

Effects of Demonstration Method and Cooperative Learning Technique on Students' Retention in the Concepts of Writing and Balancing of Chemical Equations

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Abstract

The writing and balancing of chemical equations are the basic foundational concepts of Chemistry education. These concepts are so foundational in the learning of Chemistry that without proficiency in them success in Chemistry Education is completely compromised. These concepts have been indicated as very difficult to learn at the senior school level. Chemistry teachers and educators have for a long time been striving to find effective ways of teaching the concepts successfully at the secondary school level because the concepts are very fundamental to the understanding of Chemistry. This study sought to determine the efficacy of demonstration and cooperative learning methods on students' retention in writing and balancing of chemical equations. To guide the study, two research questions were posed and three null hypotheses were formulated. Quasi experimental research design was used as the design for the study. Specifically, pre-test, post-test, non-equivalent control group design was adopted for the study. A sample of eighty [80] senior secondary one (SS1) students was used for the study. Chemistry Retention Test (CRT) in the form of achievement essay test was used as instrument for data collection. Data collected were analyzed using mean, standard deviation of scores and analysis of covariance (ANCOVA) statistics. The findings of the study revealed that there is no significant difference in the mean retention scores of students taught writing and balancing of chemical equation using demonstration method and those taught using cooperative learning strategy of teaching. Gender was not a significant factor in the students' retention in the concepts of writing and balancing of chemical equations. There is no significant interaction effect of method and gender on the retention of students in writing and balancing of chemical equations. One of the implications of the findings is that demonstration method of teaching and learning and cooperative learning strategy of teaching are statistically equally effective in enhancing the retention of students' learning in the concepts of writing and balancing of chemical equations. It was recommended that these two methods should be adopted by Chemistry teachers when they are teaching these foundational concepts to SSI students.

Introduction

Chemistry is the study of structure of matter, its composition, transformations, interactions with one another and uses and energy implications in the environment. According to Ababio, (2007), Chemistry as an aspect of science studies the composition, properties and uses of matter. Chemistry focuses on the changes that matter undergoes under different conditions. Most of the things you can touch, taste, see and smell are chemical substances. It is the explanation for everyday life, like why laundry detergent foams better in hot water than in cold water, or how baking soda causes doff to rise, and why fresh palm wine foams while stale palm wine does not foam, (Attah, 2014). The study of chemistry is important in most fields of study. Chemists, physicists, biologists, engineers study chemistry because it deals with matter at its most fundamental level, the sub-atomic level of matter. Writing and balancing of chemical equations indicate the way chemical substances interact to form substances. These two concepts are keys to successful learning of Chemistry at all levels of the discipline. Without

mastering these fundamental concepts, Chemistry education becomes a failed effort. Writing of chemical equations form the bedrock upon which chemistry education is built because it is the language of chemistry. Writing and balancing of chemical equations are the basis for the operations of the chemical industries: pharmaceuticals, food, textile, polymer, plastics, detergents, paper and pulp, and cement etc. Chemical processes are designed to utilize information provided by chemical equation for calculating quantities of inputs and outputs in the manufacture of consumer goods, such as soaps and drugs. Calculation of input and output are primarily based on accurately written and balanced chemical equations. Due to the fundamental importance of writing and balancing of chemical equations in the learning of chemistry and the importance of chemistry to the learner and the society at large, the concepts need to be taught very adequately well using effective teaching methods. Consequently, much importance is placed on the teaching and learning of these concepts at the appropriate level of senior secondary science classes.

It has however been reported in various Chemistry education literature that the learning of the concepts of writing and balancing of chemical equations is very difficult for secondary school students, (Njoku and Ekere, 2016, Johnstone 2000). Ekere (2014) reported that candidates have poor knowledge in the writing and balancing of chemical equations. Nworji (2004) stated that students have difficulty understanding the concept of writing chemical formula of molecules and compounds because they exhibit poor knowledge of the rules involved. Consequently students find it difficult to understand the concepts of writing and balancing of chemical equations.

Teachers and researchers in Chemistry education have continued to search for appropriate teaching methods and strategies that would enhance students' learning and retention of knowledge in the concepts of writing and balancing of chemical equations, (Okorie 2017). Various teaching methods and strategies have been adopted by Chemistry teachers, but the achievement levels of students continue to be low and indeed dwindle continually, as indicated by the Annual Report of Chief Examiner, West African Examinations Council (WAEC) (2015 & 2016). WAEC Chief Examiner's Analysis of students' performance in each Chemistry question continues to show that students avoid questions involving writing and balancing of Chemical equations, and when they attempt such questions, they perform very poorly, (WAEC, 2015, 2016). The implication of these reports is that students are unable to effectively learn the concepts of writing and balancing chemical equations or they find it difficult to retain what they have learnt for a reasonable time after the lessons on these concepts. This poor performance tends to persist in spite of teachers' adoption of teaching methods and techniques that have proven to be effective and adequate in improving students' achievement in science education. It is therefore desirable to ascertain how various teaching methods and strategies impact students' retention of learning in such fundamental concepts in Chemistry education as writing and balancing of chemical equations.

