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Effect of Demonstration Method on Academic Performance of Secondary School Chemistry Students in Writing and Balancing of Chemical Equation in Obio/Akpor Local Government Area in Rivers State, Nigeria

Abbey-Kalio, Ibiyengibo

Department of Chemistry Ignatius Ajuru University of Education, Port Harcourt, Rivers State, Nigeria.
Corresponding Author: email: ibkalio@yahoo.com

ABSTRACT

The study investigated the effect of demonstration method on academic performance of senior secondary school chemistry students in writing and balancing of chemical equation. A total of 240 students from four (4) (two private and two public) Secondary Schools in Obio/Akpor Local Government Area in Rivers State formed the subjects of the study. The population was 3024 students in all. A pretest posttest non-randomized control group quasi-experimental design was adopted. Drilling exercise on writing and balancing of chemical equation was adopted for the students in the experimental groups while drilling exercise was not carried out on the control groups. An instrument consisting of 20 items multiple choice Chemistry Achievement Test (CAT) covering chemical reactions and their equations of 0.78 reliability coefficient was used to assess students' academic performance. The data collected was analyzed using mean and standard deviation for the three research questions and ANCOVA for the three null hypotheses at 0.05 level of significance. The results showed that the experimental groups performed significantly better than their counterparts. Furthermore, the results revealed though not significant but slightly higher mean achievement scores for female against the male counterpart. This pattern was also observed for the school type. Based on these findings, it was recommended among others that Chemistry teachers should endeavor to regularly expose their students to drilling exercise on writing and balancing of chemical equation to secure meaningful learning in Chemistry.

Keywords *Chemistry, chemical equations, school type, chemical reactions, reactants, products, balancing*

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INTRODUCTION

Symbolic representation, writing, and balancing of chemical equations constitute essential components in the

learning of Chemistry. Indeed, the understanding of concepts in chemistry, particularly at the foundation level, is dependent on the learners' ability to identify the elements, their symbols, the ratio in which they combine as reactants and the ratio at which they form products (compounds) when they undergo reactions. Every substance is identified by its letter(s) of representation as well as the ratio in which its elements combine to form compounds during chemical changes that occur in the substance or matter.

Chemistry deals with changes that matter undergoes as a result of interactions between reactants, which eventually lead to changes in the matter as they form products. Hence, this becomes a very crucial reason why those who teach and those who learn chemistry must take into cognizance how these reactions and changes can be easily understood for all learning in Chemistry. Matters undergo reactions to form products that may have similar chemical properties to the reactants from which they are formed if physical change is involved; on the other hand, entirely new substances (products) are formed if chemical change has taken place. Physical reactions lead to physical change, e.g., melting, freezing, vaporization, and condensation, while chemical reactions lead to chemical change, e.g., burning, rusting, and explosion. The substances that go into chemical reactions are called reactants, and the substances that are produced at the end of the reactions are called products (https://www.dummies.com/science).

The concept of chemical reaction has existed for many centuries, if not as old as the creation. Even though the concept that matter is composed of tiny particles that undergo reactions to form other forms of matter has been the basis of chemical knowledge for more than 100 years (Proksa, 2017), This idea that matters undergo chemical reactions that can lead to changes began with early experiments that classified substances as elements and compounds and theories that gave explanations about the processes of substances. Hence, the concept of chemical reaction is defined in the light of experiment and theory (Triechel & Kotz, 2020). Chemical processes are defined as the processes of the changes in substances, chemical substances; forming new substances; that is, the changes that occur in the matter as the reactants give birth to new substances and these new substances formed are the products. Though the concept of chemical reaction was discovered hundreds of years ago, its activities have been around for thousands of years. Activities such as burning fuel, making pottery and glass, etc. are a few examples. This concept has developed into what is known as the science of Chemistry. Triechel and Kotz (2020) explained chemical reactions as an "'integral part of technology, of culture, and indeed of life itself''. Chemical reactions occur everywhere—in living and non-living systems on earth above and beneath, on land, at sea, and in the atmosphere—but with the same total mass. This is guided by the law of conservation of matter.

In the law of conservation of matter, it is stated that under normal conditions, matter is neither created nor destroyed and elements do not transform into other elements (Chamock, 2016). To this end, chemical equations are used to express these reactions, which equations must be balanced to further express total mass or ensure that there are equal numbers of atoms of each kind of element on both sides of reactants and products. The law of conservation of matter explains this equality in the ratio of reactants and products as chemical stoichiometry (Vicenova, 2018).

