

IDENTIFICATION AND REMEDIATION OF DIFFICULTIES IN WRITING AND BALANCING CHEMICAL EQUATIONS AS PERCEIVED BY CHEMISTRY STUDENTS IN KADUNA STATE.

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Abstract

This study was aimed at the identification and remediation of difficulties in writing and balancing chemical equations as perceived by senior secondary students in Kaduna North Local Government Area, Kaduna state, Nigeria. A descriptive survey research design guided the study. The sample comprised of 2,028 chemistry students randomly selected from 20 secondary schools in the area. Three research questions and one hypothesis guided the study. Data were collected using a 24-item four-point Likert scale questionnaire, developed and validated by the researchers. The reliability index of the instrument was 0.605 which adjudged the instrument as reliable and usable for the study. Means and standard deviation were used to answer the research questions while t-test statistic was used to test the null hypotheses at 0.05 alpha level. Findings indicated among others, that students encountered difficulties in writing and balancing of chemical equations due to inability to (i) recall correct chemical formulae of elements/compounds, (ii) identify correct valency of the species and (iii) recognize the state of the substance e.g. solid (s), liquid (l), gas (g) or aqueous (aq). Also, there was no significant difference between the mean ratings of male and female students on difficulties encountered in balancing chemical equations, since the calculated value of 0.01 was less than t-critical value of 1.96 at 0.05 alpha level. The research also suggested among others that there should be collaboration between the mathematics and chemistry teacher in their instructional delivery, in order to work on some mathematical challenges relating to chemistry e.g making subject of formula.

Keywords: Identification, Remediation, Difficulties, Senior Secondary, Chemical Equations.

Introduction

Chemistry is an important subject in secondary school curriculum. The knowledge of chemistry pervades various fields of human endeavour. Students are generally attracted to study chemistry and related disciplines because of this awareness. The Federal Government of Nigeria is not unmindful of the impact of chemistry in national economic growth and development. In this regard, the government (National Educational Research and Development Council (NERDC, 2012.

vii) articulated the goals of studying chemistry at secondary schools to include: (i) develop interest in the subject of chemistry; (ii) acquire basic theoretical and practical knowledge and skills; (iii) develop interest in science, technology and mathematics (STM); (iv) acquire basic STM knowledge and skills; (v) develop reasonable level of competence in ICT applications that will engender entrepreneurial skills; (vi) apply skills to meet societal needs of creating employment and wealth; (vii) be positioned to take advantage of the numerous career opportunities offered by chemistry; and (viii) be adequately prepared for further studies in chemistry.

Notwithstanding these goals of teaching and learning chemistry at secondary schools, a good number of students shy away from the subject on the pretext that it is abstract in nature, a difficult subject, phobia due to apathy towards mathematics as a school subject (Ali and Anaekwe cited in Anaekwe, 2019a). In addition to above, a vital area in chemistry teaching and learning which has been reported as difficult to students is stoichiometry and balancing equations (Kimberlin and Yezierski, 2016). The problem of writing and balancing of chemical equations appeared to be persistent up till now. A balanced equation is an equation for a chemical reaction in which the number of atoms for each element in the reaction and the total charge are the same for both the reactants and the products. It is very essential for every chemistry student to learn and master the proper procedures involved in the writing and balancing of chemical equations. Students' inability to write and balance equation correctly will result to difficulties in some other aspects of chemistry such as the mole concept and volumetric analysis and also cause difficulty in communication and expression within the chemistry community (Okoko, 2007, WAEC Chief Examiners' Report, 2018 and 2020).

Students' poor performance in writing and balancing of chemical equation in external examinations had been reported. West African Examinations Council (WAEC) Chief Examiner's Reports (2013, 2016, 2017, 2018 and 2020) all indicated that students performed poorly in the area of writing of chemical formulae, balancing of chemical equations and have poor knowledge of symbols and formulae. It is very clear from the fore-going that balancing of chemical equation is important and useful in the teaching and learning of modern chemical theory and practically it remains a difficult chemical or conceptual skill to learn by the majority of the students in secondary schools.

