

COMPARATIVE EFFECTS OF COLLABORATIVE
CONCEPT MAPPING AND CONCEPT MAPPING
INSTRUCTIONAL STRATEGIES ON STUDENTS'
ACHIEVEMENT AND RETENTION IN REDOX
REACTIONS

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Abstract

The study investigated comparative effects of collaborative concept mapping and concept mapping instructional strategies on students' achievement and retention in redox reactions. A sample of 142 students from 4 purposively selected secondary schools out of a population of 4,421 Senior Secondary II students from Makurdi Local Government Area of Benue State, Nigeria was used for the study. The study adopted quasi experimental research design. The instrument used for data collection was Redox Reactions Achievement Test (RRAT) with the reliability value of 0.83 using Kuder-Richardson (KR-21). Two research questions and two null hypotheses guided the study. The research questions were answered using Mean and Standard Deviation scores while the hypotheses were tested using Analysis of Covariance (ANCOVA). The study revealed that students taught redox reactions using Collaborative Concept Mapping Instructional Strategy (CCMIS) had significantly higher mean achievement scores than those taught using Concept Mapping Instructional Strategy (CMIS) [$F(1, 141) = 437.438, P < 0.05$] and students taught redox reactions using CCMIS had significantly higher mean retention scores than those taught using CMIS [$F(1, 141) = 204.142, P < 0.05$]. It was recommended among others that chemistry teacher trainees should be trained on the use of CCMIS and serving teachers should be encouraged to use CCMIS.

Introduction

Nations that are considered to be developed and largely considered as civilized have achieved that status through purposeful scientific education of their citizens (Ali, 2004). In cognizance with the importance of science and technology, science subjects such as chemistry are taught in secondary school in Nigeria to prepare a base for any science and technological development (Akinsola, 2011). Chemistry is an experimental science that systematically studies the composition, properties reactions, and activities of organic and inorganic substances and various elementary forms of matter (Senese, 2010). Its study involves exploration of relationship between theory and experiment. Redox reaction or oxidation-reduction reaction which is the main focus of this study is a type of chemical reaction that involves a transfer of electrons between two species. The two species that exchange electrons in a redox reaction are given special names. The ion or molecule that accepts electrons is called the oxidizing agent; by accepting electrons it causes the oxidation of another species. Conversely, the species that donates electrons is called the reducing agent; when the reaction occurs, it reduces the other species (Christopher, Christina & Luvleen, 2016). Redox reactions are common and vital to some of the basic functions of life, including photosynthesis, respiration, combustion and corrosion or rusting (Christopher, Christina & Luvleen, 2016).

Chemistry is a very important subject as its knowledge is required for the successful study in many important professions such as medicine, engineering, agriculture, science education and all other science related disciplines. Because of its importance, chemistry is occupying a pride of place in the senior secondary school curriculum. It is therefore necessary that students studying chemistry should understand the subject so that they can apply their knowledge to their everyday interaction with people and their ever changing environment. Therefore, chemistry teachers should adopt appropriate strategies that would enable the students to understand whatever concepts, topics or principle that

are being taught. Chemistry teachers have used a number of teaching strategies in the past. Such methods are demonstration, lecture, expository, and discussion methods among others. Studies have shown that these methods have not yielded expected results (Inomesia & Unuero, 2003; Ajayi, 2016). However, research shows that chemistry is generally a difficult subject to students at all levels (O'dwyr, 2012). This is also reflected in the achievement of students in chemistry external examinations such West Africa Examination Council (WAEC) and National Examination Council (NECO). In this regard, poor method of teaching invariably translates to students' poor achievement and inability to retain what is learnt in classroom. However, there have been ongoing endeavours to explore and implement several possible interventions to improve students' achievement and retention in Chemistry. One of such interventions is to teach the subject beginning from what the student already knows and this would bring about meaningful learning (Gregory & Mayer, 2002).