Stoichiometry describes the quantity relationship between elements in compounds and between substances as they undergo chemical reactions. The word ''stoichiometry'' is from the Greek word "stoicheion", which means ''first principle or element,'' metron'', which means ''measure'' Stoichiometry shows quantitative relationships among elements in compounds (composition stoichiometry) and among substances as they undergo chemical changes (reaction stoichiometry). The quantity, otherwise, the number in which these reactants react to form products, is assigned as an integer and not a fraction. Hence, particles (ions, atoms, and molecules) react and yield products in a whole-number ratio. The idea of the whole number ratio by English chemist John Dalton provided the foundation for chemical notation (Cons(table), 2019).

The concept of chemical reaction is also associated with heat. In some chemical reactions, heat is given out to the environment, which is called exothermic reaction, while in other chemical reactions heat is consumed or absorbed, called endothermic reaction, e.g., photosynthesis, breathing (Michaliskova et al., 2019).

Chemical reactions are represented by chemical equations, which must be balanced to give a full interpretation of the reaction that has taken place. This is otherwise called chemical notation. In view of this, the chemical reaction for the formation of water is written as follows:

$$2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$$

On the left side are the reactants (H_2 and O_2), while on the right side is the product (H2O). The plus sign (+) indicates reaction, and the arrow shows the direction of the yield, i.e., the product (Thorn, 2011). A chemical equation satisfies the law of conservation of matter and equally describes the reaction ratio. This balanced equation notifies us that two moles of hydrogen molecules react with one mole of oxygen molecules to yield two moles of water molecule. More so, in chemical reactions, the reactants and products are designated with the symbol's 'S' for solid, 'L' for liquid and 'G' for gas (Zabadi & Assaf, 2017).

There are some of these chemical reactions that are more complex and their reaction equations are written as

a set of equations. This complexity is associated with many factors such as concentration, temperature, pressure or volume (especially for gases) and the time taken for the reaction to come into the product, known as the rate of reaction. Hence, the chemical reaction rate is the time required for reactants to change into products (Vionova & Ganajova, 2017). e.g., the reaction of $NO_2 + CO \rightarrow NO + CO_2$ can be observed in a two-step mechanism as follows: -

$NO_2 + NO_2 \rightarrow N_2O_4$ (slow)
$N_2O_4 + CO \rightarrow NO + CO_2 + NO_2$ (fast)
$NO_2 + CO \rightarrow NO + CO_2$ (overall)

So far, it has been established that a chemical equation is the simplest but most concise way of conveying information about chemical reactions with their full meaning. Though chemical equations use a few expressions with letter symbols and signs, these expressions provide complete explanations of what transpires in chemical activities by any particular substance in any instance.

Therefore, chemical equations are fundamental to the science of chemistry in particular, both in theory and practical terms and in extension to all other science subjects, being that chemistry is central to all sciences.

Therefore, it is of utmost concern that the chemistry teacher engages his learners in the drilling exercise of writing and balancing chemical equations in order for the students to acquire the skills essential for better understanding and retention of concepts in Chemistry.

Practical, experimental, and interactive activities are critical in the teaching of science subjects. The reason the demonstration method of teaching is particularly important in this instance is that during the demonstration method of teaching, there is always a presentation of learning materials for the learner to manipulate.

The demonstration method of teaching offers several activities to the learner that are practical oriented and the learner's engagement with them is able to make the learner readily gain useful knowledge and acquire skills, among other useful learning.

Research Questions

Three research questions guided the study:

1) What is the relative effect of demonstration method on secondary school students' academic performances in writing and balancing of chemical equation in Chemistry?
2) What is the difference in the performance of secondary school students in writing and balancing of chemical equation using demonstration method on students' academic performances in Chemistry based on gender?
3) What is the difference in the academic performances of secondary school students in writing and balancing of chemical equation using demonstration method on students' performance in Chemistry based on school type?

HYPOTHESES

The following hypotheses were tested at 0.05 level of significance

Ho1: There is no significant difference between the mean performance scores of students taught writing and balancing of chemical equations skills in Chemistry using demonstration method and their counterpart.

Ho2: There is no significant difference between the mean performance scores of male and female students taught writing and balancing of chemical equation skills in Chemistry using demonstration method.

Ho3: There is no significant difference between the mean performance scores of students taught writing and balancing of chemical equation skills in Chemistry using demonstration method based on school type.