Furthermore, an important factor that may affect students' ability to perform well in the area of writing and balancing chemical equation is gender. According to the World Development Report (WDR, 2012), gender is defined as socially constructed norms and ideologies which determine the behaviours and actions of men and women. It is used to describe those characteristics of women and men, which are socially constructed, while sex refers to those which are biologically determined (Hesse-Biber, and Carger, 2000). It may be that this variable affects students' disposition to the problem of study in the same way or conversely. Given that previous studies have not reported gender influence on balancing chemical equations, it is worthy of investigation.

Statement of the Problem

The writing and balancing of chemical equations can be likened to the two sides of the same coin which must go hand-in-hand and play vital roles in diverse areas of chemistry, such as; chemical arithmetic, stoichiometry, volumetric analysis among others. Both concept are always handled as an entity since none of them could be satisfactorily handled independent of the other. Contrary to expectations of improved achievement at Senior School certificate chemistry Examinations, most secondary school chemistry students are yet to achieve a high level of proficiency in writing and balancing chemical equations and in solving problems related to the topics where such knowledge is applied. For example, the WAEC Chief Examiners report on the May/June 2017 clearly stated that candidates' weakness included poor knowledge of symbols, formulae and equation and inability to write correct balanced equations. The way this problem persists among male and female students is uncertain. The problem of this study is, therefore, to identify the students' difficulties in writing and balancing chemical equations, explore ways of remedying the problem as well as the influence of gender on the problem.

Research Questions:

The following research questions guided this study.

- 1) What are the difficulties encountered by students in writing and balancing chemical equations?
- 2) To what extent do difficulties encountered by students in writing and balancing chemical equations is influenced by gender?
- 3) What strategies can Chemistry teachers adopt in order to remedy students' learning difficulties in writing and balancing chemical equations?

Hypothesis

HO₁: There is no significant difference between the mean ratings of male and female students on the difficulties encountered in writing and balancing chemical equations.

Methodology

A descriptive survey research design (Nworgu, 2006) was used for the study. The sample comprised of 2,028 chemistry students randomly selected from 20 secondary schools in Kaduna North LGA, Kaduna State. Three research questions and one hypothesis guided the study. Data were collected using the 24-item writing and balancing chemical equation Questionnaire which was a four-point Likert scale questionnaire which was developed and validated by the researchers. The reliability index of the instrument was 0.605 which indicated that the instrument was reliable and usable for the study. Means and standard deviation were used to analyze the research questions while t-test was used to test the null hypotheses at 0.05 level of significance.

Results

Research Questions One: -What are the difficulties encountered by students in writing and balancing chemical equations?

Table 1: Mean and S.D of Difficulties Encountered by Students in Writing and Balancing chemical equations

S/N	Statements/Items	Mean	SD	Remark
1	Inability to recall correct chemical symbol of elements eg Na, S	2.07	1.77	Rejected
2	Inability to recall correct chemical formula of elements/compounds eg NaO, H ₂ O, CO ₂	3.20	2.80	Accepted
3	Inability to differentiate between atoms and molecules eg O, O ₂	2.01	1.76	Rejected
4	Inability to recognize the state of the substance e.g solid (s), liquid (l), gas (g) or aqueous (aq)	3.18	2.79	Accepted
5	Inability to identify the element as a metal or a non-metal	2.43	2.17	Rejected
6	Inability to identify the ionization components of the substance(s)	3.03	2.68	Accepted
7	Inability to identify correct valency of the species	2.91	2.56	Accepted
8	Inability to recognize the relationship between coefficients (in mathematics) and number of molecules (in chemistry).	3.07	2.69	Accepted

9	Inability to recognize the relationship between neutral substance (atom, molecule) and ion	2.04	1.75	Rejected
10	Inability to recognize the relationship between valency and ionic charge	2.96	2.65	Accepted
11	Inability to transcribe correctly a worded statement on chemical reaction into an equation.eg “magnesium burns in air ”	3.11	2.70	Accepted
12	In ability to recognize the two sides of the equation-reactants and products	2.00	1.72	Rejected
13	Inability to compare the number of atoms of each element in both sides of the equation.	2.08	1.81	Rejected
14	Inability to differentiate between a balanced and unbalanced equation	2.22	1.98	Rejected
15	Inability to introduce coefficients at appropriate places.	2.93	2.58	Accepted
	Grand Mean	2.62	2.29	