Concept mapping is the process of organizing concepts and relationships between them in a hierarchical manner from most inclusive concepts to more specific, least inclusive concepts (Novak & Gowin, 1996). A concept map is a diagram showing the relationships among concepts or it is a graphical tool for organizing and representing knowledge. Concept mapping is used to develop logical thinking and study skills by revealing connections and helping students see how individual ideas form a larger whole. The technique of concept mapping was developed by Novak (1970) as a means of representing the emerging scientific knowledge.

Collaborative concept mapping instructional strategy (CCMIS) is a hybrid teaching/learning strategy involving an interaction between two or more individuals during concept mapping to create a shared understanding of a previously possessed or could have come to on their own (Johnson & Smith, 2009). CCMIS or concept mapping in a group setting is a process where two or more individuals are engaged in coordinated and sustained efforts in the

creation of one or more concept maps in order to learn and construct knowledge. Collaborative concept mapping strategy connotes sharing ideas. Consequently, concept mapping strategy becomes collaborative when instead of an individual drawing the map, a group of students come together to brainstorm, share ideas, generate a pool of concepts/facts, which when put together, they eventually come out with a map that represents the thought of the group.

Collaboration connotes sharing ideas. Consequently concept mapping strategy becomes collaborative when instead of an individual drawing the map, a group of students come together to brainstorm, share ideas, generate a pool of concepts/facts, which when put together, they eventually come out with a map that represents the thought of the group. The collaborative concept mapping instructional package idea is borne out of the fact that drawing individual maps could sometimes be boring and frustrating; particularly when one is not getting it right (Samba, 2012). However, when more than one brainstorms together, each one is encouraged or stimulated to think and bring out more ideas which when shared, will go a long way to upgrade individual conceptual framework (Samba, 2012). In this regard, this will not only promote meaningful learning, but will go further to help develop critical thinking and other social skills which are fundamental in functional and impactful living. Moreover, such interactions make learning more exciting, arouse interest and keep the students focused.

Statement of the Problem

Redox reactions as a concept in senior secondary school chemistry have posed unique and formidable challenges to students as explicated by Inyang and Ekpenyong (2000) and Adesoji (2002). Consequently, the low achievement in chemistry in external examinations such as Senior Secondary Certificate Examination conducted by West Africa Examination Council and National Examination Council has been traced to the use of conventional

teaching method that does not put into consideration the students' already existing knowledge in teaching and learning processes. A good number of students that offer science and science related courses in higher institutions are expected to pass chemistry. Despite this expectation, low achievement in chemistry by students appears to have persisted which is often blamed on poor teaching methods adopted. Poor method of teaching chemistry (redox reactions) invariably translates to students' poor achievement and inability to retain what is learnt in the classroom. In this regard, the study examined whether collaborative concept mapping instructional strategy or concept mapping instructional strategies would be an effective instructional strategy to enhance students' achievement and retention in redox reactions

Purpose of the Study

The purpose of the study was to investigate the comparative effects of Collaborative Concept Mapping Instructional Strategy (CCMIS) and Concept Mapping Instructional Strategy (CMIS) on students' achievement and retention in redox reactions. Specifically, the study:

1. Determined the effects of CCMIS and CMIS on students' achievement in redox reactions.
2. Ascertained the effect of CCMIS and CMIS on students' retention in redox reactions

Research Questions

The following research questions were answered in this study:

1. What is the difference in the mean achievement scores between students taught redox reactions using collaborative concept mapping instructional strategy (CCMIS) and those taught using concept mapping instructional strategy (CMIS)?
2. What is the difference in the mean retention scores between students taught redox reactions using CCMIS and those taught using CMIS?

Hypotheses

The following null hypotheses were tested:

1. There is no significant difference in the mean achievement scores between students taught redox reactions using collaborative concept mapping instructional strategy (CCMIS) and those taught using concept mapping instructional strategy (CMIS)
2. The difference in the mean retention scores between students taught redox reactions using CCMIS and those taught using CMIS is not significant.