METHODOLOGY

The study employed a pre-test post-test, non-equivalent control group, quasi-experimental design. The population of the study comprised of all the SS2 Chemistry students in the fourteen senior secondary schools in Obio/Akpor Local Government Area, totaling 13,024 students. The sample consisted of 240 seniors secondary SS2 students from four schools—two private and two government secondary schools—out of the fourteen (14) government senior secondary schools in Obio/Akpor Local Government Area in Rivers State. The four groups were tested in the first week of the study using the Chemistry Performance Test (CPT), covering topics on chemical reactions and balanced chemical equations, after which the experimental groups were subjected to drilling on the writing and balancing of chemical equations while the control groups were taught using the conventional lecture method. This exercise lasted for three weeks; it was done during and after the normal Chemistry class schedule just to maximise the time and to do a thorough exercise. After the treatment, the four groups were administered a posttest on the same CAT and on every occasion of testing, test items were given scores as deemed appropriate. The whole exercise lasted for five weeks. Purposive sampling was used in drawing the participating schools, of which four intact classes were assigned into two experimental groups and the other two control groups for both private and government secondary schools. Students in the experimental groups were drilled on the writing and balancing of chemical equations based on different types of chemical reactions and formulas, while the others, being the control groups, were only taught the conventional method. The instrument for data collection was a researcher-structured Chemistry Achievement Test

(CAT) drawn from mostly chemical reactions and their balanced equations from the SS2 Chemistry syllabus. The test was a 20-item multiple-choice objective type. The consistency coefficient of CAT was established as r = 0.78 using the Cronbach coefficient alpha procedure. Data Analysis: the data were analyzed using the mean and standard deviation for the research questions and the analysis of covariance (ANCOVA) for the hypotheses.

RESULTS

Research questions 1: What is the relative effect of demonstration and conventional methods on secondary school students' academic performance in writing and balancing of chemical equation in Chemistry? The result in (Table) 1 shows the mean score of the demonstration method of teaching as 14.21 and the mean score of the conventional method of teaching as 9.22, meaning that the group taught using the demonstration method improved in writing and balancing the chemical equations compared to their counterparts after being drilled in the exercise using the demonstration method.

(table) 1: mean and standard deviation performance scores of students taught using demonstration and conventional methods of teaching.

Group	Mean (x)	Standard Deviation (SD)	N
Demonstration Method	14.25	5.471	95
Conventional Method	9.22	5.683	144
Total	11.23	6.109	240

Ho1: There is no significant difference in the mean performance scores of students taught writing and balancing of chemical equations skills in Chemistry using demonstration method and those of their counterpart. (Table 2) shows the F ratio for the effect of writing and balancing of chemical equation skills on groups to be .000 which is significant at 0.05 level of significance.

Table 2: ANCOVA for the mean performance scores on teaching methods

Source of variation	Sum of squares	Df	Mean square	F	Sig
Corrected model	5846.205	2	2923.103	225.459	.000
Intercept	1217.911	1	1277.911	93.938	.000
Pretest	4390.161	1	4290.161	338.614	.000
Group	632.441	1	632.411	48.780	.000
Error	3072.728	237	12.965		
Total	39204.000	240			
Corrected total	8918.933	239			

Significance (p<0.05)

Research question 2: What is the difference in the academic performance score of secondary school chemistry students in writing and balancing of chemical equation using demonstration method based on gender? Result in (Table 3) shows mean score of female students as 13.96 and mean score of male students as 14.49 meaning that the male students have better mean score in writing and balancing of chemical equation than their counterpart after been drilled in the exercise on writing and balancing of chemical equations.

Table 3: mean and standard deviation scores of female and male students taught writing and balancing of chemical equation using demonstration method of teaching

Gender	Mean (x)	Standard Deviation (SD)	N
Female	13.96	5.450	49
Male	14.49	5.524	47
Total	14.22	5.464	96

Ho2: there is no statistically significant difference between the mean achievement scores of male and female students taught writing and balancing of chemical equation skills in Chemistry as measured by the Chemistry performance test (CPT). Table 4 shows the F ratio for the effect of writing and balancing of chemical equation skills on groups to be .497 which is not significant at 0.05 level of significance.