From Table 1, all items except items 1, 3, 5, 9, 12, 13, and 14 had mean ratings of 2.50 and above. This implies that those items were considered difficult by students in writing and balancing chemical equation. All the other items with mean ratings less than 2.50 implies that they were not considered difficult in writing and balancing chemical equation. This implies that the difficulties encountered by the respondents in writing and balancing chemical equations included: Recalling correct chemical symbols of elements, Differentiating correctly between atoms and molecules, correctly identifying elements as metals and compounds in writing equations, correctly differentiating neutral substances from ions, correctly recognizing reactants and products, correctly comparing the number of atoms of each element in both sides of the equation and differentiating balanced from unbalanced equations. The grand mean value of the items was 2.62 with standard deviation of 2.29.

Research Question Two :- To what extent does difficulties encountered by students in writing and balancing of chemical equations is influenced by gender?

Table 2a: Mean and Standard Deviation of Difficulties Encountered by Male Students in Writing and Balancing Chemical Equations

S/N	Statements/Items	Mean	SD	Remark
1	Inability to recall correct chemical symbol of elements eg Na, S	2.01	1.76	Rejected
2	Inability to recall correct chemical formula of elements/compounds eg NaO, H ₂ O, CO ₂ ,	3.16	2.77	Accepted
3	Inability to differentiate between atoms and molecules eg O, O ₂ ,	1.95	1.66	Rejected
4	Inability to recognize the state of the substance e.g solid (s), liquid (l), gas (g) or aqueous (aq)	3.02	2.65	Accepted
5	Inability to identify the element as a metal or a non metal	2.32	2.05	Rejected

6	Inability to identify the ionization components of the substance(s)	2.91	2.58	Accepted
7	Inability to identify correct valency of the species	2.79	2.50	Accepted
8	Inability to recognize the relationship between coefficients (in mathematics) and number of molecules (in chemistry).	2.98	2.63	Accepted
9	Inability to recognize the relationship between neutral substance (atom, molecule) and ion	1.95	1.72	Rejected
10	Inability to recognize the relationship between valency and ionic charge	3.02	2.65	Accepted
11	Inability to transcribe correctly a worded statement on chemical reaction into an equation.eg “magnesium burns in air ”	3.06	2.68	Accepted
12	In ability to recognize the two sides of the equation - reactants and products	1.94	1.63	Rejected
13	Inability to compare the number of atoms of each element in both sides of the equation.	2.08	1.84	Rejected
14	Inability to differentiate between a balanced and unbalanced equation	2.30	2.03	Rejected
15	Inability to introduce coefficients at appropriate places.	2.91	2.56	Accepted
	Grand Mean	2.56	2.25	

From Table 2a, all items except items 1, 3, 5, 9, 12, 13 and 14 had mean ratings of 2.50 and above. This implies that the male students agree that they encounter such difficulties in writing and balancing chemical equations. This implies that the other items which have mean ratings less than 2.50 do not constitute difficulties for the male students in writing and balancing chemical equations. Overall, the male students have cluster mean rating of 2.56 and standard deviation of 2.25.

Table 2b: Mean and Standard Deviation of Difficulties Encountered by Female Students in Writing and Balancing Chemical Equations

S/N	Statements/Items	Mean	SD	Remark
1	Inability to recall correct chemical symbol of elements eg Na, S	2.02	1.76	Rejected
2	Inability to recall correct chemical formula of elements/compounds eg NaO, H ₂ O, CO ₂	3.17	2.75	Accepted
3	Inability to differentiate between atoms and molecules eg O, O ₂	1.87	1.56	Rejected
4	Inability to recognize the state of the substance e.g solid (s), liquid (l), gas (g) or aqueous (aq)	3.12	2.73	Accepted
5	Inability to identify the element as a metal or a non - metal	2.47	2.22	Rejected
6	Inability to identify the ionization components of the substance(s)	3.05	2.68	Accepted
7	Inability to identify correct valency of the species	2.93	2.61	Accepted