Research Design and Procedures

The study used pre-test, post-test quasi experimental design. The pre-test score constituted the covariant of the post-test scores. In order to find out if the knowledge gained was retained, the post-test was reshuffled and administered as retention test to measure the subjects on retention. The sample was divided into two groups' namely experimental group I and experimental group II. The group I were taught redox reactions using collaborative concept mapping instructional strategy (CCMIS) in line with lessons procedure prepared by the researcher while the group II were taught the same redox reactions topics using the concept mapping lesson notes. Redox reactions sub-topic taught are: Combination and decomposition, displacement reactions (single and double), combustion reaction, disproportionation.

The study area was Makurdi Local Government Area of Benue State, Nigeria. The population of the study comprised all the 4,421 Senior Secondary II students in the 31 government approved secondary

schools. 142 students were purposively sampled from 4 schools. One instrument known as Redox Reactions Achievement Test (RRAT) was used to collect data for this study. RRAT is a researcher made instrument that contains two sections. Section A contains bio-data information of the respondents, while section B contains 40 multi choice objective items questions to which respondents are expected to provide the correct answer by ticking the correct options (A-D). RRAT was validated by three experts of Science education/measurement and evaluation from Benue State University, Makurdi. Corrections and suggestions arising from these experts were used to review the instrument before it was used. Kuder-Richardson (KR-21) was used to obtain the RRAT reliability, which yielded a coefficient value of 0.83. Mean and standard deviation were used to answer to the research questions while the null hypotheses were answered using Analysis of covariance (ANCOVA).

Results

Presentations in this section are based on research questions and hypotheses:

Research Question One

What is the difference in the mean achievement scores between students taught redox reactions using collaborative concept mapping instructional strategy (CCMIS) and those taught using concept mapping instructional strategy (CMIS)? The answer to research question one is contained on Table 1.

Table 1: Mean Achievement and Standard Deviation Scores of Students taught Redox Reactions using CCMIS and CMIS.

Group	N	PRE-TEST		POST-TEST		Mean Gain
		Mean	SD	Mean	SD	
CCMIS	73	14.72	1.02	28.32	1.66	13.60
CMIS	69	14.70	1.01	17.15	1.53	2.45
Mean difference		0.02		11.17		11.15

Table 1 revealed that, the overall mean difference between the two groups was 11.15 in favour of the collaborative concept mapping strategy group. It implies that the collaborative concept mapping strategy group achieved significantly higher than the concept mapping group counterpart.

Research Question Two

What is the difference in the mean retention scores between students taught redox reactions using collaborative concept mapping instructional strategy (CCMIS) and those taught using concept mapping instructional strategy (CMIS)? The answer to research question two is presented on Table 2.

Table 2: Mean Retention and Standard Deviation Scores of Students taught Redox Reactions using CCMIS and CMIS

Group	N	Pre-Test		Retention-Test		Mean Gain
		Mean	SD	Mean	SD	
CCMIS	73	14.72	1.02	30.12	1.76	15.40
CMIS	69	14.70	1.01	15.25	1.64	0.55
Mean difference		0.02		14.87		14.85

The results on Table 2 revealed that, the overall mean difference between the two groups was 14.85 in favour of the collaborative concept mapping instructional strategy group. It implies that the collaborative concept mapping strategy group had significantly higher retention capacity than the concept mapping instructional strategy group.

Hypothesis One

There is no significant difference in the mean achievement scores between students taught redox reactions using collaborative concept mapping instructional strategy (CCMIS) and those taught using concept mapping instructional strategy (CMIS). The answer to hypothesis one is presented on Table 3.

Table 3: ANCOVA Test for Mean Achievement Scores of Students taught Redox Reactions using CCMIS and CMIS.

