Use of Chemistry Demonstration to Foster Conceptual Understanding and Cooperative Learning Among Students

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ABSTRACT

The study investigated the the effect of using cooperative learning strategies and demonstration method to foster conceptual understanding of electrolysis among secondary students in Ogun state. Two null hypotheses guided the study. A pre-test ,treatment, post-test quasi experimental design which employed a sample of 113 senior secondary two (ss2) chemistry students from three public schools. Electrolysis Achievement Test (EAT) was used for data collection which was validated and the coefficient of internal consistency was 0.79. Mean and standard deviation and Analysis of Covariance was used to test the null hypotheses at $p < 0.05$.The result obtained showed that students taught using co-operative learning strategy performed significantly better than those taught using demonstration and lecture methods. No significant difference of gender was found. Based on the findings, the use of co-operative learning strategy was recommended to chemistry teachers.

Key words: Conceptual understanding, cooperative learning, demonstration,electrolysis..

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1. BACKGROUND TO THE STUDY

Chemistry is the mother of all science subjects that is making essential contributions towards human life, society, industry and civilization. Despite its relevant and key role in achieving Sustainable Development Goals (SDGs) to which Nigeria has signed up on the march to 2030, students still have difficult in learning chemistry and achievement in public examination is worrisome. The data available on performance of candidates in Senior Secondary Schools (SSCE) in Nigeria from 2007- 2017 attested to the poor achievement in chemistry. Asihai (2010), Bankole (2014) have attributed the observed students' poor achievement to the use of inappropriate teaching methods by chemistry teachers. In addition, chemistry concepts are perceived to be abstract and difficult to learn. Among the difficult concepts identified by Okebukola et al, 2015 and corroborated by the chief examiners report of west Africa examination council 2010 - 2016 are mole concepts, redox reactions, calculations involving volumetric analysis, electrolysis, chemical equations and so on.

To this end, electrolysis topic which includes electrodes, electrolytes, conductor, electron transfer and balancing of redox reactions of the SS2 chemistry syllabus in Nigeria was the focus of this study. This is because of its usefulness and relevant to daily life. Furthermore, questions are set on the concept by the external examination bodies yearly and students were not properly grounded in the basic concepts. No wonder, Mari (2002) maintained that teaching strategies is a variable that can easily be manipulated by teachers to increase student's retention rate and performance as well as reduce or eliminate sex-related difference in science and mathematics performance. In Nigerian secondary schools, teachers usually use the lecture method in teaching students as it leads to easy coverage of the school syllabus which unfortunately is the main concern of the supervisors.

Gbodi and Laleye (2006), opined that in this traditional method, the teacher dominates the scene as the authority in the field while the learners are inactive so there is little or no room for challenging learners ingenuity and development of cognitive skill through experiments. This traditional method has been established not to be effective in learning especially when difficult task are involved (Asiyai, 2005). The desire to improve achievement in science through effective instructional strategy has led to the increasing awareness in recent years of the importance of learner's centeredness in teaching. When students are actively involved in the learning process, they become effective in management of their learning experiences, are self-motivated, independent and meta-cognitively active in the process of learning (Zimmermann, 1990).

Sam, (2011) regrettably observed that the number of students meeting university requirement in the field of science, and technology in Nigeria is on the low side. Odetoyinbo, 2004 lamented that most students lack interest in core science subjects and consequently decline from science oriented courses such as Medicine, Engineering and so on in the University. The main function of pedagogy is to ensure that ideas and information are meaningfully presented, clear and retained over a long period of time. Chemistry should be taught in a way in which current ideas and innovations are introduced into it, especially in this modern age where children learn a lot through cell phones and computers. Chemistry lessons should be activity packed because merely teaching the chemical concepts in the class may not be enough to achieve the desired mastery of such concepts.

Demonstration is one of the strategies of impacting scientific concepts in the students. It involves experiment that aims to exhibit a particular scientific concept. It is the act of teaching by displaying of the instruction situation with an audio- visual explanation of an idea, process or product. It involves showing, doing and telling the students the point of emphasis. There are two styles. Lecture demonstration and demonstration performance method. A lecture demonstration method is a teaching technique that combines oral explanation with "doing" to communicate processes, concept, and facts. It is particularly effective in teaching skills that can be observed. A skilled educator may wish to both tell and show what steps to take in an educational process. A demonstration is usually accompanied by a thorough explanation, which is essentially a lecture. On the other hand, the demonstration performance method of teaching is based on the simple but sound principle that we learn by "doing". Students learn physical or mental skills in actually performing those skills under supervision. Studies revealed that demonstration enhances students learning in the separation of mixtures (Agboola& Oloyede,2012).