8	Inability to recognize the relationship between coefficients (in mathematics) and number of molecules (in chemistry).	3.19	2.81	Accepted
9	Inability to recognize the relationship between neutral substance (atom, molecule) and ion	2.04	1.76	Rejected
10	Inability to recognize the relationship between valency and ionic charge	2.82	2.52	Accepted
11	Inability to transcribe correctly a worded statement on chemical reaction into an equation.eg "magnesium burns in air"	3.18	2.78	Accepted
12	In ability to recognize the two sides of the equation - reactants and products	1.95	1.69	Rejected
13	Inability to compare the number of atoms of each element in both sides of the equation.	2.95	2.61	Accepted
14	Inability to differentiate between a balanced and unbalanced equation	2.25	1.99	Rejected
15	Inability to introduce coefficients at appropriate places.	2.94	2.61	Accepted
	Grand Mean	2.66	2.34	

From table 2b, all items except items 1, 3, 5, 9, 12 and 14 had mean ratings of 2.50 and above. This implies that the female students agree that they encounter such difficulties in writing and balancing chemical equations. The other items which have mean ratings less than 2.50 implies that such items do not constitute difficulties for the female students in writing and balancing chemical equations. Overall, the female students have cluster mean rating of 2.66 and standard deviation of 2.34. Based on tables 2a and 2b, it could be seen that both male and female respondents expressed similar views on the items that constitute difficulties to them in writing and balancing chemical equations. Specifically, of all the difficulty areas identified in table 1 above, it was only item 13: correctly comparing the number of atoms of each element in both sides of the equation, that was considered difficult to males unlike the female students.

Research Question Three: -What strategies can be adopted in remedying students learning difficulties in writing and balancing chemical equations?

Table 3: Mean and Standard Deviation of strategies/measures to be adopted in remedying students' Learning difficulties in writing and balancing chemical equations

S/N	Statements/Items	mean	SD	Remark
1	Ensuring that the chemistry and mathematics teacher cooperates in their instructional delivery	3.41	2.95	Accepted
2	Encouraging team-teaching	3.33	2.88	Accepted
3	Using appropriate instructional material in teaching: charts/ periodic table	3.49	2.99	Accepted
4	Giving students Projects in groups and individually on Models of the periodic table	3.58	3.08	Accepted
5	Using appropriate instructional strategies in the class e.g cooperative learning strategy,	3.67	3.16	Accepted

6	Ensuring that practical demonstrations go hand in hand with theoretical classes	3.49	2.99	Accepted
7	Pointing out the practical application/ social relevance of each concept being taught in chemistry	3.38	2.89	Accepted
8	The teacher should give individualized attention in remedying identified difficulties	3.49	3.00	Accepted
9	Teacher should organize regular inter/intra class competitions among chemistry students.	3.41	2.94	Accepted
Grand Mean		3.47	2.99	

From table 3, all the nine (9) items were accepted by the students sampled as strategies for remedying students' learning difficulties in writing and balancing chemical equations since they all have mean rating of 2.50 and above. An average calculated mean value of 3.47 and standard deviation of 2.99 was calculated for the cluster.

Test of Hypothesis

Hypothesis One (HO1)

There is no significant difference between the mean ratings of male and female students on the difficulties encountered in writing and balancing chemical equations.

Table 4: t test of Differences Between Mean Ratings of Male and Female Students on Difficulty Encountered in Writing and Balancing Chemical Equations Based on Tables 2a and 2b.

	Male	Female
Mean	2.56	2.66
SD	2.25	2.34
N	995	1033
DF	2026	
T-cal 0.01		
T-Critical	1.96	
Decision	null hypothesis accepted	

Table 4 revealed that there is no significant difference between the mean ratings of Male and Female students on difficulty encountered in writing and balancing chemical equations, since the calculated value of 0.01 is lesser than 1.96 t-critical value at 0.05 level of significance. Thus, the null hypothesis was accepted.