Source	Type III sum of square	df	Mean Square	F	Sig
Corrected model	1906.734a	2	502.013	195.400	.000
Intercept	1090.071	1	1090.071	502.331	.000
Pre-test	421.005	1	421.005	84.921	.000
Method	1555.018	1	1555.018	437.438	.000
Error	489.127	139	9.111		
Total	123111.011	142			
Corrected Total	2369.000	141			

a. R squared = .114 (Adjusted R Squared= .111)

Table 3 reveals that there is a significant difference between collaborative concept mapping instructional strategy (CCMIS) and concept mapping instructional strategy (CMIS) in favour of CCMIS [$F(1, 141) = 437.438$, $P < 0.05$]. The null hypothesis is therefore rejected. This implies that collaborative concept mapping instructional strategy is significantly more effective than

concept mapping instructional strategy in achievement of students in redox reactions.

Hypothesis Two

There is no significant difference in the mean retention scores between students taught redox reaction using collaborative concept mapping instructional strategy (CCMIS) and those taught using concept mapping instructional strategy (CMIS).

Table 4: ANCOVA Test for Mean Retention Scores of Students taught Redox Reactions using CCMIS and CMIS.

Source	Type III sum of square	df	Mean Square	F	Sig
Corrected model	1699.872a	2	405.083	215.001	.000
Intercept	2110.001	1	2110.001	392.081	.000
Pre-test	317.005	1	317.005	96.484	.000
Method	3114.026	1	3114.026	204.142	.000
Error	601.764	139	18.810		
Total	218000.410	142			
Corrected Total	1101.001	141			

a. R squared = .206 (Adjusted R Squared= .203)

Table 4 shows that there is significant difference in the mean retention scores between the students taught redox reactions using collaborative concept mapping instructional strategy and those taught with concept mapping instructional strategy in favour of collaborative concept mapping instructional strategy [F(1, 141)= 204.142, P<0.05]. The null hypothesis is therefore rejected. This means that collaborative concept mapping strategy significantly enhanced students' retention in redox reactions compared with concept mapping.

Discussion of Findings

The findings of this study revealed that students taught redox reactions using collaborative concept mapping instructional strategy (CCMIS) achieved higher than their counterparts taught using concept mapping instructional strategy (CMIS). This finding agrees with Uchenna and Alimi (2012) and Olajide (2015) who found that students achieved higher when exposed to collaborative concept mapping strategy than their counterparts that were exposed to traditional method in Biology and Integrated Science respectively. Meanwhile, this finding contradict Karakuyu (2010), Otor (2013), Jack (2013) and Nwoke et al (2015) who found that students taught using concept mapping strategy achieve higher than those taught using conventional approach in physics, chemistry and mathematics respectively. It was also found that students exposed to collaborative concept mapping strategy have higher retention capacity than their counterpart that

was exposed to concept mapping instructional strategy. This finding agrees with Musa (2015) who found that students have higher retention capacity when they are actively engaged in solving problems through collaborative concept mapping strategy than when they become passive learners as obtained in the use of traditional method. The likely explanation for this outcome may be connected to the fact that the collaborative learning engages learners in active learning where they work and learn together in small groups to accomplish shared goals. In collaborative learning students explore their ideas, clarify them for themselves and to one another, expand and modify them and finally make them their own and thereby enhancing achievement and retention more that in concept mapping strategy.

Conclusion and Recommendation

It is evident from the findings of this study that the use of collaborative concept mapping instructional strategy (CCMIS) enhanced students' achievement and retention in redox reactions than the use of concept mapping instructional strategy. Based on the conclusion, the following recommendations are advised: Chemistry teacher's trainee should be trained on the application of collaborative concept mapping instructional strategy. Serving teachers should employ the use of CCMIS in teaching to enhance students' achievement and retention in redox reactions.

Ministry of Education and professional bodies such as Association of Science Educators (ASE) and Science Teachers Association of Nigeria (STAN) should organised conferences or seminars and workshops to popularize and sensitize chemistry teachers on the use of collaborative concept mapping instructional strategy.

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