Cooperative learning method is an instructional strategy which organizes students into small groups so that they can work together to maximize all participants' learning. Students seek information and understanding through active mental search with each group mirroring the makeup of the class in terms of ability, background and gender (Muhammad & Zaki, 2010; Sani, 2015). It is a departure from the teacher centered approach to the student centered learning technique. The essential components of cooperative learning includes i). positive interdependence among students seeking a common goal, ii). face-to-face interaction among students iii) individual and group accountability iv) use of interpersonal skills v.)group processing skills.

Bankole (2011) noted that to learn in a meaningful way, students need to actively process information, and cooperative learning activities can create an environment in which students actively engage in the task by sharing insights, ideas, and representations and teaching each other. It has been found to have positive effect on the reduction of students' anxiety in chemistry (Gorce & Derin 2007; Muhammad & Zaki, 2010; Sani, 2015). It has also been found that having students work cooperatively make them show greater positive attitude towards scientific process skills (Muhammad & Zaki, 2010; Bankole, 1998). This strategy of learning has been shown to enhance learning, relative to traditional whole class methods of teaching (Akinbobola, 2006; Olatoye, 2014; Olorundare & Aderogba, 2009; Oloyede, (2010); Sani, 2015; Udeani & Okafor, 2012). Chemistry learning can be made more interesting and stimulating to students by the use of variety of strategies. In other words, the teaching and learning of chemistry can be interesting but seeing it in action is fun. Therefore, this study sought to investigate the effect of using demonstration and cooperative learning strategies demonstration method to foster conceptual understanding of electrolysis among secondary students.

1.1 Statement of the problem

For over ten years a number of teaching strategies have been employed in teaching and learning of difficult topics in chemistry but performance in Senior secondary examinations in Nigeria continued to be poor. The West African Examinations Council reported this observation (WAEC 2005-2014). The root cause of this can be traced to how effectively science is taught in schools. Studies have been carried out on the use and potency of various teaching strategies (Aremu, & Abiodun, 2010 ; Falvo, 2008; Olatoye, 2014; Oloyede, 2010; Sani, 2015; ; Udeani & Okafor, 2012) in promoting meaningful learning in Chemistry. However, a consensus has not been reached on the most effective method that could be used in the teaching of electrolysis concepts. It therefore becomes imperative to search for effective teaching strategies that could be employed to enhance meaningful learning of electrolysis concepts in which the students can read together, interact and clarify their difficulties among themselves. Therefore, this study sought to investigate the effect of using cooperative learning strategies and demonstration method to foster conceptual understanding of electrolysis among secondary students.

1.2 Purpose of the study

This study was designed to:

1. Determine the relative effectiveness of using cooperative learning strategies and demonstration method to foster conceptual understanding of electrolysis among secondary students.
2. Examine the influence of gender on conceptual understanding when students receive instruction on electrolysis through cooperative learning strategies and demonstration method.

1.3 Research hypotheses

To guide the study, two null hypotheses were formulated and tested at 0.05level of significance.

H_{01}: There is no significant difference in the conceptual understanding of senior secondary school students when students receive instruction on electrolysis through cooperative learning strategies and demonstration method.

H_{02}: There is no significant difference in the conceptual understanding of male and female students taught electrolysis through cooperative learning strategies and demonstration method.

2. METHODOLOGY

2.1 Study design

The design of the study was quasi-experimental, specifically, the pre-test, post-test non-equivalent control group. This design was used because intact classes were employed since it was not possible to randomly assign students to experimental and control groups because of administrative set-up of the schools.

2.2 Sample and Sampling Techniques

The study involved one hundred and thirteen SSS II (mean age of 15) chemistry students from three public senior secondary schools in Ogun State. These schools were purposely sampled from three local government areas in Ogun state of Nigeria in order to minimize experimental contamination which may arise from influence of the sampled students in some ways. The schools selected have at least a graduate chemistry teacher with at least five years teaching experience, a chemistry laboratory and students offering chemistry at the senior secondary two (SS2). The schools were randomly assigned to experimental groups and the third school to the control group.