Retention is the remaining expression of experience after learning has taken place and knowledge has decayed over a period of time. It is the amount of earlier experience that is correctly remembered or recalled at later times. Retention is the continued possession of something or the continued existence of something (Eze, 2008). It is the ability of learners to reproduce the learnt concepts when the need arises (Gimba, 2012). However, students' period of retention varies because rate of knowledge decay is influenced by such variables as mental ability level, gender, and the totality of the dynamics of the learning environment. Thus teaching methods and techniques can prolonged knowledge decay rate in individual learners. Teaching methods and techniques that make learning more effective, enjoyable and reproducible would have the capacity of reducing knowledge decay rate and thereby improve retention. Consequently, topics that are abstract to students could be made clearer, easier and more meaningful for better retention of the concept learnt through the use of effective teaching methods. This is why educators and researchers on pedagogy have continued to compare various teaching methods and techniques on different Chemistry curriculum contents to assess their impacts on outcome variables like achievement and retention.

From the forgoing, it is important and indeed desirable to determine the efficacy of such as effective teaching methods and techniques as demonstration method and cooperative learning technique with a view to finding out which of them will enhance students' retention in the difficult concepts of writing and balancing of chemical equations.

Gender is the different socially constructed roles and responsibilities expected of males and females in their societies. Gender is a factor that has influenced many educational programmes and learner attainments all over the world. Akinsola & Igwe (2002) stated that gender issue is an important factor in educational setting and could be a militating factor to high achievement of learners in Chemistry. Okeke (2001) asserted that instructional strategies are known to produce different effects on the learners of different sexes. Some studies show that males and females respond differently to specific teaching methods and strategies, questions and discussion (West Virginia University for Women Students, 1997). Okeke (2001), in consonance with the position of West Virginia University for Women Students, stated that women are unlikely to volunteer to answer questions, and that men tend to answer questions more confidently and quickly regardless of the quality of their responses. The males tend to formulate their answers as they respond to the questions, which is different from the way women handle questions. Women tend to avoid responding to questions if they are unsure of the accuracy of their response, (Njoku and Ekere, 2016). It is therefore important to find out if teaching methods and strategies have differential effects on knowledge retention of male and female students in some Chemistry difficult concepts, such as the concepts of 'Writing and Balancing of Chemical Equations'.

The key objective of this study is to determine the teaching method or technique that should be preferred by Chemistry teachers who want to encourage retention of learning achievement in the fundamental concepts of writing and balancing of chemical equations.

More specifically this study sought to determine:

1. The efficacy of demonstration and cooperative learning methods on students' knowledge retention in writing and balancing of chemical equations
2. The influences of gender on students' mean retention scores of students in writing and balancing of chemical equations.
3. The interaction effects of gender and the teaching methods on students' knowledge retention in the writing and balancing of chemical equations

Research Questions and Hypotheses:

Three research questions and three hypotheses guided the study. The research questions are:

1. What are the mean retention scores of students taught writing and balancing of chemical equations using demonstration method and those taught using cooperative learning method?
2. What are the mean retention scores of male and female students taught writing and balancing of chemical equations using demonstration method and those taught using cooperative learning method?
3. What is the interaction effects of gender with methods on students mean retention scores in writing and balancing of chemical equations?

Research Hypothesis

HO₁. There is no significant difference in the mean retention scores of students taught writing and balancing of chemical equations using demonstration method and those taught using cooperative learning method.

HO₂; There is no significant difference in the mean retention scores of male and female students taught writing and balancing of chemical equations using demonstration method and those taught using cooperative learning.

HO₃; There is no significant interaction effect of gender and the teaching methods on students' mean retention scores in the writing and balancing of chemical equations.

Method

The design for the study is quasi- experimental design. Specifically, the study used pre-test, post-test, non-equivalent control group design. This is because intact classes were used to avoid disruption of normal class arrangements of the school

Sample

The sample for this study was eighty (80) SS1 students from two co-educational secondary schools whose population was 452 SS1 students. The choice of co-educational schools was because gender was one of the variables studied. One intact class of chemistry students of SS1 class was randomly selected from each of the sampled schools, making a total of two intact classes. The 40 male students and 40 female students were made possible through the help of the school chemistry teachers who graciously helped as research assistants.