Discussion

In respect of difficulties in writing and balancing chemical equations by students from table 1, all items except items 1, 3, 5, 9, 12, 13 and 14 had mean ratings of 2.50 and above. This implies that those items were considered difficult by students in balancing chemical equation. All the other items with mean ratings less than 2.50 implied that they were not considered difficult in balancing chemical equation. The result shows that the students indicated difficulty in the balancing of chemical equations. Also from the researcher's classroom experience, it was observed always that students do not write correct chemical formulae and balancing the chemical equation was also considered difficult. In balancing of equation, the reactants and the products are always written for students either in the classroom on board or text-books and the teacher will try to balance it to the

understanding of the students. Even when assignments and class work are given thereafter, students still find it difficult to balance equations. This is in accordance with Okoko (2008) who observed that a particular problem which seems to be persistent with most chemistry students was that given the reactants alone, students were not able to write the products and balance the equation correctly.

In respect of extent of difficulty encountered by students in writing and balancing of chemical equation relative to gender, was presented in tables 2a & 2b. Based on these tables (2a and 2b), it could be seen that both male and female respondents expressed similar views on the items that constitute difficulties to them in writing and balancing chemical equations. Specifically, of all the difficulty areas identified in table 1 above, it was only item 13: correctly comparing the number of atoms of each element in both sides of the equation, that was considered difficult to males unlike the female students. The male gender had average calculated mean value and standard deviation of 2.56 and 2.25 respectively while the female gender had an average calculated mean value and standard deviation of 2.66 and 2.34 respectively. Hypothesis 1, indicated that there is no significant difference between the mean ratings of Male and Female students on difficulty encountered in writing and balancing chemical equation, since the calculated value of 0.01 is largely less than 1.96 t-critical value at 0.05 level of significance.

On the strategies to be adopted in remedying students' difficulties in writing and balancing chemical equations, it was reported among others, that chemistry and mathematics teacher should cooperate in their instructional delivery (Anaekwe, 2019a); encouraging team teaching; using appropriate instructional material in teaching: charts/ periodic table; giving students projects in groups and individually on models of the periodic table; using appropriate instructional strategies in the class e.g cooperative learning strategy (Anaekwe, 2019b); ensuring that practical demonstrations go hand in hand with theoretical classes; pointing out the practical application/ social relevance of each concept being taught in chemistry; the teacher should give individualized attention in remedying identified difficulties; teacher should organize regular inter/intra class competitions among chemistry students. From table 3, all the nine (9) statements were accepted by the students as suggestions for remedying students' learning difficulties in writing and balancing chemical equations. An average calculated mean value and standard deviation of 3.47 and 2.99 respectively were obtained.

Conclusion

There are many implications from these findings which have significant impacts on education. Students' difficulty in writing and balancing of chemical equations as indicated by students using the 24-item Four-point Likert Scale Questionnaire the problem persists across class level, which negatively affect the understanding of other topics.

The difficulty students encountered in the writing and balancing of chemical equations could be attributed to poor teaching skills and lack of qualified chemistry teachers in most of our various secondary schools. It is believed that if students are properly groomed and given the basic skills in chemistry the difficult is bound to be minimized if not completely eliminated. The concept of chemical equation is so crucial that without proper mastery in it, students find virtually every other aspect of chemistry difficult.

Recommendations

Based on the findings and conclusion of the study, the following recommendations are made:

1. There should be collaboration between the mathematics and chemistry teacher in their instructional delivery, in order to work on some mathematical challenges relating to chemistry e.g making subject of formula.
2. Teachers should provide more practice questions on writing and balancing of chemical equations for students irrespective of gender in order to facilitate their understanding. Practical demonstrations should as well go hand-in-hand with theoretical classes.

3. Chemistry teachers should be regularly sponsored to conferences, workshops and seminars in order to build their skills and keep them informed on innovations in chemistry. Such update on methodology and contents in relation to the subject will help to minimize students' difficulties in writing and balancing chemical equations.
4. There is need for regular supervision of instruction in schools by the relevant education authorities in order to provide proficient solution to the menace

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