Table4: Analysis of covariance (ANCOVA) on gender

Source of variation	Sum of squares	Df	Mean square	F	Sig
Corrected model	5846.205	2	656.329	40.058	.000
Intercept	1139.899	1	1139.899	69.572	.000
Pretest	1305.915	1	1305.915	19.6705	.000
Gender	7.622	1	7.622	.465	.497
Error	1523.748	93	16.384		
Total	12245.000	96			
Corrected total	2836.406	95			

Significance (p<0.05)

Research question 3: What is the difference in the academic achievement scores of secondary school chemistry students in writing and balancing of chemical equation using demonstration method based on school type? The results in (Table) 5 show the mean score of private school-type students taught using the demonstration method of teaching as 15.13 and the mean score of public school-type students taught using the demonstration method of teaching as 13.57, meaning that there is a greater mean score performance for private school-type students after being drilled on writing and balancing chemical equations.

Table 5: Mean and standard deviation performance scores of students taught using demonstration method of teaching based on school type

School Type	Mean (x)	Standard Deviation (SD)	N
Private	15.13	5.180	40
Public	13.57	5.614	56
Total	14.22	5.464	96

Ho3: There is no significant difference between the mean performance scores of students taught writing and balancing of chemical equation skills in Chemistry using demonstration method based on school type.

Table 6: Analysis of covariance (ANCOVA) on school type

Source of variation	Sum of squares	Df	Mean square	F	Sig
Corrected model	1355.036	2	677.518	42.534	.000
Intercept	1172.771	1	1172.771	73.626	.000
Pretest	1298.719	1	1298.719	81.533	.000
School type	49.999	1	49.999	3.139	.080
Error	1481.371	93	15.929		
Total	22245.000	96			
Corrected total	2836.406	95			

Significance ($p<0.05$)

(Table) 6 shows the F ratio for the impact of writing and balancing of chemical equation skills on school type to be .080 therefore it is not significant at 0.05 level of significance.

DISCUSSION

From the findings in (Table) 2, the greater mean performance score on writing and balancing equation after the experimental group had been taught on the writing skills is an indication that the acquisition of the skills by students is fundamental for better understanding and retention of chemistry concepts. This study is equally in line with that of Thangavel (2019), who found improvement in the performance of class XII students in chemistry after drilling exercises on balancing chemical equation. Dula (2018) equally observed a change in progress in students on writing symbols, formulas, and chemical equations after the drilling exercise was done. (Table) 2 on gender shows that improvement in writing and balancing of chemical equation skills is not significantly different for both male and female chemistry students. The implication is that drilling into the writing and balancing of chemical equation skills, when acquired by the learner, whether male or female, improves understanding of concepts in Chemistry. This finding is in line with the findings of Ajayi and Ogbeba (2017), whose study did not reveal a significant difference in gender in the understanding of science concepts.

Furthermore, according to the findings in (Table) 3, students from both private and public schools showed the same level of achievement after being exposed to writing and balancing chemical equation skills.

This goes to prove that school type does not reveal a significant difference in the improvement of writing and balancing of chemical equations and consequent skills acquisition for the enhancement of students understanding of chemistry concepts. However, this position is contrary to the views of Okonkwo (2002) and Esheta (2015), who, in their separate studies, found learners from private schools to be more ready and better achievers than their counterparts in public schools.

Finally, the drilling exercise on writing and balancing of chemical equations was carried out by the demonstration method of teaching; hence, the demonstration method of teaching is revealed to effect chemistry students' academic performance better than when conventional methods of teaching are adopted, especially for teaching writing and balancing of chemical equations in chemistry. This is supported by Gindharam and Raju (2017), who in their study found that the demonstration method is significantly better than the lecture method in the teaching-learning process.

Conclusion

Writing and balancing of chemical equation skills are fundamental to understanding concepts in chemistry, and this can at the senior secondary school level improve learners' understanding, particularly in the learning of chemistry as a subject. Both male and female students have the same capacity to acquire writing and balancing of chemical equation skills and can equally apply them to get the same results in their academic performance. Likewise, the type of school students attend does not limit students' ability to acquire writing and balancing chemical equation skills.

Recommendations

Based on the findings, the following recommendations were made:

1. Chemistry teachers should endeavor to engage their students in the writing and balancing of chemical equation exercises and drills.
2. Chemistry students, on their own, should form the habit of practicing writing and balancing chemical equations to equip them with the skills and better understanding of chemistry concepts.
3. Science organizations' such as the Science Teachers Association (STAN) may introduce workbooks on chemistry engrossed with the writing and balancing of chemical equations, particularly at the beginning of classes.

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