fatokun, 2013). It is therefore recommended that Chemistry educators get acquainted with and adopt this novel approach of teaching/learning chemistry.

Conflict of Interests

The author has not declared any conflict of interests.

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