Treatment Procedure

To determine the efficacy of demonstration and cooperative methods of learning on students' retention of learning in the concepts of Writing and Balancing of chemical Equations' comprehensive lesson plans were written on the topics for all the lessons covering writing and balancing of Chemical equations. There were two sets of lesson plans on the contents: one for teaching the group with demonstration method and the other for teaching the group using cooperative learning method/technique. The regular teachers in the sample schools were thoroughly briefed on the lesson plan each would use respectively. This brief training was to ensure that each of the research assistants would stick to the teaching method/strategy allocated to his/her sample school. Under the supervision of the researchers, the two research assistants used six weeks to implement the teaching in their schools using the lesson plans prepared for the respective sample school. At the end of the teaching (after six weeks of classroom interactions), the two groups of SSI students were administered with post-test, and the data stored for use as covariate with the retention scores during data analysis. After four weeks of the post test, the retention test was administered and the scores obtained from the groups were analyzed to reveal the effects of these two teaching methods/techniques on students retention of learning in the concepts of writing and balancing chemical equations.

Instrument for Data Collection

The instrument used for data collection was Chemistry Achievement Test (CAT) developed and validated by the researchers. The contents of the achievement test were drawn from the topic: writing and balancing of chemical equations which constituted the contents taught to students. These concepts are in the curriculum provision of SS1 class. The Chemistry Achievement Test (CAT) was also used as retention test which was administered four weeks after the treatment. The difference between the post achievement test and the retention test is that the questions were reshuffled to give them different serial numbers and then printed on coloured paper instead of the original white paper.

The instrument for data collection is made of two parts. Part 1 is on personal data of the respondents who indicated their gender and name of their school. Part II is made up of forty (40) achievement test questions on the contents that had been taught to the students. The instrument was used for both post-test and retention test respectively. The retention test was administered four weeks after the post treatment test. The retention test was collected from the respondents immediately on completion of the test

Reliability of instrument

The reliability of the instrument was determined using scorer reliability method to ensure that the two researchers would indicate similar scores on the essay test items. The instrument was administered to

30 students who belonged to a school other than the sample schools of the study. Using a common marking guide prepared by the researchers the answer scripts of the respondents in this trial testing was scored and the results from the two scorers compared using Kendall Richard's coefficient of concordance method. On calculation, a coefficient of concordance reliability index (W) of 0.832 was obtained for the instrument. This value is an indication that the inter-scorer reliability is good enough to enable a credible data for the study. The internal consistency and validity of the instrument was assured by using a test blue print to construct the essay test items. All the questions were on the two concepts covered in this investigation and there was adequate coverage of the various sections like writing of chemical symbols and formulae, writing of chemical equations and balancing of chemical equations.

Method of Data Analysis

The scores from the tests were analyzed using mean, standard deviation and analysis of covariance (ANCOVA). Mean and standard deviation were used to answer the research questions and analysis of covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

Results:

The results of this study are presented in Tables according to the research questions and hypothesis.

Research Question One;

What are the mean retention scores of students taught writing and balancing of chemical equations using demonstration method and those taught using cooperative learning technique?

Table 1: Mean and standard deviation of post test and retention scores of students taught writing and balancing of chemical equations using demonstration method and those taught using cooperative learning technique.

Group	N	Post-test		Retention test		Mean Gain
		Mean	SD	Mean	SD	
Demonstration Method	40	31.13	4.50	58.88	6.85	27.75
Cooperative Learning method	40	26.10	8.21	50.30	7.63	24.30

The data in Table 1 shows the mean retention scores of students who were taught writing and balancing of chemical equations using demonstration method and cooperative learning respectively. It shows that the mean retention scores of students who were taught writing and balancing of chemical equations using demonstration method is 58.88 against a post-test score of 31.13 while those who were taught writing and balancing of chemical equations using cooperative learning had mean retention score of 50.30 against a post-test score of 26.00. And mean gain scores of 27.75 and 24.30 were for the students who were exposed to demonstration method and those exposed to cooperative learning respectively. This indicates that demonstration method tends to enhance more retention of knowledge by students in writing and balancing of chemical equations than the cooperative learning technique. It should be observed that the retention mean scores are higher than the post-test mean scores. This was not expected since there was expected to be knowledge decay between the period of post-test and the time of retention test. That the retention mean scores for both groups is higher than their posttest mean score scores can be accounted for by the possibility of the respondents working during the wait time between post test and retention test. However, whether the difference in the mean retention scores of the two groups is significant would be clear when these two mean retention scores are compared using the ANCOVA inferential statistic.

Research Question Two: Research question two was to find out the mean retention scores of male and females students when taught the concepts of writing and balancing chemical equations using demonstration method as well as cooperative learning technique. Table 2 shows the result of data analysis relative to this research question.