2.3 Instrumentation

The instrument, Electrolysis Achievement Test (EAT) was used to find out the students' conceptual understanding of electrolysis concepts. The EAT consisted of 25 items multiple choices with four options per item. The items were drawn from past questions of Senior Secondary Certificate Chemistry Examination (SSCE), conducted by the National Examinations Council (NECO), West African Examination Council (WAEC) and the Joint Admissions and Matriculation Board (JAMB). The items selected covered the concepts in electrolyte, application of electrolysis and cell construction because it was identified as one of the difficult topics for senior secondary school students (Okebukola et al, 2015). The items were moderated and the language used was modified to suit that of SSS II students by experts in chemistry. Twenty (25) out of the 47 items returned were randomly selected and trial tested on 75 students (49 male and 36 female). These students were similar in class and age range of 14 – 17 years to those for whom the instrument was finally used.

The responses were scored by awarding one point to each correct response and zero for a wrong response. The reliability of the test items was determined using the split half reliability procedure and the coefficient was found to be 0.79.The data collected were analyzed using descriptive statistics, frequency count, mean, and standard deviation in order to organize and describe the characteristics of the data collected and Analysis of Covariance (ANCOVA) using IBM-SPSS version 20.

2.4 Procedure/ Methodology

The chemistry teachers in each of the selected schools were trained by the researchers for three weeks. Each was given a copy of standardize lesson plan as well as copies of the instrument used for the study. To ensure that there was as much uniformity in the presentation of the content on the chosen topic. The same schemes of work were adopted by the teachers to ensure that the intended content was covered uniformly for all the groups involved in the study. Data was collected in two stages. The pilot stage (trial) pretest data was collected by the administration of EAT to the two experimental groups and the control group in their intact classes. The pretest data was used to assess the entry behaviors' of the students before the treatment. The treatment was then administered for a period of four weeks.

The experimental groups 1 were taught Electrolysis contents with cooperative learning strategy. This involved grouping the students into four or five members per group. Each group was provided with instructional materials needed for the lesson. The teaching featured definition of terms such as electrolysis, electrode, electrolytes and cell. Attention of each group was drawn to the instructional materials, guiding each group to find solution to the problem at hand, allowing each group to ask questions within themselves and draw conclusions. Each activity is followed by group discussion in which members of the group contributed.

The experimental group II subjects were exposed to electrolysis concept through teacher demonstration strategy. The students watched with rapt attention as the teacher demonstrates to the class. Each demonstration was presented in a manner that evolves intrigue and interest. Explanations were infused in the course of the demonstration, questions were asked to probe into the students understanding. The control group was taught electrolysis with the lecture method. The teacher in this group uses the textbook to teach and copy notes on the board for the students. The students listened, avoiding interaction with other students and seeking assistance from the teacher only in the teaching learning process. The achievement test was taken individually. Immediately after the treatment, EAT was administered as post test. Data collected were analyzed using mean, standard deviation and analysis of covariance (ANCOVA).

3. RESULTS

Table 1: Conceptual understanding according to teaching method

Method/strategy	N	Mean	Standard deviation
Cooperative method	36	19.51	4.34
Demonstration strategy	39	15.49	3.90
Lecture method	38	10.32	2.18

Table 1 show that the mean score of students in the cooperative group (19.51) is higher than their counterpart who received instruction with demonstration and lecture methods (15.49) and (10.32) respectively. As a result of this observed difference in mean achievement and process skills development scores , hypothesis 1 was tested at 0.05 level to determine if the observed difference was significant or not. H_{01}: There is no significant difference in the conceptual understanding of senior secondary school students when students receive instruction on electrolysis through cooperative learning strategies and demonstration method.

Table 2: ANCOVA showing the conceptual understanding mean scores of students in the cooperative learning strategies ,demonstration method and lecture groups

Source	Sum of squares	Df	Mean square	F	Sig
Corrected model	1696.813	2	848.406	23.896	.000
Intercept	16059.631	1	16059.631	452.332	.000
Pretest achievement	6.220	1	6.220	.175	.676
Method	1687.350	1	1687.350	47.526	.000
Error	3621.416	102	35.504		
Total	76767.000	105			
Corrected Total	5318.229	104			

R Squared =.699 (Adjusted R squared =.656)

Table 2 shows a significant difference in students" conceptual understanding in Electrolysis with respected to method of teaching $F_{(1,102)} = 47.53$; $p < 0.05$ .Consequently, the null hypothesis was rejected. This means that students" conceptual understanding in Electrolysis is influenced by the method of teaching. The adjusted R squared (0.699) shows that 69.9% of variance is contributed by the teaching strategies.