Table 2: Mean and standard deviation of retention scores of male and female students in writing and balancing of chemical equation

Gender	No	Post-test		Retention test		Mean Gain
		Mean	SD	Mean	SD	
Male	40	27.89	7.49	57.59	7.11	29.70
Female	40	29.20	6.66	57.59	7.60	28.39

For the retention of content taught by gender, retention mean scores of male and female students are the same that is 57.59. The difference in the mean gain was as a result of the differential achievement at the post-test. Although the retention mean scores were expected to be lower than the posttest mean scores due to knowledge decay, the contrary is the case. This is probably because of practice effect on the part of the students who may have work had during period between post test and retention test.

Hypotheses one: There is no significant difference in the retention mean scores of students taught writing and balancing of chemical equations using demonstration method and those taught using cooperative learning technique.

Table 3: Analysis of covariance (ANCOVA) comparing the mean retention scores of the two groups (demonstration method and cooperative learning) using their post test mean scores as covariates.

Source	Type III sum of squares	DF	Mean Square	F	Significance	Decision
Corrected model	227.405 ^a	4	56.851	1.063	.381	
Intercept	13783.895	1	13783.895	257.679	.000	
Post-test	27.224	1	27.224	.509	.478	
Group	158.639	1	158.639	2.966	.089	NS
Gender	3.378	1	3.378	.063	.802	NS
Group*						
Gender	48.985	1	48.985	.916	.342	
Error	4011.982	75	53.493			
Total	269545.000	80				
Corrected Total	4239.388	79				

a R squared = .054 (Adjusted R squared = .003*NS = Not significant)

Table 3 shows that the probability associated with the calculated value of (2.966) for the efficacy of teaching method on students' mean retention is .089. Since the probability value is greater than 0.05 level of significance ($p > 0.05$), the null hypotheses was accepted indicating that there is no significant difference in the mean retention scores of students taught the concepts of writing and balancing of chemical equation using demonstration method and those taught using cooperative learning technique. The two methods appear to have similar effects on students' retention of learning after four weeks of treatment.

Hypothesis Two: There is no significant difference in the retention mean scores of male and female students in writing and balancing of chemical equations using demonstration method and those taught using cooperative learning method

The data in Table 3 reveals that the calculated value of F (.063) for the influence of gender on students' retention score has a probability value of .802. For the fact that the probability value is greater than the 0.05 level of significance, the null hypothesis was accepted. Thus, there is no significant difference in the mean retention scores of male and female students in writing and balancing of chemical equations.

Hypothesis Three: There is no significant interaction effect of method and gender on the retention of students in writing and balancing of chemical equation.

Table 3 above shows that the calculated value of F (.916) for the interaction effect of method and gender on the retention ability of students in writing and balancing of chemical equation has a probability value of .316. Hence, there is no significant interaction effect of method and gender on the retention ability of students in writing and balancing of chemical equation since the probability value is greater than the .05 level of significance ($p > .05$).

Summary of the findings

The following findings were made from the analysis of the data:

1. There is no significant difference in the mean retention scores of students taught writing and balancing of chemical equations using demonstration method and those taught using cooperative learning technique.
2. There is no significant difference in the mean retention score of male and female students in writing and balancing of chemical equations due to teaching methods.
3. There is no significant interaction of method and gender on students' retention mean scores.

Discussion of the findings

The discussion of the findings was done under the following sub headings

- Efficacy of demonstration method and cooperative learning on the students' retention in writing and balancing of chemical equation.
- Influence of gender on students' retention in writing and balancing of chemical equation

Efficacy of demonstration method and cooperative learning on the students' retention in writing and balancing of chemical equations

Retention ability of students in writing and balancing of chemical equations was investigated using the two teaching approaches. It was observed that the students who were taught using demonstration method had higher retention of the concept taught than the students who were taught using cooperative learning. However, there is no statistically significant difference in the mean retention scores of students taught writing and balancing of chemical equations using demonstration method and those taught using cooperative learning. This implies that the retention ability of students in writing and balancing of chemical equation does not depend on any of the two teaching approaches. This finding is contrary to the finding of Igboegwu and Egbutu,(2011) who found that cooperative learning strategy enhances the retention of learning by students in science process skills than the demonstration method.

Influence of gender on students' retention in writing and balancing of chemical equations.

The findings of the study with respect to the influence of gender on student's retention in writing and balancing of chemical equations showed that the retention score of male and female students were the same. This is buttressed by the result of the hypothesis that there is no significant difference in the mean retention scores of male and female students in writing and balancing of chemical equation. Similarly, it was found that gender does not interact with method with respect to the student's retention

in writing and balancing of chemical equations. The finding of this study is in agreement with the finding of Ameh and Dantanic (2012) who observed that demonstration method does not discriminate among gender.

Recommendations

Based on the findings of this study, the following recommendations were made:

1. Chemistry teachers can freely use both demonstration method and cooperative learning technique in teaching of some difficult contents such as writing and balancing of chemical equations.
2. Science educators and curriculum planners should emphasize the use demonstration method and cooperative learning technique as viable methods for handling difficult contents of the curriculum.

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