Table 3 mean and standard deviation of the students' scores in post test by gender

Gender	N	Pre- test		Post- test	
		mean	S.D	mean	S.D
Male	53	15.37	3.10	42.40	5.68
Female	60	12.32	4.45	43.46	6.16

Table 3 shows that the pre-test mean score of male students is 15.37 while mean score for female students is 12.32 Their post-test mean scores are 42.40 and 43.46 respectively. It implies that on post scores the female students significantly perform better than their male counterparts. With this result, hypotheses two was tested.

Hypothesis 2

H_{02}: There is no significant difference in the conceptual understanding of male and female students taught electrolysis through cooperative learning strategies and demonstration method.

Table 5: ANCOVA summary of students' conceptual understanding scores by gender.

Source	Sum of squares	Df	Mean square	F	Sig
Corrected model	1.778	2	.889	.208	.813
Intercept	511.199	1	511.199	119.467	.000
Pretest achievement	.332	1	.332	.078	.781
Gender	1.367	1	1.367	.319	.574
Error	342.319	102	4.279		
Total	2603.000	105			
Corrected Total	344.096	104			

R Squared=.005 (Adjusted R Squared =.020)

Table 5 showed that no statistically significant difference existed between male and female students in their conceptual understanding in Electrolysis [$F_{(1,102)} = 0.319$; $P > 0.05$]. Therefore the null hypothesis is not rejected.

4. DISCUSSION OF FINDINGS

This study revealed that there is a relative effectiveness in the effect of using cooperative learning strategies and demonstration method to foster conceptual understanding of electrolysis among secondary students. Teaching strategies contributed 69.9% to the variance as indicated by adjusted R squared Table 2. In addition, students in experimental groups (cooperative learning strategies and demonstration method) had the highest mean score while the lowest mean was observed in the lecture method group (Table 1).

This shows that cooperative learning strategies and demonstration method foster greater conceptual understanding in students while the lecture method was the least. The reason was because they were motivated by the strategy which aroused their interest and this made them to utilize the knowledge learnt in an active manner since they interact with other students, share and make decisions together in a cooperative setting. In actual fact they were free with one another in the teaching and learning process. These findings aligned with the findings of Erlis & Subramaniam (2014) .The better performance of the experimental group was attributed to other factors. Apart from the fact that the learning interest of the students was aroused, they were able to communicate freely with each other, support and encourage one another thereby increasing their problem solving skills and they were able to relate mathematical information to everyday life. This claim was supported by Barclay *et al* (2011); Candido, (2000); Cohen *et al*(1989); Gutierrez (2014); Marasigan, (2006); Okigbo & Okeke (2013); Tuzun *et al* (2009) in their study.

Findings in this study also revealed that significant difference did not exist between male and female students that were taught electrolysis through cooperative learning strategies and demonstration method on conceptual understanding This implied that the teaching strategies were not gender sensitive. In other words, these strategies did not differentiate between genders. This agrees with many research findings Abdulkarim, and Hassan (2013); Lamidi, Oyelakin, and Olorundare, (2015). This agreement must have been because of the environment in which the teaching strategies adopted in this study were used and the classroom settings and the effect of the location in which the study was carried out. The non-significant gender difference in conceptual understanding obtained in this study could also be attributed to the fact that both male and female students participated actively in the learning experience which is an evidence of meaningful learning. This was because the teaching strategies are gender friendly and both male and female found it as an easy way to learn better. This implies that given the right conditions of learning chemistry especially electrolysis concept, both male and female students would perform equally. However, Oloyede, (2010); Otor & Achor , (2013); Safayeni et al, (2005); Udeani & Okafor, (2012) report are not in line with the findings of this study.

5. CONCLUSION

This study revealed that the use of cooperative learning strategy for teaching chemistry concepts to students enabled them to better understand the concepts taught than using demonstration and lecture method of teaching.

6. RECOMMENDATIONS

From the result of this study, the following recommendations were made .

1. Chemistry teachers should consider using cooperative learning strategies and demonstration method to teach chemistry concepts especially electrolysis. This strategy is student's centered, which would avail the students the opportunity of constructing learning in their own way thereby fostering conceptual understanding.
2. This study could be replicated using some other difficult chemical concepts such as mole, rate of reaction and some others.
3. Teachers should keep abreast with current findings that could enhance their lesson delivery by attending regularly workshops, seminars and conferences to update their knowledge and be encouraged to write text materials that incorporate the use of such strategies.

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